INCLUSIVE GROWTH IN MOZAMBIQUE
– scaling up research and capacity

Agricultural Development in Mozambique

Trends, Challenges, and Opportunities

REPORT
31 JANUARY 2025

Contents

Preface and Acknowledgements

This report on trends, challenges, and opportunities of the agriculture sector in Mozambique (2000–2020) presents the findings of the 2023 inquiry on agricultural development in Mozambique, implemented within the Inclusive Growth in Mozambique (IGM) programme. IGM is a research and capacity development programme supporting Mozambique since 2015 in designing evidence-based policies that support inclusive growth benefiting the poorest and most vulnerable groups.

The IGM programme is implemented by the National Directorate of Economic and Development Policies (DNPED) of the Ministry of Planning and Development of Mozambique (MPD; previously the Ministry of Economy and Finance) and the Centre for Economic and Management Studies (CEEG) of the Faculty of Economics of the Eduardo Mondlane University (UEM) in partnership with the University of Copenhagen Development Economics Research Group (UCPH-DERG) and the United Nations University World Institute for Development Economics Research (UNU-WIDER). The Government of Finland, the Government of Norway, and the Swiss Agency for Development Cooperation provide financial support that is gratefully acknowledged.

A particular focus of IGM activities in 2023 was the work stream entitled 'Productivity and resilience of smallholder farmers and responses to climate change', culminating in the presentation of a first draft of this report at the IGM Annual Conference on 8 November 2023 entitled 'Agricultural development in Mozambique: trends, challenges and opportunities'.[1] This report is now being launched in its final form. Overall, it aims to shed light on the evolution of the smallholder agricultural sector and to pinpoint key challenges and bottlenecks to raising farmer welfare in Mozambique. Among many other tasks, the groundwork for this study required extremely detailed cleaning and harmonization of two decades of data, including both the newer series of the agricultural surveys (*Inquérito Agrícola Integrado*, IAI) and older survey data (*Trabalho de Inquérito Agrícola*, TIA) produced by the Ministry of Agriculture and Rural Development (MADER).

This time-intensive data exercise has resulted in a truly novel dataset that makes it possible to track the recent trends in the sector – presented here – and provides a resource for further training of researchers and analysts at DNPED and UEM. An IGM Call for Research Proposals was issued in February 2023 as a mechanism to boost the participation of local researchers at the IGM Annual Conference and in the preparation of this final 2024 report. A total of 52 submissions were received by the deadline of 31 March 2023, and of these, 13 were selected by the Conference Scientific Committee. Ultimately, eight papers were selected for presentation at the Annual Conference.

The IGM Mid-Term Review (MTR) carried out in 2023 highlighted that it was a privilege for the MTR

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[1] See IGM Annual Conference 2023 | Inclusive growth in Mozambique (unu.edu) for further details on the Conference.

team to attend the IGM annual conference and noted that participation by policymakers, academics, and development partners was high and that the quality of the papers and posters was impressive. The MTR team added that given that more than two-thirds of Mozambicans live in rural areas, agriculture and rural development are critical research and policy areas if Mozambique is to address the daunting poverty challenges Mozambique is facing.

Many colleagues worked in an admirable manner with consistent commitment to undertake the 2023 IGM inquiry on agricultural development in Mozambique. The team of co-authors of this report includes Márcia Chelengo, Sofiaré Jamu, Hanna Berkel, Peter Fisker, Francesca Gioia, Sam Jones, Finn Tarp, and Neda Trifkovic. Policy considerations presented by Sofia Manussa and Celestino Pene of the Ministry of Agriculture and Rural Development (MADER) were most helpful in framing parts of the report, as were the many other contributions and feedback received at the 2023 IGM Annual Conference and in subsequent consultations with MADER and other institutions.[2]

As Programme Manager of the IGM programme, I would like to express my sincere gratitude to all of the many colleagues who contributed to producing the report we are now launching.

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31 January 2025

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[2] The report contains the research findings of the authors, so the views expressed do not necessarily reflect the views of the organizations with which they are associated or those of the programme donors.

Chapter 1

Summary and Recommendations

1.1 Introduction

Enshrined in Mozambique's modern constitution, agriculture plays a vital role in the country's economy and in the livelihoods of its people. Today, the vast majority of economically active Mozambicans continue to be reliant on smallholder farming. At the same time, Mozambique's agricultural productivity significantly lags behind that of neighbouring countries, particularly in yields of major staples such as maize, which performs well below its agronomic potential. A consequence of this situation is the widespread incidence and depth of both monetary and multidimensional poverty, the highest rates of which are found among households dependent on agriculture.

Set against this background, the present report analyses the trends, challenges, and opportunities in agricultural development in Mozambique, with a focus on the performance and challenges of smallholder farmers over the past two decades. While a variety of data sources and other information are used in the individual chapters, particular attention is drawn to Chapter 5, where we present novel micro-data and efforts carried out under the IGM programme to harmonize 11 agricultural surveys performed by MADER between 2002 and 2020.

The new harmonized dataset is unique and, for the first time, provides a coherent granular understanding of smallholder farmers, their living and working conditions, as well as production performance since the turn of the century. The underlying data include not only the newer series of the MADER agricultural surveys (*Inquérito Agrícola Integrado*, IAI) but also the older micro-data (*Trabalho de Inquérito Agrícola*, TIA). Taken together, these cover surveys completed in 2002, 2003, 2005, 2006, 2007, 2008, 2012, 2014, 2015, 2017, and 2020.

This study essentially takes as its point of departure the end of the period studied by Tarp et al. (2002), providing back-to-back insights into developments in Mozambique since Independence in 1975.[1] This earlier

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[1] The study by Tarp et al. (2002) entitled 'Facing the Development Challenge in Mozambique: An Economy-wide Perspective' was a major attempt to come to grips with developments in the Mozambican economy, with a specific focus on agriculture, addressing the period from Independence until the turn of the century. Much of what transpired in that report including the statement that "The combined legacies of colonialism, idealism, socialism, war fuelled by racism, economic collapse, and structural adjustment (inspired by stout liberalism) have made a lasting impact on the structure of the economy" (p. 1) remain relevant to the present day.

study, supported by the International Food Policy Research Institute (IFPRI), began by putting the economic and social characteristics of Mozambique in regional perspective, tracing the historical path to war during the 1980s and economic collapse in 1986. The authors noted that economic growth was relatively rapid after peace in 1992, but pointed out that recovery from an extremely low point resulting from the war, drought, and prior economic mismanagement was a major aspect of the turnaround. It was therefore concluded that underlying constraints to agricultural transformation were much the same as a couple of decades earlier, and that the more difficult development challenges were lying ahead. The present study puts focus on what happened next in the agriculture sector in Mozambique.

In line with the earlier IFPRI study, a main objective here is to examine the relevance and effects of various constraints faced by smallholder farmers, including climatic factors, infrastructure deficiencies, and technological limitations that hinder productivity and the overall development of the agricultural sector. Consequently, the report evaluates historical agricultural strategies implemented in Mozambique, emphasizing the ongoing need to prioritize smallholder farmers and address policy implementation challenges to achieve sustainable development of the agricultural sector and inclusive growth in the future.[2]

The report discusses in detail the strengths and weaknesses of the TIA/IAI harmonized dataset, which provides valuable insights into smallholder farming in Mozambique. This underscores the importance of data validation, verification, and continuous improvement to enhance the reliability and usefulness of these data sources. While we have used these new data extensively in preparing the report, this should also only be seen as an essential first step in improving the necessary information base for monitoring, reviewing, and assessing agricultural performance in the country, looking to past experiences for inspiration and key lessons as well as to emerging trends and opportunities.

Looking to the future, and to the growing impacts of climate change, the final chapter of the study simulates its potential effects on agriculture in Mozambique and discusses policy implications. It emphasizes the significance of adaptation strategies, support for smallholders, climate-smart agriculture practices, research, and the integration of traditional knowledge to address the challenges posed by climate change to Mozambican agriculture.

Overall, our aim has been to provide a comprehensive analysis of the current state of agricultural development in Mozambique, identify the key constraints and challenges, and propose policy recommendations to enhance the productivity and resilience of smallholder farmers, ultimately contributing to sustainable agricultural development in the country, leading to inclusive growth and the reduction of poverty in line with IGM objectives.

Further research using the data assembled here, as well as from other sources, will be vital to enrich the evidence base in support of policies that strengthen the agricultural sector.

1.2 Overview

1.2.1 Objectives

Our report makes several significant contributions to the understanding of agricultural development in Mozambique, with a particular focus on the challenges and opportunities faced by smallholder farmers,

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[2] See also the various chapters in Cruz et al. (Eds) (2023), including Chapter 4 on the relative neglect of agriculture in Mozambique by Carrilho et al. (2023).

as briefly summarized below.

As a first contribution, **Chapter 2** provides a comprehensive benchmarking analysis that compares Mozambique's agricultural productivity, especially in cereals yields, to that of other countries in the region and beyond. The analysis highlights areas where Mozambique is underperforming relative to its potential. It concludes that Mozambique is something of an outlier, in the sense that crop yields are lower than would otherwise be explained by conventional 'observed' determinants, underscoring the need for targeted and sustained interventions across the sector.

The benchmarking analysis is complemented in **Chapter 3** by an in-depth review of the multifaceted 'hard' and 'soft' constraints faced by smallholder farmers in Mozambique. These include soil quality, climatic factors such as droughts and floods, infrastructure challenges like poor road networks and storage facilities, and technological limitations in accessing improved seeds, fertilizers, and improved agricultural practices. In examining these constraints, the chapter notes that regions of the country least affected by 'hard' constraints, which cannot be easily modified, also face some of the most severe 'soft' constraints, reflecting persistent spatial income inequalities and a legacy of uneven public investments. As such, the report lays the groundwork for developing effective strategies to address these softer constrains and optimize investments.

A similar perspective emerges from **Chapter 4**, which gives a comprehensive evaluation of historical agricultural strategies implemented in Mozambique over the past two decades. It objectively summarizes the main priorities established by these strategies and assesses their strengths and limitations, shedding light on factors that have contributed to limited progress. This critical analysis is essential for informing future policy decisions and ensuring that agricultural development efforts are relevant, feasible, and tailored to the variegated needs of Mozambican smallholders.

As already alluded to, a significant contribution of this report is the presentation in **Chapter 5** of a new harmonized dataset compiled from 11 agricultural micro-surveys conducted in Mozambique over the period from 2002 to 2020. This consolidated dataset provides a vast wealth of information on smallholder farms (e.g., land allocations), their farming practices (e.g., crop choices), production outcomes (yields and crop incomes), and household characteristics. In harmonizing the underlying microeconomic data sources, the report permits a robust analysis of trends in the sector and enhances our understanding of the complexities of small-scale agriculture in the country.

Leveraging this new dataset, **Chapter 6** of the report compares estimates of the value of aggregate production from agricultural micro-surveys against those obtained from a range of other sources, including national accounts. The analysis paints a rather sombre picture. Not only has the rate of growth been falling in real terms, but macroeconomic estimates of agricultural production values have increasingly diverged from those obtained from original microeconomic survey data, raising concerns that some components of national accounts may be somewhat overestimated. Among other things, this has significant implications for our understanding of poverty and (spatial) inequality.

The report further demonstrates the many potential applications of the harmonized dataset. In particular, **Chapter 7** profiles smallholder farming and describes how the sector has evolved over the past two decades. Among the many topics addressed are trends in land cultivated (plot sizes), access to agricultural inputs, technology usage, commercialization, production choices and analyses of yield, as well as produce and sales values.

Chapter 8, in turn, notes that indicators of agricultural performance represent composite measures, capturing the combined effect of changes in the incidence of agricultural activity, cropping patterns, and productivity. As such, positive growth in one component can be offset by weaker performance in another. The chapter proceeds to unpack (decompose) the sources of agricultural output growth, with a view to informing policy at a more granular spatial and crop level. It shows that productivity growth in the sector has been robust, driven particularly by gains in cassava yields, likely reflecting gains from public investments in appropriate new varieties. Nonetheless, such gains have been offset by a trend decline in area farmed per household as well as a relative shift out of higher-growth crops. This indicates that barriers to successful commercialization are significant and for many rural households non-farm activities are also an important source of income diversification.

Chapter 9 focuses on how different livelihood strategies pursued by smallholders play out in terms of their well-being, aiming to address the question of what successful smallholder farming strategies actually look like in Mozambique. Cluster analysis is relied on to identify a set of distinct livelihood strategies, associated with five different types of households. It emerges that, over time, the share of households pursuing the cereals and cash crops/livestock livelihood strategies has increased, while others have decreased. Moreover, the different strategies are associated with quite different overall performance in terms of yields, revenue, and food security – but results are associated with caveats due to the underlying data. Results are, for example, downward-biased for clusters that are net buyers of food. This makes it difficult to be assertive, though it would appear that risks inherent in production and commercialization of cash crops are not well insured against shocks. All in all, the findings highlight the need for a better understanding of heterogeneity in how farmer strategies impact different performance outcomes. What is clear, however, is that production inputs are important predictors of income and yield.

Lastly, **Chapter 10** makes the point that Mozambique ranks among the top 10 countries in the world most vulnerable to natural hazards, while also being among the least prepared. Climate-smart agricultural activities are identified and the chapter concludes with some illustrative simulations of the potential impacts of climate change on smallholder farmers.

In sum, Chapters 7–10 not only showcase the versatility of the novel dataset developed by the IGM programme but also provide a framework for future research and analysis, as long as the caveats referred to are kept in mind.

1.2.2 Policy implications

Taking stock, this report emphasizes at the general level the **critical importance of prioritizing smallholder farmers** in Mozambique's development policies and strategies. Without ignoring the importance of larger farms, who have special potential to stimulate agro-industry with positive spillovers for local development, smallholder farmers play a vital role in the country's agricultural sector and for the well-being of what is a rapidly growing population. However, smallholder farmers face numerous constraints that hinder their productivity and overall development. Accordingly, the report underscores the need for policies and actions that address the specific needs and priorities of smallholder farmers; an observation that was also made more than two decades ago in the above-cited IFPRI report.

Importantly, these broad recommendations are in line with the analysis of the Mozambican labour market by Jones and Tarp (2012). They point to three jobs priorities. The first is to address existing low levels of agricultural productivity. Sustained poverty reduction requires transforming agricultural jobs. Second, the non-farm informal sector should be supported as it is a source of dynamism and entrepreneurship. Good jobs are not just formal sector jobs. Third, policy initiatives must seek to stimulate the (modern) agricultural demand side, such as labour intensive agro-industry that has export potential and can help compete with imported consumer products.

The report also emphasizes the importance of more **sustained commitment and effective implementation of well-designed and evidence-based agricultural strategies**. While the multitude of past strategies in the sector have often focused on institutional development and public-private partnerships, there have been clear challenges and weaknesses in strategy design and implementation as well as resource allocation – see also Carillho et al. (2023) for illustrative examples. The report therefore underscores not only the need for adequate resource allocation, but also the need for enhanced coordination among different stakeholders, as well as robust monitoring and evaluation mechanisms, so as to ensure successful implementation of agricultural strategies and plans. Without this, sustainable development in the sector will remain difficult.

Indeed, development of the agriculture sector is a long-term process, needing not just **vision and strategy** but also **stable public policies** to promote links between the various sectoral policies pursued by committed public institutions. To ensure that policies are inclusive, adequate, and effective, non-governmental and private social and economic organizations should be involved in their design and in the monitoring of their implementation. As argued in detail by Carillho et al. (2023, p. 111), this would help offer an avenue for the development of an alliance between the state, the producers, especially smaller farmers, their organizations, and other institutions to improve the performance in the sector.

The report highlights the large variation in challenges faced by smallholders, especially when viewed spatially, as well as among different clusters of farmers and across age groups. This means that **context-specific and iterative approaches** are required, but also that a general shift of investment toward high potential areas is recommended. This requires considerations of market access, with renewed emphasis on regional trade and infrastructure policies. Supply-side policies, while critically needed and ranging from **input supply** to **technological upgrading**, are just one aspect of the needed impetus to unblocking progress in the smallholder sector. Policies must in the longer term aim to strengthen farmer livelihoods and the transformation of family farms into commercial units. For this to happen, policies must support the integration of small farmers into effective **value chains** with high market potential as well as into goods and services markets. In this context, coordinated **infrastructure** development planning and market development activities – both internal and external – are integral parts of a well-designed strategy for the future.

In Mozambique, since tight **fiscal constraints** dominate the macroeconomic environment and will continue to do so for the foreseeable future, it is difficult to imagine that large-scale **input subsidy programmes** can be sustained. As a result, additional research is required to identify particularly cost-effective interventions around specific commodities and value chains, including, for example, cassava that has seen yield gains. An additional insight is that supporting the transition of farmers through **outgrower** schemes, with adequate oversight and regulation, is a measure that should be given more serious attention.

The whole value chain approach suggested from harvest and storage to processing and end markets will require adequate overall **market designs** as well as specific policies and market interventions. To propel agricultural transformation and development that is socially inclusive and sustained, Mozambique will also need to adopt suitable **agricultural credit and insurance policies** to stimulate investment in the intensification of agricultural production alongside price and market policies that help reduce the risk of negative impacts to production caused by fluctuations and market downturns.

Arguably, the potential of using **price floor guarantees** should be further investigated, along the lines of what is happening in the cotton sector. Care needs to be taken that fiscal constraints are observed, so it would be over-ambitious to aim in the near future at fixed national schemes, but experimentation could begin at a lower scale alongside initiatives similar to social protection. Readiness to scale up successful experiences and withdraw from less successful ones will be key. The same goes for needed investment in farming systems research and experimentation focused on crops with significant potential for small farmer welfare and productivity.

Given the vulnerability of Mozambique to the impacts of climate change, the report highlights the **urgency of addressing climate change** through targeted policies and adaptation strategies. This includes promoting climate-resilient crop varieties, water and soil management practices, early warning systems, and farmer training on climate-smart agriculture. The report emphasizes the importance of collaboration between researchers, policymakers, and farmers to develop and implement effective climate change adaptation measures for the agricultural sector.

A central premise underlying this report is the importance of developing and maintaining **improved data systems,** including methods for realistic, cost-effective, and time-sensitive crop monitoring. An important step in this regard has been the harmonization of the data available for the last 20 years, carried out by the IGM team in preparing this study. However, such efforts must obviously be continued across the institutional landscape in Mozambique and go hand in hand with research into key areas of particular importance.

Finally, in the broader perspective laid out above, agricultural development must help **stimulate and sustain dynamic rural economies**. We believe this will in the future require taking a wider perspective, where new technologies to raise productivity contribute to both enhanced resilience and the reduction of wastage. Present levels of waste in production and consumption represent a significant unrealized potential, as does improved use of biological resources in existing and future value chains of high societal value.

1.3 Conclusion

Agriculture remains at the centre of Mozambique's development trajectory, and overall, the report's main policy messages underscore the critical importance of prioritizing smallholder farmers, improving infrastructure, strengthening extension services, ensuring effective implementation of agricultural strategies, and addressing the impacts of climate change through effective adaptation strategies. Accordingly, across the different chapters we point to the importance of a broad structural reform agenda in agriculture, agro-industry, and the secondary and tertiary sectors for rural development; and we emphasize the need for integrated policies with a long-term outlook and the ability to implement them effectively.

Sustainable and inclusive development of the agriculture sector requires both a vision and stable public policies. Non-governmental and private social and economic organizations must play a structured role in policy design and implementation through dialogue and advocacy; and the focus should, as highlighted in the report, be on promoting small-scale farming to contribute to inclusive development. Agriculture is the basis for the livelihood and well-being of rural families, who make up the large majority of the population.

Policies should in general help promote better livelihoods and the transformation of family farms into commercial units, integrating them into productive value chains with high market potential and into goods and services markets. Agro-industry, which adds value to agricultural commodities, can play a key role in agricultural development.

Importantly, these recommendations align, on the one hand, with existing analyses of the Mozambican labour market, focusing on addressing low levels of agricultural productivity, supporting the non-farm informal sector, and promoting sustainable poverty reduction, and, on the other hand, with studies on the institutional challenges that are characteristic of the Mozambican economy and society.

By highlighting these policy implications both of a general and of a more specific character, and having constructed a novel database to support future analyses, we believe the report provides valuable input and guidance for policymakers and stakeholders in Mozambique's agricultural sector, aiming to promote sustainable development, increase productivity, and improve the livelihoods of smallholder farming communities.

Chapter 2

Benchmarking Smallholder Maize Productivity in Low-Income Africa: Is Mozambique an Outlier?

2.1 Introduction

Compared to higher-income countries where significant production of cereals is undertaken on commercial farms, in sub-Saharan Africa (SSA) the majority of maize production as a main staple crop is undertaken on smallholder family plots. The production on these farms is typically realized with the use of family labour and hand tools. Reliance on agricultural mechanization is almost entirely absent. The average maize productivity on smallholder farms is generally low, ranging from about 1 tonne per hectare in Mozambique to 4 tonnes in Ethiopia and 5 tonnes in South Africa. The EU average is 7 tonnes, while the US average is 11 tonnes of maize.[1]

Relative to the biological yield potential, maize yields in Africa achieve 16 to 36 per cent in tropical lowland and subtropical regions, respectively (Lobell et al., 2009). This gap between actual and potential yields is typically explained by a low use of inputs, especially fertilizers. Following the Maputo Declaration in 2003, 10 African countries started implementing input subsidy programmes. At the African Fertilizer Summit in Abuja in 2006, attending countries committed to increasing fertilizer use to 50 kg/ha by 2015 and many (re)introduced the fertilizer subsidy programmes (Scheiterle et al., 2019). Even though they reduce access barriers by offering fertilizer at a lower price, the fertilizer subsidy programmes have not reached their expected effects (Bold et al., 2017). Instead, factors such as nutrient balance, land quality, and management gained prominence in the policy discourse (Burke et al., 2020; Häring et al., 2017; Marenya and Barrett, 2009), alongside the role of institutional barriers, extension agents, timely availability of inputs, or remoteness in addressing stagnation in crop productivity (Minten et al., 2013; Duflo et al., 2011).

Several studies investigate maize productivity at a microeconomic level, which is helpful to tease out causal relations at a specific point in time (Muyanga and Jayne, 2019; Sheng et al., 2019; Mueller et al., 2012; Burke

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[1] These figures are from FAOSTAT (2023).

et al., 2020; Scheiterle et al., 2019; Carter et al., 2021), but this can miss longer term trends and differences across countries. Similarly, studies based on non-parametric techniques such as data envelopment and stochastic frontier analysis focus on aggregate agricultural productivity growth (Headey et al., 2010), which rarely provides a distinction between types of crops and potentially overlooks sub-sectoral heterogeneity that is important for policymakers.

In this chapter, we undertake a cross-country descriptive time-series benchmarking exercise. The aim is to assess key structural drivers of trends in average maize and cereals productivity, with a view to identifying higher and lower performers, as well as to isolate the potential conditional contribution of observed factors, such as access to inputs, institutions, and policies.

We first present trends across countries in terms of agricultural, maize, and cereals production, focusing on their contribution to economic growth. We then show multi-input productivity estimates of maize and cereals, focusing on how Mozambique compares to other (East) African countries.

The key finding is that production inputs (in particular, seeds and land available for agriculture) significantly correlate with maize and cereals yields, whereas structural factors such as GDP and population composition play a less important role. A negative relationship between yields and the proportion of women and youth could indicate unequal chances of productively participating in the agricultural sector for different parts of the population. Policy and institutional variables, including public agricultural expenditure and quality of institutions, are not significant correlates of productivity. In terms of both maize and cereals yields, Mozambique is performing below its potential.

2.2 Data

We use data on agricultural production and country-level macroeconomic indicators such as gross domestic product (GDP, measured in 2015 USD), population density (number of persons per square kilometre), agricultural land size (in 1000 hectares), irrigation coverage (measured as land equipped for irrigation), and government spending on agriculture (calculated as a proportion of spending on agriculture in total government spending including both central and general expenditure) from the FAO Statistical Database (FAOSTAT, 2023). Government spending on agriculture is available only in 2001–2021, so estimations using this variable have fewer observations.

The same database is the source of information about production inputs, including seeds, fertilizer, and pesticides. The main advantage of the FAO database is that the key variables are available from as early as 1960 for a large number of countries, but we limit the analysis to 45 African countries with consistent information in the period 1974–2020. Seeds data are from the FAO's Supply Utilization Accounts and Food Balance Sheet, which accounts for commodities potentially available for human consumption, so the variable seeds is the amount of maize product used as seeds. As an alternative measure, we use the value of imported seeds from the UN Comtrade Database (UN Comtrade, 2023). Fertilizers are calculated as a sum of the amount of nitrogen-, phosphate-, and potassium-based inorganic fertilizers used for agriculture. Pesticides are calculated as a sum of insecticides, herbicides, fungicides, plant growth regulators, and rodenticides used in agriculture. All input variables are divided by the size of available agricultural area in the country and expressed as quantity in tonnes per 1000 hectares. Missing values for inputs are imputed using predictions based on main country characteristics and climate variables. As shown in Table 2.2.1, Mozambique on average lags behind other African countries in terms of fertilizer and pesticide use, applying 17 per cent and

21 per cent of the continent's average of fertilizer and pesticides, respectively. In contrast, Mozambique sets double the average amount of seeds from own production to be used in the next planting season. In terms of seeds imports, the value is lower in Mozambique than elsewhere in Africa by about 30 per cent.

In terms of the climate variables, we use the average yearly surface temperature time-series data from the Climatic Research Unit (CRU) at the University of East Anglia (Harris et al., 2020). The average annual temperature values for Mozambique are very close to the average for Africa, as shown in Table 2.2.1.

The institutional quality is measured as the economic freedom index provided by the Fraser Institute in the form of The Economic Freedom of the World database. The economic freedom index is a score on a scale from 0 to 10 consisting of weighted averages within five areas, including the size of government, legal system and property rights, sound money, freedom to trade internationally, and regulation. The score in each of these areas is derived from a varying number of sub-scores per area, giving 24 sub-scores in total. The economic freedom index variable is available in five-year intervals until 2000 and yearly thereafter, resulting in fewer observations in estimations using this variable. Estimations using this variable are based on 42 countries, given that this database does not give full coverage of all African countries. All continuous variables enter estimations in a logarithmic form. Not only is the average value of the index for Mozambique lower than the average for Africa (1.18 compared to 1.41). The value of the index has also steeply declined over the past two decades.

In terms of general country characteristics, shown in Table 2.2.1, Mozambique is a poor country with low GDP per capita and lower-than-average population density. The share of rural population is higher than average and following global trends is declining over time at a similar rate as elsewhere in Africa. The share of children younger than 14 years is slightly higher and fluctuates less over time than in other African countries. Mozambique has higher-than-average availability of land for agriculture, but a negligible fraction of it is equipped for irrigation.

Table 2.2.1: Summary statistics

	All	**1970s**	**1980s**	**1990s**	**2000s**	**2010–2021**
All countries						
GDP per capita	2,007.8	1,592.1	1,601.6	1,678.1	2,248.8	2,571.0
Population density	61.2	37.4	46.7	57.1	69.6	87.3
Rural population share	0.6	0.8	0.7	0.7	0.6	0.6
Female population share	0.5	0.5	0.5	0.5	0.5	0.5
Population 0–14 share	0.4	0.4	0.4	0.4	0.4	0.4
Agricultural land (1,000 ha)	22,334.5	21,669.0	21,916.6	22,283.6	22,964.7	22,653.3
Irrigation area (1,000 ha)	271.1	204.3	221.0	264.7	299.3	339.1
Temperature (C)	24.2	23.6	23.9	24.1	24.4	24.6
Fertilizer (1,000 tonnes)	111,489.9	70,287.1	99,974.1	104,111.7	113,374.6	149,104.9
Pesticides (1,000 tonnes)	2,040.7	.	.	1,551.9	1,897.9	2,607.7
Seeds (1,000 tonnes)	21,151.6	.	.	.	.	21,151.6
Imported seeds (1,000 USD)	3,523.9	.	.	5,321.9	2,348.6	3,867.5
Agricultural expenditure	5.0	.	.	.	6.1	4.4
Institutions quality	1.4	1.6	1.5	1.5	1.4	1.4
Mozambique						
GDP per capita	358.8	.	204.8	235.9	385.8	567.0
Population density	21.8	12.4	15.5	19.0	25.0	33.7
Rural population share	0.7	0.9	0.8	0.7	0.7	0.7
Female population share	0.5	0.5	0.5	0.5	0.5	0.5
Population 0–14 share	0.4	0.4	0.4	0.4	0.4	0.4
Agricultural land (1,000 ha)	37,167.7	34,666.0	34,939.0	36,245.5	38,447.1	40,688.6
Irrigation area (1,000 ha)	99.1	43.2	92.7	110.6	117.6	118.0
Temperature (C)	24.2	23.6	23.9	24.2	24.4	24.5
Fertilizer (1,000 tonnes)	19,373.5	13,920.4	14,360.3	5,833.3	20,706.9	37,762.8
Pesticides (1,000 tonnes)	423.6	.	.	81.2	496.4	668.7
Seeds (1,000 tonnes)	46,029.6	.	.	.	.	46,029.6
Imported seeds (1,000 USD)	2,462.7	.	.	.	1,193.8	3,520.1
Agricultural expenditure	5.0	.	.	.	8.9	2.1
Institutions quality	1.2	.	.	.	1.5	1.0

Source: Authors' compilation.
Note: GDP per capita is in constant 2015 USD. Irrigation area measures land area equipped for irrigation.

2.3 Methods

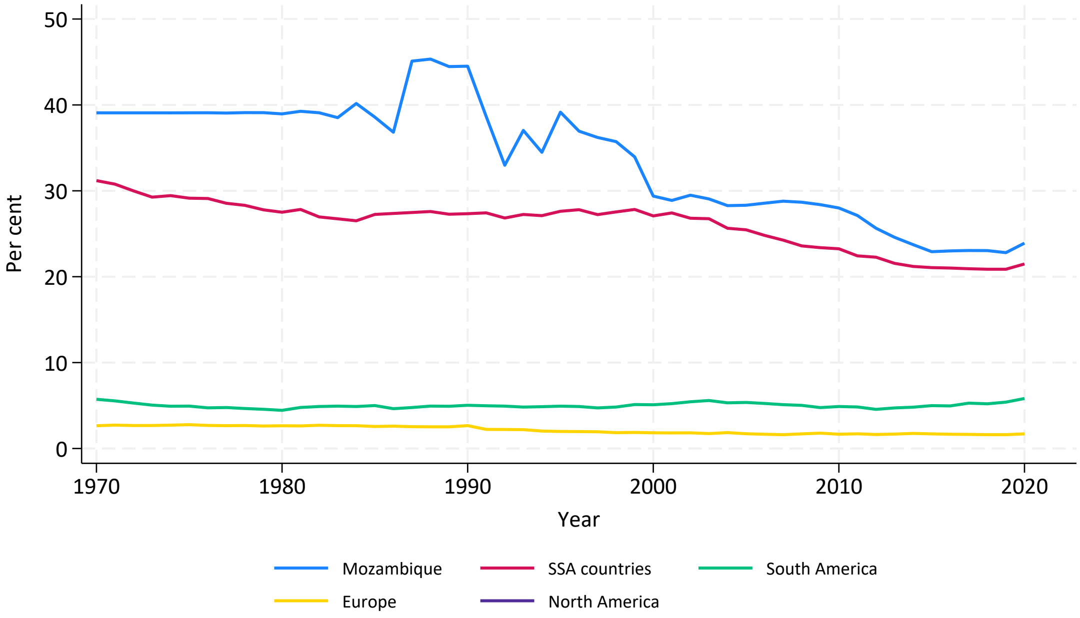
We illustrate time-series trends in graphs, calculate descriptive statistics, and perform regression analysis based on ordinary least squares and country fixed effects models. In the regression framework, we regress maize or cereals yields on key country characteristics such as GDP, population, agricultural land size, and other variables, over the years 1974–2020. Following Headey et al. (2010), our specifications assume that yields could be associated with omitted inputs (e.g., climate), inputs (e.g., seeds), the efficiency of resource allocation (e.g., institutional quality), and the development and application of new technologies (e.g., public expenditure).[2]

2.4 Results

2.4.1 Economic contribution of agriculture

In SSA, the contribution of the agricultural sector to GDP is on average higher than in other parts of the world, as shown in Figure 2.4.1. In 2019, agriculture contributed 18 per cent of total GDP in SSA, whereas it contributed 7 per cent in Asia and 5 per cent in South America. The contribution of agriculture to total GDP in Europe is 1.6 per cent and 1 per cent in North America. In Mozambique, agriculture contributed to GDP by 23 per cent, which is notably higher than the SSA average. A high contribution of agriculture to GDP is an indicator of limited diversification of African economies and in particular Mozambique. At the same time, there is a high reliance on agriculture for employment. Compared to large economies in Europe and North America, agricultural value added per worker is very low in SSA, as shown in Figure 2.4.2.

Figure 2.4.1: Value added from agriculture, forestry, and fishing as a percentage of GDP



Source: Authors' compilation based on FAOSTAT (2023).
Note: Data span 1970 to 2020 inclusive.

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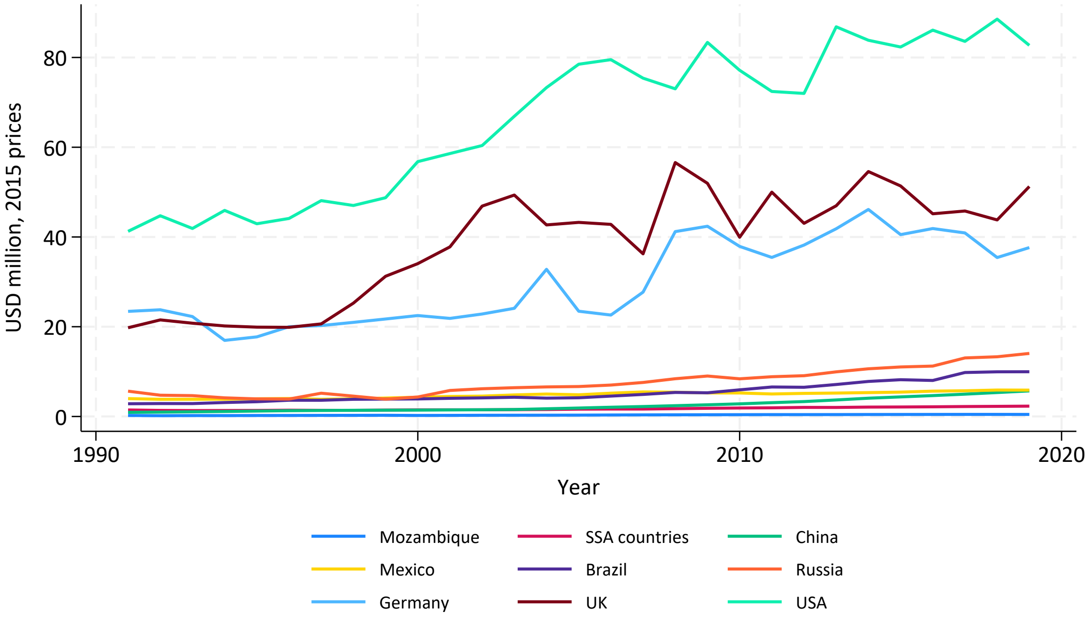
[2] We do not control for agricultural mechanization due to unreliable data coverage. For example, FAOSTAT discontinued its database on agricultural machinery in 2009.

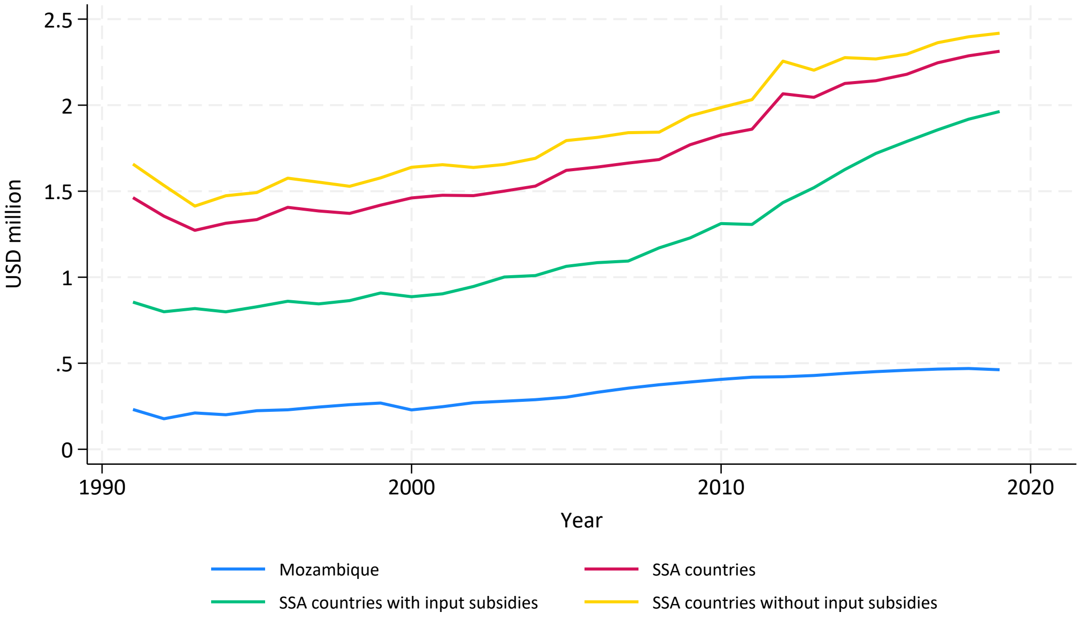
Figure 2.4.2: Value added from agriculture, forestry, and fishing per worker



Source: Authors' compilation based on FAOSTAT (2023).
Note: Data span 1991 to 2019 inclusive.

From 1991 to 2019, the value added of agricultural production in SSA, measured in constant US dollars per worker, increased by 58 per cent (Figure 2.4.3). The growth rate of the agricultural value added doubled in Mozambique in the same period (from 0.23 to 0.46 USD million per worker), but it is still only 19 per cent of the SSA average. When evaluated against agricultural land area, the growth of agricultural value added in Mozambique increased from 35 thousand USD/ha in 1991 to 90 thousand USD/ha in 2019, which is only 7 per cent of the SSA level, as shown in Figure 2.4.4. Mozambican agriculture is thus only slightly more productive in terms of labour than the land input, indicating that more consideration should be given to how land is used to achieve improvements in agricultural productivity.

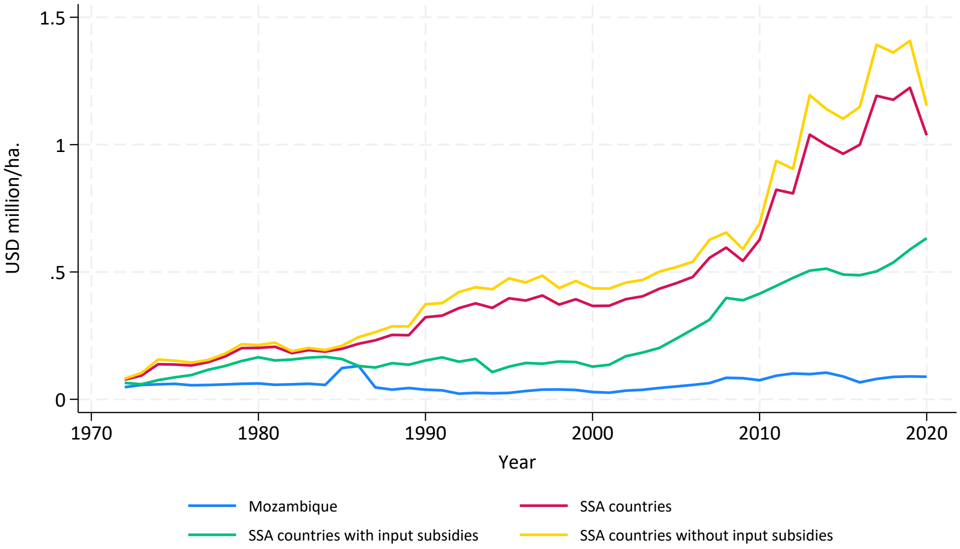
Figure 2.4.3: Value added from agriculture, forestry, and fishing per worker in SSA



Source: Authors' compilation based on FAOSTAT (2023).

Note: Data span 1991 to 2019 inclusive.

Figure 2.4.4: Value added from agriculture, forestry, and fishing per agricultural land area



Source: Authors' compilation based on FAOSTAT (2023).

Note: Data span 1972 to 2019 inclusive.

2.4.2 Cereal and maize yields in sub-Saharan Africa

The cereals sector makes up the largest share of the total agricultural production value, with maize being the single most important staple crop (Hollinger and Staatz, 2015), so we highlight some trends in cereals and maize production.

The two dashed lines in Figure 2.4.5 show the difference in yields of cereals and maize between 10 African countries that started implementing input subsidy programmes following the Maputo Declaration in 2003 and other countries. Although countries with input subsidy programmes had modestly higher cereal yields than the non-subsidy group of countries since the mid-1980s, the yield growth picked up in particular in the mid-2000s and on. In 1982, the gap between the two groups of countries was 0.28 tonnes/ha. By the early 2000s, this gap had stayed almost unchanged, but it started increasing slowly after 2005 to about 1.5–2 times the size. Only after the mid-2010s did the gap increase by 2.5–3 times, reaching 0.62 tonnes/ha in 2021.

In terms of maize, the yield gap was on the side of countries without the input subsidies until the mid-1980s. The situation shortly reversed in favour of the countries that introduced input subsidies. They enjoyed a mild yield gap until the mid-1990s. Afterwards, no gap could be observed until the mid-2010s. The subsidy countries have thereafter experienced higher yield growth. By 2020, the maize yield gap between subsidy and non-subsidy countries had widened to 0.5 tonnes per hectare, but it declined to 0.3 tonnes/ha in 2021. In spite of the input subsidy programme, the yield gap between SSA and Asia and South America continued to increase, as indicated by the black line in Figure 2.4.5.

2.4.3 Yield gaps between Mozambique and selected countries

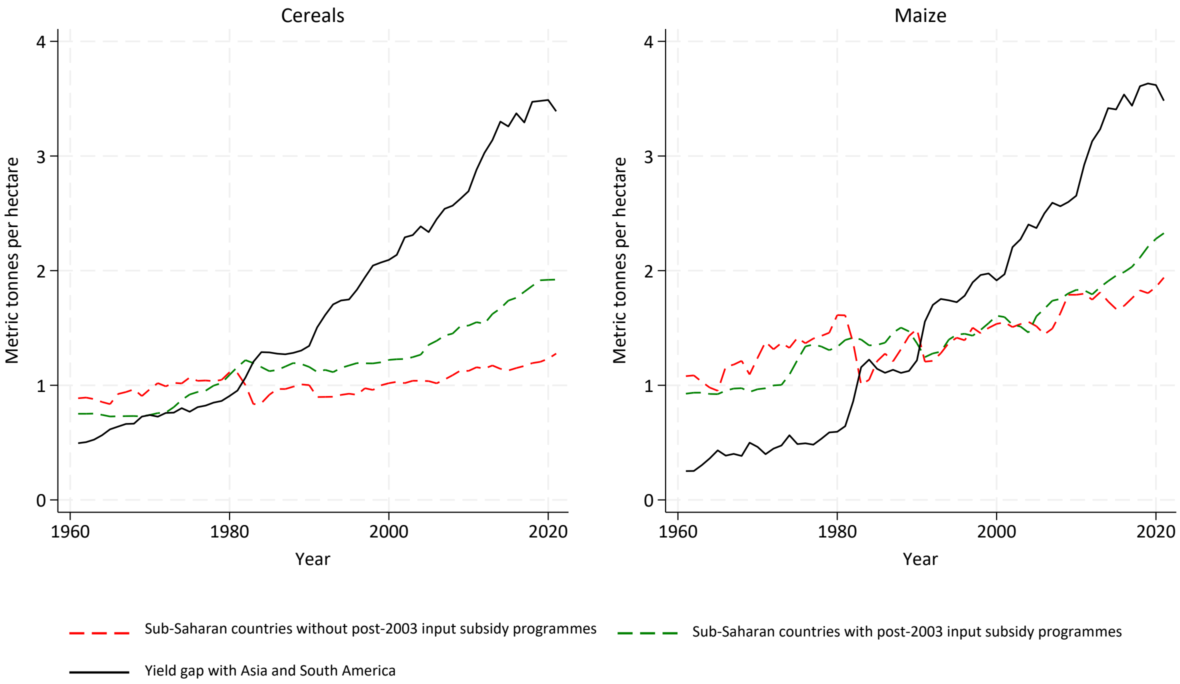
Figure 2.4.6 shows that the main maize producers in Africa are South Africa, Nigeria, Ethiopia, Egypt, and Tanzania, based on the most recent three-year average. Countries with very little production include Mauritius, Libya, Algeria, Congo, Guinea-Bissau, Mauritania, The Gambia, Eritrea, Sudan, Niger, and Morocco. Most of these countries also do not have good suitability of land for maize production, as shown in Figure 2.4.7. A paradox is Egypt, whose soil is not at all suitable for maize production but has one of the highest levels of production in Africa and good yields. The opposite is relatively true for Mozambique, which has very good soil suitability for maize production but a very modest output. Figure 2.4.7 also shows the values of the soil suitability index for eight types of cereals. Countries with low suitability for maize production do not have good suitability for other cereals either. Overall, the soil suitability index value for Mozambique is mainly driven by very good suitability for sorghum production, followed by maize and rice.

Figure 2.4.8 shows the yield gap between Mozambique and other countries in selected regions. The yield gap between Mozambique and other Sub-Saharan African countries is about 1.2 tonnes per hectare, which is not as wide as the gap between Mozambique and Asia and South America, respectively, which is about 4.5–5 tonnes per hectare.

Mozambique is among the 25 per cent least productive maize producers in Africa, evaluated in terms of maize yields. Compared to neighbouring countries such a Tanzania, Mozambique now achieves about one-half of their maize yields, while compared to Kenya and Zambia, Mozambique achieves 44 per cent of their maize yields (Figure 2.4.9). Mozambique achieves only 20 per cent of South Africa's maize yields. In the early 1970s, all these countries were at a roughly comparable level of yields.

Maize yields in Mozambique suffered substantially during the prolonged conflict period. The growth picked up in the 1990–2000 period, after which it slowed down and started to decline in the mid-2000s. After a

Figure 2.4.5: Cereals and maize yields in sub-Saharan Africa



Source: Authors' compilation based on FAOSTAT (2023).
Note: Data are three-year moving average cereals and maize yields, weighted by agricultural land share, from the FAO Statistical Database (FAOSTAT, 2023). The ten countries that implemented input subsidy programmes after the 2003 Maputo Declaration are Mali, Burkina Faso, Ghana, Senegal, Nigeria, Kenya, Malawi, Tanzania, Zambia, and Ethiopia. Yield gap is the three-year moving average of the difference in land-share-weighted average maize yields between Asia and South America, on the one hand, and sub-Saharan Africa, on the other. Data span 1961 to 2021 inclusive.

brief jump in the early 2010s, the productivity levelled off at around 0.8 t/ha.

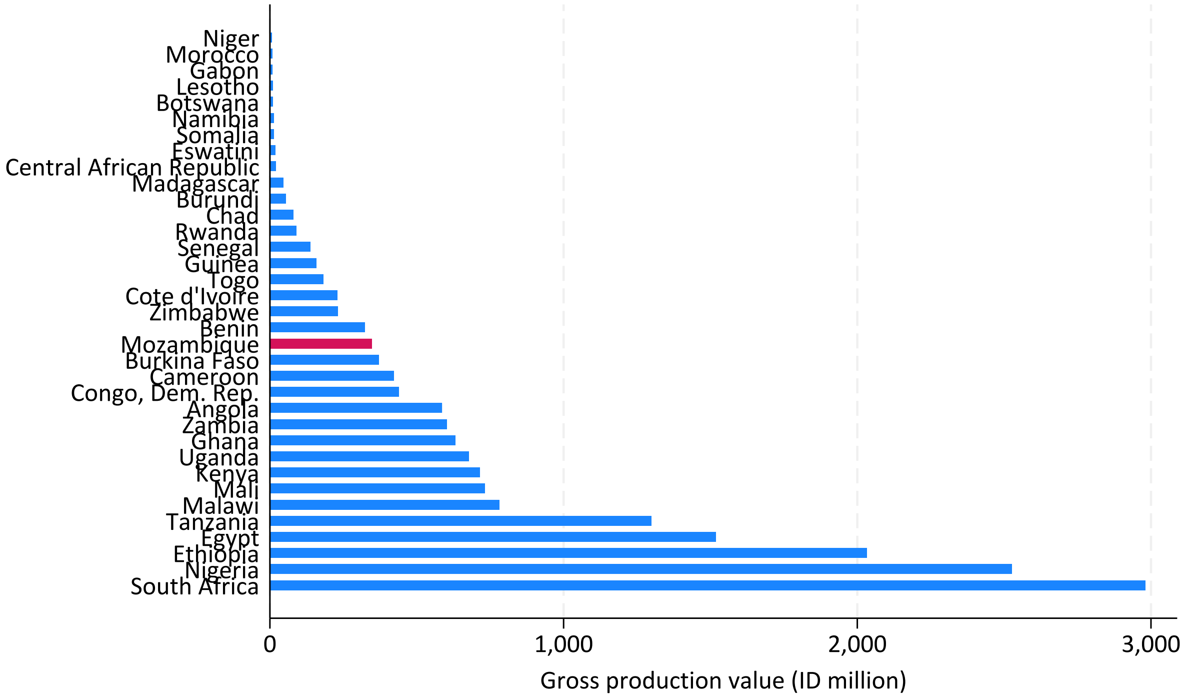
2.4.4 Determinants of maize yields

To understand how agricultural productivity in Mozambique can be improved, we analyse the proximate determinants of cereals and maize yields and compare Mozambique with neighbouring countries, some of which are at the top of the cereals and maize productivity distribution.

Cross-country regressions of maize yields in Table 2.4.1 show a positive association between GDP and yields in column 1. Climate variables such as temperature have a non-linear relationship with maize productivity both in across- and within-country comparisons. The results in column 2 show that low temperatures negatively affects yields, which increase significantly with temperature increases.

Column 3 shows a negative association between female population share and maize yields. Land available for agriculture is negatively associated with maize yields, while the squared land availability term is positive. There is a positive association between fertilizer use and maize yields. However, the importance of fertilizer declines once country-specific time-invariant characteristics are accounted for, as shown in column 4. A higher use of pesticides is negatively associated with yields. Availability of seeds (both from own production

Figure 2.4.6: Gross production value of maize (average for 2019–2021)



Source: Authors' compilation based on FAOSTAT (2023).
Note: ID stands for International Dollar.

and imports[3]) emerges as another significantly positive predictor of maize yields both in Ordinary Least Squares (OLS) and fixed effects estimations.

Columns 5 and 6 include a control for the quality of institutions measured as the economic freedom index. This variable has a negative but not statistically significant relationship with maize yields, as shown in column 5. The result is reversed in terms of the sign in column 6 when country-specific heterogeneity is accounted for, but the coefficient is not statistically significant. The role of government spending on agriculture is not precisely determined and therefore not shown.

Using a residual analysis based on our benchmark estimations, we identify which countries might be statistical outliers in terms of maize productivity. We use the specification from column 5 in Table 2.4.1, where we alternate estimations with the institutional quality and agricultural expenditure. The left panel in Figure 2.4.10 shows the results from estimations that control for agricultural expenditure, while the right panel shows the results from estimations that control for the quality of institutions instead of agricultural expenditure. Results indicate that Mozambique is, alongside Eswatini, Zimbabwe, and Kenya, performing worse than predicted, while Zambia, Uganda, and Ethiopia are performing better in the specification controlling for agricultural expenditure. Changing the specification to include institutional quality instead of agricultural expenditure, a similar pattern emerges. Mozambique is underperforming, alongside Eswatini, Zimbabwe, and Kenya, while Rwanda has moved to the side of countries performing above expectations together with Zambia, Uganda, and Ethiopia.

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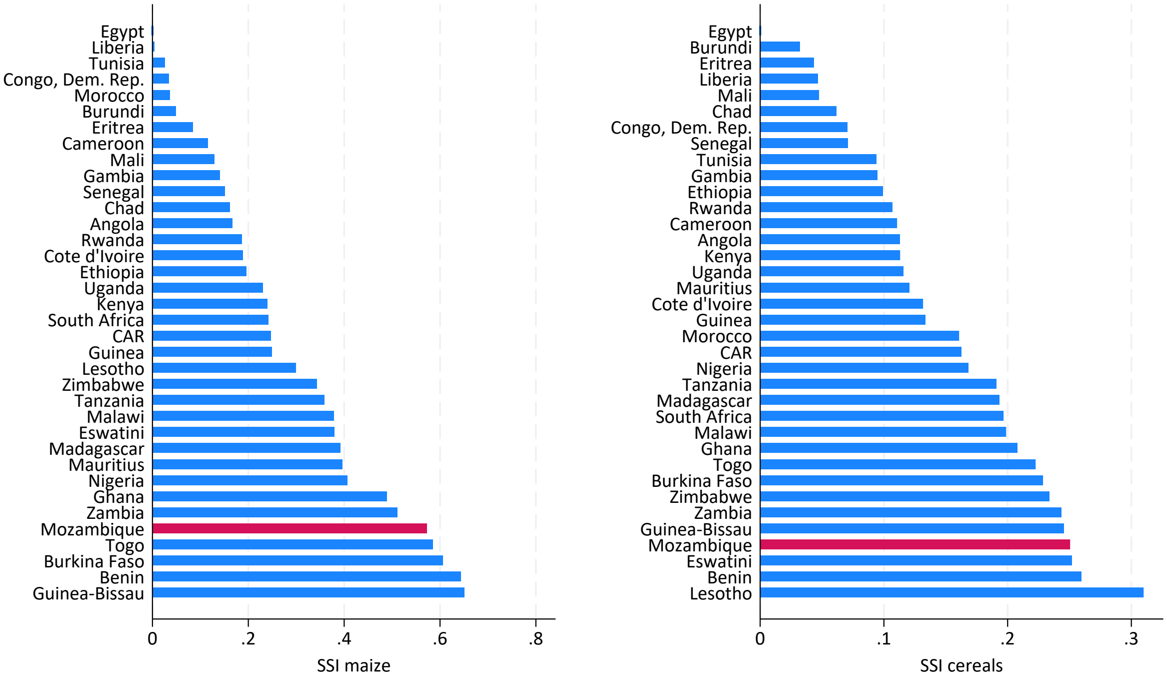
[3] Estimates with imported seeds are not shown but are available upon request.

Table 2.4.1: Determinants of maize yields in Africa

	Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE
	(1)	(2)	(3)	(4)	(5)	(6)
L.GDP per capita, ln	0.07	0.20**	-0.21***	0.06	-0.14	0.21**
	(0.09)	(0.09)	(0.07)	(0.08)	(0.10)	(0.09)
Population density	0.16**	0.33	-0.29***	0.21	-0.12	0.38
	(0.06)	(0.30)	(0.07)	(0.26)	(0.09)	(0.33)
Rural population share	-0.19	-0.17	0.07	-0.08	-0.43	-0.12
	(0.61)	(0.43)	(0.34)	(0.40)	(0.47)	(0.39)
Female population share	-6.17	7.84*	-22.26***	2.67	-15.44**	0.46
	(8.25)	(3.91)	(4.45)	(4.17)	(7.07)	(5.75)
L.Agricultural land	-0.33	0.88*	-1.65***	0.36	-1.49***	0.95
	(0.34)	(0.44)	(0.24)	(0.38)	(0.32)	(0.89)
L.Agricultural land sq.	0.01	-0.04	0.09***	-0.02	0.08***	-0.06
	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	(0.06)
Irrigation	0.12***	-0.01	0.14***	0.03	0.12**	0.05
	(0.05)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)
Population ages 0–14	0.01	-0.01	-0.06***	-0.04***	-0.03*	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Temperature	0.20*	-0.72***	0.11	-0.63***	0.16*	-0.17
	(0.10)	(0.18)	(0.07)	(0.18)	(0.09)	(0.23)
Temperature sq.	-0.00*	0.01***	-0.00	0.01***	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.Fertilizer			0.03	0.01	0.01	-0.01
			(0.02)	(0.01)	(0.02)	(0.01)
L.Pesticides			-0.00	-0.03***	0.02	-0.01
			(0.03)	(0.01)	(0.04)	(0.01)
L.Seeds			0.40***	0.14***	0.25***	0.07**
			(0.04)	(0.04)	(0.05)	(0.03)
Institutions quality					0.05	0.03
					(0.07)	(0.04)
Constant	8.44**	7.01	28.66***	13.48***	22.03***	5.15
	(4.02)	(4.49)	(3.29)	(4.41)	(4.64)	(5.80)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	Yes	No	Yes
Obs.	1,908	1,908	1,864	1,864	909	909
Countries	45	45	45	45	42	42
R^2	0.51	0.85	0.72	0.87	0.65	0.88

Source: Authors' compilation.

Figure 2.4.7: Soil suitability index (SSI) for cultivation of maize and other cereals (average for decades 1960–2010)



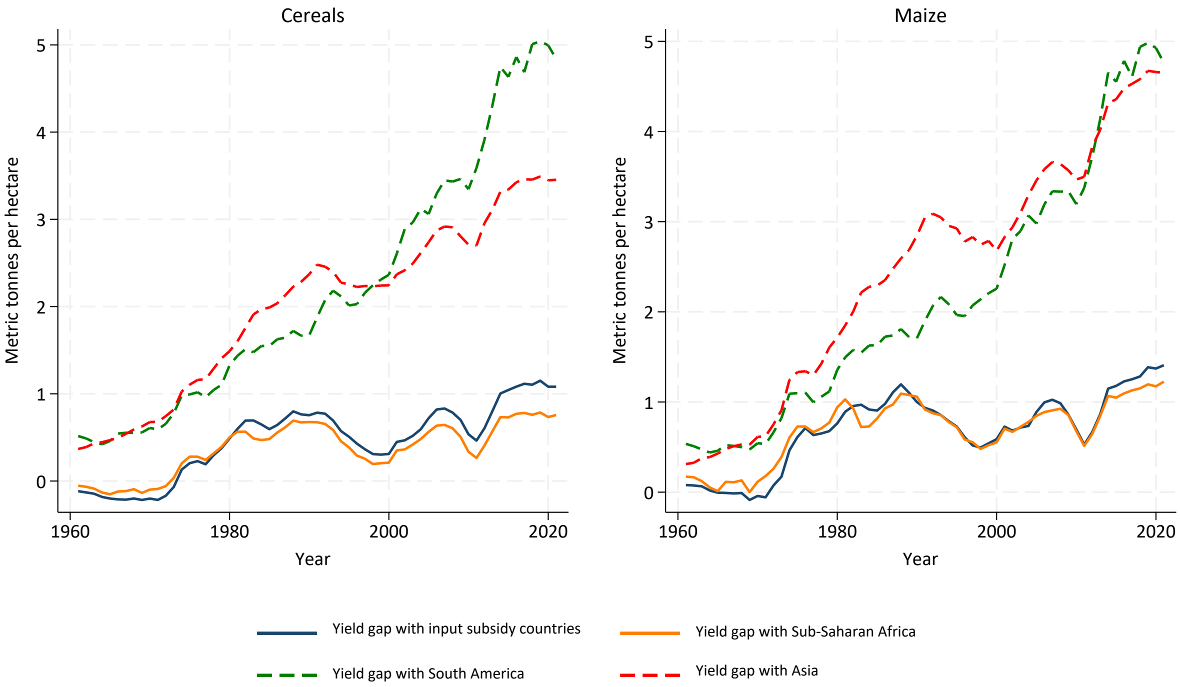
Source: Authors' compilation based on FAOSTAT (2023).
Note: The figure shows the share of land area suitable for maize/cereals cultivation (very suitable + suitable + moderately suitable land [km2] divided by total area of spatial unit in square kilometres [km2]) assuming low input level and rain-fed production. The cereals included are maize, wheat, barley, millet, oat, rice, rye, and sorghum. Countries with very low maize production excluded: Mauritania, Equatorial Guinea, Libya, Niger, Somalia, Sao Tome and Principe, Cabo Verde, Djibouti, Comoros, Sierra Leone, Congo, Gabon, Namibia, and Algeria.

In terms of the cereals production function, we find as shown in column 1 in Table 2.4.2 that population density and irrigation are positively associated with yields. Column 2 shows that after accounting for country-specific fixed effects that do not change over time, we obtain that GDP, female population share, and land size are positively associated with yields. Just as in the case of maize productivity estimates, we obtain that low temperatures contribute negatively to yields, which significantly improve with higher temperatures.

In columns 3 and 4, we include controls for production inputs, such as fertilizer, pesticides, and seeds. This reverses the result for some of the control variables. For example, in column 3, GDP, population density, female population share, young population share, and land size are all negatively correlated with yields. The increased use of seeds is, as expected, positively associated with yields. In column 4, we obtain that the young population share negatively correlates with yields. The results for the role of temperature are the same as in column 2 with a slightly lower coefficient. The results from column 2 for a positive contribution of seeds are confirmed and so is the result for a significantly negative association between pesticides and yields.

In columns 5 and 6, we additionally control for the quality of institutions. This reduces the sample size, given that the availability of this variable is patchy. Earlier results for the role of GDP and young population remain in column 6, but the results for temperature are now not statistically significant. The institutional

Figure 2.4.8: Cereal and maize yield gaps between Mozambique and selected countries



Source: Authors' compilation based on FAOSTAT (2023).
Note: Data are three-year moving average maize yields, weighted by agricultural land share, from the FAO Statistical Database (FAOSTAT, 2023). The 10 countries that implemented input subsidy programmes after the 2003 Maputo Declaration are Mali, Burkina Faso, Ghana, Senegal, Nigeria, Kenya, Malawi, Tanzania, Zambia, and Ethiopia. Yield gap is the three-year moving average of the difference in land-share-weighted average maize yields between Asia and South America, on the one hand, and sub-Saharan Africa, on the other. Data span 1961 to 2021 inclusive.

quality is not in itself a significant predictor of cereals yields.

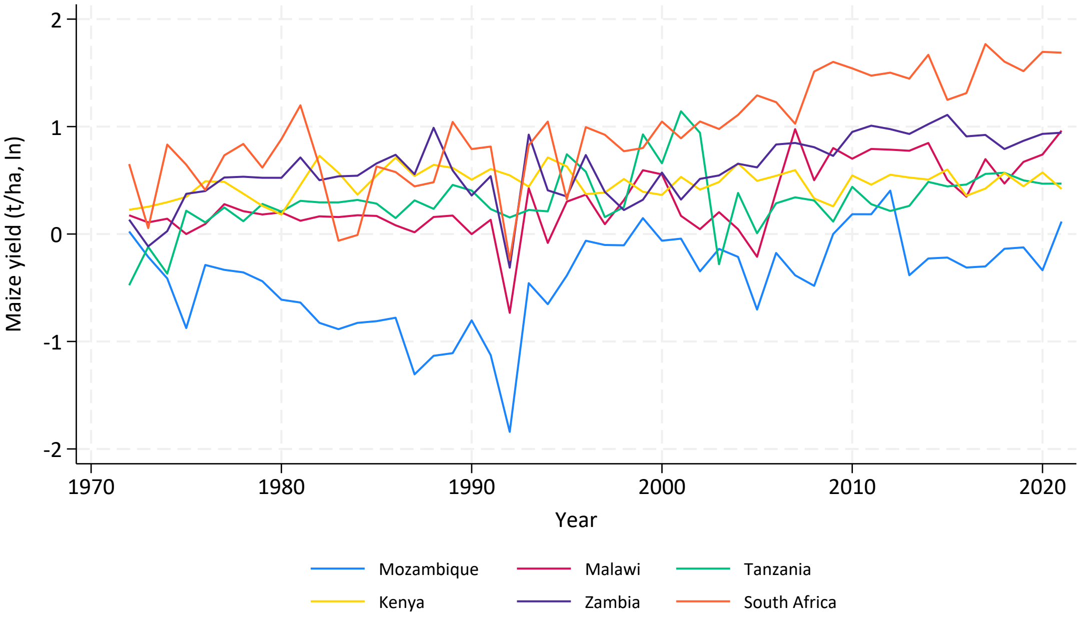
The analysis of residuals illustrated in Figure 2.4.11 indicates that in terms of productivity of cereals production, Mozambique performs worse than predicted when evaluated based on the specification that controls for agricultural expenditure. It is in that regard similar to Zimbabwe, Malawi, Ethiopia, and Kenya. The result for Mozambique is consistent in the model that includes a control for the quality of institutions. Other highlighted countries, namely Zimbabwe, Malawi, and Ethiopia, appear as underperformers as well, while Kenya now appears on the side of countries that perform above expectations, alongside South Africa, Uganda, and Zambia.

Table 2.4.2: Determinants of cereals yields in Africa

	Pooled OLS (1)	FE (2)	Pooled OLS (3)	FE (4)	Pooled OLS (5)	FE (6)
L.GDP per capita, ln	0.07	0.20**	-0.21***	0.06	-0.14	0.21**
	(0.09)	(0.09)	(0.07)	(0.08)	(0.10)	(0.09)
Population density	0.16**	0.33	-0.29***	0.21	-0.12	0.38
	(0.06)	(0.30)	(0.07)	(0.26)	(0.09)	(0.33)
Rural population share	-0.19	-0.17	0.07	-0.08	-0.43	-0.12
	(0.61)	(0.43)	(0.34)	(0.40)	(0.47)	(0.39)
Female population share	-6.17	7.84*	-22.26***	2.67	-15.44**	0.46
	(8.25)	(3.91)	(4.45)	(4.17)	(7.07)	(5.75)
L.Agricultural land	-0.33	0.88*	-1.65***	0.36	-1.49***	0.95
	(0.34)	(0.44)	(0.24)	(0.38)	(0.32)	(0.89)
L.Agricultural land sq.	0.01	-0.04	0.09***	-0.02	0.08***	-0.06
	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	(0.06)
Irrigation	0.12***	-0.01	0.14***	0.03	0.12**	0.05
	(0.05)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)
Population ages 0–14	0.01	-0.01	-0.06***	-0.04***	-0.03*	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Temperature	0.20*	-0.72***	0.11	-0.63***	0.16*	-0.17
	(0.10)	(0.18)	(0.07)	(0.18)	(0.09)	(0.23)
Temperature sq.	-0.00*	0.01***	-0.00	0.01***	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.Fertilizer			0.03	0.01	0.01	-0.01
			(0.02)	(0.01)	(0.02)	(0.01)
L.Pesticides			-0.00	-0.03***	0.02	-0.01
			(0.03)	(0.01)	(0.04)	(0.01)
L.Seeds			0.40***	0.14***	0.25***	0.07**
			(0.04)	(0.04)	(0.05)	(0.03)
Institutions quality					0.05	0.03
					(0.07)	(0.04)
Constant	8.44**	7.01	28.66***	13.48***	22.03***	5.15
	(4.02)	(4.49)	(3.29)	(4.41)	(4.64)	(5.80)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	Yes	No	Yes
Obs.	1,908	1,908	1,864	1,864	909	909
Countries	45	45	45	45	42	42
R^2	0.51	0.85	0.72	0.87	0.65	0.88

Source: Authors' compilation.
Note: Country and year fixed effects (FE) included; 'L.' prefix indicates variable is lagged one period.

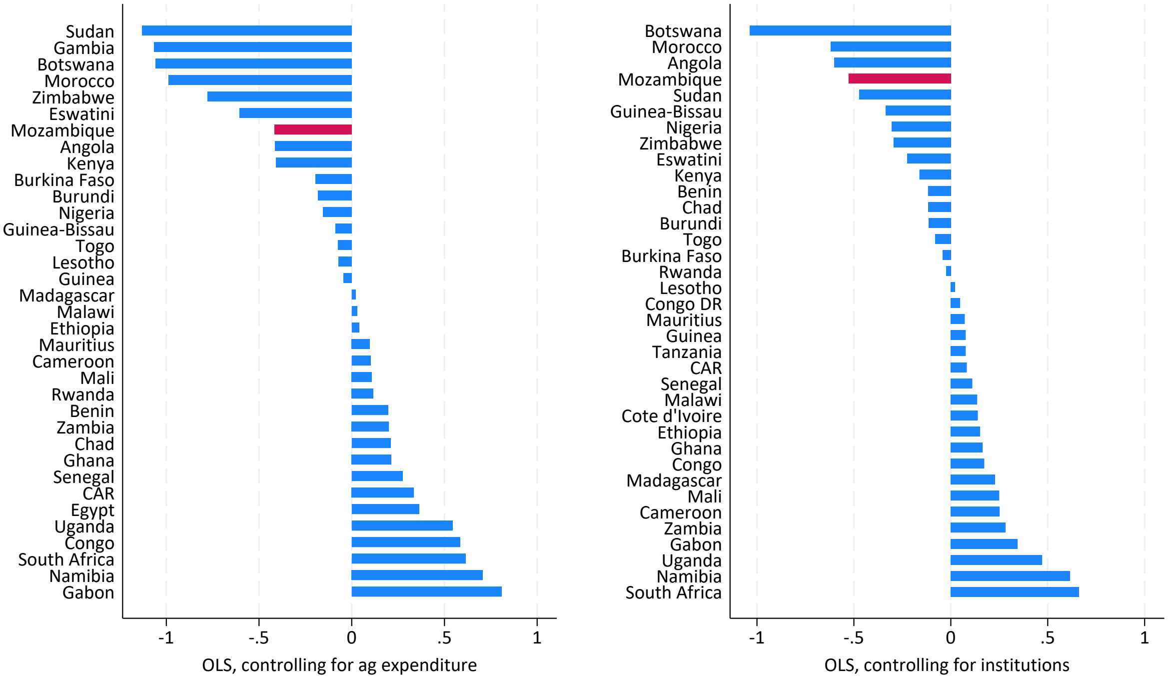
Figure 2.4.9: Maize yield in selected African countries



Source: Authors' compilation based on FAOSTAT (2023).

Note: Data are three-year moving average maize yields from the FAO Statistical Database FAOSTAT (2023). Data span 1972 to 2021 inclusive.

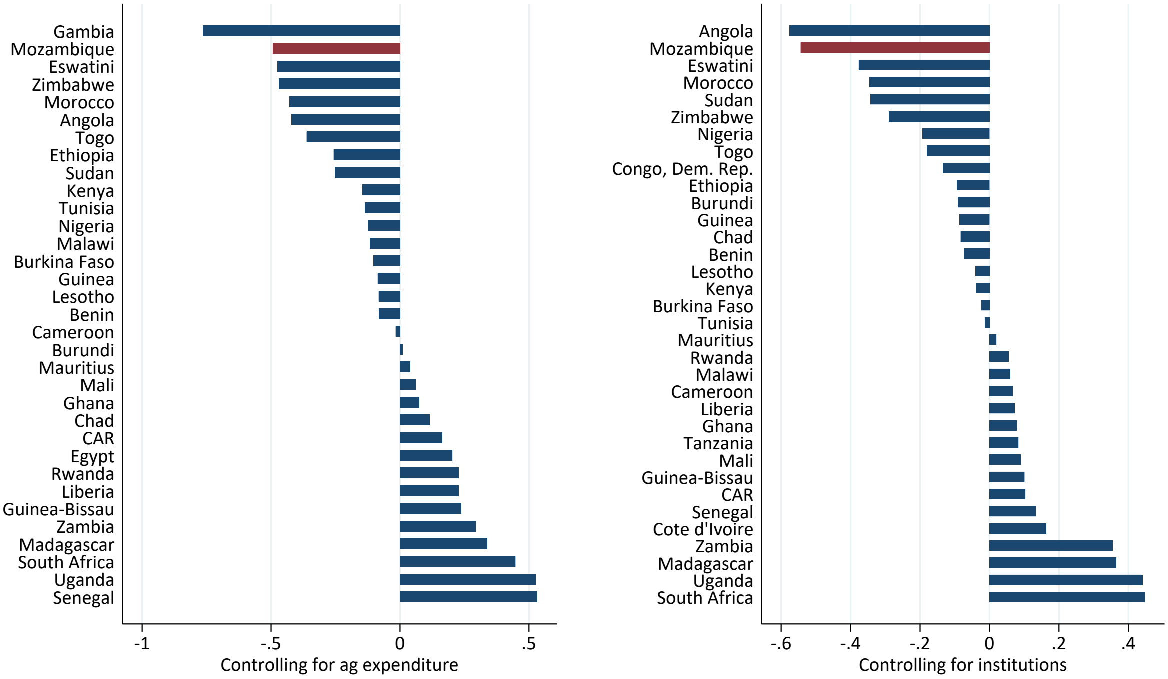
Figure 2.4.10: Residuals showing an unexplained fixed component in maize production



Source: Authors' compilation.

Note: The specification is as in column 5 in Table 2.4.1. Countries with very low maize production excluded: Mauritania, Equatorial Guinea, Libya, Niger, Somalia, Sao Tome and Principe, Cabo Verde, Djibouti, Comoros, Sierra Leone, and Algeria.

Figure 2.4.11: Residuals showing an unexplained fixed component in the production function for cereals



Source: Authors' compilation.

Note: The specification is as in column 5 in Table 2.4.2. Countries with very low maize production excluded: Mauritania, Equatorial Guinea, Libya, Niger, Somalia, Sao Tome and Principe, Cabo Verde, Djibouti, Comoros, Sierra Leone, Botswana, Congo, Gabon, Namibia, and Algeria.

2.5 Conclusion

We analysed the trends and key factors determining maize and cereals productivity and compared Mozambique with other African countries over the 1974–2021 period. We used descriptive analysis as well as pooled OLS and fixed effects estimations. As expected, we found higher between- than within-country variation in the degree to which structural, productive, policy, and institutional factors determine productivity.

Our results indicate a stronger influence of production inputs than structural, policy, and institutional factors, which play either a negative or no significant role at all in explaining productivity. Our most robust finding is a large and significant association between yields and agricultural inputs, including land and seeds. Pesticides and fertilizer usage are not consistently precisely estimated, which adds to the generally ambiguous findings in this line of literature (Scheiterle et al., 2019). The institutional quality and agricultural expenditure variables have limited coverage (both across countries and over time) and may therefore not capture key features of a country's institutional and policy environment. Our result for the limited role of the institutional factors is in contrast to earlier findings of productivity gains from public agricultural expenditure (Headey et al., 2010). The difference could arise from variations in data coverage and different estimation methods and measures, given that most earlier studies use aggregate productivity measures (i.e. the focus on total agricultural value added as opposed to yields) and use data from all continents.

We found that a couple of population characteristics such as the share of female and young population are negatively associated with yields. This could indicate the presence of structural obstacles to these two groups productively participating in the agricultural sector. Earlier studies document disadvantages of women and youth in terms of land ownership and access and utilization of production assets and technology (Quisumbing and Pandolfelli, 2010; White, 2012; Achandi et al., 2018).

We also found that Mozambique seems to underperform in terms of yields compared to nearby East African countries, but our analysis is not able to answer whether the same exact approach towards higher yields followed by these countries would work in Mozambique given its unique historical context and political structure. Other chapters in this report delve into productivity determinants using farm-level data, which allows a more in-depth approach.

An important caveat to our results is that the key variables entering the regression models are most likely endogenous. We attempted to deal with reverse causality from productivity to GDP and production inputs use by lagging the right-hand side variables. Omitted variables could also affect the results by driving both the yields and the level of inputs use. Accounting for endogeneity would require estimations with instrumental variables to go beyond the country fixed effects used in the regressions shown in Tables 2.4.1 and 2.4.2.

Our results highlight that data limitations prevent us from developing a deeper understanding of the drivers of productivity growth in maize and cereals production in Africa. To the extent that our results can be taken as causal, our findings point to a couple of concentrated intervention areas. These include removing obstacles to women and youth participation in agriculture. Our results also point to a strong role of seeds usage in supporting higher yields. However, we do not know whether these are high-yield variety, hybrid, or other seeds.

Sparse data availability has prevented controlling for other important variables, including public spending on research and development in agriculture. This variable alone may not indicate much without equally reliable measures of the quality of the extension systems that transmit this relevant new knowledge to farmers (Headey et al., 2010). A significant way forward in advancing our understanding of agricultural productivity drivers would include enabling access to new data or extending the existing databases with important new variables.

Chapter 3

Hard and Soft Constraints to Smallholder Farming in Mozambique

3.1 Introduction

Despite the importance of agriculture, the sector faces a number of challenges that restrict its potential for growth and improvement. This chapter aims to shed light on both hard and soft constraints that affect agricultural productivity across the country. Hard constraints include geographical and environmental conditions that are unalterable, even over longer time horizons, whereas soft constraints may be affected by political priorities and economic development over time. As such, the chapter serves as a background to the subsequent sections of the report, providing an overview of both hard constraints, such as the weather, climate, and climate change, and softer constraints, such as access to markets and fertilizer. Additionally, examining agricultural constraints at the local (district) level is particularly important due to the significant variation that exists over relatively small geographical areas in this large country. Mozambique's diverse climates and topographies mean that conditions suitable for agriculture change markedly from one district to another, while local infrastructure, poverty, and political prioritization of certain areas also play central roles. Understanding the local supports more targeted policy-making and investment, leading to better outcomes for local farmers and communities.

The chapter begins with an examination of climatic constraints, focusing on rainfall, temperature, and greenness. Second, it discusses land suitability for three different crops, utilizing FAO's Global Agro-Ecological Zones (GAEZ) database. Third, the chapter addresses demand-side constraints related to rural infrastructure and the size of the local markets. Finally, a set of potential farming technology constraints are outlined. In most of the chapter, variables that might constitute constraints to the agricultural sector are summarized at the district level, while broader patterns are mostly described using provinces as the unit of observation. The data are drawn from a variety of sources, including the TIA/IAI harmonized dataset, various satellites, the national bureau of statistics (INE), and OpenStreetMaps. Specific sources are cited where the data are presented.

3.2 Climatic constraints

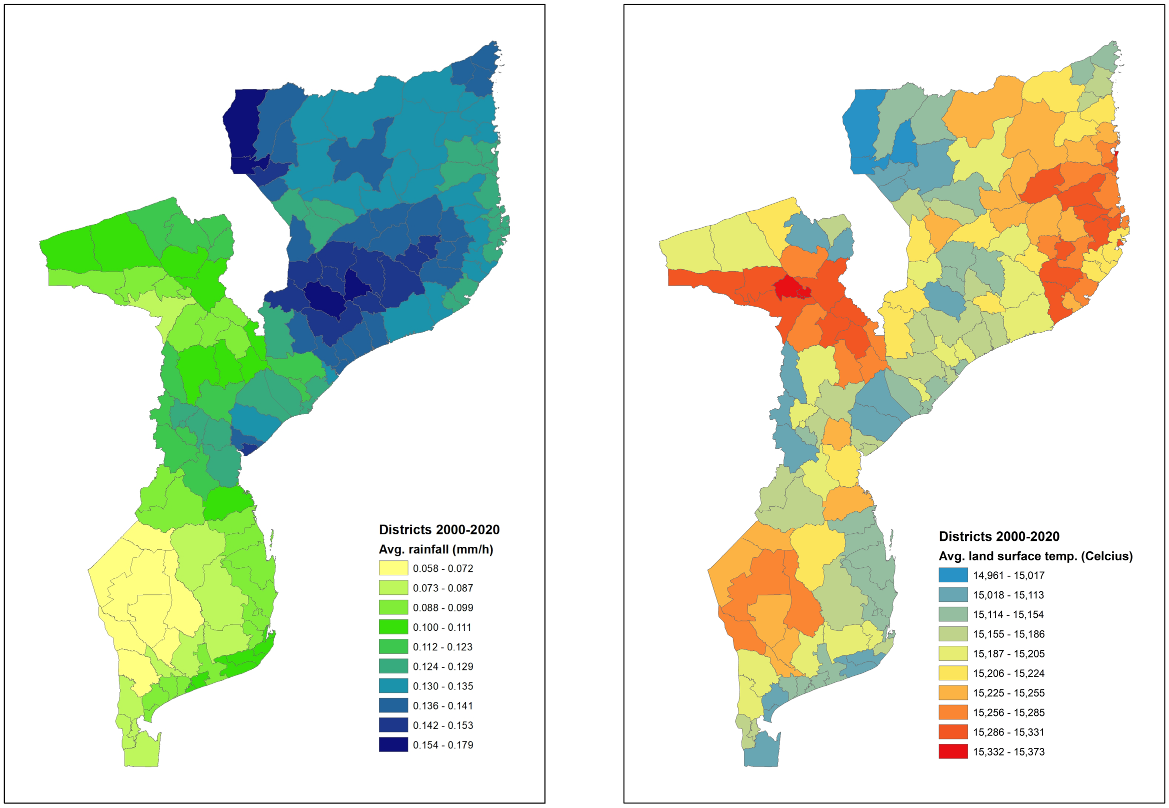
3.2.1 Rainfall, temperature, and greenness

Figure 3.2.1 shows two important climatic variables, rainfall and temperature, that affect agriculture in Mozambique. In all cases, the values depicted refer to average values over the period from 2015 to 2020.

Rainfall (Huffman et al., 2014) varies significantly by region, with an average intensity of 118.36 mm per hour across all districts, but with a considerable standard deviation of 23.45 mm/h. Nampula and Zambezia, in the north and central regions respectively, receive more intense rainfall, averaging above 133 mm/h, while the southern province of Gaza receives much less, averaging around 79 mm/h.

The average land surface temperature (LST) (Wan et al., 2015) across Mozambique's districts is more consistent, with a mean of approximately 15.2 degrees Celsius. Cooler average temperatures are seen in Niassa province, with an average of around 15.1 degrees, while Tete and Nampula have slightly warmer averages, above 15.3 degrees Celsius. It is noteworthy that while the average LST is very consistent, the diurnal range (difference between daily highs and lows) varies much more and is generally larger further away from the coast.

Figure 3.2.1: Climatic Constraints



(a) Rainfall

(b) Temperature

Source: Administrative boundaries from INE, data from MODIS Terra
and the Global Precipitation Measurement (GPM).

Rainfall provides the essential water needed for crops, but its intensity and distribution over time can pose challenges. Intense rainfall can lead to soil erosion and nutrient leaching, while insufficient rainfall may not meet crop water requirements, leading to stress and reduced yield. In regions of Mozambique where rainfall is low, such as Gaza province, there may be insufficient soil moisture for crops, necessitating irrigation, which can be costly or unfeasible. Conversely, excessive rainfall, like that in Nampula or Zambezia, can cause flooding, which disrupts planting schedules and damages crops.

Temperature influences the rate of evapotranspiration, which is the sum of evaporation from the soil and transpiration from plants. High temperatures can accelerate evapotranspiration, leading to a quicker depletion of soil moisture, especially if not matched with adequate rainfall. In areas of Mozambique with higher average temperatures, such as Tete province, this can create water stress for crops, requiring more efficient water management practices.

Figure 3.2.2, which shows average vegetation health, as measured by the Normalized Difference Vegetation Index (NDVI) (Didan, 2015a), indicates a mean value of 0.5807 (after adjusting the scale to range between 0 and 1), with the province of Zambezia showing particularly robust vegetation with an average NDVI of 0.6342. In contrast, Tete has a lower average NDVI of 0.5234, which may reflect less dense or stressed vegetation, possibly due to lower rainfall or higher temperatures.

NDVI reflects the density and health of vegetation, which is directly influenced by the availability of soil moisture and the rate of evapotranspiration. Lower NDVI values indicate stressed vegetation, potentially due to inadequate soil moisture or excessive evapotranspiration rates. In regions with lower NDVI values, such as Tete, this suggests that crops may be under stress, likely due to a combination of high temperatures and insufficient rainfall.

Rainfall, temperature, and NDVI are intertwined factors that constitute constraints to agriculture through their effects on evapotranspiration and soil moisture, which are crucial for crop growth.

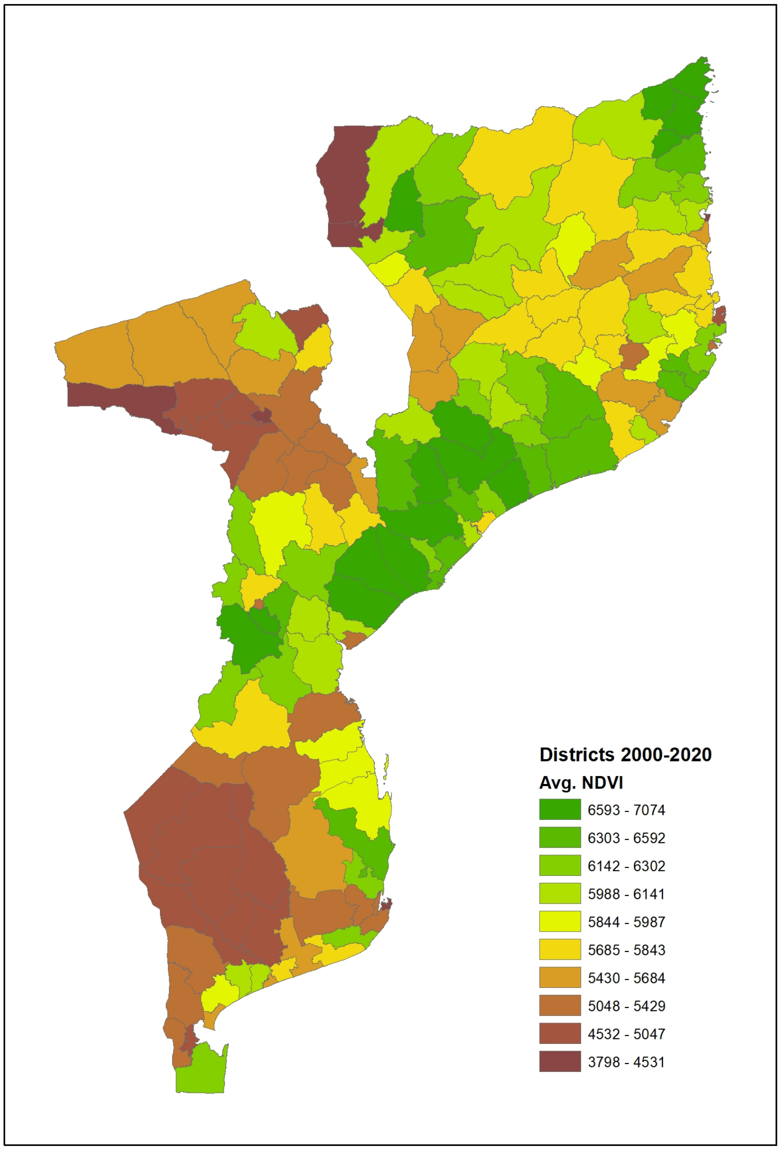
These factors must be balanced for optimal agricultural productivity. Adequate rainfall must coincide with moderate temperatures to minimize evapotranspiration and maximize soil moisture retention. This balance supports healthy vegetation growth, as indicated by higher NDVI values, and ensures better conditions for agriculture. However, when any of these factors are out of balance, e.g., when the variability and timing changes due to global warming, existing constraints may be aggravated, necessitating more adaptive farming practices.

3.2.2 Land suitability

The constraints imposed by rainfall, temperature, and NDVI are critical in determining the suitability of land for agriculture, particularly for specific crops. This suitability is assessed using models like those from FAO's Global Agro-Ecological Zones (GAEZ) database (FAO, 2024), which incorporates these environmental factors to evaluate the potential productivity of different crops. The FAO GAEZ database takes into account not just the direct conditions of climate and vegetation but also soil properties, topography, and other ecological factors to classify land according to its potential and limitations for agricultural use.

In our dataset, the suitability for maize, dryland rice, and cassava is quantified for each district in Mozambique. These values, derived from GAEZ, give us an index or score that represents the relative potential for growing these crops based on the local agro-ecological conditions. A higher score suggests that the district has the favourable conditions needed for the crop, whereas a lower score indicates potential constraints or

Figure 3.2.2: Average greenness



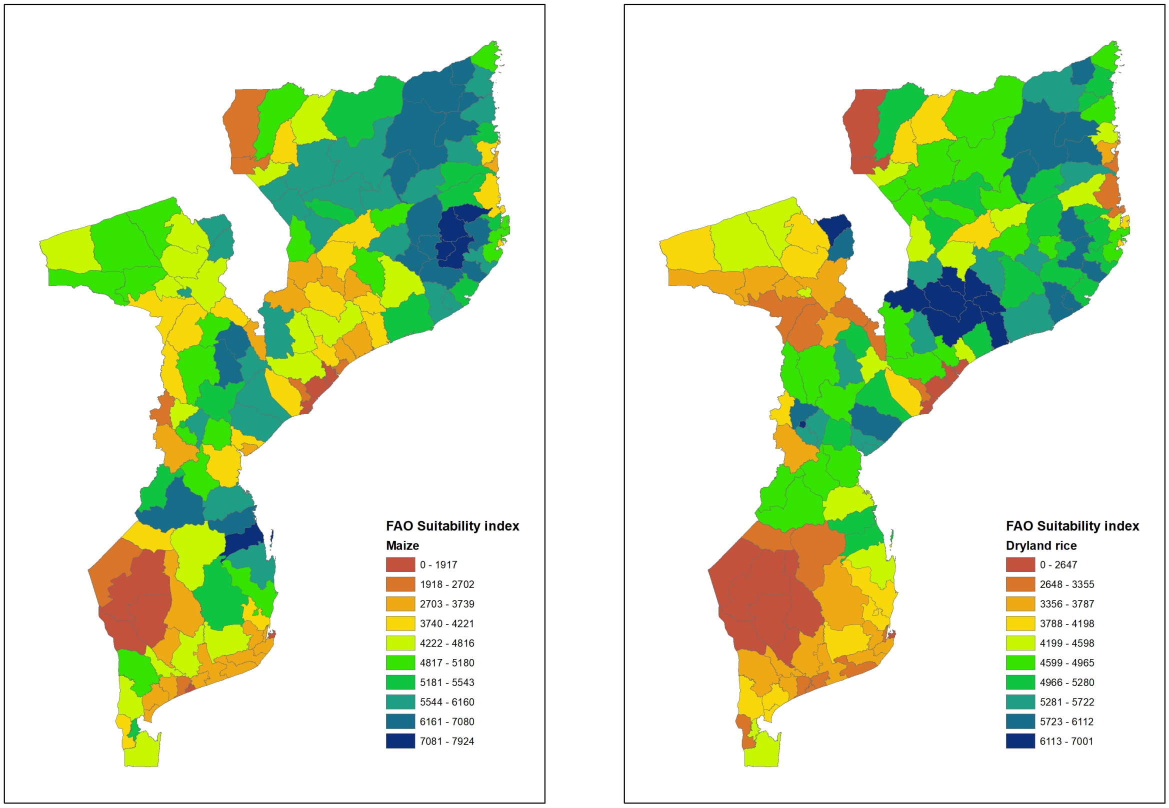
Source: Administrative boundaries from INE, data from MODIS Terra.

limitations that could hinder crop production.

Figure 3.2.3 shows land suitability for maize and dryland rice. For maize, Nampula stands out with a high average suitability score. On the other hand, Gaza has a much lower average suitability score, which may be due to less optimal conditions such as insufficient rainfall or less suitable soils. Dryland rice suitability also shows substantial variation: Zambezia province has a high average suitability score for rice, possibly benefiting from its rainfall patterns and temperatures conducive to rice cultivation. In contrast, other areas with lower scores, like Gaza, may face limitations due to their drier climate.

Table 3.2.1 shows the district-level correlations between crop suitability and climatic factors. Each crop ex-

Figure 3.2.3: Land suitability



(a) Maize

(b) Dryland Rice

Source: Administrative boundaries from INE, data from Food and Agricultural Organization (FAO).

hibits unique relationships with the climatic factors, highlighting the need for tailored agricultural practices and resource management. Maize shows a moderate positive correlation with both rainfall (0.214) and temperature (0.273), indicating that it favours warmer and slightly wetter conditions. Dryland rice cultivation is highly correlated with rainfall and greenness (0.575 and 0.495), likely reflecting favourable soil and moisture conditions for rice growth. Cassava demonstrates a positive correlation with rainfall (0.288), indicating its need for adequate moisture despite its drought tolerance. The negative correlation with temperature (-0.154) suggests a slight preference for cooler conditions.

Table 3.2.1: Correlations between climatic factors and crop suitabilities

	Maize	Rice (Dry)	Cassava
Avg Rainfall	0.214	0.575	0.288
Avg LST	0.273	-0.014	-0.154
Avg NDVI	0.195	0.495	0.364

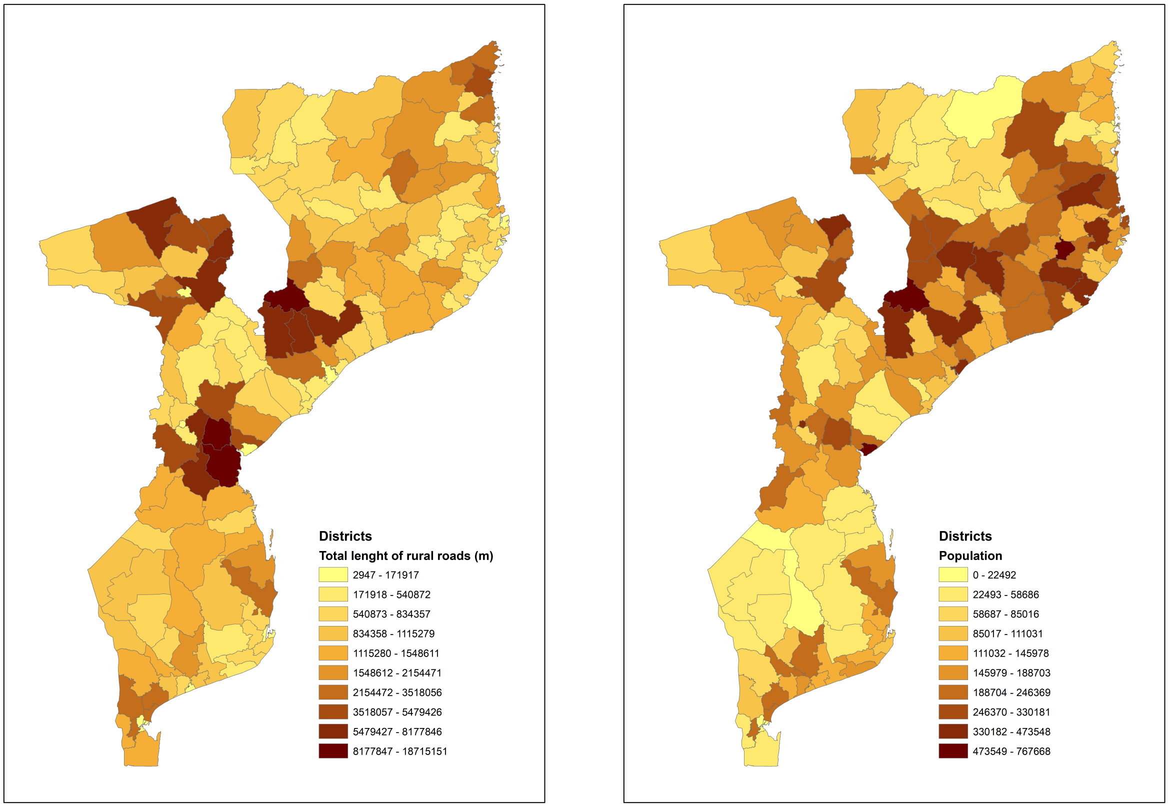
Source: Authors calculations.

3.3 Infrastructure and demand

3.3.1 Rural infrastructure

Figure 3.3.1 consists of two panels that highlight potential constraints related to infrastructure and local demand. Panel (a) shows the total length of roads in rural areas in each district of Mozambique, measured in meters. These data are derived from OpenStreetMaps (OpenStreetMap contributors, 2023), and roads in urban areas are filtered out before summarizing at the district level. The best road coverage in rural areas seems to be concentrated along the transport corridors of Sofala, Manica, Tete, and Zambezia.

Figure 3.3.1: Infrastructure, population, and consumption



(a) Rural Roads

(b) Population

Source: Administrative boundaries from INE, data from TIA/IAI harmonized dataset.

3.3.2 Population

Also shown in Figure 3.3.1, the district population varies substantially across Mozambique. Areas with higher population densities generally indicate larger potential local markets for agricultural produce. Likewise, the purchasing power of the local population affects demand for agricultural products. Both factors can influence the demand for smallholder farms' products.

Areas with low population density generally coincide with areas facing other constraints, be they climatic or technological. Inland Gaza, Inhambane, Niassa, and Cabo Delgado exemplify this. The provinces of Nampula and Zambezia have relatively high population densities, but consumption per capita and the quality of rural infrastructure are low, so there is likely room for improvement of local demand if these factors could improve. Central Mozambique around Sofala and Manica seems to have better rural road networks and local purchasing power, so farmers in these areas may be less hindered by demand-side constraints arising from poor infrastructure.

3.4 Technological constraints

3.4.1 Access to inputs

The distribution of fertilizer use across provinces and districts in Mozambique shows significant variability, as reflected in Figure 3.4.1.

Fertilizer use exhibits a large variability across space. Tete province stands out with a particularly high average use of fertilizer (17.3%), presumably due to a larger share of cash crops. Niassa also shows a relatively high mean value for fertilizer use (9.8%). Conversely, provinces like Zambezia and Sofala report very low mean fertilizer use. Differences in usage across the country of both pesticides and fertilizer may reflect constraints in access to agricultural inputs or simply a different crop composition, as noted above.

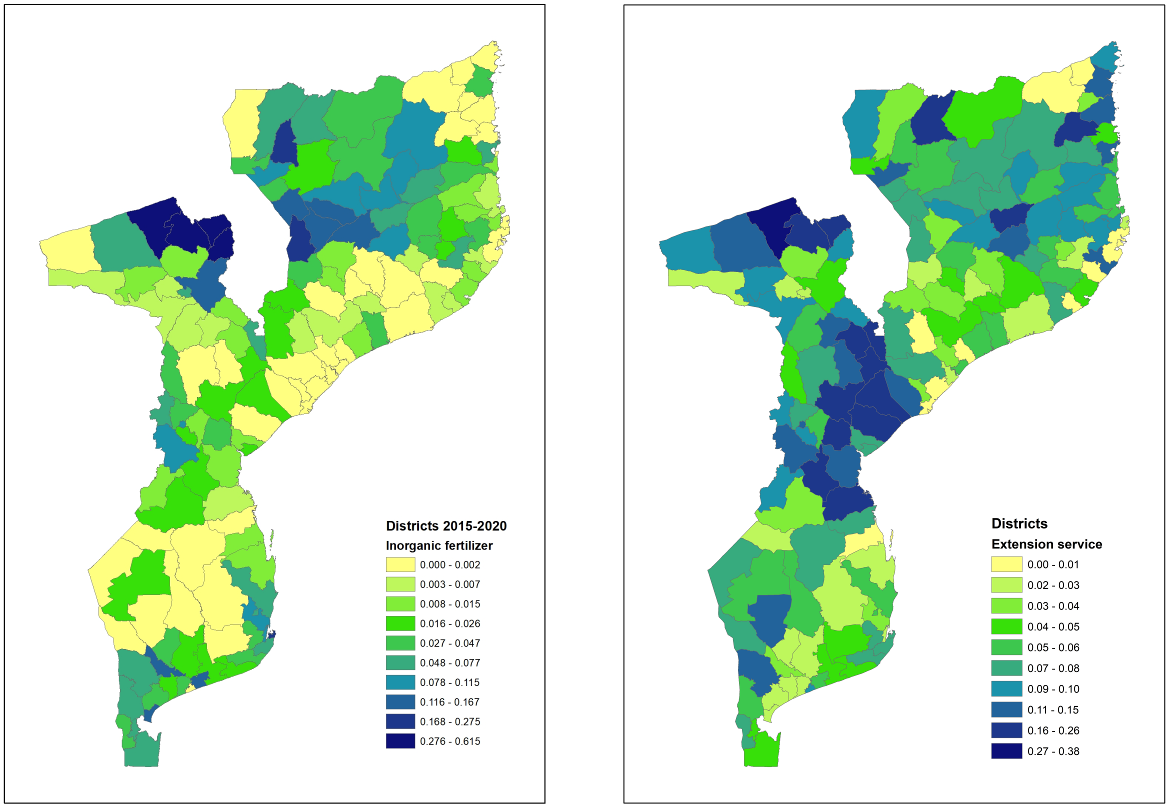
For pesticides (not shown), the average use across all districts is relatively low (4.2%). Some provinces, such as Niassa and Tete, have higher mean values (7.0% and 8.9%, respectively), suggesting more intensive use of pesticides in these areas. This could be due to the presence of larger prevalence of cash crops in these provinces. In contrast, provinces like Zambezia have a very low mean value (0.5%).

3.4.2 Access to modern farming technologies

For smallholder farmers, a critical route to accessing modern farming technologies is via extension services. Extension often provides training on modern farming techniques, pest and disease management, post-harvest handling, and market access. As shown in panel (b) of Figure 3.4.1, access to extension across the provinces and districts in Mozambique, as reflected in the TIA/IAI harmonized dataset, shows variability, with a mean value of approximately 7.6 per cent of households reporting visits by extension services.

Sofala stands out with the highest mean access to extension services, at about 17.7 per cent. Tete also has a relatively high mean value of 11.1 per cent. In contrast, Zambezia has the lowest access, with only 4.1 per cent of farmers benefiting from access to extension services. Since Zambezia is also one of the provinces with *high* agricultural potential, this points to a misallocation of investments into improvements in agriculture; a finding that equates with the figures presented in Chapter 2 on the provincial allocation of investments in agricultural development.

Figure 3.4.1: Access to inputs and technology



(a) Fertilizer

(b) Extension Services

Source: Administrative boundaries from INE, data from TIA/IAI harmonized dataset.

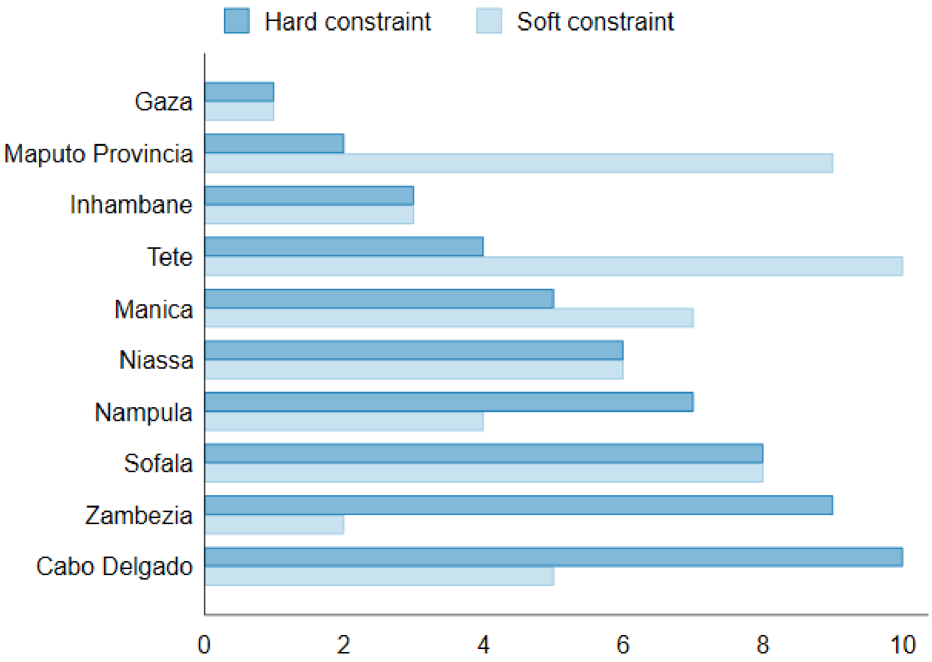
3.5 Conclusion

In conclusion, Mozambican farmers are faced with a multitude of constraints, which can roughly be grouped into those that cannot be changed, i.e. hard constraints (climatic, geographic, and geological), and some that might be affected by policy over time, i.e. soft constraints (infrastructure, average consumption, and access to farming technology).

To gain an overview of the findings in this chapter, it might be useful to rank Mozambique's ten rural provinces according to their scores on the individual constraints and analyse which parts of the country face more hard or soft constraints than others. Figure 3.5.1 shows the aggregate rankings where the label 'Hard constraints' comprises the individual rankings of average rain, NDVI, maize suitability, and rice suitability, and 'Soft constraints' the rankings of access to pesticide, fertilizer, and extension services along with average district population, consumption, and rural road network. The lower the ranking, the more constrained a province is.

Agriculture in Gaza and Inhambane faces both hard and soft constraints due to a dry climate and lack of infrastructure, local demand, and technologies.

Figure 3.5.1: Hard and soft constraints by province



Source: Author's estimations
Note: Averages of rankings on individual constraints. A lower score indicates a larger constraint on the province.

However, it is especially noteworthy that some of the provinces that rank lowest in terms of hard constraints, i.e. have high potential and favourable climate for cultivation of various crops, at the same time lag behind in terms of soft constraints, i.e. infrastructure and technology. Specifically, the provinces of Cabo Delgado, Zambezia, and Nampula have overall favourable conditions for agriculture, but are faced with large constraints in term of market access and farming technologies. There is, in other words, a large gap between potential and realization in these provinces, which may be due to long-term underinvestment, a view corroborated by Nova et al. (2019), who note that:

> "... the provinces of Zambézia and Nampula are the least prioritized in the budget considering the number of agricultural production units."

Broadly, the provinces with greater soft than hard constraints coincide with areas characterized by widespread rural poverty, meaning that investments into scaling up extension services and promoting fertilizer use could potentially serve a dual purpose: boosting production *and* alleviating extreme poverty. This would be in line with the Agricultural Policy and Implementation Strategy, as noted in Table 1.1. of Chapter 2.

Chapter 4

Agricultural Strategies: Historical Overview and Evaluation of Achievements

4.1 Introduction

Agriculture stands as the backbone of Mozambique's economy, with the majority of the country's population actively engaged in the sector. Over the years, Mozambique has undergone significant political and economic transitions, each leaving an indelible mark on its agricultural landscape. From the socialist policies of the post-independence era to the market-oriented reforms of the late 20th century and the challenges of the 21st century, Mozambique's agricultural strategies have continuously evolved to address changing circumstances and priorities. However, despite the centrality of agriculture to national development, external evaluations have consistently pointed out shortcomings and disparities in policy implementation, resource allocation, and outcomes.

This chapter first delves into the historical trajectory of various programmes, policies, and plans to address the needs of Mozambique's agricultural sector. Collectively, we refer to these initiatives as "agricultural strategies". After providing a summary of Mozambique's agricultural strategies since independence, this chapter presents an overview of the government's public expenditures in agriculture.

4.2 Historical overview of agricultural strategies

The purpose of this section is to give a broad overview of and contextualize Mozambican agricultural strategies from independence until today, with a particular focus on the period from 1995 onwards. The summary of strategies is not exhaustive, meaning that there might have been more agricultural strategies in the studied period than presented here.

Under colonialism, Mozambicans were forced to work for public and private entities for a below subsistence level wage, as well as obliged to cultivate cash crops. It is estimated that, during the 1940s and 1950s, at least half of the Mozambican adult male population had to work under the system of forced wage labour. Such a system left the local population unskilled and exploited (Jones and Gibbon, 2024). The obligation to cultivate cash crops implied there was no time to privately cultivate sufficient food crops, which led to widespread food insecurity and famine among the Mozambicans (Isaacman, 1996). To this day, people who were forced to cultivate cotton are more likely to be farmers and more risk averse (Barros et al., 2024).

After ten years of armed struggle against Portuguese settlers, Mozambique became independent in 1975, with the Liberation Front of Mozambique (Frelimo) as governing party. Mozambican farmers played an instrumental role in the independence fight as they refused to take part in the forced labour schemes and hoped for an independent Mozambique to enable them to participate in the economy (Bowen, 2000). The Portuguese had been in charge of government institutions and private companies before independence. When the education system, land, houses, and enterprises were nationalized by Frelimo, many Portuguese settlers decided to leave. Out of 200,000 Portuguese in Mozambique, some 80 per cent left the country (Pimenta, 2018).

Before leaving, many Portuguese deliberately sabotaged the economy by destroying enterprises, farm animals, and equipment. The agricultural marketing system broke down and smallholders lost access to the system of distribution of goods (Arndt et al., 2000b). The country was left with very few skilled professionals as the Portuguese had not encouraged any education for Mozambicans under colonialism and had left the responsibility of the local education system to the Roman Catholic Church, which did not have the capacity to provide education to the entire Mozambican population (Mondlane, 1963). Fewer than 10 per cent of Mozambicans were literate upon independence (Huffman, 1992).

Upon independence, the ruling party Frelimo proclaimed agriculture as the cornerstone of development within a socialist one-party system. It established communal villages and cooperatives with the intention of eliminating the smallholder sector. Emphasis was placed on the development of large state-owned farms. Initiatives promoting advanced technological practices were implemented, at the expense of local agricultural knowledge and the interests of smallholders (Tarp, 1984; Mosca, 2015). There existed a small group of more productive, middle-class farmers that could have advanced Mozambique's agricultural development, had Frelimo invested in them. Instead, Frelimo prioritized differently (Bowen, 2000; Huffman, 1992).

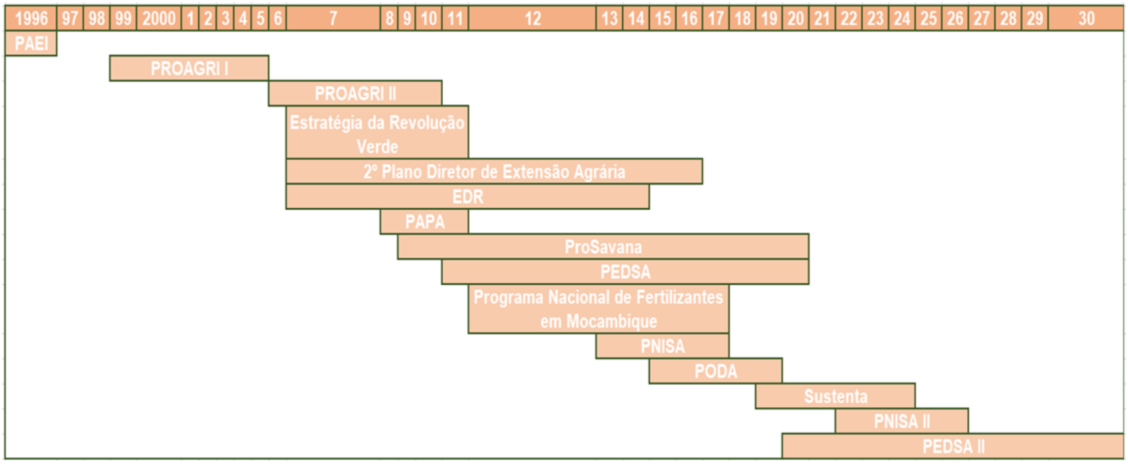
Frelimo's Marxist approach was opposed by the guerilla group Mozambican National Resistance (Renamo), which was supported by the anti-communist governments of neighbouring countries Rhodesia and South Africa. Among the Mozambican population, discontent with Frelimo's approach was slowly rising, which helped Renamo grow. Renamo regularly attacked civilians and communal villages and destroyed public infrastructure, which had negative effects on agriculture, the economy, and society as a whole. Rural areas were more affected than cities, meaning that the impact on agriculture was particularly negative (Brück, 1997). The conflict lasted from 1977 to 1992.

In the 1980s, the 4th Frelimo Congress (April 1983) acknowledged it had neglected smallholders in favour of state farms, and promised more substantial support (Tickner, 1992; Marshall, 1990). However, agricultural programmes largely proved ineffective. The country faced significant challenges, including conflict and severe droughts, leading to a collapse of the economy in 1986 and close to 1 million war-related deaths. Consequently, socialist strategies were abandoned, and the political focus shifted toward a market-oriented system. This transition was marked by the launch of an Economic and Social Rehabilitation Programme (ESRP) in 1987 (Jenkins et al., 2015; Tarp, 1984).

The ESRP included the devaluation of the metical, credit restrictions, a raised income tax, set producer prices, and a reduced government budget (Tickner, 1992; Arndt et al., 2000b). The International Monetary Fund and the World Bank were major designers of the programme and placed conditionality onto Mozambique, while its government was constrained in effectively negotiating the programme details (Arndt et al., 2000b). One of the programme's major goals was to boost agricultural production and support agricultural producers (Tickner, 1992). In practice, the structural adjustment programmme rendered little attention to smallholders (Mosca, 2015). In rural areas, smallholders did not benefit from price liberalization due to poor terms of trade, rising inflation, and declining purchasing power. Foreign investors and government officials benefited from the structural adjustment programme (Bowen, 2000), implying that the programme appeared effective at a macroeconomic level (Marshall, 1990). However, the majority of the population remained poor and the root causes of underdevelopment were still to be lifted (Arndt et al., 2000b).

In 1990, the Mozambican Constitution was revised. It stated that "agriculture shall be the basis for national development" (Article 103) and that "the family sector shall play a fundamental role in meeting the basic needs of the people" (Article 105) (Carrilho and Ribeiro, 2020). After the first free general elections in 1994, thousands of people who had been displaced during 16 years of war went back to rural areas and reinstated agricultural production. Mozambique experienced rapid economic growth, primarily driven by the process of economic recovery. Government priorities lay in education, health, and primary road infrastructure, meaning that agriculture did not receive much attention. Nevertheless, the government made an effort to integrate smallholders into the economy through value chains, with the objective of exporting and supplying major cities. At the same time, it ignored the needs and wishes of smallholders (Mosca, 2015).

Figure 4.2.1: Overview of agricultural strategies in Mozambique



Source: Authors' illustration

Agricultural strategies such as the Agrarian Policy and Implementation Strategy (PAEI), endorsed in 1995 as a blueprint to guide the formulation of subsequent agricultural strategies, were not fully implemented. Instead, there was a notable emphasis on commercial agriculture, often benefiting the ruling elites. There was a prevailing belief that Foreign Direct Investment (FDI) served as the primary engine of growth, with significant investments directed towards industries such as sugar production (Arndt et al., 2000b). Various donors with competing interests, priorities, and policy recommendations contributed to confusion and lack of strategic direction. This also implied that insufficient priority was placed on agriculture (Carrilho and Ribeiro, 2020). Figure 4.2.1 illustrates the timeline of the agricultural strategies considered in this chapter from 1995 onwards.

At the end of the 1990s, policy analyses and technical reports included recommendations to focus on agricultural productivity and particularly on smallholders (Tarp et al., 2002). For example, Tarp et al. (2002) outlined that agriculture, in comparison with non-agricultural sectors, has large sectoral multipliers and that agriculture is a more effective use of scarce capital than industry and services. Maize, rice, livestock, and forestry were mentioned as commodities worth promoting (Tarp et al., 2002).

Throughout the first two decades of the 2000s, agriculture in Mozambique was not given the priority it warranted, despite its significance to the majority of the population and its designation as a priority in the country's constitution (Carrilho et al., 2021). From 1999 to 2005, a substantial portion (45 per cent) of agricultural spending was allocated to institutional development and decentralization, indicating limited resources available for agricultural services, inputs, and public goods. Criticism from external evaluations highlighted that this emphasis on institutional development diverted attention from the needs of farmers on the ground (Carrilho et al., 2021; Mogues and Do Rosario, 2016).

Despite significant investments in agricultural institutions, a complex web of levels and authorities responsible for agriculture persisted. The Ministry of Agriculture and Rural Development, established in 2000, underwent several name changes and restructuring, with a new Ministry of Agriculture and Food Security (MASA) formed in 2015, only to revert to the Ministry of Agriculture and Rural Development in 2020 (Carrilho and Ribeiro, 2020; MADER, 2024). Alongside these changes, responsibilities such as agricultural marketing, land and forest administration, and rural development were shuffled between ministries, exacerbating challenges in effective implementation of agricultural strategies (Mogues and Do Rosario, 2016; Carrilho and Ribeiro, 2020).

Between 2005 and 2013, approximately 10 agricultural strategies were introduced (see Figure 4.3.3) amidst shifting government responsibilities among various ministries, leading to ambiguity, overlap, and inadequate attention and funding for agriculture at the local level (Carrilho et al., 2021). Mozambique also engaged in several agriculture-related agreements with other African nations, including the Comprehensive Programme for the Development of Agriculture (CAADP) of the East African Community. However, targets set under these agreements, such as 6 per cent annual growth in agricultural GDP and allocation of at least 10 per cent of public expenditures to the agricultural sector, remained unmet (see also the following section 4.3) (Carrilho et al., 2021).

In 2008, the global economy experienced a significant upheaval due to a sharp increase in food and fuel prices. Over the course of eighteen months, real prices for world food surged by over 60 per cent, while the price of oil escalated by approximately 125 per cent (Arndt et al., 2016). Mozambique bore the brunt of this crisis, facing a decline in exports, heightened costs for imports, and soaring prices for both food and fuel. In response, the government formulated the Food Production Action Plan (PAPA 2008–2011) with the objective of ensuring food security for the populace. PAPA encompassed various initiatives, including the promotion of food storage and distribution, as well as endeavours to bolster food processing utilizing local resources. Notably, the construction of granaries for cereal storage was initiated with the aim of generating a surplus in domestic production to enhance food security and mitigate the impact of international food price fluctuations (Nhate et al., 2013).

Regrettably, these initiatives failed to yield substantial improvements in agricultural productivity. On the contrary, agricultural productivity exhibited a declining trajectory throughout the 2010s, while poverty levels increased. Despite the initial promise, many of the activities outlined in PAPA were abandoned following the general elections in 2010. This shift underscores a perception that agricultural endeavours were primarily employed as short-term measures to appease the population rather than being part of a comprehensive, long-term strategy (Nhate et al., 2013).

From 2007 onwards, there was a notable shift in focus from institutional development towards the promotion of public-private partnerships (PPPs). These partnerships entailed direct collaboration with smallholders, farmers' associations, and commercial enterprises. Public institutions increasingly relinquished the responsibility for smallholders to enterprises, non-governmental organizations (NGOs), and donor projects (Carrilho et al., 2021; Mogues and Do Rosario, 2016).

During the 2010s, a focus on modernization based on the industrialization of agriculture and technology dominated agricultural strategies. The Strategic Plan for the Development of the Agricultural Sector (PEDSA) (2011–2020) embodied a medium- to long-term vision to complement already existing shorter-term visions. It was based on existing national and international agricultural strategies such as the Green Revolution Strategy and the Abuja and the Maputo Declarations (Carrilho and Ribeiro, 2020). In practice, however, the discovery of large reserves of natural gas in the Rovuma Basin in 2010 meant that government priorities were on minerals and other natural resources (Cruz et al., 2021).

The outlined agricultural strategies acknowledge Mozambique's agro-ecological diversity and propose various priorities tailored to different regions. This approach considers the country's ten agro-ecological zones, delineated based on criteria such as topography, rainfall, and soil composition, as classified by the Agricultural Research Institute of Mozambique (IIAM). Consistently, the strategies concentrate on the most pertinent crops and sub-sectors, aligning interventions with the unique characteristics and needs of each agro-ecological zone. Theoretically, such targeted efforts ensure that agricultural development initiatives are contextually relevant and optimized for effectiveness across diverse geographical areas within Mozambique. There is a consistent focus on the most relevant crops and sub-sectors:

- **Food:** Maize, rice, kidney beans, potatoes, and tomatoes
- **Cash crops:** Cashew, cotton, tobacco, soy, sunflower, and sugar cane
- **Livestock:** Ruminants, cattle, milk, chickens, and eggs
- **Aquaculture:** Various fish (including tilapia), and freshwater shrimp
- **Timber products:** Eucalyptus and pine trees

Although Mozambique's agricultural strategies and legislation are assessed to be of high quality, compliance remains a challenge. The emphasis on commercialization and modernization overlooks the realities faced by smallholders, leading to minimal improvements in their conditions from the colonial era to the present day (Carrilho et al., 2021).

In sum, since Mozambique gained independence, agriculture has not been high on the priority list of the Mozambican government (Mosca, 2015; Carrilho et al., 2021). Mozambican agricultural strategies have primarily emphasized commercialization, modernization, and the development of large-scale farms. These assessments also underscore that despite the inclusion of rhetoric prioritizing smallholders, agricultural policies and strategies have largely overlooked the majority of stakeholders within the agricultural sector. Agricultural strategies have mostly been top-down, through measures such as the establishment of communal villages, the promotion of highly technical solutions, or the integration of smallholders into value chains.

These measures have not taken the reality of local systems and farmers' preferences into account, which might explain why the agricultural strategies have not been successful (Mosca, 2015).

The following strategies are recommended to obtain inclusive growth in agriculture (Carrilho and Ribeiro, 2020; Carrilho et al., 2021; Kaarhus, 2018; Sørensen et al., 2020; Mosca, 2015):

- Improve quantity and quality of public support to farmers
- Support use of fertilizers and improved seeds
- Promote access to credit and extension
- Create access to input and output markets for smallholders
- Place priority on agriculture and agro-industry to boost structural transformation
- Consider the local context of smallholders and traditional knowledge
- Have an education system that teaches agricultural knowledge relevant to Mozambique
- Promote agricultural research

4.3 Public spending on agriculture

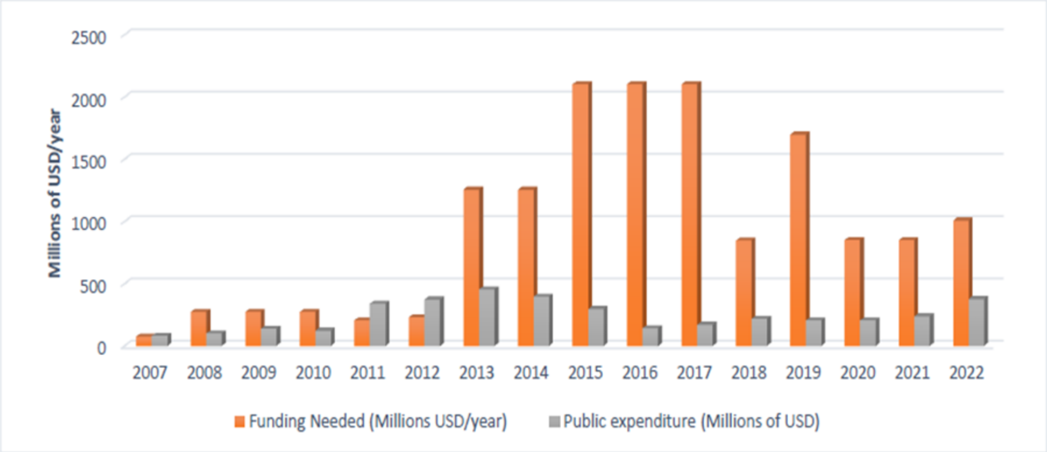
The following figures depict the investments made by the Mozambican State in the agriculture and rural development sector, considering the funding required to implement the summarized strategies, alongside the state's plans and projections over the years.

Figure 4.3.1 compares the funding needed for an appropriate implementation of agricultural strategies with the actual public expenditure in the agriculture and rural development sector from 2007 to 2022. The expenditure data necessary for implementing the strategies were sourced from official documents and organized by year (Appendix 4.A summarizes the strategies considered). The annual public expenditure by sector is derived from the General State Account, the State Budget, and the Budget Execution Report.

Between 2007 and 2012, the estimated funding needed for agricultural strategies remained relatively low, consistently below 200 million USD annually. However, actual public expenditure only exceeded these modest requirements in 2011 and 2012, with notably lower investments from 2007 to 2009. In 2013, the estimated funding skyrocketed to over 1000 million USD, yet actual expenditure, although increasing significantly, remained below 500 million USD, failing to meet the substantial increase in requirements. By 2015, estimated funding needs soared to over 2000 million USD, yet paradoxically, actual expenditure decreased instead of rising. Mozambique's economic crisis from 2015 onwards likely contributed to the reduction in estimated funding needs to below 1000 million USD by 2018.

Although there has been a slow but consistent increase in actual public expenditure since 2019, it still falls short of the required amounts, remaining below 500 million USD annually. Consequently, since 2013, there has been a persistent deficit, averaging 775 million USD annually, indicating a consistent inadequacy in state funding for agricultural strategies. In summary, the funding shortfall has persisted over the years, with estimated funding requirements far exceeding achievable levels, highlighting the ongoing challenge of securing sufficient resources for agricultural development.

Figure 4.3.1: Funding needed to implement the programmes/strategies versus public expenditure in the agriculture and rural development sector



Source: Authors' illustration (based on the Appendix Tables 4.A, which summarize the agricultural strategies taken into account)

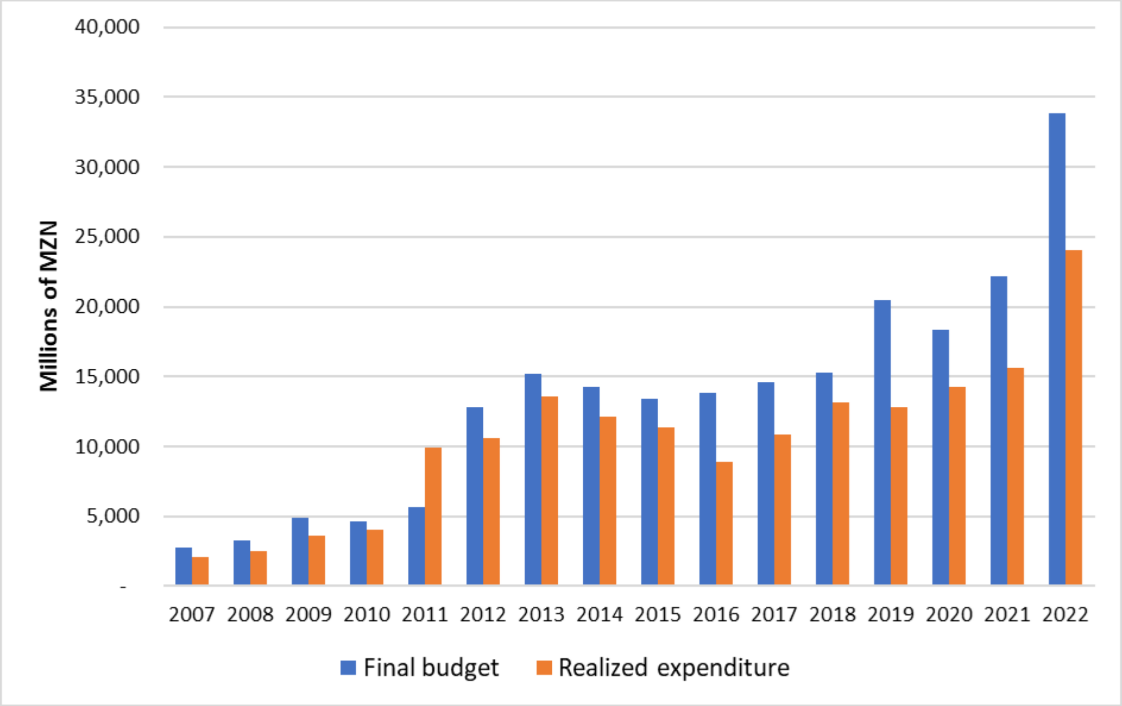
Figure 4.3.2 illustrates a comparative analysis of the final projected budget and the actual funds disbursed by the State in the agriculture and rural development sector from 2007 to 2022. The data pertaining to budget allocations and disbursements are obtained from reputable sources such as the General State Account, the State Budget, and the Budget Execution Report.

Over the years, there has been a gradual increase in the final projected budget, rising from below 50 million Mozambican meticais (MZN) in 2007 to nearly 350 million MZN in 2022. Notably, the projected annual final budget has consistently surpassed the realized budget since 2011, indicating a persistent gap between projections and actual disbursements. On average, this gap amounts to 2.9 million MZN per year. Throughout the period under consideration, the State's disbursements to the agriculture and rural development sector have consistently fallen short of meeting the budgeted amounts, underscoring the inadequacy of funding allocation in this critical sector.

The Second Assembly of the African Union, convened in Maputo, Mozambique, in July 2003, marked a significant milestone by endorsing a declaration on food security and agriculture. This declaration, known as the Maputo Declaration, embraced a pivotal pan-African initiative under the New Partnership for African Development (NEPAD) called the Comprehensive African Agriculture Development Programme (CAADP). CAADP was envisioned as the catalyst for enhancing production and ensuring food security across the continent. Notably, the Maputo Declaration gained prominence for its commitment to allocating a minimum of 10 per cent of the national budget to agriculture, with the objective of attaining a 6 per cent growth rate in agriculture (African Union Commission, no date). Subsequently, the Malabo Declaration on Accelerating Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods reaffirmed the core tenets of the Maputo Declaration, particularly the pledge to allocate 10 per cent of public resources to agriculture. Furthermore, it delineated a more detailed set of commitments in agriculture, including increasing investments in irrigation and mechanization, as well as addressing post-harvest losses.

However, as depicted in Figure 4.3.3, from 2007 to 2022, these commitments were not fulfilled. Throughout

Figure 4.3.2: Budgted versus realized spending by the State in the agriculture and rural development sector (Millions of MZN)



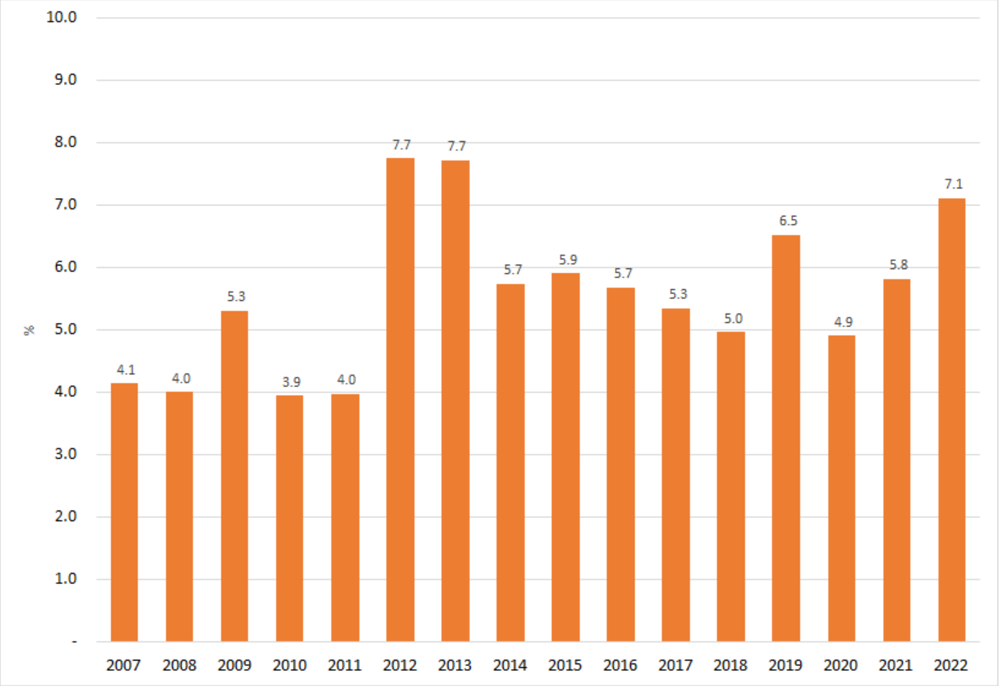
Source: Authors' illustration (based on the Mozambican General State Account, the State Budget, and the Budget Execution Report)

this period, the Mozambican state allocated less than 10 per cent of its budget to the agriculture and rural development sector. The lowest contributions occurred in 2010, with an allocation of approximately 4 per cent to the sector. Conversely, the highest state contributions to the sector were recorded over a decade ago, in 2012 and 2013, with allocations of close to 8 per cent. These percentages pale in comparison to the period from 1975 to 1986, during which 24 per cent of total expenditures were directed towards the agricultural sector (do Rosário, 2012).

We move from the national towards the provincial level in Figure 4.3.4. Specifically, we examine the internal and external investments transferred to each Provincial Directorate of Agriculture in 2007, 2010, and 2020. These illustrate that investments in provinces are unequally distributed. In 2007, the internal investment that Cabo Delgado received (24 per cent of total investment made to Provincial Agricultural Delegations) was equal to the share that the two provinces Nampula and Zambezia received jointly (11 and 13 per cent, respectively). Further, the Delegations of the southern provinces received significantly higher amounts of internal investment (Maputo City and Province, Gaza, and Inhambane jointly received 37 per cent) than the central provinces (Zambezia, Manica, and Sofala jointly received 21 per cent). The provinces with particularly low amounts of internal investments were Sofala (0.8 per cent) and Tete (3 per cent). Lastly, Zambezia, Nampula, and Tete, where more than half of the country's cultivated land is farmed, only received 27 per cent of internal investments.

This unequal distribution of internal investment to provinces continued in 2010, with similar patterns. Some provinces, the same as in 2007, received much more financial investment than others. By 2020, the distribution remained unequal but had changed across provinces. In that year, a huge amount (25 per cent)

Figure 4.3.3: Percentage of spending in the General State Budget invested in the agriculture and rural development sector



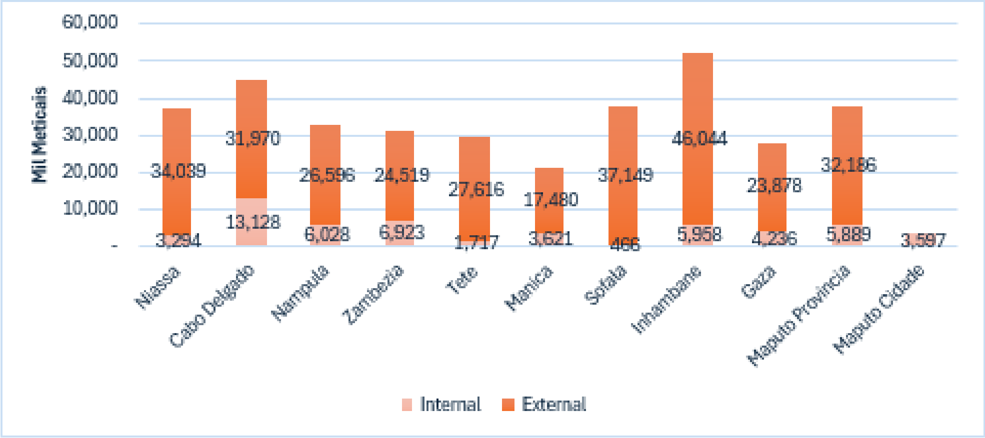
Source: Authors' illustration (based on the Mozambican General State Account, the State Budget, and the Budget Execution Report)

of total provincial internal investments went to Maputo Province, and about 45 per cent of total investments in provinces stayed in the South. The provinces with the largest populations, Nampula (more than 6 million) and Zambezia (5 million), received only 11 and 15 per cent of total internal investments made to Agricultural Directorates. Niassa and Cabo Delgado stood out as receiving particularly small shares, of 4 per cent each.

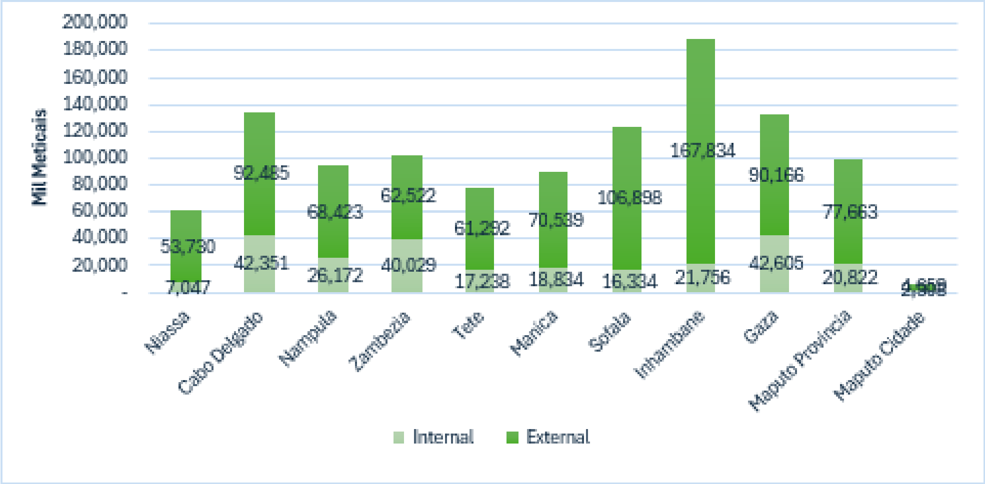
In Figure 4.3.5, we present a hypothetical calculation aimed at providing insight into the magnitude of expenditures flowing from the Mozambican state to agriculture and rural development. This figure illustrates the relationship between the actual value of state disbursements distributed to small producers at the national level over the years. Accordingly, if all the state expenditure allocated to the agriculture sector were directly transferred to small farmers nationwide, each farmer would hypothetically receive approximately 2500 MZN. However, upon a quick and cursory evaluation, it becomes evident that this investment is relatively insignificant. For instance, 2500 MZN would barely cover the cost of a 50-kilogram bag of fertilizer, which typically ranges from 3000 to 3500 MZN in the national market.

Figure 4.3.4: Internal and external financial investment allocated to the Provincial Directorates of Agriculture (in thousand meticais)

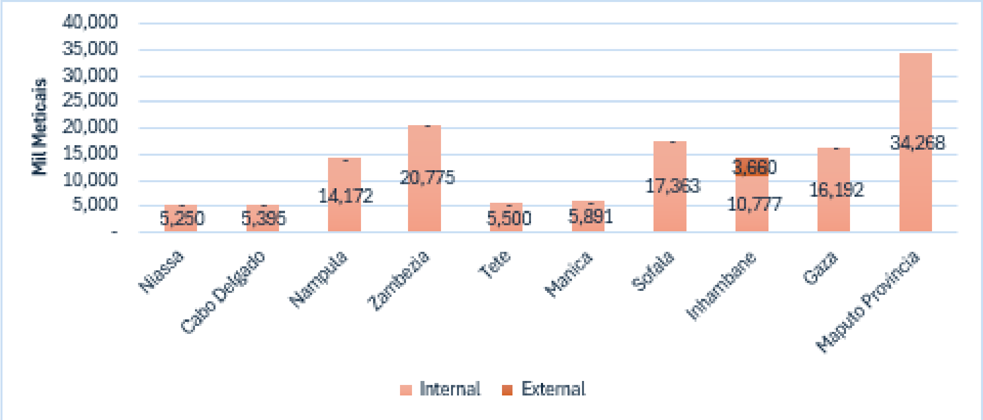
a) 2007



b) 2010

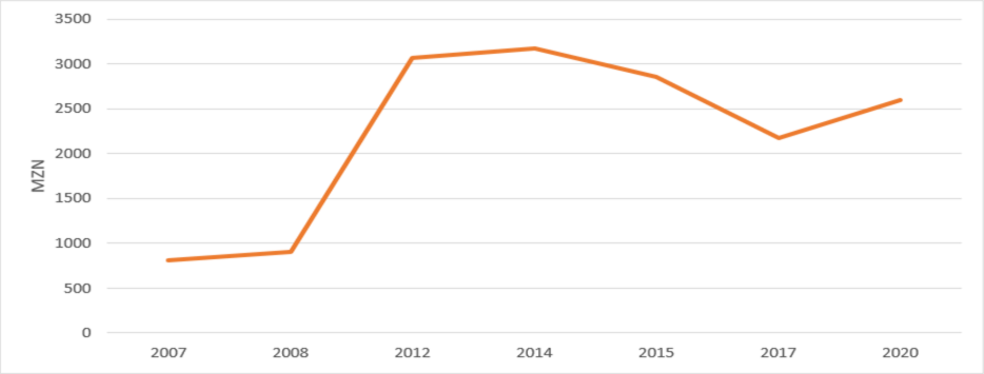


c) 2020



Source: Authors' illustration (based on the Mozambican General State Account)

Figure 4.3.5: Hypothetical calculation of the allocation of resources disbursed by the State to the agriculture and rural development sector to small producers at the national level



Source: Authors' illustration based on the Mozambican General State Account, the State Budget, and the Budget Execution Report

4.4 Conclusion

This chapter began with a historical overview of Mozambique's agricultural strategies. Since the country gained independence, and even though it is a priority on paper, agriculture has not been a practical priority for the Mozambican government. The country's agricultural strategies have predominantly focused on commercialization, modernization, and the development of large-scale farms. Despite rhetorical commitments to prioritize smallholders, these policies have largely overlooked the majority of stakeholders in the agricultural sector. Instead, agricultural strategies have often been implemented through top-down approaches, such as the establishment of communal villages, the promotion of highly technical solutions, or attempts to integrate smallholders into value chains. However, these measures have failed to consider local realities and farmers' preferences, which may explain their lack of success (Mosca, 2015).

The second part of the chapter illustrates the lack of prioritization of agriculture through statistics. Specifically, it delves into the investments made by the Mozambican State in the agriculture sector. These show that insufficient funding has gone to agriculture and that the Mozambican provinces most populous and dependent on agriculture have often received the least financial support over the past two decades.

Appendix

4.A Agricultural Strategies

Table 4.A.1: Summary of Mozambican Agricultural Strategies

Policies	Objectives/ Goals	Source
Agricultural Policy and Implementation Strategy, 1996	It fits agricultural activity into Mozambique's economic development objectives in 4 main areas, namely: 1) Food security; 2) Sustainable economic development; 3) Reduction in unemployment rates; and 4) Reduction in absolute poverty levels	Ministry of Agriculture, 2011a
PROAGRI I 1999–2005	Make agricultural institutions more capable and efficient	Cunguara et al., 2013
PROAGRI II (2006–2010)	1) Support the small producer sector to develop its agriculture and activities related to natural resources; 2) Stimulate production based on increasing agricultural productivity and natural resources, to guarantee sufficient domestic production to satisfy the basic food needs of all Mozambicans and increase income levels in rural areas. This must be complemented with the promotion and development of agro-industries that add value to the country's agricultural products for domestic and export markets; 3) Ensure sustainable management of natural resources that produces economic, social, and environmental results based on integrated management (access, security of tenure, and rights), and conservation actions involving the interests of communities, the public sector, and the private sector.	Ministry of Agriculture and Rural Development, 2004
Green Revolution Strategy, 2007	Increased production and productivity of basic food products and the introduction of cash crops, in order to guarantee in a competitive and sustainable way: 1) Food security; 2) Reduction of hunger; 3) Production of surpluses for export; 4) Greater food supply; 5) Increase in exports and supply of raw materials for local industry	Ministry of Agriculture, 2011a; Cunguara et al., 2013
Second Agricultural Extension Master Plan (2007–2016)	1) Dissemination of information on technology options for the various production systems, and training producers to apply these technologies through the expansion of the rural extension network; 2) Promotion of producer organizations to take responsibility for managing available resources; 3) Establishment of links between suppliers of agricultural inputs and users (producers and associations); 4) Establishment of clear links with private sector companies and NGOs involved in the provision of extension services, strengthening rural extension networks through outsourcing.	Ministry of Agriculture, 2007
Rural Development Strategy (EDR) 2007–2014	1) Increased competitiveness, productivity, and accumulation of rural wealth; 2) Productive and sustainable management of natural resources and the environment; 3) Expansion of human capital, innovation, and technology; 4) Diversification and efficiency of social, infrastructure, and institutional capital; 5) Good governance and planning for the market.	Ministry of State Administration, 2007
Food Production Action Plan (PAPA) (2008–2011)	Elimination of the deficit of the main food products (corn, rice, wheat, oilseed crops, cassava, potatoes, fish, and poultry) in the following 3 years and reduce dependence on imports.	Ministry of Agriculture, 2008; Cunguara et al., 2013
ProSavana 2009-2020	Create new models of agricultural development, considering environmental and socio-economic aspects, and seeking market-oriented agricultural/rural/regional development in a competitive manner. In the short term, it was expected that there would be a reinforcement of the National Agricultural Research Capabilities. In the long term, an increase in regional agricultural production of 12%, on average, from 2015 values was expected.	ProSAVANA-PD, 2013; Ekman and Macamo, 2023
Strategy Plan for Agricultural Sector Development (PEDSA) (2011–2020)	Contribute to food security and to the income of agricultural producers in a competitive and sustainable way, ensuring social and gender equity. Having as pillars: 1) Agricultural productivity – Increased productivity, production, and competitiveness in agriculture, contributing to an adequate diet; 2) Market access – Services and infrastructures for greater market access and a guiding framework conducive to agricultural investment; 3) Natural resources – Sustainable use and full exploitation of land, water, forest, and fauna resources; 4) Strong agrarian institutions	Ministry of Agriculture, 2011a
Fertilizer National Programme in Mozambique 2012	Stimulate the supply and demand of fertilizers by the productive sector in order to improve soil and crop productivity, taking into account the quality of the environment.	Ministry of Agriculture, 2012
National Plan for Agricultural Sector Investment (PNISA), 2013–2017	1) Accelerate the production of basic food products; 2) Guarantee income for producers; 3) Ensure access and secure possession of necessary natural resources; 4) Provide specialized services aimed at developing the value chain; 5) Boost the development of areas with greater agricultural and commercial potential.	Ministry of Agriculture, 2011b
Operational Plan for Agriculture Development (PODA) (2015–2019)	1) Guarantee the production of food of plant and animal origin; 2) Ensure food and nutritional security; 3) Reduce import levels of foods of plant and animal origin; 4) Promote an increase in the family income of small producers; 5) Promote forest plantations and sustainable management of natural resources (land and water).	Ministry of Agriculture and Food Security, 2015
Sustain 2019-2024	Improve the quality of life of rural households by promoting sustainable agriculture (social, economic, and environmental)	Ministry of Agriculture and Food Security, s.d.
National Plan for Agriculture Sector Investment (PNISA II) (2022–2026)	It adopts the objective of PEDSA II, which is sustainable agrarian transformation that will result in significant growth in the agrarian sector, increasing the income of family farmers, improving food and nutritional security for all Mozambicans, and increasing exports of agricultural products.	Ministry of Agriculture and Rural Development, 2022
Strategic Plan for the Development of the Agricultural Sector (PEDSA II) (2030)	1) Increase agricultural productivity in a way that is sustainable and resilient to climate change; 2) Promote the integrated, sustainable, and resilient management of natural resources; 3) Strengthen and facilitate the access of agricultural products to the domestic, regional, and international market, in an inclusive and competitive way, maximizing the inclusive involvement of the private sector; and 4) Strengthen the efficiency and effectiveness of public and private agrarian institutions and civil society in carrying out their roles in the development of the agrarian sector.	Ministry of Agriculture and Rural Development, 2022

Source: Authors' compilation.
Note: The objectives/goals of each policy are summarized based on available documentation.

Table 4.A.2: Priorities of Mozambican Agricultural Strategies: Culture and Geography

Policies	**Geography**	**Products**	**Source**
Agrarian Policy and Implementation Strategy	National based on agro-ecological zones	corn, rice, sorghum, millet, beans, peanuts, cassava and animal protein	Ministry of Agriculture, 1996
PROAGRI I	Central Level	-	Ministry of Agriculture and Rural Development, 2004
PROAGRI II	National	Soybeans, beans, chickpeas, peanuts, corn, sweet potatoes, cassava, cattle and poultry	Ministry of Agriculture and Rural Development, 2004
Green Revolution Strategy	National based on agro-ecological zones	Corn, rice, sorghum and wheat, beef and dairy cattle, chickens	Ministry of Agriculture, no date
Second Agricultural Extension Master Plan	National based on agro-ecological and peri-urban zones	Sunflower, sesame, cashew nuts, cotton, corn, beans, peanuts, rice, goats and chickens	Ministry of Agriculture, 2007
Rural Development Strategy (EDR)	National	Promotion of biofuel production and livestock farming	Ministry of State Administration, 2007
Food Production Action Plan (PAPA)	National based in agricultural Potential	Corn, rice, wheat, peanuts, cassava, potato, sunflower, soybeans, peanuts, chicken and fish	Ministry of Agriculture, 2008
ProSavana	Nacala Corridor (19 districts in the Provinces of Nampula, Niassa and Zambézia)	Basic: Corn, cassava, common beans, cowpeas and peanuts; Yield: soybeans, potatoes, vegetables, cashew, cotton, tobacco; Others: sesame, sunflower and tea; Chicken farming	ProSAVANA-PD, 2013
Strategic Plan for the Development of the Agricultural Sector (PEDSA)	National based on agro-ecological zones	Corn, rice, beans, sorghum, cotton; Yield: Soybeans; Livestock: Cattle, ruminants, chickens and eggs	Ministry of Agriculture, 2011a
Fertilizer National Programme in Mozambique	National	-	Ministry of Agriculture, 2012
National Investment Plan for the Agrarian Sector	National based on agro-ecological zones	Food: Corn, rice, wheat, common beans, reno potatoes, tomatoes; Yield: Cashew, cotton, tobacco, soybeans, sunflower, sugar cane, biofuels; Livestock: Fish, ruminants, cattle, milk, chickens and eggs	Ministry of Agriculture, 2011b
Operational Plan for Agrarian Development (PODA)	Corridors agrarian development: Pemba-Lichinga, Nacala, Zambezi Valley, Beira, Limpopo and Maputo	Potatoes, wheat, beans, corn, cassava, soybeans, vegetables, fruit, rice, sugar cane, forestry, cotton, sesame and poultry farming; Livestock: cattle, goats	Ministry of Agriculture and Rural Development, 2015
Sustain	National	Rice, Corn, Beans, Soy, Sunflower, Sesame and Cotton; Livestock: Cattle, Poultry and Pig; Tomato, Potato, Cabbage, Onion, Garlic, Baby Corn, Carrot and Green; Fruit: Mango, Banana, Pineapple, Citrus, Avocado, Litchies, Strawberries, Papaya, Tobacco, Peripiri, Potato, Macadamia, Copra, Cashew, Tea, Coffee, Sisal, Dairy products, Buffalo, Goat	Ministry of Agriculture and Food Security, s.d.
National Plan for Agricultural Sector Investment (PNISA II)	National based on agro-ecological Zones	Oilseeds: cotton, sesame, sunflower and soybeans; Grain legumes: butter beans and pigeon peas; Cereals: corn and rice; Roots and tubers: cassava, reno potatoes and sweet potatoes; Vegetable and fruit crops: mangoes, bananas, macadamia and cashew; Livestock: especially red meat, poultry and eggs; Wood products: eucalyptus and pine; Aquaculture: tilapia and freshwater shrimp	Ministry of Agriculture and Rural Development, 2022b
Strategic Plan for the Development of the Agricultural Sector Sector (PEDSA II)	National based on agro-ecological zones	Corn, rice, sesame, soybeans, cotton, cashew nuts, tomatoes, reno potatoes, macadamia; Livestock: Beef, chickens, eggs, goat meat, tilapia; Pine and Eucalyptus	Ministry of Agriculture and Rural Development, 2022a

Source: Authors' compilation.
Note: The products listed are based on the priorities of each strategy.

Chapter 5

TIA/IAI Harmonized Dataset: Strengths and Limitations

5.1 Introduction

This chapter introduces the core motivation behind the preparation of this report on small-scale farming in Mozambique, namely the creation of the TIA/IAI harmonized dataset (2002–2020). This new repeated cross-sectional database makes it possible to compare data from the 11 agricultural surveys conducted between 2002 and 2020 by the Ministry of Agriculture of Mozambique (MADER). Representative at the provincial level, this new database gathers insights into the development of small-scale farming in Mozambique over the first two decades of the 21st century.

Despite its apparent simplicity, until now no one had facilitated in this systematic manner a comparison of these agricultural survey rounds. Undoubtedly, initiatives had been undertaken in this direction, and the sustained effort to preserve a pseudo-consistent questionnaire over time laid the groundwork for data unification. However, numerous factors hindered the execution of a precise and reliable unification as the one outlined in this chapter. Challenges inherent in the data collection and minor changes in the questionnaire structure rendered harmonization difficult. Moreover, countries with limited capacity for gathering high-quality data, like Mozambique, may face issues with biased or unreliable statistics given the complexity of collecting data in remote areas. In our harmonization initiative, the efforts extended beyond merely consolidating the survey rounds. Another key achievement was the data cleansing process, aimed at enhancing the clarity and usefulness of the information gathered.

Our work brought together three sets of data containing information on household characteristics, agricultural practices and inputs, and production and plot measures. After the unification of these survey rounds, we augmented the datasets with climate-related and caloric data to facilitate ad hoc analyses so as to provide a more distinct perspective on the sector's trends. This database enables an in-depth examination of the dynamics and progression of small-scale farming in Mozambique. In the next chapters, we will further explore these aspects, relying primarily on the TIA/IAI datasets for analytical grounding.

The purpose of this chapter is to introduce and elucidate how the TIA/IAI harmonized dataset was established, as well as to enlighten readers about the strengths and weaknesses of the data at hand. While this dataset may not be flawless – a common occurrence with quantitative data in developing countries –, it stands as one of the most valuable tools for exploring the agricultural dynamics of small-scale farming in Mozambique. After introducing the primary data source and the structure of the agricultural surveys, this chapter presents the harmonization process and decisions and concludes by discussing the limitations and reliability of this new dataset.

5.2 The TIA and IAI data

The primary data used for this harmonization were provided by the Ministry of Agricultural and Rural Development.[1] The data from the period 2002–2008 correspond to the *Trabalho de Inquérito Agrícola* (TIA). Starting from 2012, the TIA was integrated with the *Aviso Prévio*, becoming known as *Inquérito Agrícola Integrado* (IAI). The aim of this integration was to enhance data accessibility, as discrepancies periodically arose in the statistical outputs from these two sources. Consequently, since 2012, MADER advised the consolidation of these data origins into a single unified source. In the context of this report, the term *Agricultural Survey* is used interchangeably to denote datasets from both the TIAs and the IAIs.

These agricultural surveys covered rural and urban households with both small- and large-scale farms, using two different questionnaires. Our harmonized dataset focuses on smallholder farmers, with less than 50 hectares of agricultural land. Small-scale farmers form the backbone of this sector, encompassing 98 per cent of all agricultural practitioners in Mozambique (MADER, 2022).

The agricultural survey samples are drawn from the reference population outlined in the Agriculture and Livestock Census (*Censo Agro-Pecuário*, CAP). Prior to 2008, all agricultural surveys used CAP 1999–2000 as a foundation. Afterwards, starting in 2012, CAP II (2009–2010) became the designated reference dataset. The samples of each annual survey are stratified by province,[2] ensuring robust representation both at the provincial and at the national level. The total number of households sampled varies each year, with recent surveys encompassing almost all districts and employing a slightly expanded sample size. The number of surveyed households and the number of surveyed districts increase progressively over time.

To better understand the scope, it is useful to present the questionnaire structure of the agricultural surveys as well as the status of the data received prior to harmonization. This will give the reader greater insight into the rationale behind the harmonization decisions discussed in the next section.

The data received comprise 16 datasets, representing distinct sections of the questionnaire and spanning the surveyed years from 2002 to 2020. Table 5.2.1 provides a summarized outline of relevant sections sourced from the agricultural surveys. This table illustrates the questionnaire's framework and the dataset's available information. It bears noting that in 2017 and 2020 a separate questionnaire for cashew and coconut products was implemented. Hence, for these years, we received separate files that we integrated with the previous years. Lastly, alongside these 16 datasets, we received a separate dataset containing population weights at the household level. These datasets encompass information categorized into three units of observation: individual household members, the households themselves, and agricultural products. In addition to the

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[1] We would like to extend our gratitude to Dr. Benedito Cunguara for facilitating access to the data and providing clarification on key uncertainties.

[2] The technical document provided with the dataset also reported a stratification at the agro-ecological zone level. Unfortunately, it was not possible to verify this information. Moreover, in the data there is no variable taking this aspect into account.

data files, we were provided with the corresponding annual questionnaires.

Household identification combines two variables in the dataset: 'caseid' and 'year'. The 'caseid' variable is the identification number for a single household, but is it not unique across years. Therefore, an identical 'caseid' is associated with two distinct households in two different years. To accurately identify a household, we thus need to employ the combination of 'caseid' and 'year'. The questionnaire's framework limits our ability to track individual households over time, permitting only a broad understanding of provincial trends. Consequently, the three harmonized datasets are structured not as a longitudinal panel but rather as a repeated cross-sectional dataset.

Column 3 in Table 5.2.1 specifies the unit of observation in each section: individual household member, household, and product level. Part B is the only one in the dataset that reports information at the level of the individual household member; five parts of the questionnaire report data at the household level and the remaining nine parts all refer to the agricultural product. As a result, we created three new datasets, merging all the datasets with the same unit of observation.

With regard to data consistency over the surveyed years, we have encountered some difficulties. On the one hand, information at the individual household member level was consistently available for all years and the questions were comparable. Hence, the individual level dataset consistently provides details on individual characteristics of household members and the household head across all years. On the other hand, the datasets created from observation at the household level and observation at the product level present more considerable inconsistency across years. The next paragraphs summarize the issues encountered in the different questionnaire parts presented in 5.2.1 and clarify our decisions.

Part C, focusing on access to services and technology, captured a diverse array of information, including agricultural practices, usage of agricultural inputs, access to credit, financial inclusion, and extension services. Notably, there were slight variations in the questionnaire across different years. In certain rounds, responses were confined to a straightforward 'yes' or 'no' format, while in other years the questionnaire was more elaborate, offering multiple choice options and follow-up questions asking for detailed information. In instances where the questionnaire's format varied significantly, we created a "minimum" binomial variable for it to present in the maximum number of surveyed years. An example of this strategy is the access to extension services. In 2002, 2005, 2006, 2007, 2008, and 2012, the questionnaire included detailed queries about various types of extension services, such as information on livestock, food processing, and commercialization. However, in other years, these specific details were not requested. Moreover, questions about specific agricultural practices, like intercropping, crop rotation, or row cultivation methods, were not uniformly included in all survey years. Also, financial inclusion questions were exclusively asked in 2020. Usage of agricultural input such as fertilizer and pesticides, however, was consistently inquired about in every year.

Part D contains information on off-farm income, remittances, and pensions. In this part, information is scattered across years and the whole section was not present in 2017. In general, the main takeaway from this part was the creation of a dummy variable capturing whether someone in the household is also performing activities other than agriculture. However, we also cleaned other relevant dummy variables such as remittance and pension receivers and having worked abroad, although these are only available for 2005, 2008, and 2012. This information could have been useful to create a household income variable, which unfortunately is lacking in the harmonized dataset.

Part E contains information on the agricultural land used by the household, the extension of the plot, the

Table 5.2.1: Description of questionnaire sections

Questionnaire Section	Section Topic	Unit of Observation	Description
Part A	Household identification	Household	Province, district, household identification
Part B	Demographic characteristics	Household member	Information on household members: gender, relation to head of the household, age, education, agricultural involvement, paid work/self-employment, and 12-month household residency status
Part C	Access to services and technology	Household	Extension service, agricultural credit, farm organizations, agricultural practices
Part D	Off-farm income	Household	Off-farm work, remittances, and pensions
Part E	Plot area per household	Household	Land area, land ownership, division of land within the family, use of land, fallow land
Part F	Cultivated area	Product	Cultivated area (Hectares), irrigation, agricultural input use
Part GH	Cereals and legumes	Product	Quantity produced and sold, seed used, market information
Part I	Edible roots	Product	Quantity produced and sold (Kilograms), seed used, market information
Part J	Cash crops	Product	Quantity produced and sold (Kilograms), seed used, market information
Part K	Vegetables	Product	Quantity sold, market information
Part L	Fruit trees	Product	Number of trees, quantity sold, market information
Part N	Livestock	Product	Number of animals, value of the livestock (Meticais)
Part M1	Cashew	Product	Quantity produced and sold (Kilograms), seed used, market information
Part M2	Coconut	Product	Quantity produced and sold (Kilograms), seed used, market information
Part O	Means of production	Household	Labor, animal traction, and other means of production used
Part P	Food security	Household	Perception based measures of well-being, food security, and household vulnerability

Source: Author's compilation based on TIA/IAI datasets and questionnaires.

irrigation system, the fallow area, and land ownership. The whole part was missing observations from 2014. The use of irrigation was also missing in 2008 and 2012. Moreover, when comparing Part E with Part F – containing information on the cultivated area at the product level –, inconsistencies were observed between the total cultivated areas declared in each of them. As it is more relevant for the yield measures, we decided to rely on the crop-specific area data (Part F) and to sum those crop areas to obtain the total cultivated land by household. Nonetheless, we kept information on irrigation system and land ownership from Part E.

Part O focuses on means of production, including data on hired labour and both mechanical and non-mechanical equipment. The hired labour variables presented a small number of observations with inconsistency across years. Although a low number of hired workers in smallholdings could partially explain these results, it limits our ability to fully trust and understand the data. Therefore, we opted to create a simple binary variable to indicate the presence or absence of hired labour in the farm, leaving aside other information contained in this part of the survey due to its incompleteness. In addition to this, we created two dummy variables to represent the use of mechanical and non-mechanical equipment, respectively. For this latter information, data from 2003 are not available. This lack of reliability does not allow us to assess the cost of labour and therefore the cost of production, which emerges as a problematic trait of our analysis.

In Part P, the surveys posed categorical questions to assess the food security levels of agricultural households. These inquiries covered aspects such as the number of meals consumed daily, the primary staple foods, the duration of food stocks, and various qualitative measures of food security. There was a consistent pattern only, with identical questions posed in the surveys conducted in 2004, 2005, 2006, 2007, and 2008. We incorporated this food security assessment in the final harmonized dataset, although the resulting variables were not the primary focus of our analysis.

Lastly, the product-level dataset was created by merging data from various product parts (Part G, H, J, I, K, L, N, M1, M2) and the section on cultivated areas (Part F). Figure 5.2.2 illustrates key variables in this dataset: quantity produced, quantity sold, value of sales, and cultivated area. Undoubtedly, these variables are pivotal to gain an understanding of the production trend in small-scale farming. Yet, almost all these variables report incomplete data, with quantity produced and sold available only for cereal grains, legumes, cash crops, and roots. The most present variable across categories and years is the value of sold production (meticais), which was reported in each categories and is a key variable to start analysing farmers' performance.

The next section will delve deeper into our harmonization decisions, taken to maximize the value of the existing data. This effort also includes our attempts to derive reliable measures of the value produced from these baseline data.

Table 5.2.2: Production data availability by crop categories

	Quantity produced (kg)	Quantity sold (kg)	Sold value (MZN)	Crop area (He)
Cereal grains	All years	Missing 2002	Missing 2002	Missing 2003
Legumes	All years	Missing 2002	Missing 2002	Missing 2003
Cash crops	All years	All years	All years	Missing 2003
Roots	All years	All years	All years	Missing 2003
Vegetables	N.A.	N.A.	Missing 2003, 2007, 2020	Missing 2002 and 2003
Fruits	N.A.	N.A.	Missing 2003, 2007, 2017	Missing 2002, 2003, 2006, 2017
Cashew	Missing 2017	Missing 2017, 2020	Missing 2017	Missing 2002, 2008, 2017, 2020
Coconut	Missing 2014	Missing 2014, 2020	Missing 2014	Missing 2002, 2003, 2005, 2006, 2008 2014, 2020
Livestock	N.A.	N.A.	Missing 2014	N.A.

Source: Author's elaboration based on TIA/IAI data.
Note: The availability of individual crops within these categories may vary annually. This table synthesizes the data, serving as a starting point for decision-making and maximizing value and information from the TIA/IAI data. For fruits, cashew, and coconut, crop area was calculated based on the declared number of trees. Therefore, any missing years in the 'crop area' column for these categories relate to the number of trees, not directly to the cultivated area.

5.3 The TIA/IAI harmonized dataset

As emerged from the last section, our harmonization goal was to minimize the exclusion of similar variables and to accurately interpret trends, setting aside cases where variables lacked meaningful interpretation. This section details the remaining decisions for unification and introduces the methodology behind the calculations of selected key metrics. Each of the following chapters offers more detailed explanations on the measures used in the analysis.

Having outlined the overarching approach to data harmonization and trend interpretation, it is important to address specific regional considerations, starting with the exclusion of Maputo City from our analysis. The data from Mozambique's capital contained numerous outliers, making it challenging to interpret. Furthermore, the specific urban setting and its limited geographic extent have convinced us to exclude it from the analysis. Hence, we focused on the other 10 provinces, grouped into three regions: North, Centre, and South. The map in Figure 5.3.1 presents the regional division of Mozambique, with Cabo Delgado, Niassa, and Nampula in the North; Zambezia, Tete, Manica, and Sofala in the Centre; and Inhambane, Gaza, and Maputo Province in the South. This distinction is particularly salient for agricultural studies, as it captures variations in climate, soil composition, and growing seasons that are critical for regional crop viability.

Table 5.3.1 details the distribution of households and district counts across each survey year in the harmonized dataset. Observably, the agricultural surveys exhibited consistent growth in sample size. Starting from 2008 onwards, the agricultural surveys extend the coverage to almost all districts in Mozambique. Later, in 2020, MADER expanded the sample size to encompass nearly 24,000 households.

Table 5.3.1: Number of surveyed households and districts

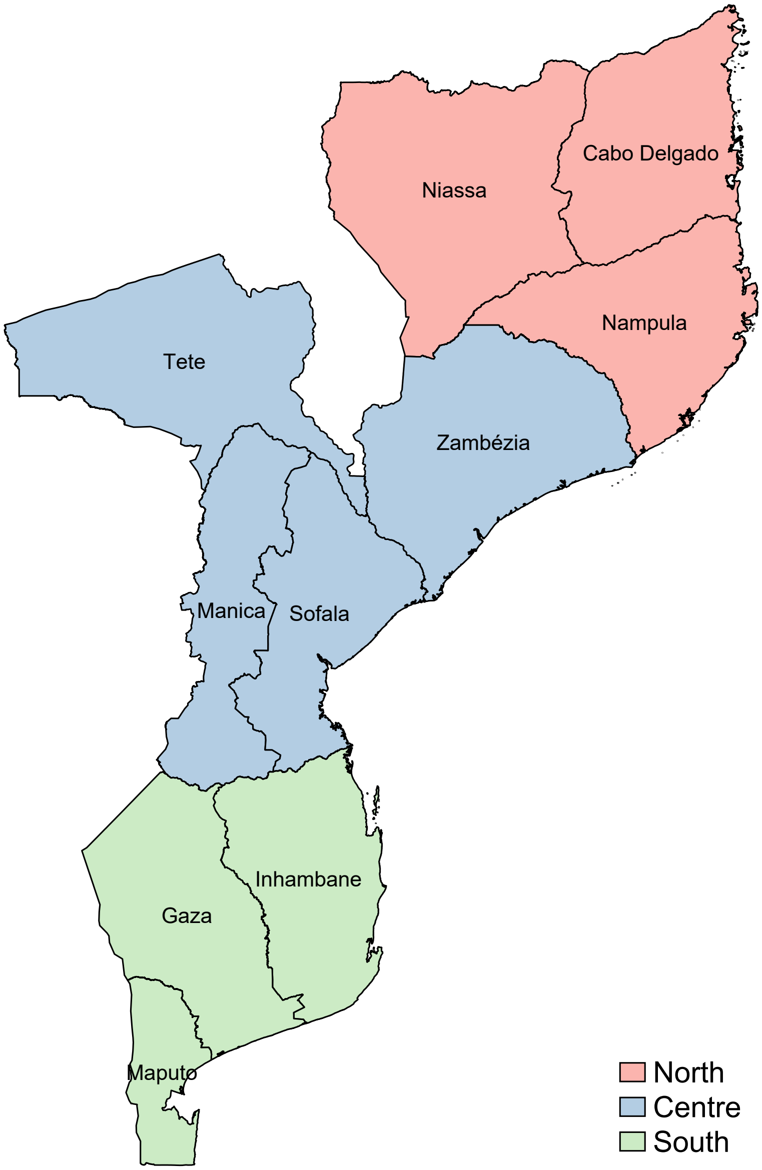
Year	Number of surveyed households	Number of surveyed districts
2002	4,908	80
2003	4,935	80
2005	6,149	94
2006	6,248	94
2007	6,075	94
2008	5,968	138
2012	6,745	141
2014	6,043	141
2015	7,050	141
2017	7,031	139
2020	23,743	133

Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: The total number of districts in Mozambique is 154.

Reflecting on the expanding scope of the agricultural survey over the years, we next turned our attention to the critical aspect of sample representativeness, an essential element in ensuring the validity of our analysis. In principle, the agricultural data should be representative at the provincial level. Indeed, population weights were provided for each year in a separate database. The original population weights displayed certain unusual patterns, particularly evident in the central regions after 2012. This discrepancy appeared linked to the transition from the previous census to the 2007 census, prompting our decision to refine the weights using estimations for small farms from CAP 2009–2010. The two graphs in Figure 5.3.2 show the differences in the evolution of population weights, with the old TIA/IAI weights displayed in panel (a) and the adjusted weights anchored to the CAP 2009–2010 provincial data in panel (b).

In order to reduce noise associated with large changes in the relative weight of different regions (and provinces) in derived sample estimates, we modified the raw sample weights from the TIA/IAI surveys in three steps. First, we calculated the annual average of province-level annual smallholder population growth rates based on two data sources: (i) the TIA/IAI series; and (ii) the series of household budget surveys, focusing only on those households stating agriculture as their primary occupation. Next, we used estimates of the number of households practising smallholder agriculture in each province from CAP 2009–2010 as fixed anchor points; and, for each province, we then applied (backwards and forwards) a smoothed growth rate to yield annual province-level estimates of the number of smallholders. Finally, we modified the existing sample weights from each TIA/IAI survey to ensure expanded estimates of the total smallholder population in each province match the estimated target values (from the previous step).

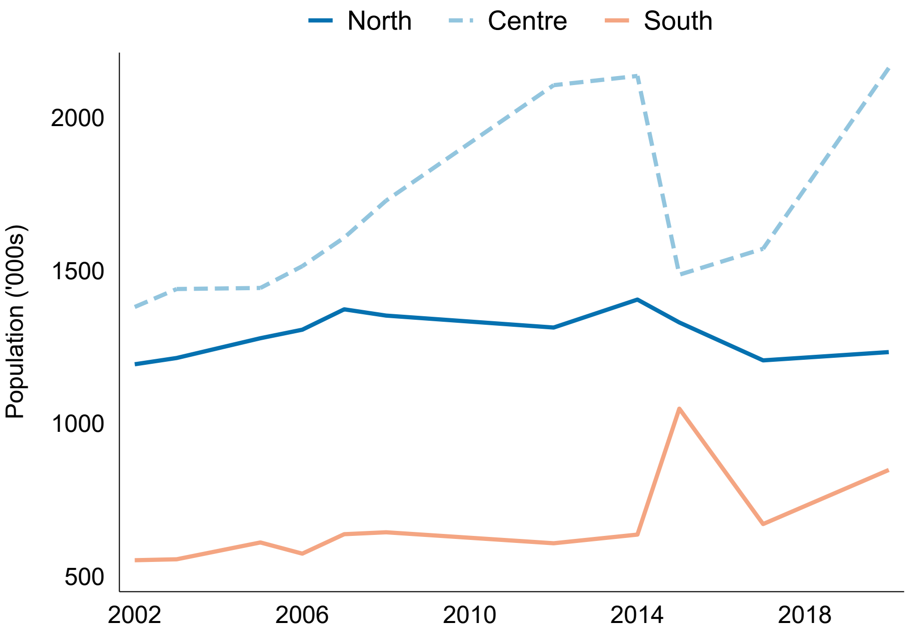
Figure 5.3.1: Mozambique regional division



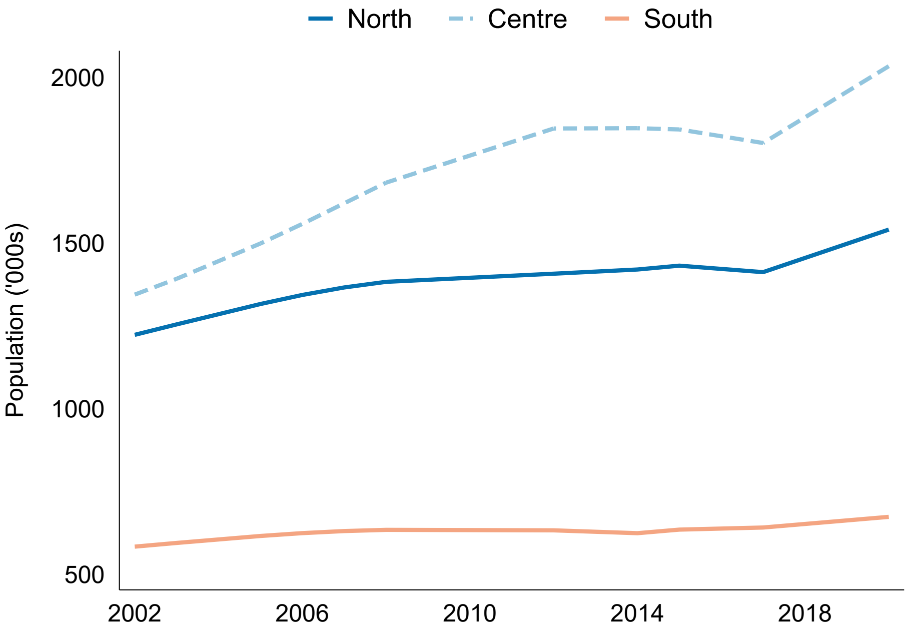
Source: Author's elaboration based on TIA/IAI harmonized dataset.

Figure 5.3.2: Population weights compared

(a) TIA/IAI weights



(b) Adjusted weights



Source: Author's elaboration based on TIA/IAI harmonized dataset.

5.3.1 Merging datasets by observation unit

The harmonization process continued by merging datasets that shared a common unit of observation. This resulted in the creation of three distinct datasets: individual characteristics, farm characteristics, and products. Through meticulous collapsing, these datasets seamlessly merge using the unique household identification, the combination of 'caseid' and 'year'. As the primary interest of this report is the agricultural household, we also aggregated the most relevant production information at the household level.

As mentioned above, the first dataset, focusing on individual-level data, did not present significant challenges due to its straightforward and consistent questions across different years. However, in the household-level questionnaire, we encountered greater complexity. Over time, certain questions were occasionally repeated with slight variations in categorical options, and in some instances, respondents were prompted for dichotomous responses. To maintain consistency in our results, we have reclassified these variables as binary, simplifying the data while setting aside more granular details. This approach was applied to variables such as extension services, off-farm work, and financial information.

5.3.2 Product-level harmonization

Moving towards the product-level section, we merged together parts F to M2 (with reference to Table 5.2.1), namely cultivated area, cereals, legumes, edible roots, cash crops, vegetables, fruits trees, livestock, cashew, and coconut.

Although the agricultural questionnaire already included a crop categorization defined by the different sections, we opted to establish a new system to facilitate international comparisons. This reclassification involved the creation of six distinct categories: cereals, legumes, roots, vegetables, fruits, and cash crops. Table 5.3.2 presents the new categorization and the corresponding products. Crops produced by less than 20 households cultivating them per year were grouped into a category of "other" (e.g., other legumes, other grains, etc...).

Table 5.3.2: New crop categories

Crop Category Name	Crops
Legumes	Peanuts, Butter bean, Cowpea, Yoke bean, Pigeon pea, Soy, Green bean, Oloko bean
Cereal grains	Maize, Rice, Sorghum, Millet, Wheat
Roots	Potato, Cassava, Sweet potato, Taro, Beetroot, Carrot
Cash crops	Cotton, Tobacco, Sisal, Tea, Ginger, Sunflower, Sesame, Paprika
Vegetables	Pumpkin, Lettuce, Onion, Cabbage leaves, Watermelon, Cucumber, Okra, Tomato, Garlic, Eggplant, Pea, Pepper, Chilli, Cabbage
Fruits	Taro, Avocado, Pineapple, Banana, Guava, Jamba, Orange, Lemon, Mafurra, Mango, Papaya, Tangerine, Sugar apple, Lychee, Apple, Indian jujube, Pear, Peach, Grapefruit, Grapes, Passion fruit, Cashew, Coconut

Source: Author's elaboration based on TIA/IAI harmonized dataset.

Data on the cultivated area for specific fruit crops, such as coconut and cashew, were not available in our dataset. Nonetheless, we could estimate the land area dedicated to fruit cultivation by examining the registered number of trees for each fruit crop. To approximate the total land holdings of rural households more accurately, we converted these tree counts into hectares, based on the assumption that one tree typically occupies about 0.01 hectares. Therefore, we divided the number of trees by 100 for an estimated measure in hectares.

Production levels reported as quantity in kilograms are a key element in agricultural surveys, as they provide fundamental insights into the agricultural sector's efficiency and trends. The presence of significant outliers in our data required a winsorization[3] for all continuous variables, which includes quantities produced, quantities sold, and the area cultivated.

Price information also emerged as a critical indicator, offering insights into the value generated by agricultural households. The agricultural questionnaire collected price data by asking farmers about the selling prices of their products. However, comprehensive price data were limited for most crops across different years. This gap can be attributed partly to the lower levels of commercialization, with many farmers primarily engaging in subsistence farming. Yet, understanding the value of production is essential for evaluating small-scale farmers' economic well-being and income. To illustrate the availability of price data in the original TIA/IAI dataset, Table 5.3.3 displays the available maize price information per year, counting those maize observations (at the product level) that recorded both quantity produced and price level sold. Maize was chosen as a point of focus because of its prevalence in agricultural production, as this cereal is the most commonly produced crop in the TIA/IAI data. The table indicates sparse data availability, with the years 2002 and 2006 notably lacking records for both quantity and prices. Furthermore, it underscores regional disparities in data collection, especially in the Northern region, where price observations are scarce. An upward trend in data availability over time suggests an increasing focus on and awareness of pricing among farmers. For instance, while 30 per cent of millet producers in the Southern region reported their product prices, this figure drops drastically to just 2.4 per cent in the Northern region.

Table 5.3.3: Number of observations and percentage of maize producers

	Number of Observations			Percentage of Maize Producers (%)		
Year	North	Centre	South	North	Centre	South
2002	0	0	0	0.0	0.0	0.0
2003	5	63	33	0.4	3.0	3.2
2005	13	151	78	0.8	6.8	5.8
2006	0	0	0	0.0	0.0	0.0
2007	20	249	159	1.3	11.3	13.4
2008	13	120	67	0.9	5.7	4.8
2012	14	116	65	0.9	5.2	4.3
2014	25	215	167	1.8	10.6	11.6
2015	26	309	177	1.4	12.6	11.0
2017	38	243	275	2.1	10.5	17.8
2020	158	1798	1307	2.4	24.2	28.8

Source: Authors' elaboration based on TIA/IAI dataset.
Note: The observation refers to the number of households reporting prices.

In evaluating the quality of our sample's price level data, we embarked on a careful adjustment and imputation process using the data we had. Initially, when unit prices were not available, we extracted price information

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[3] Winsorization is the process of replacing the extreme values of statistical data in order to limit the effect of the outliers on the results. For the TIA/IAI, we winsozired at the 5 per cent level.

by calculating unit prices, which involved dividing total sales value by the quantity sold. To address outliers, we then applied winsorization at the provincial level to smooth the price distribution for each product.

Moving forward, we determined median prices across several geographic layers, starting with districts and progressing to the provincial, regional, and national levels, considering medians only when supported by more than 15 observations to ensure statistical reliability. Finally, for entries lacking specific price data, we systematically imputed missing values, beginning with district medians. If district data were unavailable, we imputed the provincial level, followed by regional, and as a last resort, national medians. This structured approach allowed us to fill gaps in our dataset responsibly, ensuring our analysis rested on as complete a price dataset as possible.

5.3.3 Incorporating additional data

To enhance the comprehensiveness and accuracy of our analysis, we have augmented our dataset with three crucial data dimensions: climate metrics at the district level, caloric values for a range of agricultural products, and an assessment of soil suitability tailored to the predominant crops in the region.

Firstly, for calories we rely on the food composition tables developed by Korkalo et al. (2011), which contains calorie values per gram of the most common agricultural products in Mozambique. When applying the caloric conversion factors, we specified that the beans calories are for dry beans and that the cashew calories are for raw cashew nuts. For maize, we used the mean value between food composition tables for Mozambique (Korkalo et al., 2011) and Africa in general (Leung et al., 1968) given their huge variation. When calorie content information was missing for certain crops, we filled in the gaps by using the average calorie values for their respective categories.

The yield performance depends, among other factors, on the weather conditions to which the land is exposed. Therefore, we incorporated three distinct sets of climate variables into our dataset: rainfall in mm^3, the normalized difference vegetation index (NDVI), and temperature, all specific to each district area. The average rainfall data are monthly data retrieved from the Integrated Multi-satellitE Retrievals for GPM (IMERG) work developed by NASA's Precipitation Processing Center (Huffman et al., 2015). The NDVI is a measure to quantify vegetation greenness and it is useful in understanding vegetation density and assessing changes in cultivation. The NDVI and monthly temperature data set retrieved from the NASA Earth Observing System Data and Information System (EOSDIS) land process distributed active archive centre (Didan, 2015b) (Wan et al., 2015), which collected satellite data monthly. The inclusion of these variables aims to enhance our ability to measure climate variations over the past 20 years, allowing us to monitor anomalies that have occurred. In addition, it enables us to consider climate fluctuations when examining factors influencing crop yields. Hence, our primary focus is on weather and climate conditions during the growing season. As a result, we aggregated the average values of these variables at the district level for the relevant months within that period. Given Mozambique's extensive geographical span, it was necessary to account for regional differences in growing seasons. In the Southern and Central provinces, we computed average monthly values from November to March for rainfall, and December to April for NDVI and temperature. Conversely, in the Northern provinces, we shifted this period by a month. It is noteworthy that different crops have distinct growing seasons. To capture an aggregate trend at this stage, we opted for a standardized growing season for all crops. While this approach allows us to examine general trends in the data, a more beneficial analysis for specific crops would involve adjusting for their unique and varying growing seasons in each respective area.

Lastly, we added a soil suitability index (SSI) for maize, cassava, cowpea, and rice, the most produced crops. The SSI measures come from FAO and IIASA. (2022), which evaluates the characteristics of land units in terms of soil types for specific crops.

5.3.4 Creating relevant metrics

For our analysis we decided to create relevant metrics based on the variables introduced thus far, as an efficient measures of value of productions and a more accurate overall yield.

We established three different measures of production values: nominal, real, and caloric. For the nominal value, we calculated the value produced and sold by multiplying quantities in kilos by the price per kilo. When data were missing, we used median values from the same geographical area and same crop categories. To enhance comparability, we calculated real values using 2012 as the base year. The caloric measure is essential for understanding the nutritional impact of agricultural practices. In cases where specific crop caloric data were missing, we used median average calories of the crop categories. This method includes adjustments such as reducing cassava's caloric value by one-third and the edible part of fruits by half, to reflect their actual nutritional value and consumption patterns. This enabled us to assess the caloric output of household agriculture, providing vital insights into both the economic and nutritional facets of Mozambique's agriculture. Such analysis could be useful for researchers and policymakers in examining the intersection of agriculture, nutrition, and food security in Mozambique.

Yield serves as another crucial performance metric. For crops with complete data on both quantity produced and area cultivated – cereals grains, legumes, roots, and cash crops – we created a yield measure by dividing the quantity in kilos produced by the respective cultivated area in hectares. We decided to create an aggregate yield measure at the household level, following the methodology by Desiere et al. (2016). This 'overall yield' is the weighted sum of crop-specific yields (mt/he) cultivated by one household, weighted with caloric values and crop area share. The formula for this calculation is detailed in Equation 5.1.

$$\text{Overall Yield}_j = \sum_{i=1}^{n} \frac{\text{cal}_i}{\text{cal}_{\text{maize}}} * \frac{A_{ij}}{A_{\mathrm{T}_j}} * \text{yield}_{ij} \tag{5.1}$$

Whereas j indicates a specific household, i refers to specific crops and n is the number of crop i cultivated by household j. A_{ij} is the cultivated area for crop i in the household j and A_{T_j} is the total cultivated area by household j. Lastly, cal_i refers to the number of calories per kilo of crop i. The overall yield of the household j is the sum of the yield of n crops i cultivated by household j weighted by their share of cultivated area and their caloric contribution relative to the calories of maize. Hence, this aggregate measure takes into account all cultivated crops, but gives more weight to crops that account for a larger share of total cropped area as well as to the crop with higher caloric values.

In our evaluation of agricultural value, we also endeavoured to measure the value of livestock holdings. To achieve this, we adopted the Tropical Livestock Unit (TLU) methodology, an approach that is widely recognized in agricultural economics. The TLU methodology is instrumental for its ability to standardize a diverse range of livestock into a uniform unit. This standardization is based on the potential productive capacity of each type of livestock, thereby enabling a more coherent and comparable evaluation of their overall value. The specific TLU coefficients employed in our analysis were retrieved from the work of (LHC, 2014). Upon integrating these TLU coefficients into our dataset, we were able to compute the TLU value for each type of livestock in every household for each year. This computation involved multiplying the specific TLU value by the number of each type of livestock present, thus yielding a comprehensive measure of livestock value at the household level.

5.4 Limitations and reliability

The TIA/IAI dataset has been instrumental in understanding the agricultural dynamics of Mozambique, providing unmatched insights into the field. This section recognizes the significant progress in harmonizing and applying these data, while also considering their limitations for effective policy-making and research.

Initially, we analyse the dataset's strengths and weaknesses, underlining how our detailed approach has improved the reliability of the conclusions we draw. We spotlight the dependable parts of our results, yet caution is advised in certain areas. We propose future surveys and strategies to enhance data, particularly aimed at increasing accuracy in Mozambique's agricultural sector.

Beginning with its advantages, this repeated cross-sectional dataset is undoubtedly vital for tracking the progression of small-scale farming in Mozambique. It offers extensive demographic data on farming households, facilitating the assessment of changes from 2002 to 2020.

Furthermore, the dataset provides valuable insights into production trends and crop selections throughout the years. Although there are certain gaps in product-specific data, it has reliably captured the production of major crops. This consistency is key in accurately reflecting the changing preferences and strategies of farmers. Notably, while the dataset may not uniformly represent every crop, the information on the most widely cultivated crops is thorough and consistent, significantly boosting the reliability of the data. Indeed, the TIA/IAI dataset enables an examination of both the quantity and the economic value of the primary crops produced.

The integration of climate-related and caloric variables into the TIA/IAI dataset marks a significant enhancement, broadening the scope for comprehensive analysis. These additions are not only valuable for current studies but also pave the way for their integration into future survey round. This advancement enriches the dataset, facilitating more nuanced studies that can link agricultural trends with climatic patterns and nutritional outcomes.

Addressing the dataset's limitations, it faces significant challenges in representation. The current sampling methods may not fully capture the diverse range of agricultural practices throughout Mozambique, potentially affecting the dataset's ability to accurately represent the sector's true diversity and variability. This lack of representation could result in skewed insights, leading to inappropriate policy decisions. In addition, the dataset's irregular and sometimes inconsistent information regarding production factors diminishes its effectiveness. Consistency is crucial in longitudinal studies, and the present state of the data may impede our ability to track changes in farming practices and resource utilization accurately over time.

From a food security perspective, the dateset is also incomplete, limiting the scope of analysis. While it details the production side by quantifying calories produced through agriculture, it lacks data on the purchasing side of food security. This absence of consumption data is a gap, particularly in areas where reliance on the market for food is substantial.

In assessing the cultivated land area, we rely on aggregated data from crop-specific information, which unfortunately do not offer detailed, plot-level insights. This limits our ability to thoroughly analyse shifts in land usage patterns, including the transition of land into or out of fallow states. Moreover, calculating the cultivated area by summing crop-specific area by household is straightforward yet prone to overestimation. Particularly among small-scale farmers, this risk is accentuated due to a lack of accounting for intercropping practices. Consequently, the same plot of land might be counted multiple times if it supports more than one crop, leading to an inflated representation of land use.

Finally, the task of calculating household income and production costs presents significant challenges, largely due to the incomplete and unreliable financial data within the dataset. There are numerous instances where data are simply missing, and the data that are available often include outliers or produce results that do not seem realistic. This lack of reliability does not allow us to estimate revenues and costs of small-scale farmers.

With these considerations in mind, the TIA/IAI harmonized dataset stands as a laudable achievement, essentially serving as a key foundational tool rather than a conclusive source. It directs us towards identifying trends and areas requiring more detailed examination, in spite of its restricted scope. The creation of this report was driven by the goal of this unification. Having introduced the dataset's construction, the subsequent chapter will delve into utilizing the TIA/IAI data.

Chapter 6 provides an overview of additional data sources for assessing the overall size of Mozambique's agricultural sector and compares these with the TIA/IAI harmonized data. Chapter 7 explores the profile and evolution of small-scale farming as revealed by the harmonized dataset. Chapter 8 employs the data to conduct growth decomposition analyses, aiming to discern the key factors influencing performance outcomes. Finally, Chapter 9, also based on the TIA data, seeks to identify predominant livelihood strategies, characterize farms, and compare performance metrics.

These contributions underscore the immense importance of the TIA and IAI survey harmonization process in addressing concrete questions about Mozambique's agricultural sector. By recognizing and tackling its limitations, we can enhance the outcomes of our research and ensure that the policies and interventions developed are more effectively aligned with the true needs and conditions of the sector.

Chapter 6

How Large Is Mozambique's Agricultural Sector?

6.1 Introduction

The question posed in the title of this chapter may appear facile. As underlined elsewhere in this report, agriculture has been and continues to be one of Mozambique's most important sectors. The Constitution not only states that 'agriculture shall be the basis for national development' but also affirms the State shall 'guarantee and promote rural development in order to meet the growing and diverse needs of the people'. According to the most recent general population census in 2017, 84 per cent of the economically active population in rural areas identify their primary economic activity as agriculture, as do 28 per cent of the urban population (INE, 2022b). Similarly, data from the national accounts in 2020 indicate the agricultural sector contributes around one-quarter of total national income (in current prices), which is moderately larger than in 2000, when it was under one-fifth.

Following these general points, accurate and timely information regarding the performance of the agricultural sector is no doubt essential. This is only reinforced by the fact that rates of poverty are highest among households dependent on agriculture (Jones and Tarp, 2016a). And it is here, when we compare estimates of the size and growth of the agricultural sector based on household surveys to those from official macroeconomic data, that we encounter a critical puzzle. On the one hand, national accounts report the agricultural sector grew by 5.4 per cent per year in real terms from 2000 to 2020, implying the real income (value added) attributable to this sector more than doubled over the period. On the other hand, micro-survey evidence suggests less dynamism. Comparing the aggregate real value of agricultural production from the first and last surveys contained in the harmonized TIA/IAI series discussed in Chapters 5 and 7 (from 2002 and 2020, respectively), the implied annual growth rate is less than 3 per cent; and an estimate of the trend rate of growth derived from the full set of surveys is just 1.2 per cent.[1] Similarly, rates of monetary consumption poverty among agricultural households taken from separate household budget surveys increased from 49 to 72 per cent over the period 2002–2020. These same surveys also indicate zero growth in the total value of

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[1] The equivalent trend based on the national accounts data is 5.1 per cent.

consumption of these same households over the period in constant price terms.[2]

The purpose of this chapter is twofold. The first is to investigate the internal and external consistency of the primary official sources of aggregate statistics on the agricultural sector in Mozambique. The second is to explore candidate explanations for their apparent divergence. Recognizing that aggregated agricultural statistics combine information from diverse activities (e.g., permanent and seasonal crops) as well as distinct types of producers (e.g., smallholders and commercial farms), a specific focus is on differences in data coverage and timeliness across sources. As such, this study does not constitute a(nother) review of the formal structure of the agricultural statistical system or its quantitative performance (number of indicators produced). Rather, of central interest is the coherence of final statistical aggregates, which speaks to their quality and overall reliability as a guide to performance in the sector.

A main finding is that there are large and growing divergences in estimates of total agricultural production in Mozambique, especially as regards its absolute level. Indeed, comparing estimates derived from micro-surveys to a composite of 'macro' estimates (such as from the national accounts or as compiled by the Food and Agriculture Organization [FAO]), we find the latter has grown to almost twice the former. Put differently, the 95 per cent confidence interval around an ensemble estimate of the real value of total agricultural production is about plus or minus 30 per cent the point estimate. While some of this can be attributed to differences in methods or crop coverage, remaining differences are large. Consequently, efforts to improve the quality of the agricultural statistical system are needed.

The analysis in this chapter speaks to two main strands of literature. The first is studies critiquing the quality of statistics in sub-Saharan Africa, which has often represented a blind spot and where agriculture is recognized as a specific area of difficulty (Devarajan, 2013; Jerven, 2014). Indeed, the myriad challenges in measuring output from the (large) smallholder sector are well-known – e.g., written accounts are rare, farmers have poor or distorted perceptions of plot sizes, quantities are often non-standard, plots are frequently intercropped, and various crops are harvested on a continuous or irregular basis (Carletto et al., 2015). Despite the country having a structured system to collect agricultural statistics, the analysis of this chapter underlines the ongoing severity of such challenges in Mozambique. It also makes the empirical point that these measurement problems do not simply wash out in the aggregate – rather, severe bias emerges from differences in crop coverage, estimates of yields, and other sources, including methodological differences.

A second strand concerns studies that seek to triangulate data collected at different levels of aggregation (e.g., macro versus micro) or from distinct sources (e.g., surveys versus administrative data). Although exercises of this sort are fairly limited, Desiere et al. (2018) compare meat and fish consumption from household surveys versus FAO estimates, while Gollin et al. (2014) compare crop yields derived from two similar sources but for different sets of countries and periods. Both studies point to strong consistency – e.g., the latter states: "we find essentially no disagreement between the FAO yield data and these micro estimates of grain yields" (p.168). One reason for this may be that FAO simply uses the same source data. However, comparing household survey and national accounts estimates of consumption, other studies find large and systematic differences (Kulshreshtha and Kar, 2002; Ravallion, 2003; Robilliard and Robinson, 2003; Prydz et al., 2022). The present chapter affirms the importance of such triangulation exercises and also cautions that even where there may be agreement on mean yields for specific crops, there nonetheless can be important divergences when aggregate production values are compiled. In addition, this chapter demonstrates a number of triangulation methods, including the comparison of household agricultural and

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[2] For the purposes of this calculation the applied deflator is the poverty line; see below for further details.

consumption surveys, as well as benchmarking against FAO data and that from the national accounts.

6.2 Measuring total crop production

It is helpful to review how the market value of total agricultural production (V) in a given period is defined. In simple terms, it is the product of the quantity produced (Q) and the market price (p), aggregated across the universe of producers and products. Adopting the conventional distinction – relevant in many developing country settings – between petty smallholders (set $\mathcal{S}$) and large-scale commercial producers (set $\mathcal{L}$), we have:

$$\begin{aligned} V_t &= V_t^{\mathcal{S}} + V_t^{\mathcal{L}} && (6.1) \\ &= \sum_{i\in\mathcal{S}}\sum_{c} Q_{ict}p_{ct} + \sum_{j\in\mathcal{L}}\sum_{c} Q_{jct}p_{ct} && (6.2) \end{aligned}$$

where i, j index smallholders and commercial producers respectively; c indexes different crops; and t denotes time. Similar to Chapter 7, this can be stated equivalently as:

$$V_t = \underbrace{N_t \frac{A_t}{N_t}}_{\text{Crop area}} \sum_{i\in\mathcal{S},\mathcal{L}} \underbrace{\frac{A_{it}}{A_t}}_{\text{Producer weight}} \sum_{c} \underbrace{p_{ct}\frac{A_{ict}}{A_{it}}}_{\text{Crop weight}} \underbrace{\frac{Q_{ict}}{A_{ict}}}_{\text{Yield}} \tag{6.3}$$

This expression illuminates some of the statistical information typically used to derive aggregate estimates of the total value of agricultural production. Moving from left to right in equation (6.3), four main ingredients are: (i) the total area farmed, also equal to the number of producers multiplied by the mean farm size; (ii) the relative importance of each individual producer in total farmland; (iii) the relative importance of each crop in a given farmers' portfolio, given by the product of its market price and land share; and (iv) crop-specific yields. In addition, all crops and producers must be covered in some way – i.e., there should be no systematic exclusions or blind spots. From this it follows that a complete statistical system must move across different levels – that is, micro- or individual-level information on crop yields and land allocations must be expanded upward to the population level, based on estimates of the overall scope of agricultural activity across space.

With these demands in mind, general guidance from FAO and other competent entities suggests an agricultural statistical system should contain a broad mix of data collection activities pursued at different levels and frequencies.[3] As sketched in Table 6.2.1, these range from detailed census-type operations, which are generally only undertaken infrequently (due to their high cost), to more rapid and in some cases also remote operations, used to estimate changes in key variables at higher frequency but at lower cost. Different elements provide insights into the components of equation (6.3) – e.g., census data provides the most accurate picture of the scope of agricultural activity, while sample surveys and geospatial data (alongside information on prices) provide regular updates to this benchmark, supporting estimates of (annual) production. Integrated farm surveys provide more granular insights into farmer behaviour, including technology choices, determinants of variation in performance, and input costs. Taken together, such a system thus aims to provide a comprehensive view of the agricultural sector at different levels (national, regional, farm) and constitutes a relevant input into national accounts (AfDB, 2017).

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[3] See for instance `https://www.fao.org/statistics/data-and-statistical-standard-series/en`.

Table 6.2.1: Key elements of a generic agricultural statistics system

Component	Description	Frequency	Additional Notes
Census of Agricultural Holdings	Collect detailed baseline data on land use, crop types, livestock, and farm sizes	10 years	Establish national and regional benchmarks, track changes in the sector
Integrated Farm Surveys	Detailed agricultural and household data, including inputs use, income, expenditure, and household characteristics	Periodic (e.g., 3–5 years)	Holistic view of agricultural livelihoods, informs evaluations and targeted interventions, *inter alia*
Sample Surveys	Collect representative data on land allocation, crop yields, livestock production, and other key indicators	Annual	Probability-based, stratified random sample to ensure adequate spatial & farm-type coverage
Remote Sensing and Geospatial Data	Monitor land use, crop health, and environmental factors through satellite imagery	Ongoing (seasonal)	Combine with ground-truthing for accuracy
Administrative Records & Commercial Surveys	Organize data from large commercial farms (firm surveys, export/import records, land and livestock registers)	Ongoing (quarterly)	Supplement other sources, supports triangulation
Price Monitoring	Track agricultural commodity prices across the value chain (farm-gate, wholesale, retail).	Ongoing (monthly)	Monitor formal and informal market trends

Source: Author's estimates.

6.3 Data sources

Turning to Mozambique, at first glance the agricultural statistical system in the country appears comparatively well-organized, containing most elements of Table 6.2.1. Following reforms in the late 1990s, the first post-conflict agricultural census was completed in 2000, followed by a series of household-based agricultural surveys (e.g., Donovan, 2008; Kiregyera et al., 2008, see also Chapter 4) and surveys of large commercial farmers. Various external assessments have rated the country's (agricultural) statistical system positively along multiple dimensions, particularly in comparison to peer countries. For instance, the AfDB (2014) assess the availability of agricultural statistical information in the country as 'strong', ranking the country 6th out of 52 with respect to statistical methods and practices, despite only having 'poor' resource availability. Echoing this, an overall index of agricultural statistics development computed by the Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation Member Countries places Mozambique as second in the sub-Saharan African region, giving particularly high scores to statistical methodology and data availability (COMEC, 2014). A more basic comparison is also informative. While Mozambique's most recent agricultural census was undertaken in 2009/2010, the situation in Kenya in the same year reported by the World Bank suggests fundamental information of this sort was simply absent: "the Census of Agriculture has not been conducted since the 1960s [and] has resulted in the declining quality of data on agriculture, a limited survey programme, and increased use of desk-based or eye estimation approaches to fill gaps" (Braimoh et al., 2018).

As in other countries, while the national statistics agency (*Instituto Nacional de Estatística*, INE) holds ultimate legal responsibility for and authority to collect and disseminate official information on the agricultural sector, this competency is delegated primarily to the relevant line ministry. Thus, it is the Ministry

Table 6.3.1: Sources of data on agricultural production in Mozambique

			Coverage			
	Dataset	Source(s)	Temporal	Population	Products	Vars.
(a)	TIA/IAI surveys	Micro-surveys	Periodic	Smallholders	All crops	A, Q, p
	BdPES reports	Ministry estimates	Annual	All farmers	Selected crops	A, Q
	Statistical annuals	INE	Annual	All farmers	Selected crops	A, Q
	National accounts	INE	Annual	All farmers	–	$V - I$
(b)	IAF/IOF surveys	Micro-surveys	Periodic	Consumers	Food items	$V + \theta^*$
	FAOSTAT	FAO	Annual	All farmers	All crops	A, Q, p
	Bal. of Payments	Central Bank	Annual	Formal sector	Traded goods	X, M

Source: Author's estimates.

of Agriculture and Food Security (*Ministério da Agricultura e Desenvolvimento Rural*, MADER) that currently collects and publishes most of the primary data required to fulfil INE's mandate. The main sources of official public data on the sector are elaborated in panel (a) of Table 6.3.1 below. These are the series of micro-surveys, administrative reports on crop production summarized in official annual monitoring reports of the government plans (previously known as the *Balanço do Plano Económico e Social*, hereafter BdPES; more recently known as the *Balanço do Plano Económico, Social e Orcamento do Estado*), INE statistical annuals including periodic sector-specific reports, and total production statistics by sector found in the national accounts, also published by INE.

It should be highlighted that coverage of these different sources varies. Limitations of the TIA/IAI series have been noted elsewhere (Chapter 5). Most importantly, production quantities are generally only consistently available for major annual crops (staples), which are harvested once or twice a year, meaning that complete information needed to place a value on production (minimally, Q, p) is not available for many other permanent crops and vegetables (which are continuously harvested), nor for various cash crops. The TIA/IAI series is also designed to capture activities of smallholder farmers, defined as those farming less than 10 hectares of rain-fed land or under 5 hectares of irrigated land. A separate survey (or census) of large farms has been undertaken alongside the TIA/IAI surveys; however, data from these exercises are generally not published (in part to maintain confidentiality), even at an aggregate level. Also, while the TIA/IAI samples are – in principle – drawn from the complete rural and urban sampling frame constructed from the most recent agricultural (and population) census, comprehensive methodological documents on the sample design are not in the public domain and urban/rural identifying information is not included in the available micro-data.[4]

The BdPES data pertain to administrative estimates constructed by the Ministry of Agriculture. These only cover specific major food crops and livestock production, giving information on two dimensions – total production quantities and (for crops) area farmed. The underlying methodology used to produce these estimates is not published and, thus, the exact coverage of the published information is unclear. However, individuals familiar with the process indicate that the data are sourced in a bottom-up fashion – district-level government officials (from the *Serviço Distrital de Actividades Económicas*) report crop-level estimates of the land allocated to different major crops, as well as estimates of yields or total harvested outputs, typically based on site visits to selected plots and other qualitative information. These estimates are then aggregated

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[4] For present purposes, we use adjusted survey weights aligned to the most recent agricultural census for all statistics derived from the TIA/IAI surveys – see Chapter 5 for further details.

centrally and cleaned. Overall, this process appears the natural counterpart to the *Aviso Prévio* (early warning) system, whereby forecasts for the same indicators are updated with estimates of their realized values.[5]

The most granular statistical information published by INE on the sector is contained in their *Anuário Estatístico* (statistical annuals) series, as well as occasional reports containing agricultural production and food security indicators (e.g., *Indicadores Básicos de Agricultura e Alimentação*). In both outputs it is clear that primary data are sourced directly from the relevant line ministry, including the TIA/IAI series. The statistical annuals largely mirror the structure of the BdPES, presenting only farmed area and output quantities for selected major crops. To these, data on some major commercial crops are also added (e.g., cashew, tobacco, sugar cane). INE's sector reports are more detailed. On the one hand, they include headline information regarding the number of so-called non-household 'statistical units' (e.g., commercial farms or associations) active in the agricultural sector. But these are small in absolute terms – as at 2020, this number was just 1212 units versus 4,456,518 smallholders (INE, 2022a). On the other hand, production and land use data given in these reports appears to be derived exclusively from the TIA/IAI micro-data, which pertain *only* to the household sector. Price data are reported from a separate source, namely the ministry's *Sistema de Informação de Mercados Agrícolas* (SIMA), which collects data on the prices of agricultural commodities in primary markets. Notably, no attempt in these reports is made to place a value on production at the crop-level.

Theoretically, the national accounts data are the most complete of all sources, albeit at an aggregate level – i.e., by definition, they should cover *all* economic activities within the scope of the agricultural sector in the country, including commercial farms, as well as both rural and urban smallholders. Nonetheless, the available data here are not disaggregated (by crops or farm size), nor do they indicate the gross value of production. Rather, the statistical aggregate published in the national accounts refers to agricultural 'value added', defined as the gross market value of the sector's outputs minus the value of intermediate goods (inputs) consumed in the production process, such as fertilizers or seeds.[6] Furthermore, given primary data sources appear to be incomplete (see above), it is not clear how data gaps (temporal and otherwise) are currently addressed in the compilation of national accounts. Indeed, according to Cunguara et al. (2012), the main primary sources used in this process have been the *Aviso Prévio* (BdPES) estimates.

Panel (b) of Table 6.3.1 summarizes other sources of data on the sector. At the micro-level we have the (periodic) household budget surveys, denoted by their national acronyms.[7] These are standard consumption-based surveys and do not collect detailed production-level data. Nonetheless, as elaborated further below, these can be used in different ways to approximate the value of agricultural production, which is particularly helpful for triangulation purposes. At the same time, *consumption* values of agricultural goods will often be significantly larger than their raw production (output) values. This is partly because the value of consumption will reflect market prices, and thereby incorporates costs associated with marketing, transport, and storage. Also, many food items are consumed *after* some degree of processing or preparation (e.g., bread), the costs of which also enter in their final price when this processing occurs outside the home.

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[5] A number of observers suggest that the *Aviso Prévio* system was integrated with the TIA/IAI surveys since 2012. However, while this seems to have been a major goal, it does not appear to have occurred in practice, especially since these micro-surveys remain only periodic. Thus, the reliance on subjective estimates made by district-level of both forecast and actual production remains in place.

[6] Farm-gate prices should be applied in order to focus on the direct value of outputs from agriculture rather than those of additional transport services or processing (AfDB, 2017).

[7] The IOF is the *Inquérito sobre o Orçamento Familiar*; and the IAF is the *Inquérito aos Agregados Familiares*.

The FAOSTAT series represents a comprehensive compilation of data from multiple sources, available at the crop level. As a general rule, data from official sources are employed to complete this series where possible. Prior to 2005, *Aviso Prévio* (BdPES) estimates were used for relevant crops; since then, the (official) TIA/IAI results have been incorporated. As such, this database should represent a curated version of all official production estimates, given alongside estimates of their farm-gate values. However, where relevant official data are missing, estimates or imputations are employed to ensure complete coverage of the sector by year and product.

Finally, data provided by the Central Bank refer to the value of trade in agricultural and related products. Obviously, this provides a partial view of total domestic production, but such information is pertinent for (cash) crops that are primarily exported without processing. The value of imported agricultural goods is not directly informative, but combined with information on consumption and exports provides an indirect means to estimate total agricultural incomes. Specifically, as per the national income identity, as well as FAO's food balance tables methodology, the sum of consumption plus exports minus imports of agricultural goods should yield a reasonable (albeit imperfect) approximation to the value of domestic production in the sector.

6.4 Aggregate consistency

Following the discussion of the previous section, we now investigate the consistency of data on agricultural production across these alternative sources. First, we focus on internal consistency, by which we refer to consistency or agreement across the four official data sources described in Table 6.3.1(a). To do so, an immediate challenge is the lack of common variables in the three datasets. However, where intermediate consumption is minimal or is a stable proportion of gross production, the value of total production from the TIA/IAI series should be broadly comparable to agricultural income in the national accounts, assuming the two series cover the same activities and producers. Thus, using a common methodology, we transform aggregate real production values from both the TIA/IAI harmonized data (see Chapter 5) and national account series to constant 2015 international dollars.[8] To derive production values quantity and area data contained in the the BdPES and INE annuals, crop-specific price measures are needed. To facilitate later comparisons, we apply constant 2015 international USD unit prices for each relevant crop, taken from the FAOSTAT database. All values are stated in international USD millions and missing data between IAI/TIA survey years are interpolated.

Figure 6.4.1 presents the main 'internal' comparison with respect to both: (a) the real size of the sector, which is the total level of production; and (b) smoothed real growth rates. The main takeaway is the large and widening discrepancies between the series, especially between the level of production indicated from the micro-surveys relative to the BdPES and national accounts aggregates. To get a sense of this, the average deviation, calculated as the average absolute relative difference between the mean of the four series and their actual values, increased from around 23 per cent before 2010 to over 30 per cent in the last decade. Put differently, while agricultural income taken from the national accounts was on average 1.8 times the aggregate value taken from the micro-surveys in periods prior to 2005, this gap had increased to a multiple of 2.2 after 2015.

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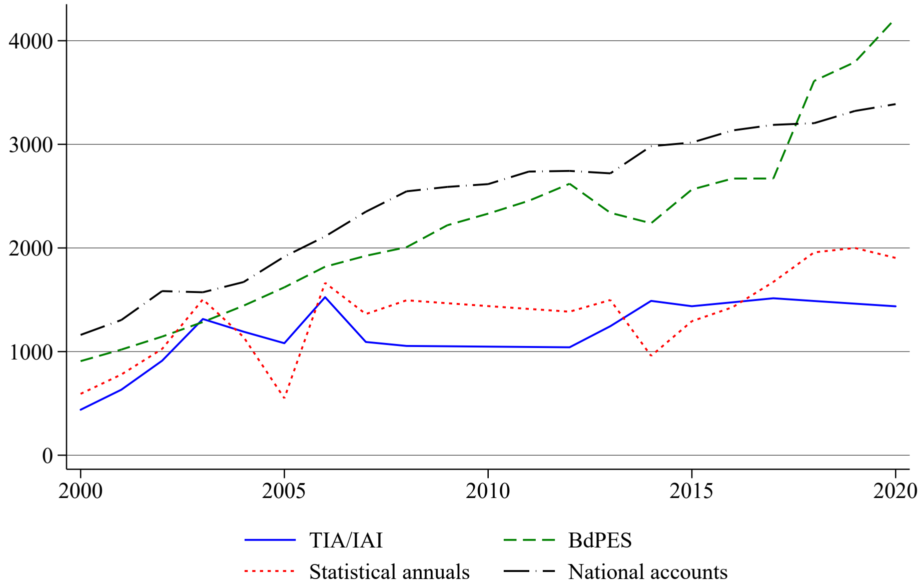
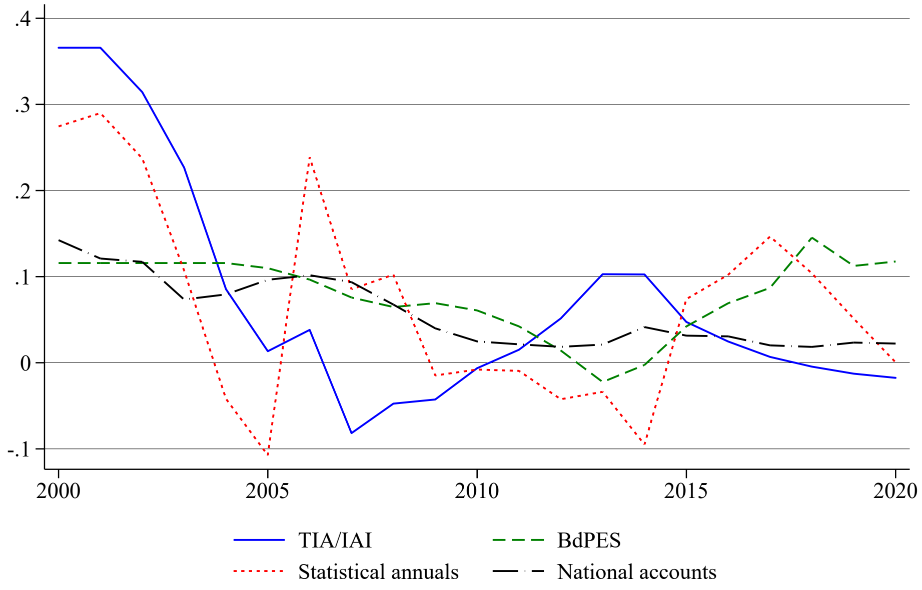
[8] Specifically, we use the agricultural sector price deflator from the national accounts to (re)state values from both series to prices in the chosen base year (2015); then we apply the 2015 USD:MZN exchange rate and finally apply the USD to international USD adjustment factor, based on information from the FAOSTAT database. Use of international USD is for consistency with the FAOSTAT series.

Figure 6.4.1: Agricultural production in millions of constant 2015 international USD, official sources (2002–2020)

(a) *Production values*:



(b) *Production growth rates (smoothed)*:



Source: Author's estimates.
Note: Series are as described in the text; panel (a) reports total values (millions of USD); panel (b) reports growth rates, calculated as the first difference in log levels and using a weighted moving-average, based on a 5-year window with weights inversely proportional to the distance from the target observation.

The second main takeaway is that, at least prior to around 2012, there was a close correspondence between the national accounts and the BdPES series. Indeed, the smoothed growth rates show a pairwise Spearman correlation coefficient of 0.87 during this period, but shift to a negative correlation thereafter (-0.57). As noted above, this suggests the compilation of national accounts for agriculture relied heavily on data from the line ministry (the BdPES) during this earlier period; however, the primary data used to inform the most recent national accounts estimates are not so obvious. Since 2012, the pairwise Spearman correlation coefficient between the national accounts and TIA/IAI series is 0.42, but this is statistically not different from zero. At the same time, the production aggregate constructed from the INE statistical annuals appears to most closely follow the TIA/IAI series in terms of levels (total values), differences likely being driven by a more complete coverage of (commercial) cash crops in the former. But, overall, the large gap between the two estimates derived from alternative official INE sources is difficult to reconcile.

To validate external consistency, we pursue similar descriptive comparisons. First, we take the total value of agricultural production estimated by FAO. Second, as a lower bound approximation to the same aggregate from the household surveys, we calculate the total real value of food consumption declared to have been own-produced, expanded to the entire population. Third, a corresponding upper bound is derived as the total value of food consumption (own-produced or otherwise) minus net agricultural and food imports as reported by the Central Bank. Recognizing this estimate includes marketing and (some) processing costs, as well as fish and meat consumption, we adjust it downward making the assumption that additional components are fixed at 50 per cent of output costs. This is likely to be conservative – e.g., Arndt et al. (2000a) estimate domestic margins on basic food crops in Mozambique were more than 100 per cent in the late 1990s, and over 50 per cent for export crops. Again, all estimates are presented in constant 2015 millions of international dollars.[9]

Figure 6.4.2 presents the results, showing estimates from the three external sources (derived from the consumption surveys and FAO data) as well as the upper and lower limits from the four official sources presented earlier (the highest and lowest values in each year).[10] Focusing on real output levels in panel (a), as may be expected the household survey-based estimates track each other fairly closely but deviate somewhat in the later period, when net agricultural/food imports show greater volatility. Similarly, the upper bound IAF/IOF estimates appear to be very closely aligned to the value in the national accounts, diverging by an average of just -4 per cent or at most -30 per cent in the final period. The FAO estimates are also of a comparable order of magnitude to those in the national accounts, but are typically larger in value and show greater annual volatility.

Taking stock of this exercise, it cannot be over-emphasized that we do not have a 'true' benchmark, against which these various official (internal) and unofficial (external) estimates can be evaluated. Nonetheless, it remains a motive for concern that estimates taken from the micro-surveys with respect to both levels and growth rates in the sector are consistently lower than those from other sources. This is demonstrated in Figure 6.4.3, which combines the micro-survey estimates (TIA/IAI and IAF/IOF) into one composite mean and estimates from the four other 'macro' sources into a second composite mean. While the macro composite is always larger in levels, we observe a dramatic divergence in the most recent period – the micro-surveys indicate a decline in production in real terms, while the macro sources suggest robust growth. Thus, at the end of the period the levels of the two series differ by around a factor of nearly two.

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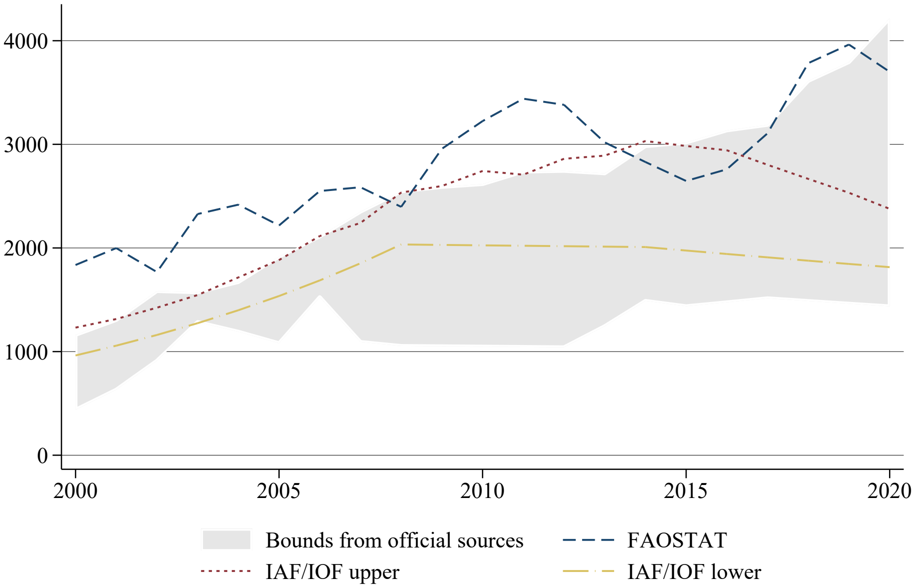
[9] For the IAF/IOF series, we deflate nominal values by the agricultural price deflator from national accounts, convert to USD at the 2015 exchange rate, and adjust to international dollars.

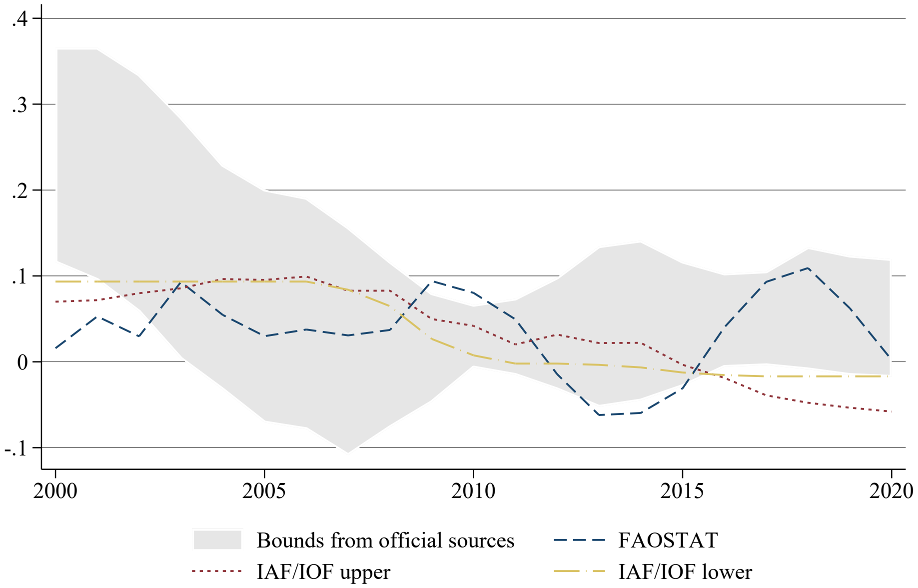
[10] Appendix Figure 6.A.1 plots the levels and smoothed growth rates of all seven series for more direct comparison.

Figure 6.4.2: Agricultural production in millions of constant 2015 international USD, external sources (2002–2020)

(a) *Production values*:



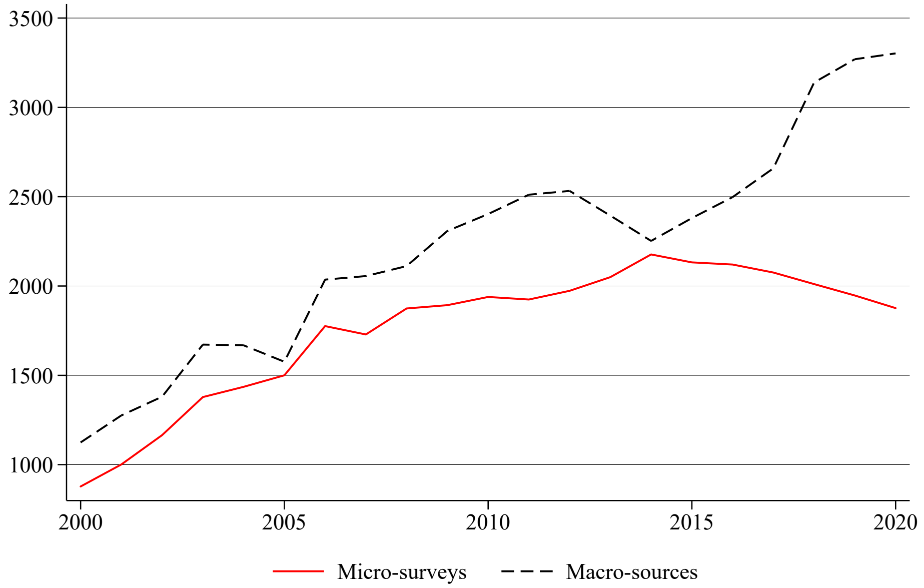
(b) *Production growth rates (smoothed)*:



Source: Author's estimates.
Note: Series are as described in the text; panel (a) reports total value (millions of USD); panel (b) reports growth rates, calculated as the first difference in log levels and using a weighted moving-average, based on a 5-year window with weights inversely proportional to the distance from the target observation.

Figure 6.4.3: Agricultural production in millions of constant 2015 international USD, combined micro- and macro-estimates (2002–2020)

(a) *Production values*:



(b) *Production growth rates (smoothed)*:

Source: Author's estimates.
Note: Micro-surveys are annual (interpolated) means of the TIA/IAI harmonized dataset; macro-sources are means of national accounts, statistical annuals, FAOSTAT, and the BdPES. Panel (a) reports total values (millions of USD); panel (b) reports growth rates, calculated as the first difference in log levels and using a weighted moving-average, based on a 5-year window with weights inversely proportional to the distance from the target observation.

Another way to combine information from alternative sources is shown in Figure 6.4.4, which illustrates naïve 'ensemble' estimates. Echoing Pinkovskiy and Sala-i Martin (2016), who recognize that satellite- and household-based estimates of consumption *both* contain useful information, these are equal to the unweighted average of the levels and growth rates from the six different sources in each period. To these point estimates an approximate 95 per cent confidence interval also is added, calculated from the standard error of the same underlying sources. These results useful reinforce the material and increasing uncertainty associated with measuring the aggregate performance of the agricultural sector in Mozambique. Indeed, stated in relative terms, the distance from the point estimate of the production level to the lower/upper bound is about 30 per cent on average. That said, there is a moderate consensus across the sources that the rate of growth of agricultural production has weakened over time, possibly not being different from zero since the mid-2000s.

Figure 6.4.4: Agricultural production in millions of constant 2015 international USD, ensemble estimates (2002–2020)

(a) *Production values*:

(b) *Production growth rates (smoothed)*:

Source: Author’s estimates.
Note: Panels show mean production values in levels and growth rates from six underlying series; shaded area is 95% confidence interval; growth rates are calculated as the first difference in log levels; a weighted moving average is used in panel (b), based on a 5-year window with weights inversely proportional to the distance from the target observation.

6.5 Sources of uncertainty

To further probe possible sources of uncertainty that may be driving the discrepancies outlined above, we take guidance from equation (6.3) and look at three primary dimensions. These are: the (selective) coverage of crops and producers; estimates of harvested areas; and crop-specific yields. While differences in prices represents a further dimension, these are not discussed further here.

6.5.1 Crop and producer coverage

Our earlier discussion (e.g., Table 6.3.1) hints that not all data sources appear to provide complete information on the full range of crops or producers. Coverage of crops also seems to vary *within* sources across different years. To get a clearer sense of this, Table 6.5.1 summarizes the total number of unique crops or crop categories from which the production value estimates are derived in each year. As may be expected, the TIA/IAI series is the most extensive, covering more than 80 different types of crops in some years. However, differences in the questionnaire and data quality/availability mean such coverage is not totally consistent over time. At the other extreme is the BdPES, which provides information on at most 10 major annual crops. Coverage in the INE annuals also varies across years. The most consistent are the FAO data, which apply a standardized methodology and fixed set of crop categories. The obvious puzzle is that lower crop coverage does not map to lower total production values – as shown in Figure 6.4.1, production values derived from the BdPES (using FAO unit prices) are consistently among the highest of all sources, despite being based on the fewest unique crops. Similarly, the TIA/IAI series tends to give the lowest production values, but has the highest crop coverage by this metric.

One potential reason for the latter puzzle is that large commercial producers are included in the BdPES estimates but are absent from the TIA/IAI estimates. Although this is difficult to fully validate, the latest information available on large (commercial) farms, reported in MADER (2021), indicates these are just 873 in number and farm under 80,000 hectares in total, of which less than 10 per cent pertains to crops covered by the BdPES data – the majority of commercial farms specialize in fruit, cash crops, or livestock. Furthermore, even if we apply an extreme assumption that land productivity in the commercial sector is 10 times that of the household sector, the relative contribution of the commercial sector to total production would be less than 10 per cent at most. Indeed, FAO estimates total land farmed in Mozambique corresponded to about 6.8 million hectares in 2020, implying just one per cent is under commercial operation. So, while data gaps in terms of crops and producers are material, these clearly are not sufficient to explain the aggregate discrepancies in a logical way.

Table 6.5.2 shows this information in another way, presenting average value shares from different major crops across the four granular sources. In line with the above, INE statistical annuals place a larger weight on two important commercial crops (sugar cane and tobacco), while over one-quarter of the FAO value aggregate comes from crops not covered by either the BdPES or INE annuals. Using this gap, and assuming the national accounts data are based on the same data as per the INE statistical but with some adjustment for 'missing' crops, these estimates imply the national accounts estimates should be at most 1.5 times those of the aggregate derived from the statistical manual (100/70). However, in practice this difference is about 1.9 times. Thus, 'obvious' differences in coverage (sample frames) are not sufficient to fully reconcile gaps in production aggregates across sources.

Table 6.5.1: Crop coverage in alternative data sources

	Source			
Year	TIA/IAI	BdPES	INE	FAO
2000	.	.	.	49
2001	.	.	8	49
2002	74	.	9	49
2003	58	.	9	49
2004	.	.	9	49
2005	85	7	8	49
2006	75	7	10	49
2007	84	7	11	49
2008	83	7	12	49
2009	.	8	5	49
2010	.	8	5	49
2011	.	8	5	49
2012	84	8	12	49
2013	.	10	12	49
2014	68	7	11	49
2015	86	8	12	49
2016	.	9	11	49
2017	59	9	5	49
2018	.	9	12	49
2019	.	9	12	49
2020	83	8	12	49

Note: Table count number of distinct crops or crop aggregates for which production values are provided or can be estimated per year (using production quantities and unit values); BdPES is the *Balanco do Plano Economico e Social*; INE refers to the statistical annuals of the National Statistics Institute; FAO is the FAOSTAT database.

6.5.2 Area farmed

Turning to the total area farmed, Figure 6.5.1 plots aggregated estimates from the four granular sources containing information on cultivated areas by crop. Reflecting differences in overall crop coverage, large discrepancies emerge. However, now these discrepancies appear more logical – the TIA/IAI and FAO series, which cover the largest range of crops, give the largest total values. Even so, these latter two series diverge considerably in the most recent 5 years, both in levels and trends, perhaps reflecting imputation methods used by FAO where data are missing or problematic. Also, despite considerable overlap in terms of crop coverage, aggregate farmland derived from the INE statistical annuals broadly follows the trend of the TIA/IAI series and remains significantly lower than the BdPES estimates in recent years.

To assess whether these differences reflect not only the number but also the type of crops included in the area calculation, Table 6.5.3 reports average estimates of cultivated areas for individual major crops. With the odd exception (e.g., pulses and beans in the INE source) these are fairly closely aligned, suggesting no major structural differences. Thus, aggregate differences in farmland estimates do indeed appear to be mainly driven by differences in the range of crops and possibly by the types of producers covered in the alternative data sources. In addition, it may be noted that TIA/IAI surveys focus on the areas of plots cultivated in the previous agricultural season, while other sources such as the BdPES potentially reflect areas planned to be cultivated.

Table 6.5.2: Mean crop value shares in alternative data sources (2000–2020)

	Source			
Crop	TIA/IAI	BdPES	INE	FAO
Beans	5.1	9.9	2.3	4.3
Cashew nuts	1.1	0.0	9.0	2.9
Cassava	48.1	55.0	33.4	27.1
Citrus trees	0.1	0.0	1.8	0.1
Coconuts	1.2	0.0	0.5	1.8
Groundnuts	2.7	6.0	4.4	3.0
Maize	14.6	14.9	15.6	10.1
Millet	0.2	0.5	0.6	0.3
Potatoes	5.6	7.3	0.0	6.6
Pumpkins	0.1	0.0	0.0	0.0
Rice	2.3	3.7	2.5	2.1
Sorghum	2.1	2.7	2.1	1.4
Sugar cane	0.0	0.0	10.5	3.9
Tobacco	5.1	0.0	17.3	5.2
Tomatoes	5.0	0.0	0.0	3.7
Other	6.6	0.1	0.0	27.4

Note: Table count number of distinct crops or crop aggregates for which production values are provided or can be estimated per year (using production quantities and unit values); BdPES is the *Balanço do Plano Económico e Social*; INE refers to the statistical annuals of the National Statistics Institute; FAO is the FAOSTAT database.

6.5.3 Yields

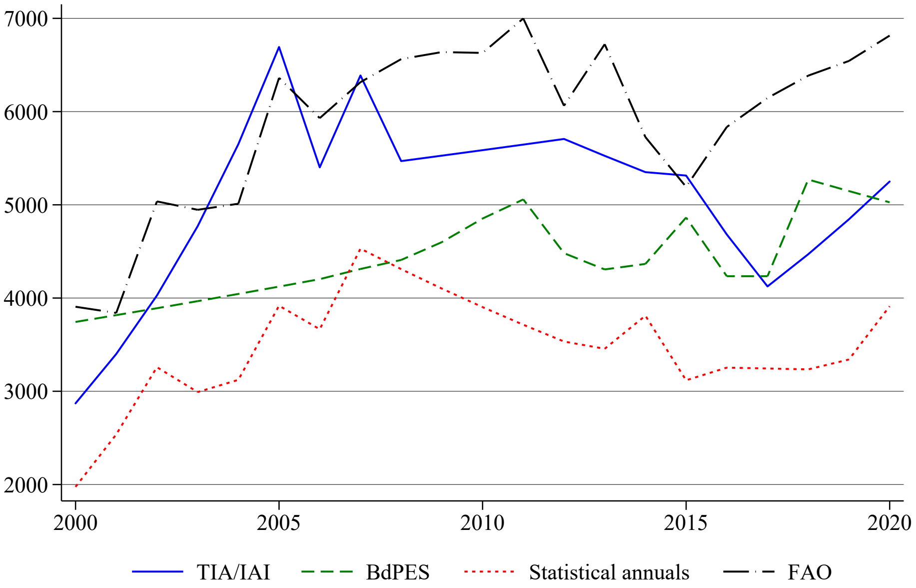
Finally, we completed the last analysis looking at average yields per major annual crop. While, again, there is some degree of consistency – the rankings are generally stable across the sources – the most notable feature is much higher mean yield estimates in the BdPES for the two major staples (cassava and maize). In the former case, the estimated average yield is 70 per cent larger than the corresponding TIA/IAI estimate; while the BdPES average maize yield is around 60 per cent higher than what is found from the micro-surveys. By way of emphasis, effects of major climate events such as droughts and floods typically are not observed in the BdPES estimates, raising doubts as to their quality. Given the importance of these two crops by land area (and value), this goes a long way to explain the high aggregate value of production in the BdPES series.

Table 6.5.3: Median area harvested from alternative data sources, selected crops (2000–2020)

	Source			
Crop	TIA/IAI	BdPES	INE	FAO
Beans	708	653	99	596
Cassava	758	1079	776	864
Groundnuts	373	402	397	401
Maize	1660	1596	1640	1664
Potatoes	51	193	.	65
Rice	303	236	291	325
Sorghum	385	569	374	407

Note: Table count number of distinct crops or crop aggregates for which production values are provided or can be estimated per year (using production quantities and unit values); BdPES is the *Balanço do Plano Económico e Social*; INE refers to the statistical annuals of the National Statistics Institute; FAO is the FAOSTAT database.

Figure 6.5.1: Total cropland, selected sources (2002–2020)



Source: Author's estimates.
Note: Area is in '000s of hectares; series are as discussed in the text.

Table 6.5.4: Median crop yields from alternative data sources, selected crops (2000–2020)

	Source			
Crop	TIA/IAI	BdPES	INE	FAO
Beans	0.29	0.51	0.55	0.36
Cassava	5.00	8.50	5.76	4.71
Groundnuts	0.25	0.47	0.27	0.28
Maize	0.71	1.14	0.75	0.80
Potatoes	7.66	10.02	.	8.24
Rice	0.27	1.21	0.31	1.01
Sorghum	0.37	0.62	0.43	0.50

Note: Table count number of distinct crops or crop aggregates for which production values are provided or can be estimated per year (using production quantities and unit values); BdPES is the *Balanço do Plano Económico e Social*; INE refers to the statistical annuals of the National Statistics Institute; FAO is the FAOSTAT database.

6.6 Conclusion and discussion

The purpose of this chapter was to provide an in-depth review of what alternative sources of data tell us about the aggregate size of the agricultural sector in Mozambique. To do so, we collated information from seven separate sources, both official and external, yielding seven separate estimates of the value of agricultural production over the period 2000–2020. The headline insight is that these estimates vary by a very large margin, with the highest and lowest values derived from official sources differing by a factor of two in most recent years. A major concern is the finding that estimates derived from micro-data, namely periodic agricultural and household budget surveys, are significantly more conservative than those deriving from the national accounts and have diverged dramatically over most recent years. In addition, this chapter highlighted large deviations between two separate estimates of aggregate production derived from information published by the national statistics institute, namely the (higher) metric of value added versus the (lower) measure compiled from statistical annuals.

A candidate explanation for differences in estimates from these alternative sources is an unequal coverage of crops and types of producers. Indeed, the TIA/IAI series focuses on the family sector, while ministry (BdPES) and INE statistical reports only cover selected major crops. However, a complementary analysis showed these specific gaps are not sufficient to explain the very large differences in aggregate values. In particular, divergent estimates of (median) yields for major crops appears to be a major factor behind the large aggregate size of the agricultural sector derived from the BdPES, which itself appears to be a main input into estimates of the national accounts. Also, back-of-the-envelope estimates of the role of commercial farming, based on total area farmed, suggest that such producers may only contribute as much as 10 per cent of the value of aggregate production, not enough to account for the gap between the TIA/IAI surveys and macro-estimates.

It should be reiterated that this chapter does not take a stand on which of these various estimates is ‘correct’. Nonetheless, the lack of consistency across different sources and the absence of a coherent set of explanations for such divergences is concerning. Consequently, we close with a set of recommendations. First, as a minimum, greater methodological clarity and rigour is required as regards the coverage and compilation of official aggregates, particularly the total value added of the agricultural sector in the national accounts. This should encompass the specific data sources used and how estimates are made for crops where primary data are missing. This exercise is essential given the importance of agriculture to total GDP, as well as the importance of trends and levels of GDP for many other macro-fiscal indicators (e.g., tax- or debt-to-GDP ratios). Greater transparency would help identify where improvements are required to improve data quality and consistency.

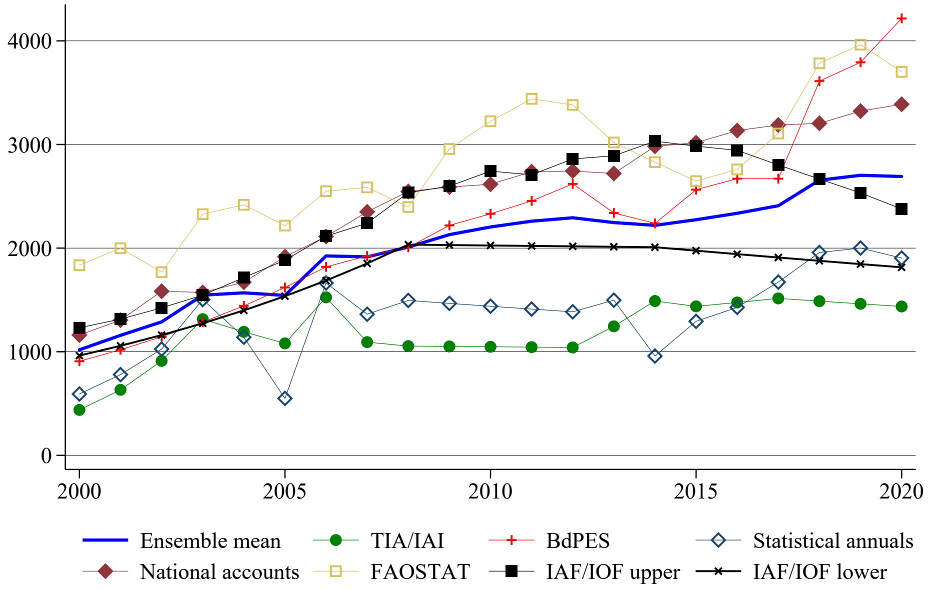
Second, realization of a new agricultural census is needed to provide up-to-date benchmarks for cropping patterns as well as the overall scope of agricultural activity, both urban and rural. Third, it should be recognized that funding required to undertake *annual* large-scale household-based agricultural surveys is not available on a reliable basis, and that − even if it were − these surveys are not suited to generate timely data on the performance of the sector that can input into national accounts and other time-sensitive official documents. At the same time, it is increasingly clear that (yield) estimates reported in the annual BdPES submissions suffer significant distortions relative to other available information. To overcome these limitations, a lower-cost yet more reliable high-frequency crop monitoring system should be considered. This might involve combining small-scale crop-cut surveys with expert input and remote-sensing of major crops, all of which can be benchmarked against rigorous data from the agricultural census. When undertaken on a consistent and transparent basis, using a peer-reviewed methodology, this should be sufficient to produce annual estimates of aggregate production values. In turn, periodic household surveys, perhaps integrated with existing consumption-based surveys, may be used for other analytical purposes such as rural livelihood analysis. In short, in light of concerns regarding the quality of data, a thorough review of the agricultural statistical system is required to provide reliable as well as higher-frequency production estimates.

Appendix

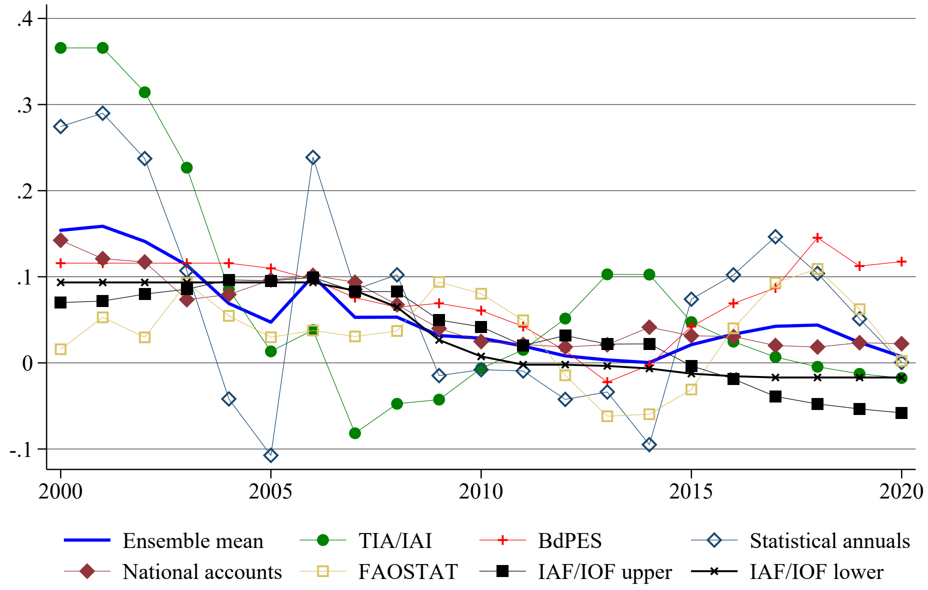
6.A Additional figures

Figure 6.A.1: Agricultural production in millions of constant 2015 international USD, all sources (2002–2020)

(a) *Production values*:



(b) *Production growth rates (smoothed)*:



Source: Author's estimates.
Note: Growth rates are calculated as the first difference in log levels; a weighted moving average is used in panel (b), based on a 5-year window with weights inversely proportional to the distance from the target observation.

Chapter 7

Profile and Evolution of Smallholder Farming in Mozambique

7.1 Introduction

Understanding the significance of smallholder farming in Mozambique transcends mere agricultural productivity. It is a window into the nation's soul, mirroring its socio-economic heartbeat. These farms, often family-run, form the backbone of rural communities, contributing significantly to food security and livelihoods. Small-scale farming keeps local markets vibrant and plays a crucial role in sustaining rural economies. However, its potential remains partially untapped due to challenges like limited access to resources, markets, and technology. Addressing these barriers is not just an agricultural concern, it is a step towards inclusive development, ensuring that growth benefits the many, not just the few (Carrilho et al., 2023).

The aim of this chapter is to present a comprehensive picture of smallholder agriculture in Mozambique, using the household data retrieved from the TIA/IAI harmonized dataset (see Chapter 5). It explores the multifaceted aspects of their lives: household characteristics, farm characteristics, agricultural inputs, production choices, and market participation. Our contribution is to provide evidence of the strengths and weaknesses of small-scale farming in Mozambique, examining its evolution since the beginning of the 2000s, its current state, and ultimately draw some stylized facts of the sector useful for recommendations on future prospects.

Agricultural production in Mozambique is dominated by smallholder farmers, with 53 per cent of all farming occurring on plots smaller than 1 hectare and another 44 per cent on fields between 1 and 5 hectares (Falcão, 2009). Smallholders cultivate 90 per cent of all farmland, with the remaining being cultivated by a limited number of large commercial farms. Over 95 per cent of agricultural production is small-scale (Carrilho et al., 2023). Rural agricultural households predominantly rely on family labour, with many experiencing poverty and food insecurity. Their choices are constrained by their land, the low availability of agricultural input, and limited access to local markets. Yet, small-scale farming contributes to the food production for a substantial proportion of Mozambique's population.

Like in other developing contexts, rural households in Mozambique face a multitude of decisions, including crop selection, input management, and timing of tasks like plowing and harvesting. These decisions, influenced by market conditions and various risks like adverse weather and price fluctuations, are significantly impacted by the unreliable nature of markets in their operating environments, thus affecting their choices and overall livelihoods. According to MADER (2022), smallholder farmers encompass 98 per cent of all agricultural practitioners in Mozambique. Moreover, in 2019 women represented the majority of the agricultural labour force; and 80 per cent of the female workforce found employment in this sector (ILO, 2024).

Maize, cassava, peanut, and cowpea are the major staple crops cultivated by small-scale farmers, and a consistent portion of their production is for own consumption. They practice rain-fed agriculture, with few adopting low-intensity fertilizer and minimal pesticides. Farming is largely done without mechanization, and productivity of the land is typically low. Cash crops cultivation is usually done by larger farms specializing in crops like sugar, cotton, tea, and export-grade tropical fruits. Notably, the production of cotton and tobacco involves collaborative outgrower schemes, where smallholder farmers are contracted to cultivate these crops for larger commercial farms in the region (Benson et al., 2014).

This chapter is organized in six sections, each illuminating a different aspect of smallholders' agricultural lives. In Section 7.2, the focus is on identifying who the smallholders are, with an emphasis on their demographic characteristics and economic activities. Section 7.3 shifts the attention to the evolution and changes in cultivated land, describing its geographical distribution. Section 7.4 presents evidence of the use of agricultural inputs, access to markets, and the adoption of technological equipment by smallholders. Section 7.5 delves into the production choices of smallholders, commenting on how these have evolved over time and the factors influencing such decisions. Section 7.6 presents yield performance, the value of production and the commercialization engagement of these farmers. Finally, Section 7.7 synthesizes the main findings and derives some stylized facts from the sector's evolution in the first two decades of the 21st century.

7.2 Who are the smallholders?

This section will present the demographic characteristics of the agricultural household, by firstly presenting some household characteristics in 2020 and then portraying their evolution since 2002. Further demographic details at the provincial level are provided in Appendix 7.A, where comprehensive tables outlining these characteristics can be found.

In Mozambique today, the typical[1] small-scale farmer, who heads a family farm, is approximately 40 years old. This individual usually oversees a family of four members, including two dependents, who are either children or elderly relatives. Their educational background is generally limited, with an average of four years of formal schooling completed. However, one-third of agricultural households have not received formal education. During periods commonly referred to as the 'famine season', these families subsist on an average of two meals per day, highlighting the precarious nature of food security in their circumstances. Economically, the family's income solely comes from the farm; there is no additional income from external sources. Moreover, these households are typically excluded from the formal financial sector; the median farmer does not possess a bank account or engage with mobile money services such as Mpesa or Emola. Additionally, their involvement in traditional informal savings mechanisms, known locally as 'xitique', is notably absent.

Figure 7.2.1 shows an array of average features of rural households in Mozambique in 2020, drawing attention to educational levels, economic activities, gender leadership, and the state of financial inclusion.

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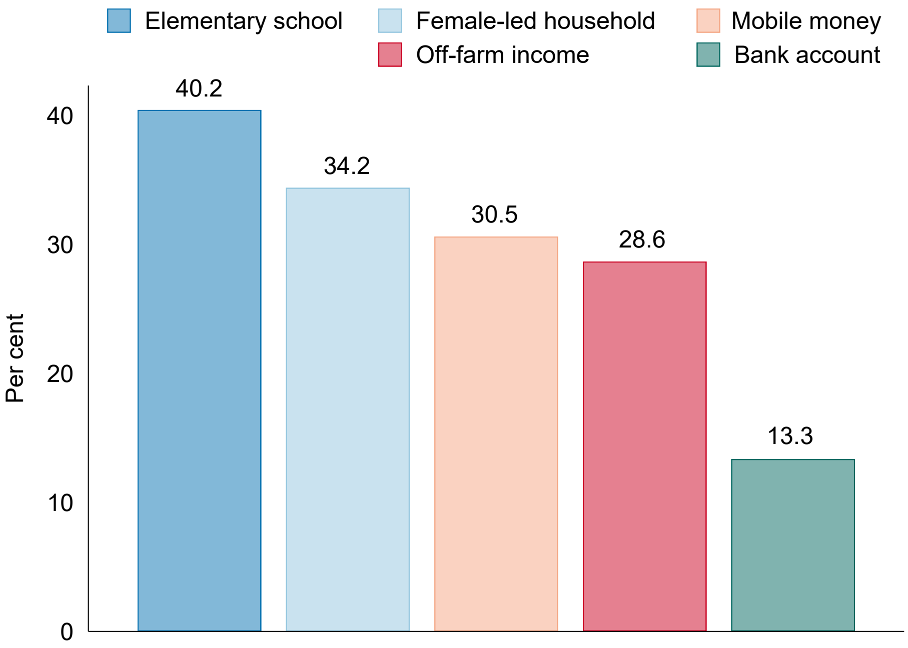
[1] Here we are referring to the median household in the distribution.

Figure 7.2.1: Household characteristics in 2020



Source: Author's elaboration based on TIA/IAI harmonized dataset.

Approximately 40 per cent of household heads have completed elementary school, suggesting a moderate level of basic education among rural household leaders. It is noted that nearly one-third of these households engage in additional economic activities beyond their primary agricultural work. Moreover, the use of mobile money is more prevalent than having a bank account, indicating a reliance on alternative financial services over traditional banking methods. Lastly, 34 per cent of the households are led by women, highlighting significant female participation in household leadership within the rural context.

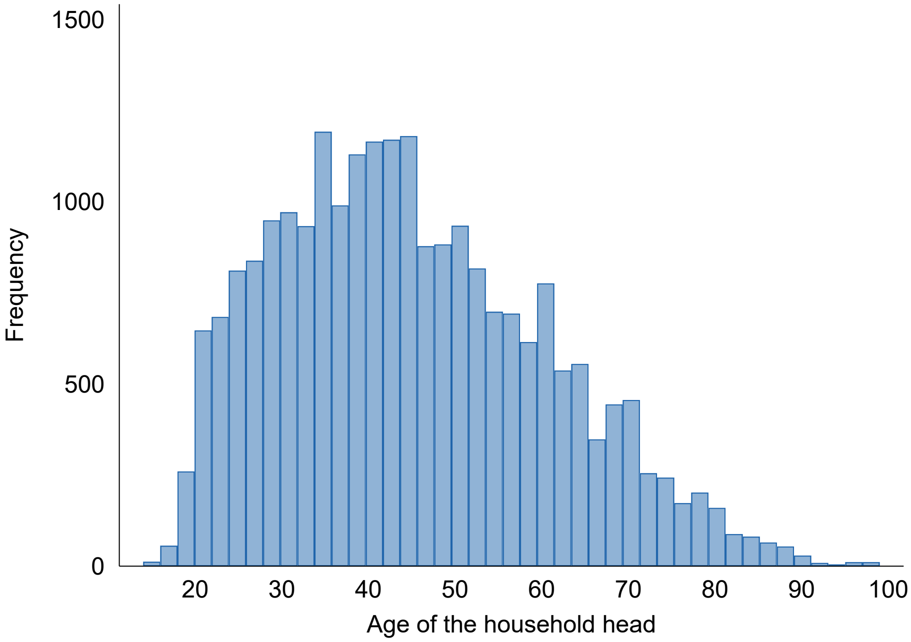
Figure 7.2.2 displays the age distribution of household heads in 2020, as derived from TIA/IAI harmonized data. The majority fall between ages 30 and 60, with a peak around 40–50 years. Beyond 60, frequency declines, suggesting fewer individuals head households in older age.

Figure 7.2.3 illustrates a shift towards smaller households among smallholder farmers between 2002 and 2020. In 2020, there is a higher frequency of smaller households, and a decline in larger ones, with those over 20 members being marginal at less than 1 per cent. This trend indicates a demographics change, as the median number of household member decreased from 6 to 5 in the analysed period.

The regional trends in female-led agricultural households show a significant increase, as depicted in Figure 7.2.4. By 2020, around 40 per cent of family farms in the Southern region of Mozambique were managed by women, with notable growth also observed in the Central and Northern regions. Additionally, the proportion of households led by single women rose from 17 per cent in 2002 to 20 per cent in 2020. Notably, in 2020, 74 per cent of the households headed by women were led by single women, highlighting changing dynamics in family farm management.

Turning our attention to education, we explore the differences in educational levels among men and women in Mozambique. Figure 7.2.5 illustrates the educational attainment of household heads in 2002 and 2020,

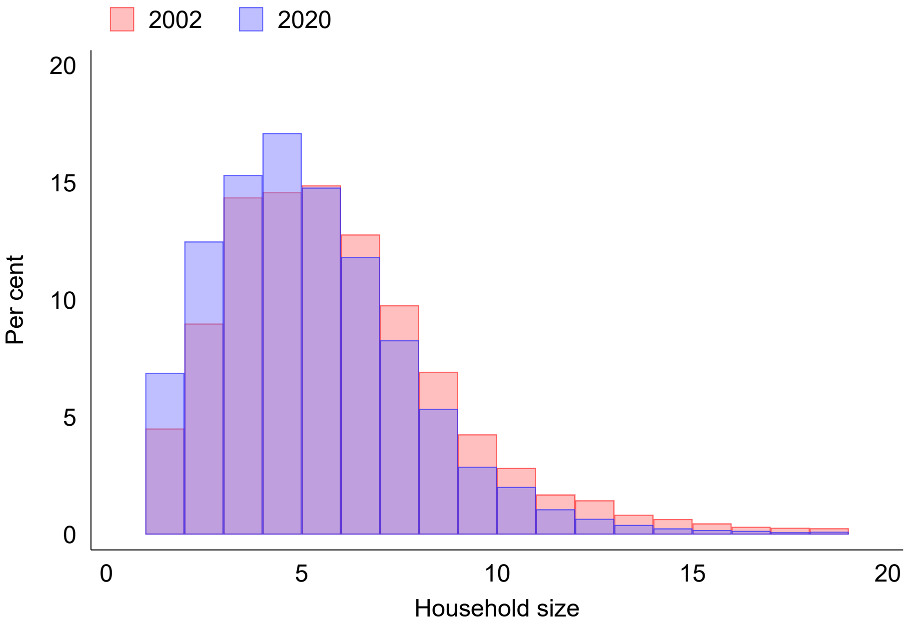
Figure 7.2.2: Age distribution of household head in 2020



Source: Author's elaboration based on TIA/IAI harmonized dataset.

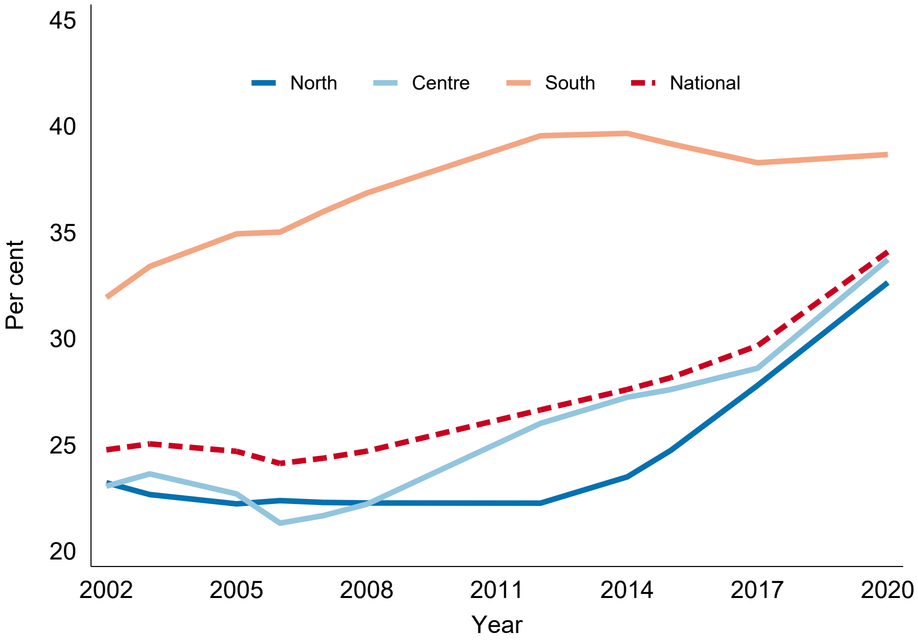
differentiated by gender. The data show significant progress in education for both men and women over this period. Despite high percentages of individuals without formal education, there has been a noticeable decrease, suggesting improved access to at least primary education. The rise in secondary education levels is more evident among men than women, highlighting a persistent gender gap in higher education. Furthermore, university-level education is quite low for both genders, albeit slightly higher among men. This points to positive trends in educational access and strides towards gender parity. Nonetheless, it also underscores the ongoing challenges, particularly in higher education, and the sustained discrepancy in educational attainment between men and women at secondary and university levels.

Figure 7.2.3: Household size in 2002 and 2020



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Household size accounts for the members in the household. Households with more than 20 members represent less than 1 per cent of the sample for both years.

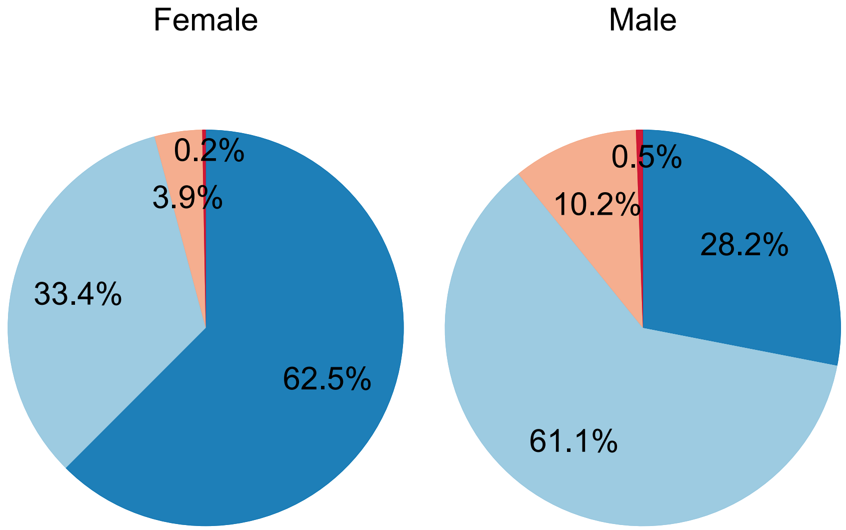
Figure 7.2.4: Female-led household



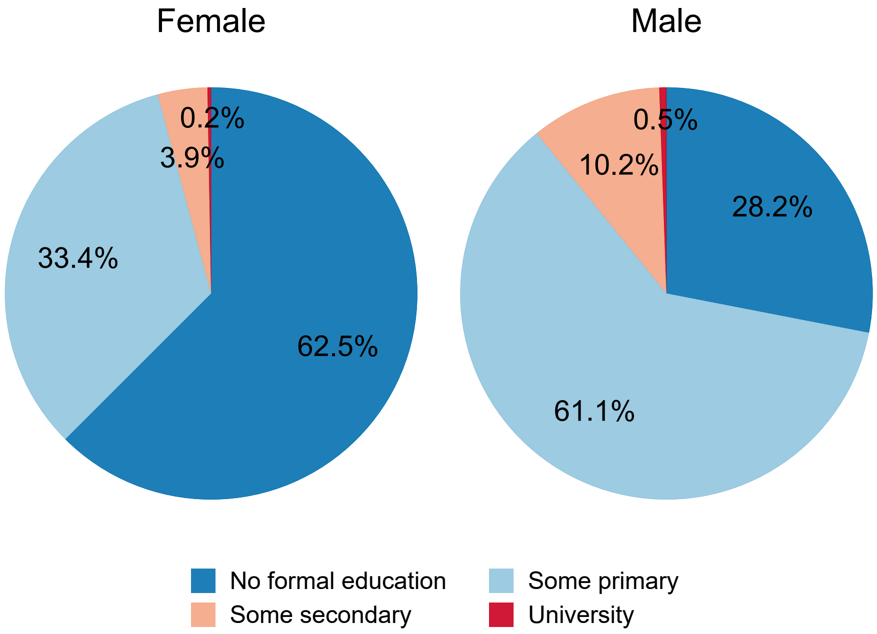
Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

Figure 7.2.5: Education by gender, 2002 versus 2020

2002



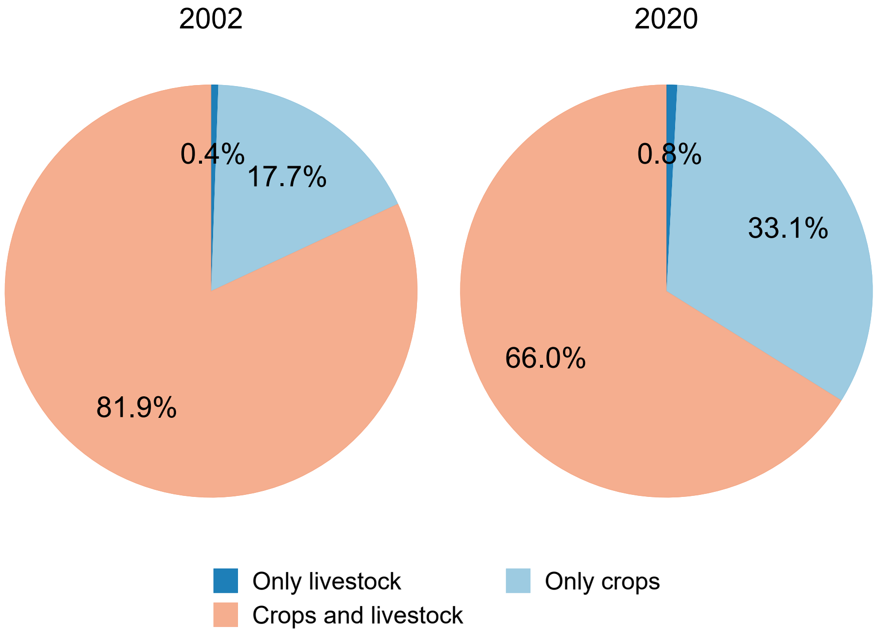
2020



Source: Author’s elaboration based on TIA/IAI harmonized dataset.

Figure 7.2.6 presents the engagement with cultivation and livestock activities among the population in 2002 and 2020. The share of farmers specialized only in crop production has almost doubled in this period, accounting for one-third of the population in 2020. This increase is driven by farmers who stopped holding livestock and decided to focus on crop production. Indeed, the share of households invested only in livestock activities remained fairly stable in this period, accounting for less than one per cent of the population.

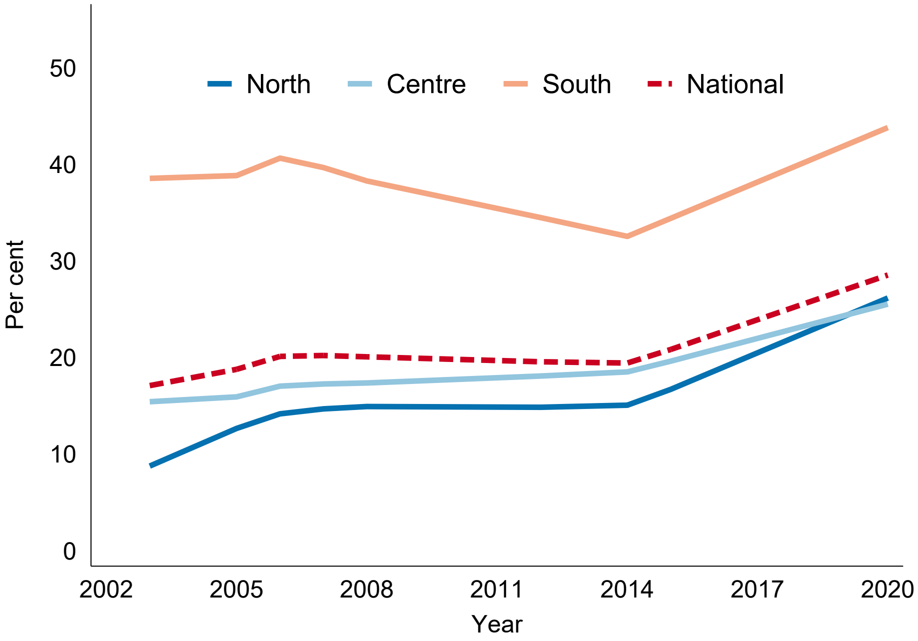
Figure 7.2.6: Proportion of farmers by different farming activity



Source: Author's elaboration based on TIA/IAI harmonized dataset.

Turing to the non-farm activities, Figure 7.2.7 refers the participation in off-farm work across three regions of the country. Throughout the years, there is an increase in the undertaking of non-agricultural activities to diversify income. The Southern region presents the highest level of off-farm work, with more than 40 per cent of the households engaged in this type of work.

Figure 7.2.7: Off-farm activities



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

7.3 Evolution of cultivated land

Mozambique's agricultural land comprises approximately 50 per cent of the country's total land area. Agricultural land is defined as the area designated for activities such as cultivation of crops, permanent crops, and pastures, and it includes managed forests and fishing grounds. However, only 7.2 per cent of this land is arable, which denotes land under active cultivation for crop production, as opposed to land that merely possesses the potential for cultivation (FAO, 2021). The TIA agricultural data contain information on the arable land cultivated by smallholder farmers in Mozambique. Table 7.3.1 illustrates the cultivated area by region measured in thousands of hectares, spanning the period from 2002 to 2020. There has been an overall increase in the cultivated land in Mozambique, predominantly driven by the Northern and Central provinces. By constrast, the amount of agricultural land managed by small-scale farmers in the South has decreased over time. This trend is in line with the shift towards other economic activities in this region. It is relevant to recall that here, the cultivated land in the TIA/IAI harmonized dataset refers to the aggregate sum of crop areas reported at the product level. For further clarification, see Chapter 5.

Table 7.3.1: Aggregate cultivated area by region (Millions of hectares)

	2002	2005	2006	2007	2008	2012	2014	2015	2017	2020
North	1.30	1.96	1.76	1.85	1.92	1.84	1.62	1.62	1.52	1.73
Centre	1.93	2.82	2.48	2.50	2.55	2.44	2.31	2.48	1.96	2.73
South	0.80	0.82	0.77	0.72	0.74	0.49	0.59	0.45	0.43	0.58
Total	4.03	5.60	5.01	5.07	5.21	4.77	4.52	4.56	3.91	5.05
Observations	4804	5954	6010	5784	5716	6299	5693	6594	6461	21570

Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: The cultivated area does not take into account the agricultural land dedicated to trees. Not all crops were reporting crop area and not all crops were available all years (see Chapter 5).

Turning attention to the provincial distribution of agricultural land, Table 7.3.2 details the spread of cultivated area across Mozambique's provinces from 2002 to 2020. Not surprisingly, the share of cultivated land is larger in Niassa and Zambezia provinces, where cultivation benefits from abundant water resources. Indeed, more than half of the cultivated area is located in the Central region. By contrast, the aggregate cultivated area in the Southern provinces has decreased, while the Northern provinces have maintained a fairly stable share over the years.

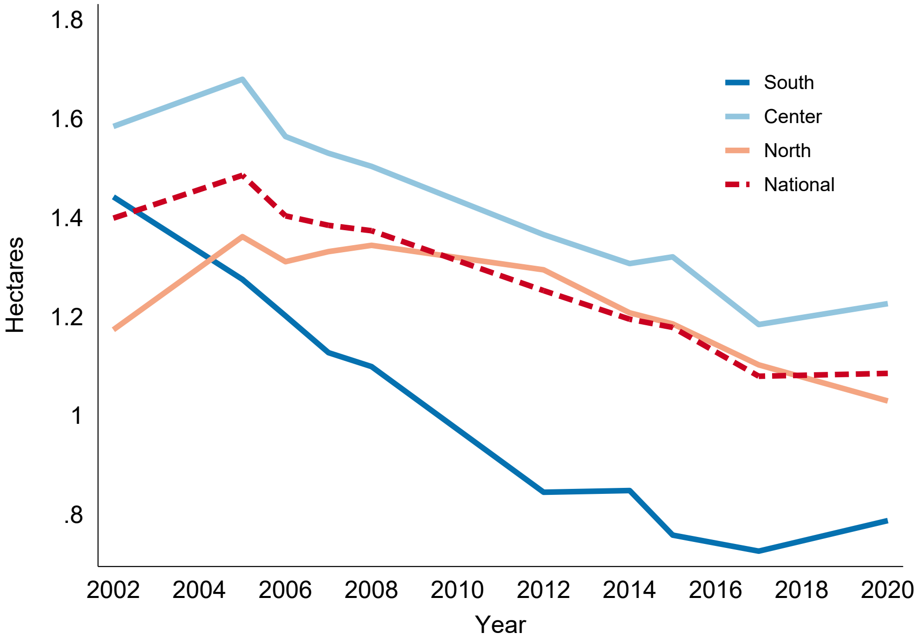
Table 7.3.2: Share of cultivated land by province (Per cent)

	2002	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	6.5	7.3	7.1	6.9	7.4	7.4	6.2	6.9	7.8	6.5
Cabo Delgado	9.2	9.6	9.6	9.2	9.1	7.8	9.9	9.2	9.6	8.0
Nampula	16.7	18.2	18.4	20.4	20.3	23.4	19.7	19.5	21.5	19.8
Zambezia	18.5	20.9	20.3	20.6	19.8	21.3	22.5	23.7	19.4	19.5
Tete	12.4	13.6	12.6	11.8	12.7	11.8	11.9	14.4	12.8	13.5
Manica	8.7	8.5	8.3	8.9	7.2	9.3	8.4	9.1	8.7	9.2
Sofala	8.3	7.4	8.2	7.9	9.2	8.7	8.4	7.3	9.1	11.8
Inhambane	9.5	6.9	7.2	6.5	6.3	4.8	5.4	4.9	5.4	3.9
Gaza	7.4	5.7	6.4	5.7	5.5	4.4	5.4	4.5	4.7	6.0
Maputo Province	2.9	2.0	1.8	1.9	2.4	1.2	2.2	0.4	1.0	1.7
Observations	4804	5954	6010	5784	5716	6299	5693	6594	6461	21570

Source: Author's elaboration based on TIA/IAI harmonized dataset. Note: The cultivated area does not take into account the agricultural land dedicated to trees. Not all crops were reporting crop area and not all crops were available all years (see Chapter 5).

Having established that the total cultivated land dedicated to small-scale farming has increased over the years, it is relevant to shift the focus to the household level. In 2020, the average farm size nationwide stood at 1.22 hectares. The Central region was at 1.38 hectares, while the Northern region maintained 1.14 hectares, and the Southern region reported 0.92 hectares. Figure 7.3.2 presents the evolution over time of the average cultivated area by small-scale agricultural household. Overall, there has been a decline in the average area cultivated by agricultural household across all regions, with a marked decline in the South.

Figure 7.3.1: Average cultivated area by region



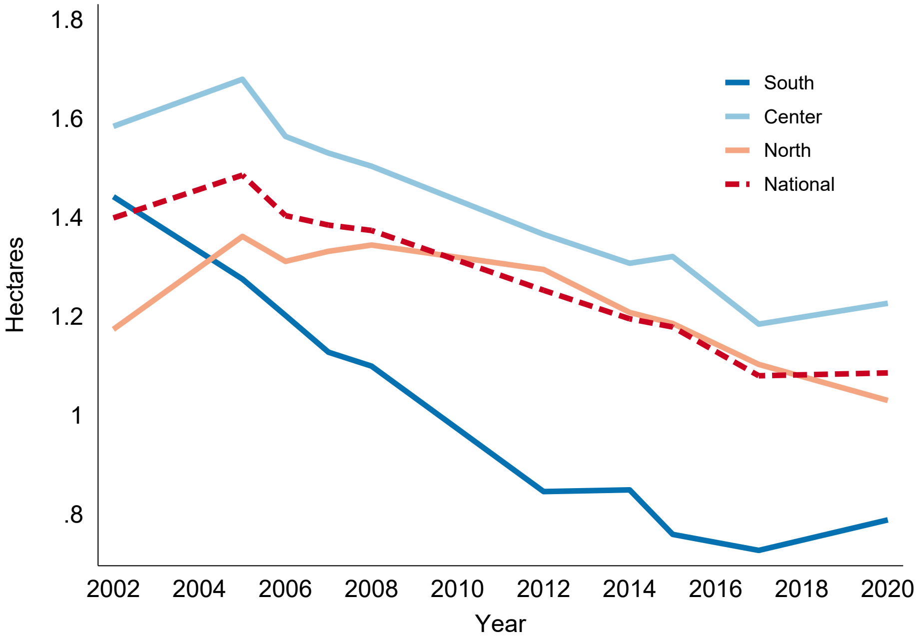
Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

Table 7.3.3 showcases varying patterns in the average cultivated land area per household in different provinces from 2002 to 2020. In the South, there is a noticeable decrease in average cultivated area in provinces like Inhambane, Gaza, and Maputo, with Maputo Province experiencing the most significant drop, from 1.1 hectares in 2002 to just 0.5 hectares in 2020. On the other hand, in the Northern provinces, specifically Cabo Delgado and Nampula, there has been an increase in the average area cultivated by households over the same period. Despite these regional differences, the general trend across the country points to a diminishing average cultivated area, signalling substantial shifts in the use of agricultural land that merit closer examination.

Furthermore, the consistent finding that the median cultivated land area is lower than the average suggests a concentration in agricultural land use. This means fewer farms are managing larger areas of land, thereby affecting the overall distribution. The decrease in the average size of individual farms, coupled with an overall increase in cultivated land at the national level, indicates a potential shift towards concentrated land ownership among a fewer number of farmers. It appears that while a small group of farmers may be expanding their landholdings, the majority are experiencing a reduction in their individual land sizes. This pattern becomes more evident when analysed in conjunction with Figure 7.3.3.

As mentioned in Chapter 5, the TIA/IAI harmonized dataset includes only farms smaller than 50 hectares,

Figure 7.3.2: Average cultivated area by region



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

leaving out of our analysis the large agricultural farms. To facilitate our analysis, we delineate a farm categorization, as follows: micro-sized farms, comprising those up to 1 hectare; small-sized farms, spanning between 1 and 3 hectares; and medium-sized[2] farms, encompassing those larger than 3 and up to 5 hectares. Figure 7.3.3 illustrates the changing distribution of these three categories. While there is an evident increase in the number of micro-sized farms, the growth in small-sized and medium-sized farms has been comparatively lower. However, it is important to note that the number of micro-sized firms is 10 times greater than that of medium-sized firms, reinforcing the consideration that the majority of agricultural explorations are experiencing a reduction in land size.

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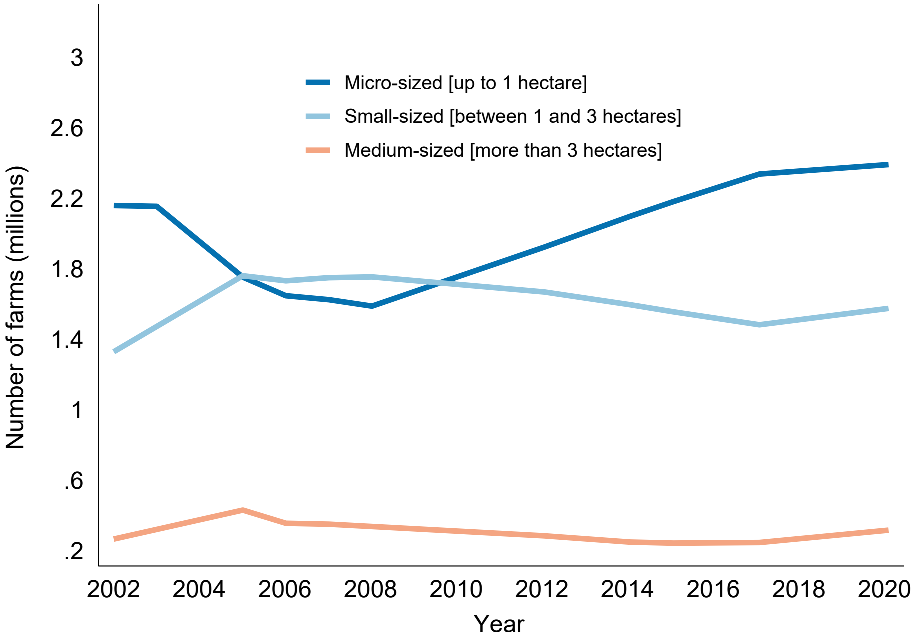
[2] Despite these categories, in this report we will continue to refer to small-scale farming for the sake of simplicity.

Table 7.3.3: Average cultivated area by province

	2002	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	1.6	2.1	1.8	1.7	1.8	1.6	1.3	1.4	1.4	1.4
Cabo Delgado	1.2	1.6	1.5	1.5	1.5	1.2	1.4	1.3	1.2	1.2
Nampula	0.9	1.4	1.2	1.3	1.3	1.4	1.1	1.1	1.0	1.1
Zambezia	1.1	1.6	1.4	1.4	1.3	1.2	1.2	1.3	0.9	1.2
Tete	1.8	2.4	1.9	1.7	1.9	1.4	1.4	1.7	1.3	1.5
Manica	1.9	2.1	1.8	1.9	1.6	1.8	1.5	1.8	1.4	1.9
Sofala	1.7	1.9	1.8	1.7	1.9	1.5	1.3	1.2	1.2	1.5
Inhambane	1.5	1.4	1.4	1.3	1.3	1.0	1.1	1.0	1.0	1.0
Gaza	1.5	1.6	1.6	1.5	1.4	1.1	1.3	1.1	1.0	1.4
Maputo Province	1.1	1.1	0.8	0.9	1.1	0.7	1.2	0.7	0.4	0.6
Total	1.3	1.7	1.5	1.5	1.5	1.3	1.2	1.3	1.1	1.3
Observations	4804	5954	6010	5784	5716	6299	5693	6594	6461	21570

Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: The cultivated area does not take into account the agricultural land dedicated to trees.

Figure 7.3.3: Smallholder agricultural farms by size categories



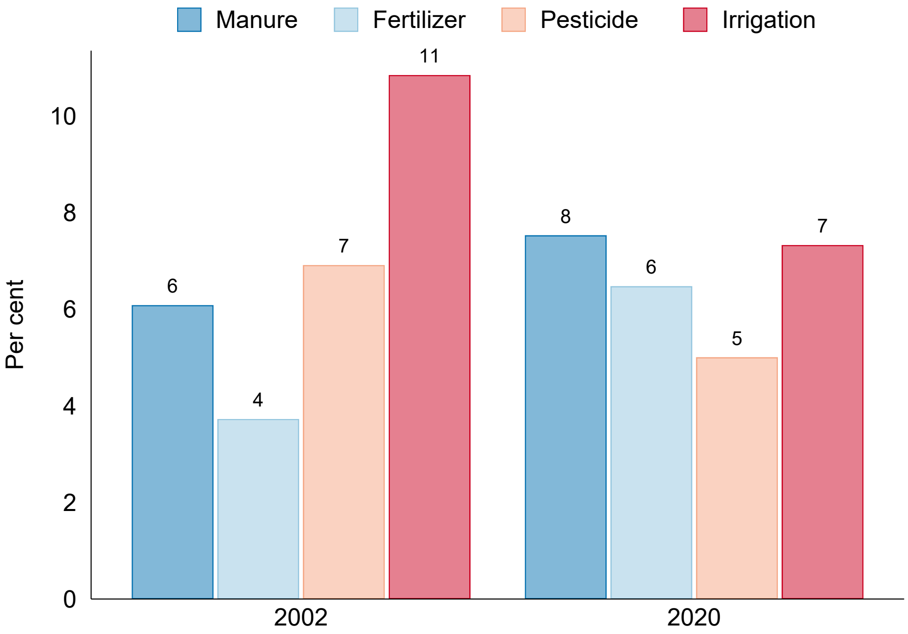
Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

7.4 Agricultural inputs, market access, and technology usage

Agricultural inputs are essential materials and resources utilized in crop and livestock production, pivotal for enhancing productivity and ensuring sustainable growth. These inputs, crucial in modern farming practices, contribute to increased yields and efficiency. Key inputs encompass a range of materials, including seeds; fertilizers, vital for restoring soil nutrients; pesticides, crucial for safeguarding crops against pests and diseases; and irrigation systems, indispensable for effective water management. Furthermore, machinery used for planting, harvesting, and processing is important for agricultural production. Smallholder farmers have limited access to these resources. This section examines input usage in different farm sizes and crop types, highlighting shifts towards modernization and providing insight into agricultural evolution and the increasing emphasis on efficiency and market-readiness.

Starting with the introduction of land inputs in agriculture, Figure 7.4.1 shows the percentage of farmers who used manure, fertilizer, pesticides, and irrigation in 2002 versus 2020. The uptake of these inputs is quite low overall, with each input used by less than 10 per cent of the small-scale farmers in 2020. The data from 2002 and 2020 show a slight increase in the use of manure and fertilizer, each by about two percentage points. However, this small uptick does not really point to a major move towards transforming agriculture. Alongside this, there has been a drop in the use of pesticides and irrigation over time. This trend suggests that the use of inputs for agricultural land among small-scale farmers is quite restrained.

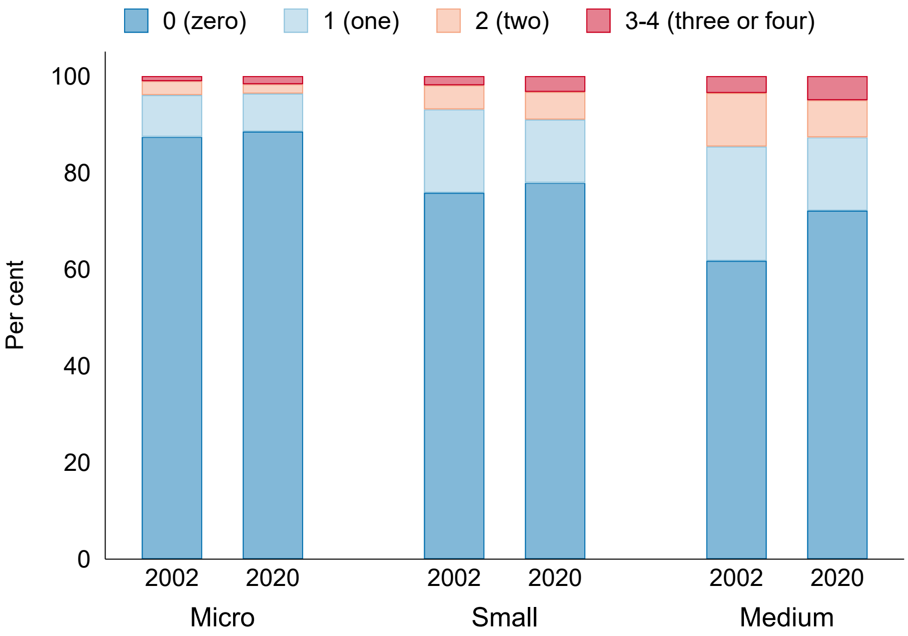
Figure 7.4.1: Modern agricultural input over time



Source: Author's elaboration based on TIA/IAI harmonized dataset.

Figure 7.4.2 offers a comparative analysis of the use of agricultural land inputs across micro-, small-, and medium-sized farms. An index was created by aggregating the four previously mentioned land inputs. Notably, there is significant variation in input usage correlated with farm size. Medium-sized farms exhibit higher index values in both years, while micro farms utilize the fewest inputs. However, as previously highlighted, the index levels for 2002 surpass those of 2020, raising concerns about the future implementation

Figure 7.4.2: Modern agricultural input index by farm size



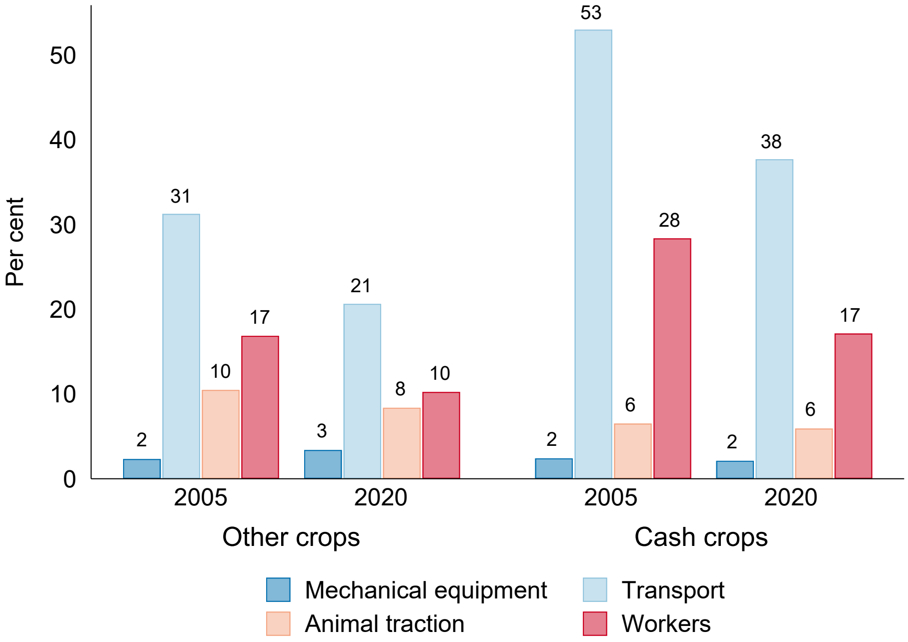
Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Groups are mutually exclusive; farmers cultivating at least one cash crop are categorized under 'Cash crops'.

of Mozambique's shift towards modernization in agriculture.

Shifting focus to mechanic and animal equipment, transport, and labour inputs in Figure 7.4.3, it is relevant to compare their usage between cash crop growers and producers of other crops. This distinction is based on the assumption that cash crop growers, being more market-oriented, are likely to utilize these inputs more extensively since cash crops are typically cultivated not just for personal consumption but for sale. Transport, in this context, includes bicycles, motorcycles, trucks, and cars. The graph in Figure 7.4.3 reveals that mechanized equipment consistently exhibits a low adoption rate among growers of both crop types throughout this period. Similarly, the use of animal traction does not appear to be significantly influenced by the type of crop cultivated and has not shown an increase, maintaining an adoption rate of less than 10 per cent. In contrast, hired labour, not including household members, is more frequently employed by cash crop farmers. However, there has been a noticeable decline in their employment over the years. Additionally, cash crop farmers are more likely to have access to various means of transport compared to those growing other crops. Interestingly, a comparison of the availability of transport for both groups of farmers shows that in 2005, transportation resources were more accessible to non-cash crops growers. However, there has been an overall decrease in the accessibility of transport and the utilization of labour. In contrast, the usage of mechanical equipment and animal traction appears to have remained relatively stable throughout the analysed period.

To gauge how well these farmers are integrated into the market, we looked at how many farmers got pricing information before they started planting, the use of any extension services during the growing season, and whether these smallholders were part of any farm organization. Figure 7.4.4 shows that from 2002 to 2020 there has been an increase in the number of farmers receiving price information. In fact, about half of the

Figure 7.4.3: Machinery and labour use for cash crops



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Labour data not available for 2002.

farmers growing cash crops were able to access market pricing information. The use of extension services, while not widespread, has unfortunately seen a decrease. Yet, it is more common for those growing cash crops to engage with these services. Finally, joining a farm organization is still not very common among small-scale farmers, and there was no noticeable difference in this between cash crop and non-cash crop growers as of 2020.

Figure 7.4.4: Access to price information, extension services, and farm organizations

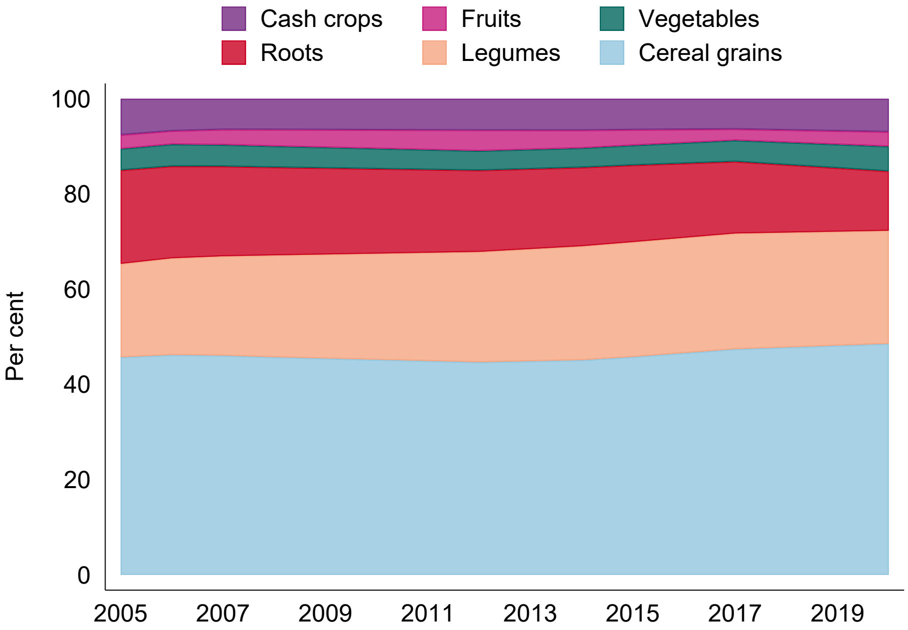
Source: Author's elaboration based on TIA/IAI harmonized dataset.

7.5 Production choices over time

Small-scale farmers exhibit a diverse range of crop choices, reflective of the varied agro-ecological zones and socio-economic conditions (Rapsomanikis, 2015). Small-scale farms are often characterized by a broader spectrum of food production compared to their larger, more commercialized counterparts. They tend to cultivate not only their primary staple crops but also a variety of others (e.g., to ensure a more nutritious diet). This diversification persists even among those smallholders who participate in commercial activities, as they often sell and purchase food in the market. The strategy of cultivating multiple crops serves as a risk management tool, helping to stabilize income by minimizing vulnerability to market fluctuations, such as price shocks. While specializing in a single crop can enhance efficiency, these small-scale farmers prioritize diversifying their crop production as a means to distribute and mitigate agricultural risks across a wider range of products. In this section, we will examine whether Mozambican smallholder farmers align with these practices, presenting the evolution of their production choices along with yield and productivity measures.

Figure 7.5.1 illustrates the allocation of cultivated land among six crop categories from 2005 to 2020. It is evident that cereal grains dominate, consistently comprising the largest segment, which underscores their essential role in dietary staples. Both legumes and roots are significant too, each occupying nearly 20 per cent of the total cultivated area, highlighting their crucial contribution to local nutrition and food security. Vegetables and fruits represent a smaller proportion, each category accounting for about five per cent of the cultivated land. It is noteworthy that the area devoted to cash crops in small-scale farming has maintained a steady state, hovering around eight per cent. However, it is important to acknowledge that the data pertaining to fruit cultivation, derived from an estimation in hectares based on the number of trees reported by farmers, may carry some degree of inaccuracy

Figure 7.5.1: Cultivated area by crop categories



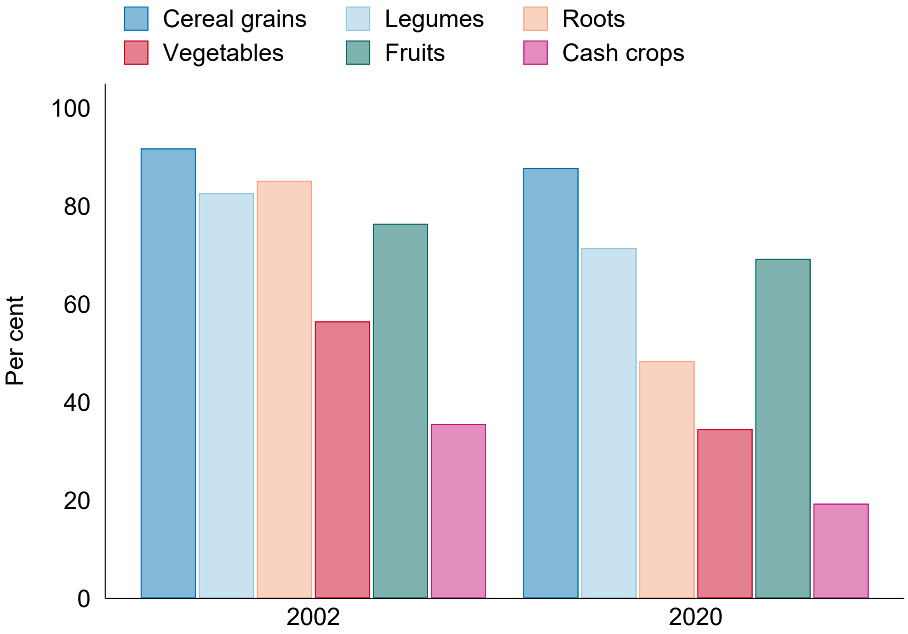
Source: Author's elaboration based on TIA/IAI dataset
Note: The graph starts in 2005 because data on vegetables were not available in 2002. Crop categories include Cereal Grains (Maize, Rice, Sorghum, Pearl millet, Wheat), Legumes (Peanut, Butter bean, Cowpea, Yoke bean, Pigeon pea, Green bean, Oloko bean, Soy), Roots (Cassava, Sweet potato, Potato, Beetroots, Taro), Vegetables (Paprika, Pumpkin, Lettuce, Garlic, Eggplant, Onion, Carrot, Cabbage, Pea, Watermelon, Cucumber, Pepper, Chilli, Okra, Tomato), Cash Crops (Cotton, Tobacco, Sisal fibre, Sugar cane, Sunflower, Sesame, Ginger), and Fruits (Cashew, Coco, Avocado, Walnut, Guava, Orange, Lemon, Lily, Apple, Macanikera, Mafureira, Mango, Papaya, Pear, Peach, Mandarin, Jambaloo, Grapefruits, Grapevine, Passion fruit, Pineapple, Banana).

Figure 7.5.2 presents the share of households cultivating the various crop categories in 2002 and 2020. Almost 90 per cent of the population cultivates cereal grains, in line with the high share of agricultural land dedicated to these cultivations. Overall, the graph shows a small decline in the share of households cultivating each single category. A more significant reduction has affected the roots category, with fewer farmers deciding to plant cassava and sweet potato.

To further illustrate these agricultural shifts, Figure 7.5.3 showcases the national proportion of households engaged in cultivating the top ten crops produced, comparing the 2002 and 2020 levels. While maize cultivation has remained relatively stable, all other crops have seen a marked decrease in cultivation when comparing data from 2002 to 2020. Cassava, although still the second most cultivated crop, has seen a drop, with the percentage of small farms growing it falling from 75 to 40 per cent. Cowpea and pigeon pea cultivation has also declined. Furthermore, the cultivation of rice and sweet potatoes has diminished in its significance among smallholder farming choices. In Appendix 7.C, the same graph is replicated for each region so as to make it easier to understand where the changes are more pronounced.

Figure 7.5.4 illustrates the progression of the Simpson Diversity Index (SDI) over the years for each region. The SDI is a measure used to assess the diversity level in the context of crop diversification, and it quantifies the variety of different crop species within a given agricultural area. The value of the index ranges from 0 to 1, with higher values indicating greater diversity. As shown by the graph, there is an evident decline in

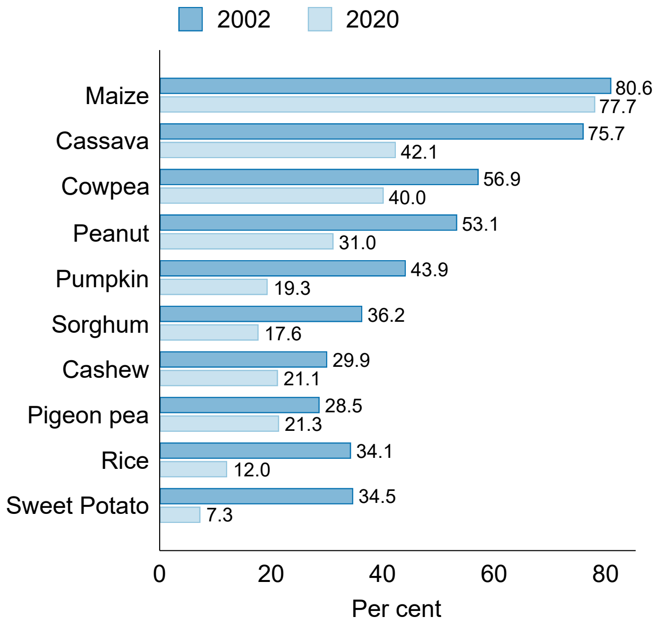
Figure 7.5.2: Share of households cultivating different crop categories



Source: Author's elaboration based on TIA/IAI harmonized dataset.

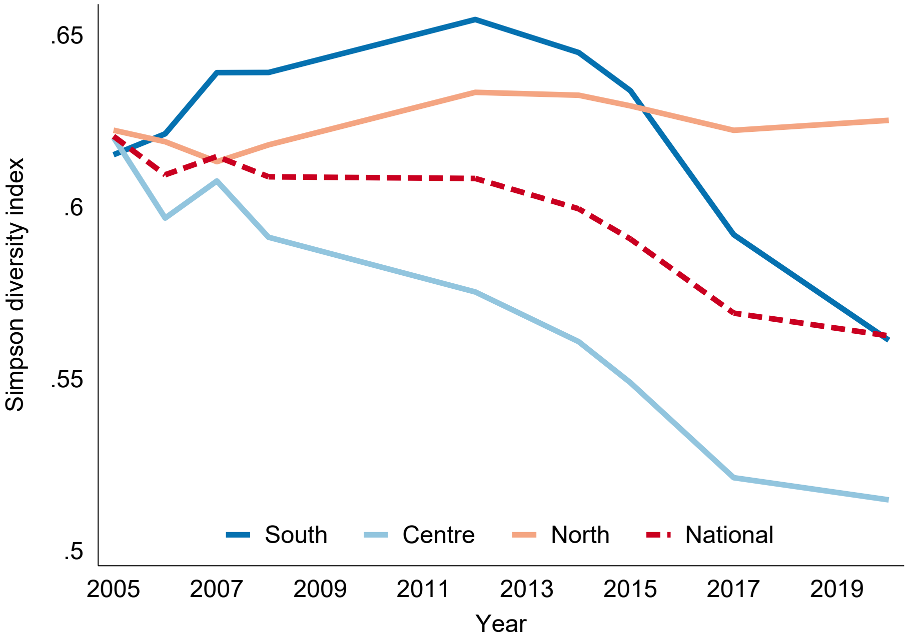
the SDI level over time with the Central regions driving the change. The level of diversification in the North appears to maintain a relatively stable state. The production trends analysed thus far suggest an increasing concentration in agricultural practices, as smallholder farmers shift towards cultivating a narrower range of products.

Figure 7.5.3: Percentage of households cultivating the main crops in 2002 versus 2020



Source: Author's elaboration based on TIA/IAI harmonized dataset.

Figure 7.5.4: Diversification index by region



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

7.5.1 Livestock

Livestock represents a vital capital asset within smallholder farming, not only as a food source but also by providing manure, an important organic fertilizer. Moreover, in difficult times or under economic shocks, it could be sold and converted into liquid assets. In the context of Mozambique, the variety of livestock types commonly found in the region includes goats, sheep, swine, poultry, and cattle, as well as less common farm animals like rabbits and donkeys. There is a tendency to keep smaller livestock, such as poultry, pigs, sheep, and goats, as these animals are more financially accessible and less costly to maintain than larger livestock like cattle. 'Backyard' poultry farming particularly stands out for smallholders due to its low initial investment and high return on investment, making it a pragmatic and lucrative choice.

To better understand the value and evolution of the livestock sector, we have decided to convert the animal holdings of households into Tropical Livestock Units (TLU). The TLU is a concept that serves as a universal metric to equate and assess the productive potential of different types of livestock within tropical agricultural systems. Each animal type has a specific coefficient proportional to its average weight and the role it plays in the local agricultural economy. This methodology facilitates the comparison of various livestock species by converting their live weight into a standardized unit. The conversion TLU coefficients in the TIA/IAI harmonized dataset were derived from LHC (2014).

Table 7.5.1 presents the evolution of the average TLU per household with livestock by region between 2002 and 2020. It shows the predominant role of livestock in the Southern region, where the average farm with livestock had 10 times more value than the average farm in the North in 2020. Overall, at the national level there has been an increase in the average values. The Southern region consistently reports higher TLU values, indicative of larger farms.

This trend becomes even more significant when examined in conjunction with the data from Figure 7.2.6, which shows a 15 percentage point decrease in the number of farms keeping livestock over the same period. This suggests that although there are fewer farms with livestock, the overall value of the animals has risen. The evolution of total TLU value by animal categories is further detailed in Appendix 7.C.

Table 7.5.1: Average TLU value among farm with livestock

	2002	2003	2005	2006	2007	2008	2012	2015	2017	2020
North	0.5	0.4	0.6	0.5	0.5	0.4	0.5	0.5	0.5	0.5
Centre	2.3	2.7	2.8	2.2	2.8	2.1	2.5	2.9	2.5	2.9
South	4.0	4.1	5.5	4.8	5.4	3.8	4.5	4.8	3.9	5.1
Total	2.3	2.7	3.2	2.7	3.1	2.2	2.6	3.1	2.6	3.4
Observations	3979	3697	4646	4779	4489	4382	4641	4730	4599	15832

Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Only households with livestock are included.

Lastly, Table 7.5.2 tracks the percentage share of TLU value across livestock categories from 2002 to 2020. It shows a marked increase in the value of cattle, rising from 36 to 57 per cent in the period. The table also reports a decline in the role of swine and a gradual decrease for goats and sheep. Poultry remains fairly stables across years.

Table 7.5.2: Share of TLU value by livestock categories 2002–2020 (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2015	2017	2020
Goats and sheep	30.6	30.5	27.6	27.1	25.4	26.2	22.5	18.5	17.0	18.9
Swine	18.6	16.7	17.1	14.5	14.4	15.4	15.9	14.5	12.2	12.6
Poultry	14.2	10.1	8.3	11.7	10.2	9.5	8.1	7.7	8.8	11.2
Cattle	36.4	42.4	46.8	46.5	49.8	48.7	53.4	59.2	61.9	57.1
Rabbits and Donkeys	0.2	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1

Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Only households with livestock are included.

7.6 Yields, value produced, and commercialization

Assessing yield performance provides a tangible basis for examining the productivity and outcomes of small-scale farmers. As discussed in Chapter 5, the yield values were calculated by dividing the total quantity produced by the crop area, resulting in measurements expressed in kilograms per hectare. Although yield measures are not exhaustive, they are frequently employed as indicators of farming efficiency and effectiveness. While recognizing the constraints inherent in our dataset, including a significant incidence of outliers and errors, this section will focus on presenting the yields of four most cultivated crops throughout the analysed period. Additionally, we will delve into the variations in performance outcomes: values of production both in calories and monetary terms.

To enhance our comparison of yield performance, we plotted the yield indices for Mozambique's primary crops, with 2012 as the reference year. Indexed yields are crucial in understanding agricultural trends, as they provide a standardized comparison of crop yields across various years against a baseline. This approach effectively simplifies the identification of trends and patterns in crop production, facilitating a clear visualization of their growth or decline. As depicted in Figure 7.6.1, the yields of maize, cassava, peanuts, and cowpeas are presented. These crops were selected due to their widespread cultivation and significant role in Mozambique's agriculture. While peanuts and cassava have demonstrated a positive growth trajectory since 2012, the yields of cowpeas and maize have experienced a slight decline since 2017. Notably, the decrease in cowpea yield since 2017 can be attributed to the infestation of the parasitic weed *Alectra* in Northern Mozambique, as extensively detailed in the International Institute of Tropical Agriculture (IITA) 2018 report (IITA, 2018). This decline has implications for regional agricultural practices and food security.

Figure 7.6.2 illustrates the evolution of the average overall household yield by region measured in tonnes (1000 kg) per hectare. The overall yield is a weighted average of different crop yields, adjusted for the energy content of each crops relative to the energy content of maize.[3] The trends reveal consistent growth in yields across the regions, with the North registering the most notable increase post-2012. The upward trajectory since 2014 across all regions suggests effective agricultural strategies and possible favourable environmental conditions. The increase in overall yields, while indicative of agricultural progress, does not inherently signal enhanced livelihoods for small-scale farmers who must balance yield maximization with risk mitigation in their farming practices.

Figure 7.6.3 presents the average overall yield for each farm size category. Since 2002, smaller farms demonstrate higher average yields per hectare than larger ones. Specifically, micro-sized farms (up to 1 hectare) and small-sized farms (1 to 3 hectares) outperform medium-sized farms (more than 3 hectares). The yield

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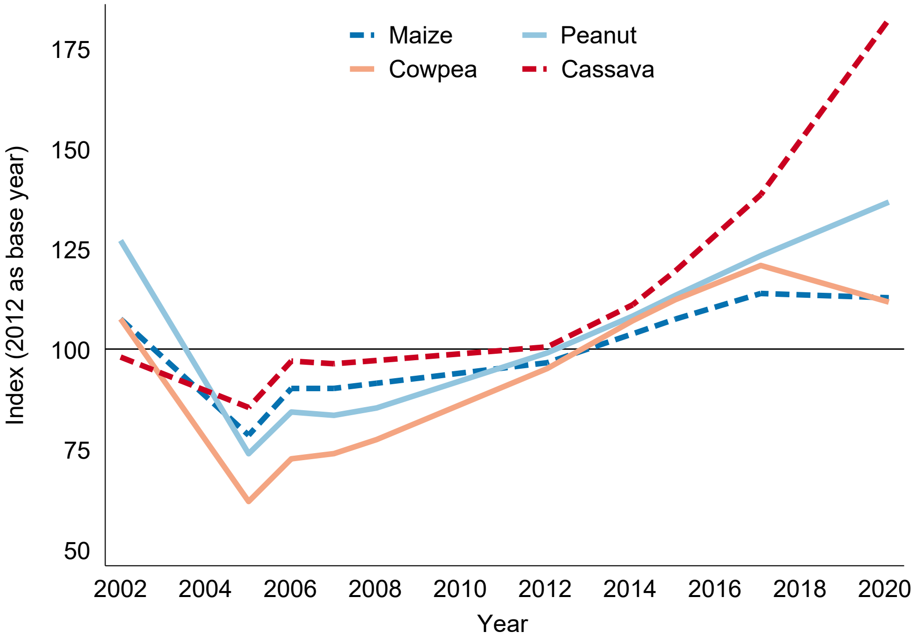
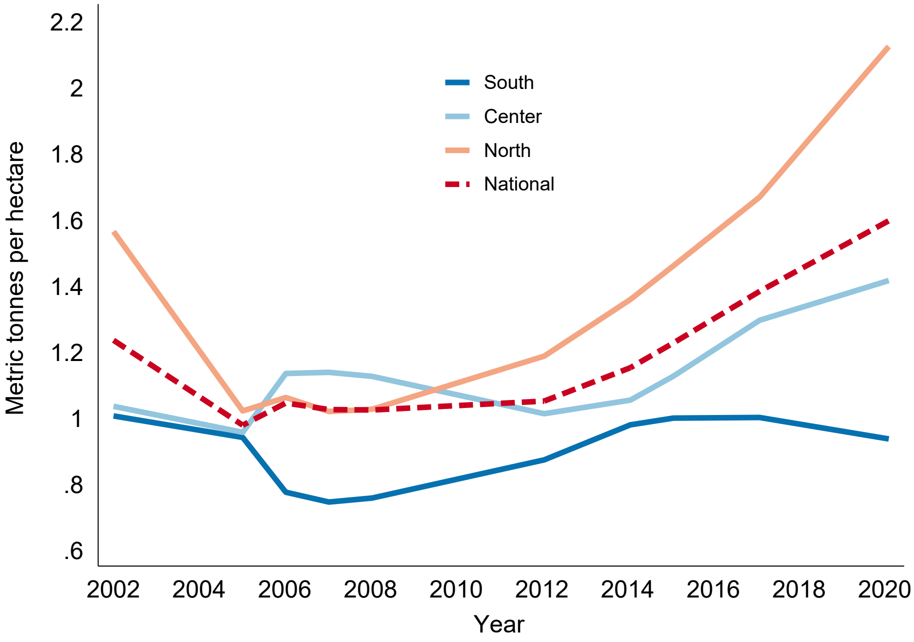
[3] See Chapter 5 for clarification on the overall yield measure.

Figure 7.6.1: Yield evolution index (2012=100)



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

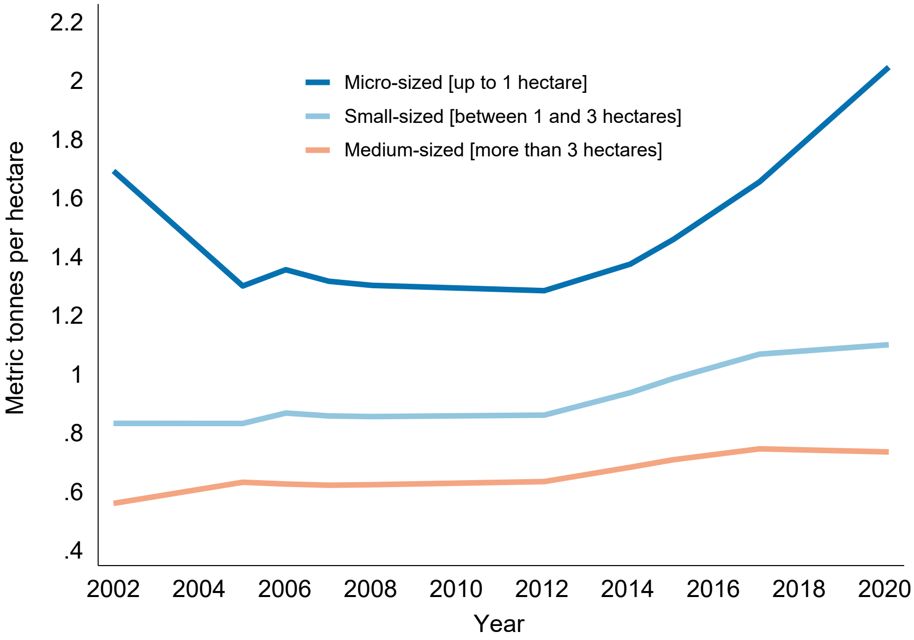
Figure 7.6.2: Average overall yield by region 2002–2020



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Overall yield is weighted average where weights are indexed to the caloric contribution of maize.

gap increased only in the recent period. The inverse relationship between farm size and yield performance has long been documented (Barrett et al., 2010)

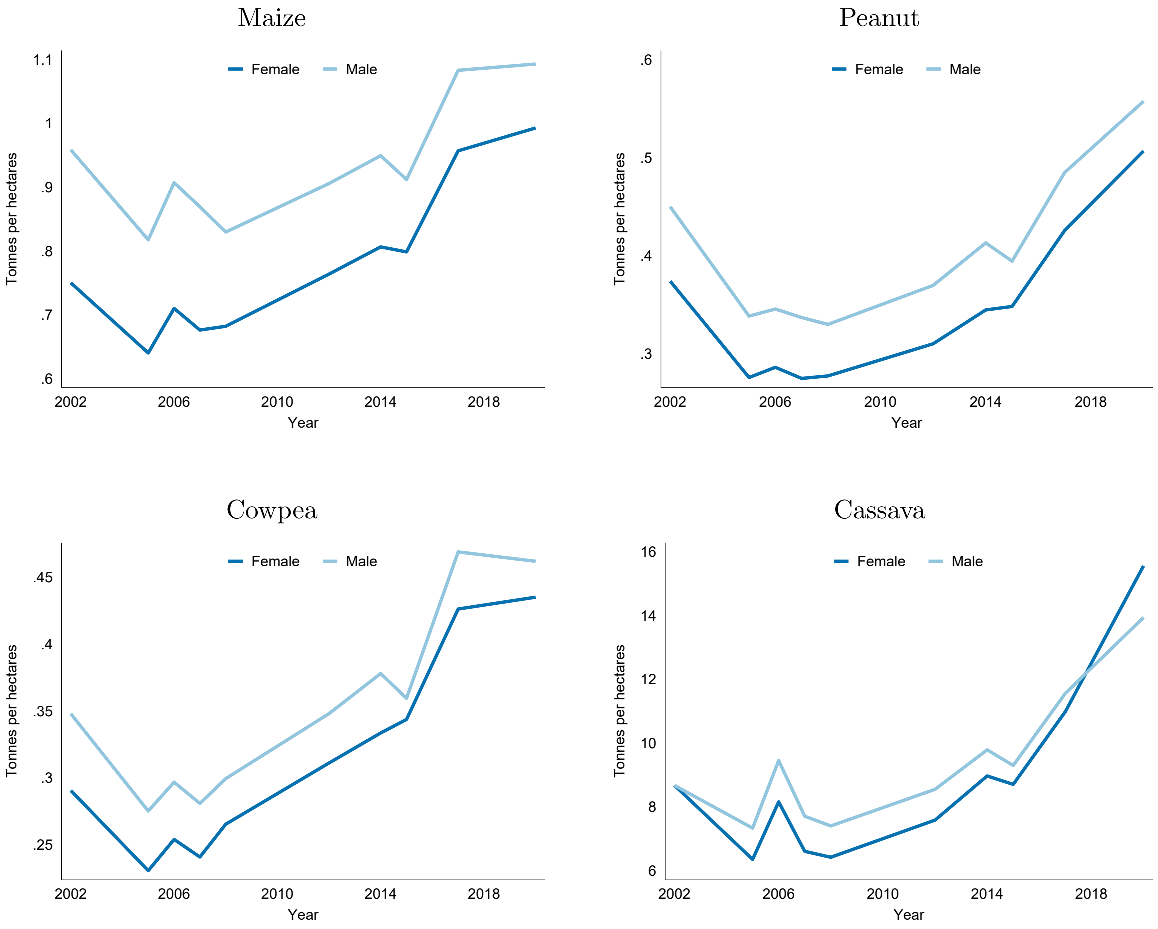
Figure 7.6.3: Average overall yield by farm size categories 2002–2020



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

Figure 7.6.4 displays four graphs, each illustrating the average yield of the four main crops cultivated, segmented by gender. A consistent yield gap between male and female farmers is evident across all crops. However, it is noteworthy to observe a "closing gap", indicating that the disparity in yields between genders has narrowed from 2002 to 2020. Particularly remarkable is the performance of cassava yields on female-led farms, which surpass those on male-led farms. When testing both conditionally and unconditionally the means of this two groups, it holds true that women are more productive. This finding is significant and warrants further investigation to understand the underlying factors contributing to this trend.

Figure 7.6.4: Yield evolution by gender


Maize

Peanut

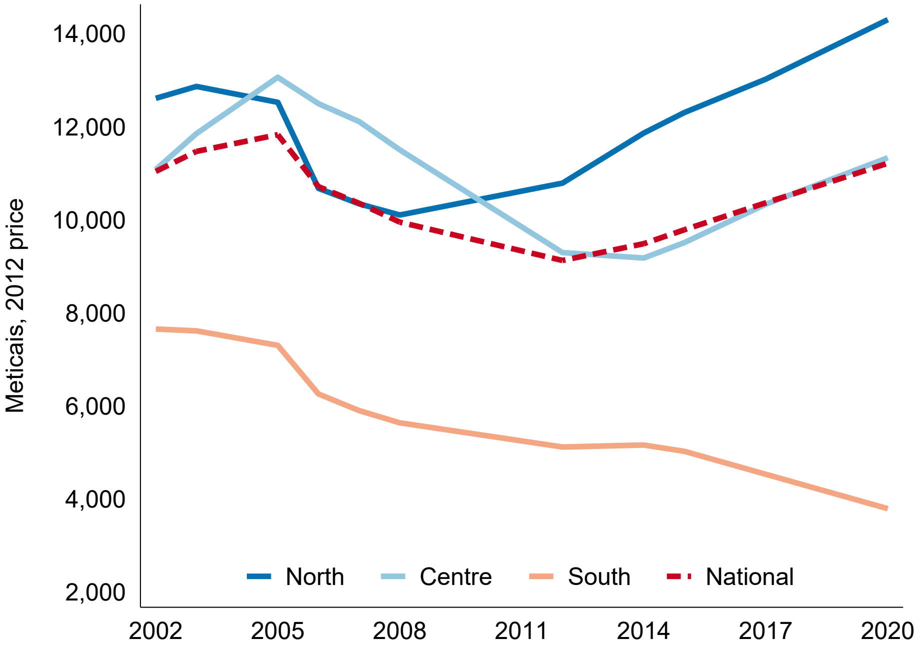
Cowpea

Cassava

Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

Moving on to production value, Figure 7.6.5 shows the average household's production value measured in meticais (MZN). There is clear regional disparity, with the Southern region consistently showing the lowest production level. The average farm household in the Southern region has over the period in reference seen its average real value of production decrease to half. The North and Central regions, on the other hand, display a gradual increase in production value.

Figure 7.6.5: Average household production value by region



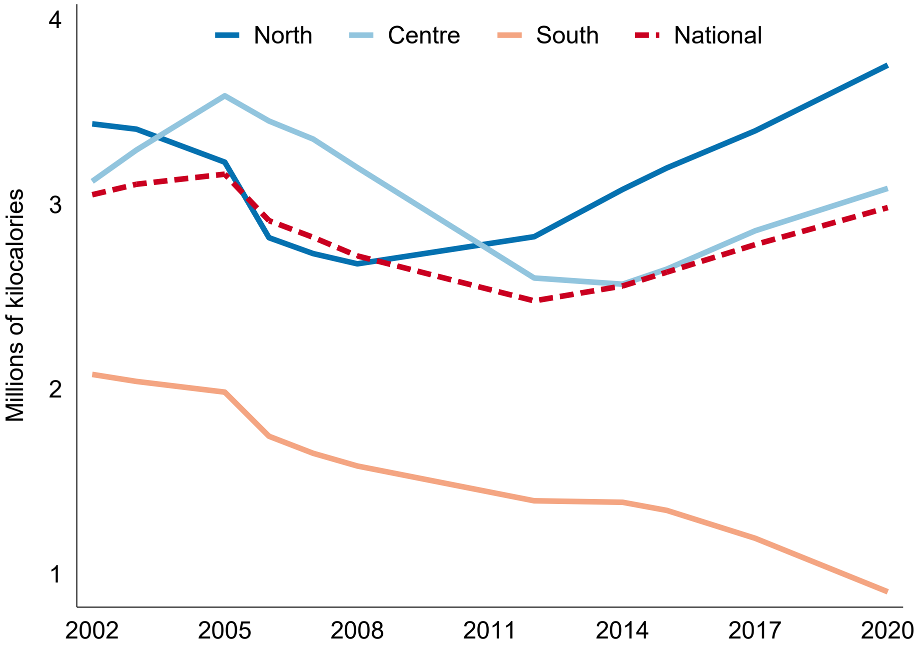
Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

Delving into the average kilocalorie production of each region, as illustrated in Figure 7.6.6, we observe a decreasing trend that corresponds with the previous graph showing the economic value of production expressed in meticais. This trend of caloric values is particularly evident in the Southern region, which shows the least kilocalorie production. Conversely, the Northern and Central regions exhibit a more substantial caloric yield. Such disparities highlight the regional differences in agricultural productivity and raise important considerations about potential food security challenges across Mozambique.

Table 7.6.1 sheds light on a significant trend: from 2002 to 2020, there has been a marked drop in the percentage of households engaging in sales activities in all regions, with the period between 2014 and 2017 seeing a particularly stark decrease. The Southern region, notably, experienced a 30 percentage point fall in commercial activities during this time frame. This downturn is not just isolated to the Southern region; the Central region, too, shows notable dips in market participation. These declines suggest a major shift in the economic fabric that influences farmers' capacity to market their produce.

Despite the fall in sales, the fact that households continue to use their agricultural plots primarily for personal consumption points to a form of resilience. It reflects an enduring commitment to food security through subsistence farming. The reduction in sales is somewhat unexpected, as it is common to associate smallholder farming with the goal of generating income through sales. This emerging trend, therefore, raises

Figure 7.6.6: Average kilocalories produced by region



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

several pertinent questions about the challenges these households face. It brings into focus issues like market access, pricing strategies, or even a possible decrease in production.

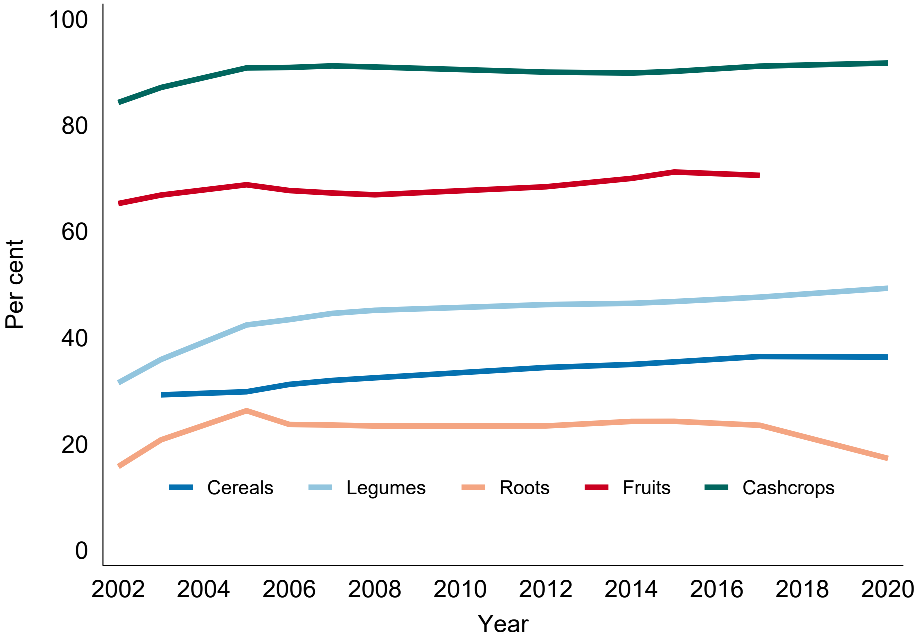
Table 7.6.1: Commercialization share of households by region (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
North	64.9	66.7	71.5	66.9	63.0	63.9	61.2	56.4	57.6	60.5	65.8
Centre	73.1	66.1	67.1	72.3	63.7	68.3	62.5	50.7	60.5	53.1	57.0
South	54.2	45.9	48.7	45.9	38.9	38.0	29.6	18.5	23.5	24.1	19.4
Observations	4908	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration based on TIA/IAI harmonized dataset.

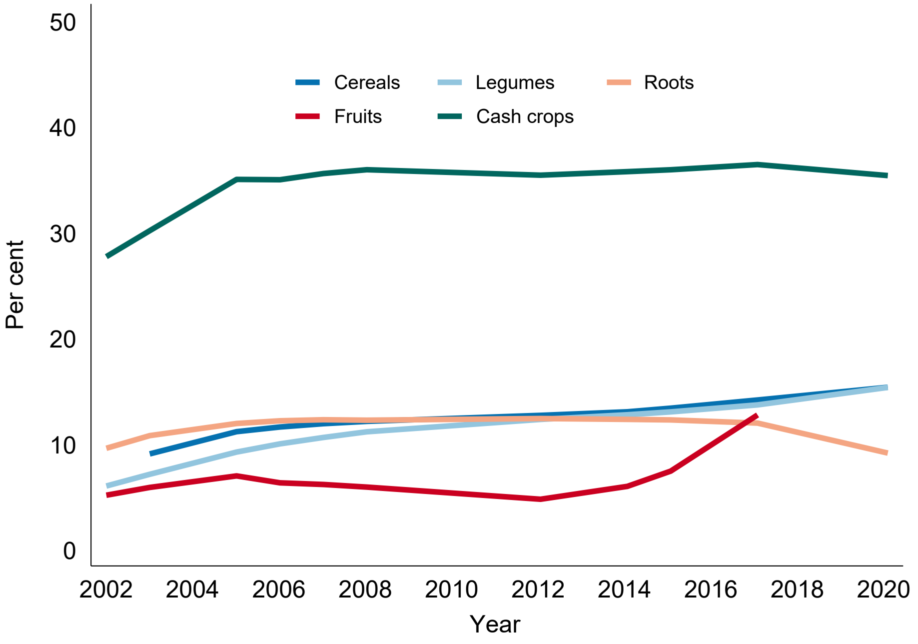
Finally, Figure 7.6.7 depicts the share of crop sales from 2002 to 2020. The proportion of each crop category sold has remained relatively stable over the years. Not surprisingly, cash crops reports the highest sales ratio, exceeding 80 per cent. Indeed, they are primarily grown for sale rather than household consumption. Moreover, fruits also have a high sales rate, with over 60 per cent being sold, likely due to the prolific nature of fruit trees, where a single tree can yield enough fruit for multiple households. Although data on vegetables were unavailable, there has been an uptick in the sales of legumes and cereals. Conversely, root crops have seen a slight decrease in sales and are the category least likely to be sold.

Figure 7.6.7: Evolution of share sold by crop categories 2002–2020



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Households not reporting any sales are not included. Fruits sales not available in 2020, cereals sales not available in 2020. Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

Figure 7.6.8: Value of share sold over total value by crop categories 2002–2020



Source: Author's elaboration based on TIA/IAI harmonized dataset.
Note: Households not reporting any sales are not included. Fruits sales not available in 2020, cereals sales not available in 2020. This is the average share of value sold by crop categories. Time series are smoothed using a locally weighted scatterplot smoothing (lowess) approach.

7.7 Conclusion

The emphasis on small-scale farming as a catalyst for inclusive development is not just an academic assertion; it is a critical socio-economic strategy (Carrilho et al., 2023). Small-scale farming goes beyond mere agricultural output; it is intertwined with the fabric of Mozambique's rural economy and plays a significant role in alleviating poverty, especially in areas where alternative economic opportunities are limited (Castigo and Salvucci, 2017).

In this chapter, our journey has been to illuminate the nuances of small-scale farming in Mozambique, spanning the early 2000s to 2020. Our exploration was anchored in a thorough examination of the TIA/IAI harmonized dataset, a pivotal resource compiled from 11 agricultural surveys by Mozambique's Ministry of Agriculture (referenced in Chapter 5). This repeated cross-sectional dataset opened the door to a world of information, allowing us to dissect and present the evolving trends and shifts in the agricultural landscape over these two decades. It provided us with a lens to view not just the obvious changes but also the more subtle evolutions in Mozambique's agricultural sector.

This fundamental sector has experienced changes over the years, including demographic changes, evolving land use, and technology adoption. The same goes for crop diversification, livestock trends, productivity, and marketing. A noteworthy demographic shift is the rise in female farmers and an overall increase in education among household heads. The trend of smaller household sizes and a growth in off-farm activities, especially in the Southern provinces, mirrors the dynamic socio-economic environment.

From 2002 to 2020, the total cultivated area grew from 40,000 to 50,000 hectares, but this growth was not uniform across all regions. The Southern provinces saw a decrease in their share, while the North and Central regions, particularly Zambezia, Tete, and Manica, expanded significantly. Despite the overall increase, the average size of farms decreased to 1.2 hectares, with Southern provinces having the smallest farms. The slow pace of technological adoption in agriculture remains a concern, with a limited use of modern inputs like fertilizers and irrigation. The low utilization of agricultural extension services, despite their increased availability, highlights a need for more effective support strategies. Additionally, it is important to recognize that access to inputs and technologies is largely confined to certain geographic regions. This disparity creates uneven opportunities and challenges across different areas of Mozambique's agricultural sector.

Crop patterns reveal a focus on cereals, primarily maize, but there is a decline in crop diversity. This reduction might impact the sustainability and resilience of the agricultural system. Livestock trends show an interesting dynamic: fewer farmers are engaged in livestock activities, but those who do have more animals, notably cattle, contributing to an overall increase in livestock value.

In observing crop patterns, there is a clear emphasis on cereal cultivation, with maize being cultivated by more than 80 per cent of the small farmers. There has been a decrease in diversification, indicating a shift in farming practices and crop selection. Yet smaller farmers tend to specialize less and produce more variety of crops. Furthermore, a significant trend is the reduction in the percentage of households growing cassava, highlighting a shift in the farming landscape. This reduction in variety may affect the agricultural system's ability to be sustainable and resilient. In the realm of livestock, the situation is quite unique: there are fewer farmers engaged in livestock activities, but those who are typically have a larger number of animals, especially cattle. This results in an increased overall value in the livestock sector.

Productivity improvements are evident, with increased yields in main crops and at the household level.

Interestingly, in cassava production, farms led by women and smaller farms exhibit higher productivity, challenging traditional views on farming efficiency. Commercialization, however, has not kept pace, with a notable decline in the proportion of households engaged in market sales, especially in the Central and Southern regions.

Commenting on regional differences, it is evident that the Southern region of Mozambique is experiencing a notable decline in the prominence of its agricultural sector. This shift is marked by a few critical developments: the transition towards smaller agricultural plots, which naturally limits farming activities' scale and scope. This reduction in plot size is coupled with decreased production levels, highlighting a downturn in agricultural output. Furthermore, there is a growing trend towards off-farm employment, suggesting a broader economic shift and a diversification of income sources away from traditional agriculture. These factors together signify a substantial change in the agricultural landscape and economic dynamics of the region.

In light of these findings, future policy initiatives should focus on bridging the technological gap in agriculture, especially in regions with limited access to modern farming tools and inputs. Policies could also aim to encourage crop diversification, enhancing the agricultural system's resilience against market fluctuations and climate change. Furthermore, fostering market access and commercialization for small-scale farmers is essential, ensuring they can fully benefit from their agricultural endeavours. In closing, it is imperative to reiterate the vital role of small-scale farming as the cornerstone of Mozambique's agricultural sector. Policies tailored to support and enhance this sector will not only nurture rural livelihoods but also fuel sustainable agricultural growth, reinforcing the country's socio-economic fabric.

Appendix

7.A Demographic characteristics

Table 7.A.1: Female-led household (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	33.4	31.7	25.5	25.5	33.3	20.6	22.1	25.1	32.3	30.0	35.3
Cabo Delgado	22.8	18.9	22.4	23.4	27.0	20.9	28.6	31.4	30.9	33.6	40.6
Nampula	21.7	20.9	21.1	20.9	20.3	21.3	19.6	15.4	21.3	25.1	29.2
Zambezia	20.0	25.6	21.2	18.1	14.9	21.9	27.5	29.5	28.7	27.4	39.5
Tete	27.2	30.7	29.2	23.4	20.6	20.0	23.9	28.1	27.9	27.1	28.3
Manica	20.9	20.4	23.9	20.9	24.6	22.8	29.5	21.8	25.3	19.7	26.9
Sofala	23.3	24.0	24.2	20.7	19.0	20.8	32.7	23.5	28.1	24.3	33.5
Inhambane	29.0	32.0	33.0	35.9	36.7	36.3	42.4	36.3	40.0	40.6	35.5
Gaza	33.2	38.3	38.4	33.8	34.9	41.7	45.6	44.1	39.4	34.1	42.2
Maputo Province	33.4	34.2	36.9	31.3	27.2	31.2	36.2	32.1	35.5	36.4	38.1
Total	24.4	25.8	25.3	23.4	23.2	24.0	27.9	26.4	28.4	28.2	34.2
Observations	4908	4935	6149	6248	6075	5968	6611	5966	6984	6771	23007

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.A.2: Average household size (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	5.3	5.3	5.7	5.0	4.9	4.9	4.8	5.1	4.8	4.9	4.4
Cabo Delgado	4.3	4.2	4.9	4.5	4.1	4.7	4.6	4.9	4.7	4.3	4.5
Nampula	4.4	4.7	4.7	4.5	4.5	4.5	4.8	5.0	4.8	4.6	4.2
Zambezia	4.8	4.7	5.3	4.9	4.9	4.9	4.8	4.8	4.7	4.5	4.3
Tete	5.1	5.2	5.7	5.1	4.8	5.4	5.0	5.1	4.8	4.6	4.5
Manica	5.7	5.8	6.6	5.7	5.1	5.7	6.0	6.2	5.8	5.7	5.7
Sofala	5.9	5.8	6.3	5.5	5.5	5.9	5.3	5.9	5.4	5.8	5.1
Inhambane	5.3	5.2	5.7	5.7	4.8	5.2	5.0	5.3	4.6	4.9	3.9
Gaza	5.7	6.1	6.3	6.2	6.1	6.0	5.4	5.9	5.7	5.8	5.1
Maputo Province	5.5	5.2	5.8	5.4	5.3	5.4	4.8	5.1	4.8	4.9	4.2
Total	5.0	5.0	5.4	5.1	4.9	5.1	5.0	5.2	4.9	4.8	4.5
Observations	4908	4935	6149	6248	6075	5968	6611	5966	6984	6771	23007

Source: Author's elaboration on TIA/IAI harmonized dataset.
Note: Average number of household members reported by a household.

Table 7.A.3: Off-farm income (Per cent)

	2003	2005	2006	2007	2008	2012	2014	2015	2020
Niassa	8.8	16.3	27.0	19.2	13.4	6.7	15.6	13.8	24.6
Cabo Delgado	5.3	7.6	11.2	13.4	14.6	8.4	12.9	17.8	22.0
Nampula	10.7	11.1	15.8	20.7	13.6	17.7	12.5	17.6	27.8
Zambezia	11.5	12.5	18.7	16.9	14.2	14.7	12.7	14.5	27.0
Tete	24.0	7.7	14.3	14.8	10.8	12.8	15.4	14.3	14.3
Manica	13.2	14.9	25.9	23.7	26.8	19.3	31.8	30.9	33.0
Sofala	22.4	17.5	25.9	29.8	22.7	24.9	26.2	32.2	30.2
Inhambane	31.5	23.4	39.9	34.0	35.5	24.8	35.0	31.6	37.6
Gaza	45.3	44.3	52.1	58.0	46.0	30.0	45.4	52.9	41.9
Maputo Province	47.3	36.6	43.7	46.2	39.0	24.2	25.7	9.2	53.4
Total	17.6	15.7	23.0	23.6	19.6	17.1	19.2	20.6	28.6
Observations	4935	6149	6248	6075	5968	6676	6030	7034	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

7.B Access to technology, inputs, credit, and information

Table 7.B.1: Extension service (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	10.6	9.2	13.7	23.1	12.1	8.9	7.0	15.0	4.9	9.5	6.0
Cabo Delgado	18.7	14.2	15.6	11.4	5.8	6.8	6.5	5.2	10.3	7.1	6.1
Nampula	16.1	16.5	18.7	9.8	8.5	10.9	7.9	8.1	4.4	11.7	4.3
Zambezia	9.5	8.6	10.3	9.7	11.6	6.6	4.1	4.7	1.9	7.9	3.5
Tete	19.9	16.3	16.0	13.4	13.5	12.8	9.4	17.1	9.7	18.2	6.1
Manica	14.9	8.9	11.6	14.9	10.9	7.5	3.4	9.8	5.3	10.1	7.7
Sofala	19.8	24.0	21.1	16.9	14.4	10.2	10.0	8.9	4.6	17.8	23.1
Inhambane	4.6	9.9	7.8	6.6	7.4	4.6	7.6	8.7	4.1	7.0	3.2
Gaza	10.4	18.4	22.2	15.3	7.7	4.0	8.0	10.3	1.1	5.1	4.6
Maputo Province	11.0	14.5	11.0	9.8	19.9	6.8	2.9	5.4	0.6	3.6	2.1
Observations	4908	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.2: Farm organization (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	2.9	0.0	10.6	12.3	9.2	6.3	2.0	4.2	1.7	6.0	2.4
Cabo Delgado	3.9	2.3	4.7	7.2	5.6	3.4	5.3	3.6	6.4	4.2	1.8
Nampula	4.8	6.6	8.1	6.0	10.3	7.1	6.0	2.9	3.1	5.0	2.0
Zambezia	3.0	2.9	4.1	4.9	9.7	9.6	3.7	2.1	1.1	4.2	1.6
Tete	2.7	6.7	7.7	2.8	4.8	5.4	4.6	4.5	3.9	7.1	3.9
Manica	4.2	3.7	4.7	6.0	7.1	6.2	4.2	1.4	3.4	4.4	8.1
Sofala	2.1	3.1	3.0	4.3	7.2	4.2	3.7	2.6	4.7	6.4	7.9
Inhambane	1.6	1.4	2.6	4.8	5.0	9.8	3.1	3.6	2.2	6.3	1.6
Gaza	4.2	9.1	10.0	13.6	10.4	7.8	5.5	8.2	1.5	7.1	3.7
Maputo Province	11.6	16.1	19.5	13.5	12.9	12.3	4.5	7.0	1.1	5.8	2.8
Observations	4908	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.3: Access to agricultural credit (Per cent)

	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	7.0	9.1	6.6	5.8	1.7	2.4	4.3	1.9	1.0	1.2
Cabo Delgado	1.0	4.2	3.7	3.0	2.7	1.9	1.0	0.2	0.8	0.6
Nampula	3.5	5.4	1.9	4.2	2.7	4.4	1.5	0.4	0.8	0.4
Zambezia	0.9	0.4	1.5	2.3	1.0	1.3	1.1	0.5	1.1	0.6
Tete	9.3	7.7	6.2	13.6	5.2	1.6	1.3	2.4	4.6	0.8
Manica	2.0	1.0	1.1	3.3	4.8	2.3	0.1	1.2	0.7	1.2
Sofala	3.1	3.3	6.7	5.1	3.7	1.3	0.4	0.5	1.5	0.4
Inhambane	0.5	1.7	1.1	6.3	0.8	1.1	1.1	0.1	0.9	0.1
Gaza	3.1	1.9	2.7	3.7	2.4	0.8	0.9	0.5	0.7	0.3
Maputo Province	2.9	3.5	2.4	3.6	4.7	0.5	0.4	0.2	0.4	0.4
Observations	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.4: Implementing crop rotation (Per cent)

	2005	2008	2012	2014	2015	2017
Niassa	88.9	92.7	86.0	80.9	78.6	77.4
Cabo Delgado	88.8	78.5	61.6	84.2	80.7	73.8
Nampula	78.4	83.4	86.9	75.7	81.3	78.2
Zambezia	84.8	70.9	80.4	61.0	73.8	66.2
Tete	89.2	93.9	74.2	84.4	75.8	83.3
Manica	88.9	73.2	65.6	78.4	55.8	56.4
Sofala	77.8	52.2	53.1	67.1	59.8	67.9
Inhambane	92.6	85.7	84.0	78.8	88.1	87.3
Gaza	88.6	84.9	82.4	90.0	75.7	72.4
Maputo Province	83.5	74.1	29.0	39.0	11.4	43.2
Observations	6149	5968	6676	6030	7034	7004

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.5: Intercropping use (Per cent)

	2005	2008	2012	2014	2015	2017
Niassa	88.9	92.7	86.0	80.9	78.6	77.4
Cabo Delgado	88.8	78.5	61.6	84.2	80.7	73.8
Nampula	78.4	83.4	86.9	75.7	81.3	78.2
Zambezia	84.8	70.9	80.4	61.0	73.8	66.2
Tete	89.2	93.9	74.2	84.4	75.8	83.3
Manica	88.9	73.2	65.6	78.4	55.8	56.4
Sofala	77.8	52.2	53.1	67.1	59.8	67.9
Inhambane	92.6	85.7	84.0	78.8	88.1	87.3
Gaza	88.6	84.9	82.4	90.0	75.7	72.4
Maputo Province	83.5	74.1	29.0	39.0	11.4	43.2
Observations	6149	5968	6676	6030	7034	7004

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.6: Planting in rows (Per cent)

	2005	2008	2012	2014	2015	2017
Niassa	47.4	50.0	51.8	63.1	44.6	65.9
Cabo Delgado	33.3	46.1	43.8	44.5	45.0	47.0
Nampula	35.6	26.8	29.7	27.1	25.2	25.4
Zambezia	32.8	20.1	31.2	20.7	23.6	22.4
Tete	82.9	68.9	67.1	68.3	73.6	71.3
Manica	35.9	53.5	33.3	47.9	50.1	51.3
Sofala	50.7	40.2	50.7	51.2	42.5	56.7
Inhambane	57.5	47.3	39.2	45.8	46.3	52.3
Gaza	35.0	40.1	35.4	37.6	30.4	33.9
Maputo Province	37.4	31.8	16.1	21.8	6.0	19.5
Observations	6149	5968	6676	6030	7034	7004

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.7: Land title (Per cent)

	2002	2005	2007	2008	2012	2014	2015	2017	2020
Niassa	0.4	0.0	0.2	0.0	0.2	0.6	0.6	0.5	1.3
Cabo Delgado	1.2	1.2	0.6	0.9	0.4	0.1	2.6	0.9	4.3
Nampula	0.7	0.9	0.7	1.4	0.7	0.3	1.3	1.2	2.9
Zambezia	0.6	3.8	2.2	0.9	0.7	2.8	2.4	2.4	5.6
Tete	0.6	0.8	0.6	0.6	0.0	0.1	2.3	0.7	0.7
Manica	2.0	2.0	0.2	2.0	3.0	3.7	4.0	5.3	2.2
Sofala	1.0	1.7	0.6	0.3	0.7	3.1	1.8	6.5	5.1
Inhambane	1.5	3.4	1.4	2.5	1.1	4.7	2.8	7.9	4.6
Gaza	2.8	8.0	5.1	3.0	0.7	6.6	3.9	3.4	4.2
Maputo Province	7.7	8.5	8.7	6.9	6.5	3.5	1.0	8.5	6.9
Observations	4908	6149	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.8: Received price information (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	29.2	50.4	32.4	49.7	35.1	31.9	47.8	71.0	9.9	15.1	48.6
Cabo Delgado	36.3	43.9	51.9	41.4	38.1	35.6	52.6	44.7	19.0	13.0	55.3
Nampula	65.6	73.3	60.3	52.7	37.8	44.1	60.9	48.6	15.1	27.0	46.6
Zambezia	21.5	30.3	24.7	27.6	39.9	20.0	61.5	31.9	5.7	5.1	37.6
Tete	24.6	45.9	45.9	33.6	38.9	41.1	72.9	73.6	17.4	38.2	46.7
Manica	59.3	45.5	25.6	42.8	25.5	51.8	66.4	56.2	3.3	13.0	62.7
Sofala	26.4	62.1	55.4	40.7	41.6	29.2	79.0	58.1	13.6	24.2	37.4
Inhambane	12.5	33.5	32.5	13.7	23.5	28.8	47.7	44.6	3.0	16.0	16.2
Gaza	9.4	39.2	30.7	19.9	23.4	38.2	40.5	47.9	2.6	8.5	17.0
Maputo Province	17.4	39.9	16.2	12.6	26.3	20.8	25.2	25.6	4.0	6.5	21.5
Observations	4908	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.9: Irrigation system (Per cent)

	2002	2003	2005	2006	2007	2014	2015	2017	2020
Niassa	8.1	5.1	2.1	6.1	7.8	6.2	6.7	2.4	2.8
Cabo Delgado	3.5	0.8	1.6	2.0	3.1	2.2	1.3	0.4	6.8
Nampula	2.2	1.9	4.5	5.5	5.9	1.2	1.6	1.3	4.6
Zambezia	1.4	3.4	1.4	3.4	5.4	1.7	0.6	0.5	2.0
Tete	27.9	18.6	9.2	16.3	29.8	3.4	8.4	2.9	14.1
Manica	22.3	4.6	3.2	9.2	29.2	5.8	2.6	4.9	9.9
Sofala	5.6	4.9	4.2	4.1	10.1	0.9	1.5	2.9	5.8
Inhambane	29.5	9.6	14.2	20.1	25.4	7.2	9.4	10.9	5.4
Gaza	26.7	14.7	16.7	17.9	15.4	9.0	9.1	9.2	22.0
Maputo Province	24.4	17.3	23.2	19.0	26.6	8.7	1.3	6.2	17.2
Observations	4908	4935	6149	6248	6075	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.10: Manure use (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	4.4	0.4	1.0	2.1	2.9	2.1	1.4	2.7	0.7	1.1	4.0
Cabo Delgado	1.2	0.0	0.2	0.5	1.1	0.1	0.2	0.5	0.7	1.0	6.0
Nampula	1.1	1.5	0.4	1.3	0.8	1.9	1.8	0.2	0.5	0.6	3.4
Zambezia	0.9	0.1	1.4	0.2	2.4	0.0	0.3	0.4	0.9	0.3	10.1
Tete	13.6	8.8	1.9	10.5	8.5	6.4	3.3	3.1	2.8	0.6	13.5
Manica	9.4	3.0	16.7	2.5	6.1	9.1	5.7	2.3	5.1	0.4	5.1
Sofala	2.3	0.0	0.0	1.5	1.2	2.1	1.6	1.5	0.0	0.8	4.8
Inhambane	24.3	2.9	7.9	9.4	16.9	19.7	9.7	4.9	14.3	1.6	8.8
Gaza	12.2	0.6	3.0	4.1	7.3	6.0	3.7	3.5	3.3	1.2	12.8
Maputo Province	14.7	7.3	8.1	9.2	13.5	12.2	3.2	6.3	1.1	0.8	9.3
Observations	4908	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.11: Fertilizer use (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	7.5	11.6	17.7	15.0	7.1	9.8	8.4	10.5	15.9	11.0	7.3
Cabo Delgado	2.6	0.0	0.2	4.5	1.1	2.7	0.4	2.8	2.2	2.6	7.6
Nampula	3.3	0.3	2.8	2.8	2.2	2.6	1.9	1.0	1.3	1.6	3.7
Zambezia	0.7	0.7	0.0	1.6	1.1	0.4	0.1	0.1	0.4	0.9	1.6
Tete	15.1	12.1	16.5	17.7	21.0	14.7	10.6	22.2	24.0	19.2	28.0
Manica	3.0	2.8	2.3	0.8	1.1	4.4	1.8	1.2	4.1	4.0	3.5
Sofala	0.7	1.5	0.5	1.6	1.1	0.6	1.9	0.5	1.0	1.3	1.8
Inhambane	1.7	1.8	1.0	2.3	3.5	2.2	4.0	2.1	4.1	5.5	3.3
Gaza	5.1	2.1	3.9	2.3	1.7	3.6	1.6	3.4	5.7	3.8	5.5
Maputo Province	3.5	3.1	6.1	6.1	10.1	7.9	1.6	2.9	0.7	2.7	4.9
Observations	4908	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.12: Pesticide use (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	5.2	6.6	6.8	10.9	3.3	8.0	6.5	9.7	12.4	4.4	6.5
Cabo Delgado	10.4	9.3	10.8	16.4	9.8	10.1	21.7	11.5	13.1	3.0	13.2
Nampula	14.5	10.3	9.7	4.1	2.9	2.8	10.8	2.0	5.5	1.4	5.3
Zambezia	0.9	1.4	1.0	1.5	0.8	0.4	0.9	0.0	0.9	0.3	1.4
Tete	8.5	4.7	7.1	8.9	12.5	6.9	1.6	5.6	13.0	5.3	9.2
Manica	3.0	1.8	2.4	0.6	1.2	3.7	3.0	1.2	3.9	3.0	1.7
Sofala	3.1	7.9	7.7	9.2	5.4	0.4	4.4	1.2	1.2	1.4	4.2
Inhambane	3.7	1.9	0.7	1.2	1.2	1.8	5.0	2.3	2.0	3.3	2.4
Gaza	6.2	1.9	2.4	0.9	2.4	3.3	1.4	2.6	4.1	2.0	3.5
Maputo Province	4.4	2.1	4.2	5.6	6.9	6.4	1.1	3.1	0.5	2.1	4.4
Observations	4908	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.13: Mechanical equipment use (Per cent)

	2002	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	2.2	0.4	0.9	0.0	1.0	0.0	1.0	0.0	1.8	1.1
Cabo Delgado	1.1	0.5	1.1	0.8	0.7	2.0	0.7	0.7	1.2	1.3
Nampula	0.0	0.5	0.0	0.1	0.3	0.3	0.6	0.3	1.5	0.6
Zambezia	0.0	0.0	0.6	1.1	0.3	0.6	0.0	1.1	1.5	2.3
Tete	0.4	5.6	0.8	1.7	0.7	1.2	0.8	1.5	2.9	3.2
Manica	3.1	3.1	2.9	2.3	3.5	2.4	0.8	2.6	4.4	1.0
Sofala	4.0	2.1	3.0	4.1	2.9	2.5	3.0	3.8	7.8	10.4
Inhambane	0.2	0.4	0.3	0.3	0.2	0.7	0.8	1.1	0.8	2.2
Gaza	7.7	10.2	6.3	6.6	5.8	5.2	6.4	8.8	11.0	5.4
Maputo Province	22.3	17.5	15.9	14.3	16.8	6.9	14.5	2.5	12.2	11.4
Observations	4908	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.14: Transport (Per cent)

	2002	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	49.0	63.3	60.7	67.6	64.6	64.7	66.4	63.6	44.7	50.4
Cabo Delgado	23.5	31.6	37.0	41.2	52.5	22.7	30.7	26.6	29.2	27.5
Nampula	16.1	36.5	33.3	41.4	38.3	28.4	32.9	22.4	28.9	17.6
Zambezia	41.8	44.8	55.0	55.2	56.5	45.1	35.9	45.0	45.6	27.7
Tete	40.6	36.5	47.2	44.2	53.0	39.2	46.8	31.0	26.2	17.5
Manica	20.5	32.8	40.1	46.0	34.7	56.0	39.3	42.0	34.1	31.8
Sofala	23.4	44.2	49.5	58.7	59.1	45.5	32.1	45.3	43.0	33.2
Inhambane	6.4	1.8	4.4	15.8	7.5	6.5	8.3	10.7	2.0	5.6
Gaza	14.9	15.9	15.4	20.6	8.5	11.6	8.4	10.0	11.6	11.9
Maputo Province	14.7	7.9	13.3	10.3	16.8	4.2	8.3	1.3	5.7	5.5
Observations	4908	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.B.15: Animal traction (Per cent)

	2002	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.1	0.0	0.3
Cabo Delgado	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.0	0.4	0.2
Nampula	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.1	0.4
Zambezia	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.1
Tete	35.2	24.6	41.4	45.6	28.7	20.7	32.8	29.3	37.6	27.4
Manica	11.4	11.7	13.8	13.7	19.1	24.3	26.3	23.8	27.6	17.7
Sofala	1.5	2.4	1.8	2.2	7.0	1.9	2.5	1.5	2.4	2.3
Inhambane	46.9	44.7	51.3	44.4	45.5	40.8	49.0	52.0	50.1	20.9
Gaza	44.1	38.1	58.0	55.2	48.6	41.5	48.9	42.8	42.9	34.2
Maputo Province	11.5	16.4	14.5	13.0	27.5	8.7	12.0	2.5	6.6	5.3
Observations	4908	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

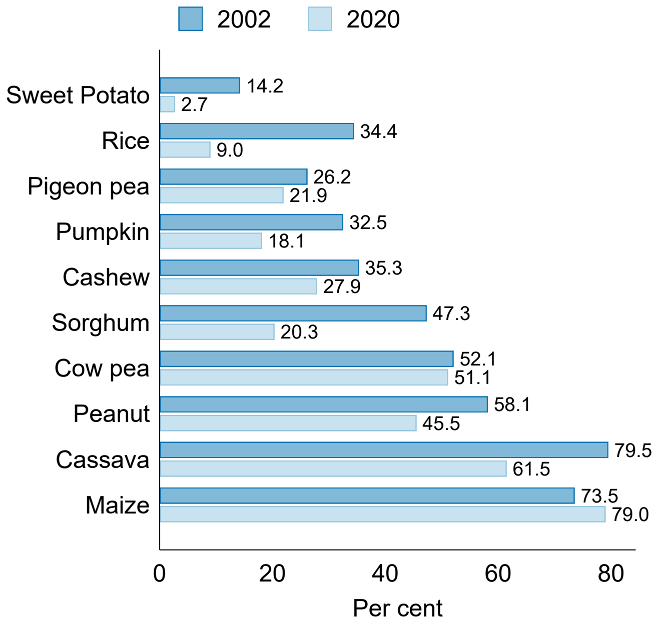
Table 7.B.16: Share of farms with at least one worker employed (Per cent)

	2005	2007	2008	2012	2014	2015	2017	2020
Niassa	13.0	24.6	19.9	21.4	19.0	13.4	13.8	14.9
Cabo Delgado	19.4	24.7	26.4	8.6	15.3	10.2	14.0	17.9
Nampula	18.2	10.7	12.8	13.7	9.5	11.0	13.5	8.0
Zambezia	12.8	23.4	17.6	19.5	11.3	15.0	10.3	6.4
Tete	22.5	33.7	22.5	14.7	24.0	17.4	20.6	13.2
Manica	22.1	18.4	30.3	19.8	16.6	22.8	25.6	21.5
Sofala	28.6	28.5	21.5	25.0	24.1	12.7	26.6	19.7
Inhambane	17.4	21.0	23.4	16.9	11.3	6.5	15.5	6.9
Gaza	21.6	22.7	22.1	26.8	21.6	12.4	16.3	5.4
Maputo Province	24.2	28.2	24.6	7.5	24.4	11.9	13.8	8.8
Observations	6149	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

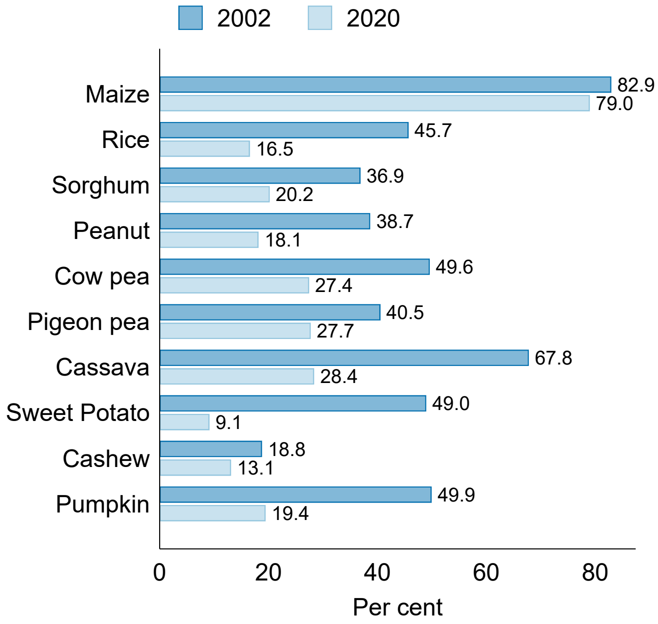
7.C Production

Figure 7.C.1: Percentage of households cultivating main crops: Northern Region



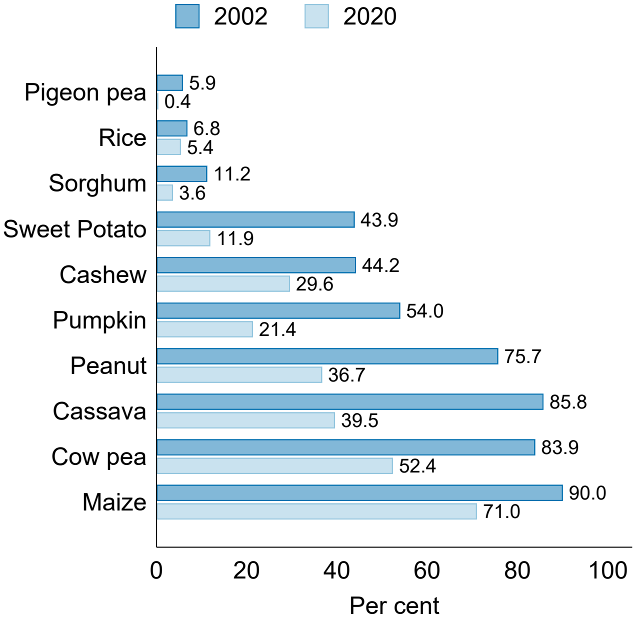
Source: Author's elaboration on TIA/IAI harmonized dataset.

Figure 7.C.2: Percentage of households cultivating main crops: Centre Region



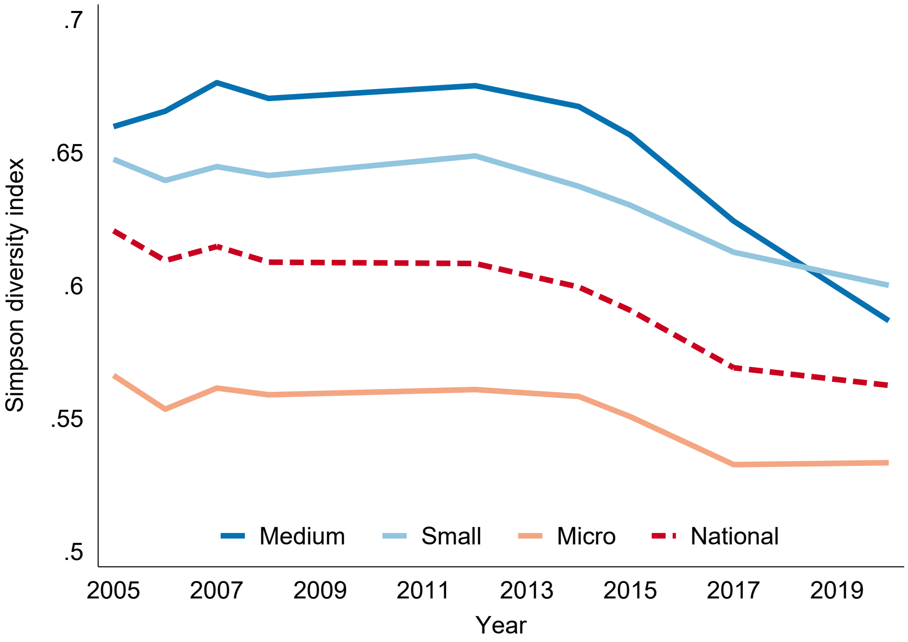
Source: Author's elaboration on TIA/IAI harmonized dataset.

Figure 7.C.3: Percentage of households cultivating main crops: Southern Region



Source: Author's elaboration on TIA/IAI harmonized dataset.

Figure 7.C.4: Evolution of Simpson Diversity Index by farm size category



Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.C.1: Total TLU value by animal categories (Millions of TLU)

	2002	2003	2005	2006	2007	2008	2012	2015	2017	2020
Cattle	0.60	0.67	0.89	0.78	0.90	0.91	1.06	1.14	1.20	1.28
Goats	0.49	0.47	0.51	0.44	0.44	0.46	0.42	0.34	0.31	0.41
Sheep	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01
Swine	0.31	0.26	0.32	0.24	0.26	0.29	0.32	0.28	0.24	0.28
Donkeys	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chickens	0.21	0.14	0.14	0.18	0.17	0.16	0.14	0.13	0.15	0.22
Rabbits	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ducks	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.03
Turkeys	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.18	0.18	0.21	0.19	0.20	0.21	0.22	0.21	0.21	0.25

Source: Author's elaboration on TIA/IAI harmonized dataset.

Table 7.C.2: Commercialization share of households by province (Per cent)

	2002	2003	2005	2006	2007	2008	2012	2014	2015	2017	2020
Niassa	65.6	69.7	67.8	74.7	64.2	62.4	65.8	59.6	61.1	63.7	65.0
Cabo Delgado	73.3	60.1	63.1	67.7	59.6	62.7	45.7	46.3	57.9	58.5	67.1
Nampula	61.1	68.9	76.0	64.6	64.2	64.8	66.3	59.6	56.5	60.3	65.6
Zambezia	75.1	68.6	67.4	77.8	66.7	74.9	69.6	53.0	64.5	51.3	59.0
Tete	70.3	62.0	65.4	63.5	61.2	65.3	60.2	46.8	59.0	57.2	58.6
Manica	71.0	69.2	65.5	70.8	62.3	53.1	54.6	49.2	59.4	53.2	61.6
Sofala	71.7	60.3	69.9	68.7	59.2	67.2	51.4	50.5	51.8	52.8	47.7
Inhambane	67.7	57.4	56.8	56.7	49.5	49.8	49.5	25.7	41.5	38.7	21.1
Gaza	43.9	38.9	46.4	39.7	33.4	32.6	24.0	18.8	23.8	21.6	20.9
Maputo Province	40.7	31.5	34.2	32.5	25.6	23.5	9.4	9.8	3.4	10.8	15.4
Observations	4908	4935	6149	6248	6075	5968	6676	6030	7034	7004	23708

Source: Author's elaboration on TIA/IAI harmonized dataset.

Chapter 8

Decomposing Agricultural Output Growth in Mozambique, 2002–2020

8.1 Introduction

Summary indicators of agricultural performance represent composite measures, capturing the combined effects of changes in the incidence of agricultural activity, cropping patterns, and productivity. As such, positive growth in one component can be offset by weaker performance in another. For this reason, unpacking these components and their proximate determinants represents a valuable analytical objective. Not least, it can help identify both successes and challenges that can, in turn, inform policy at a more granular spatial and crop level.

The present chapter presents two complementary decompositions of mean growth in agricultural output per farm over the period 2002–2020, based on the harmonized series of TIA/IAI agricultural micro-data surveys. The first approach is a component decomposition, which is an exact algebraic decomposition that partitions output growth in any given period into contributions from changes in average plot size, cropping patterns, yields, and their covariance. Applied extensively in the Indian context (for early examples, see Minhas and Vaidyanathan, 1965; Sagar, 1977, 1980), this conceptually mimics popular decompositions of labour productivity growth, which identify the roles of 'within', 'between', and 'dynamic reallocation' effects across sectors (e.g., Dumagan, 2013; Jones and Tarp, 2016b). The second decomposition uses econometric methods to understand the gap between unconditional and conditional growth rates in output levels, using a production function to apportion the difference to individual proximate determinants of output, including variation in area farmed, climatic factors, and use of modern inputs.

Our main finding is that the slow long-run rate of average agricultural output growth, which is not different from zero based on an unconditional log-linear trend, does not reflect inherently slow productivity growth *per se*. Rather, aggregate growth in yields, which also broadly corresponds to an econometric measure of total factor productivity (TFP) growth, is positive and significant at about 4 per cent per year, driven in particular by gains in cassava yields. According to the component decomposition, this is undermined by negative 'between' growth and a negative covariance term – i.e., there has been a shift out of higher-yielding crops (such as cassava) in both static and dynamic terms. This result is supported by the econometric analysis, which also highlights trend declines in mean cropped area, use of non-family labour and climatic factors as important explanations of the large observed gap between unconditional conditional rates of growth.

Although analysis of this sort ultimately is associational and cannot identify precise causal parameters, it does suggest two main policy implications. First, as is (acutely) evident from the component decomposition, there are very large variations in aggregate yields across years, at least some of which are likely to be due to measurement errors in either output quantities or plot sizes. For this reason, further investment in reliable and regular measures of agricultural performance are essential, particularly covering crops such as cassava and vegetables that are inherently more difficult to measure due to irregular harvesting and uneven cropping. Second, the juxtaposition of positive growth in yields and shifts out of higher yield, higher growth crops points to barriers to effective commercialization of (surplus) output in these specific crops. From our analysis, more careful attention to cassava value chains, including support to or development of domestic and export marketing opportunities, would seem essential.

8.2 Component decomposition

8.2.1 Methodology

Starting with the component decomposition approach, to fix ideas it is helpful to begin with a basic statement of a measure of the total real value of agricultural production (V), clarifying its underlying or constituent elements:

$$\begin{aligned} V_t &= \sum_{c\in\mathcal{C}} p_c Q_{ct} = \sum_{c\in\mathcal{C}} p_c A_{ct} \frac{Q_{ct}}{A_{ct}} \\ &= \sum_{c\in\mathcal{C}} p_c A_{ct} y_{ct} = A_t \sum_{c\in\mathcal{C}} p_c a_{ct} y_{ct} \qquad (8.1) \end{aligned}$$

where t indexes time and c crops. In terms of the components, p represents constant (real) weights, which may be represented by either monetary prices or caloric values; Q is the raw quantity of output, which can be further expressed as the product of the land area cropped (A) and the yield (y). Note, to facilitate exposition, lower case letters are used to represent ratio variables – e.g., $a_{ct} = A_{ct}/A_t$.[1] And from equation (8.1), it is evident that an aggregate measure of yield can be derived as a weighted-sum of crop-specific yields (Chapter 5; also Desiere et al., 2016):

$$Y_t = V_t/A_t = \sum_{c\in\mathcal{C}} p_c a_{ct} y_{ct} \qquad (8.2)$$

$$\implies V_t = A_t \cdot Y_t \qquad (8.3)$$

These two expressions provide a starting point for a summative decomposition of changes over time between two arbitrary periods, hereafter denoted $t = 1$ and $t = 0$, such that $\Delta V_1 \equiv V_1 - V_0$. Following standard

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[1] The same expression can be further disaggregated by geographic location $V_t = \sum_{c\in\mathcal{C}} \sum_{j\in\mathcal{J}} p_{cj} A_{cjt} y_{cjt}$, where j indexes distinct locations and prices are permitted to vary across locations. However, for the main analysis we look at either national or subregional trends.

algebraic methods we have:

$$\begin{aligned}\Delta V_1 &= A_1 Y_1 - A_0 Y_0 \\ &= \Delta A_1 Y_0 + \Delta Y_1 A_0 + \Delta A_1 \Delta Y_1 \qquad (8.4)\end{aligned}$$

which also neatly carries over to growth rates (relative changes):

$$\dot{V}_1 = \dot{A}_1 + \dot{Y}_1 + \dot{A}_1 \dot{Y}_1 \qquad (8.5)$$

where $\dot{Y}_1 = \Delta Y_1 / Y_0$.

Equation (8.5) defines aggregate growth in the value of agricultural production as the sum of the three separate terms: changes in the area allocated to production; changes in yields; and their interaction, which can be thought of as a covariation term.

Following equation (8.2), changes in aggregate yields can be further decomposed according to changes in cropping patterns and yields at the crop level. To see this, note for any given crop the change in the weighted value of the yield is given by the product of three similar terms:

$$\Delta(p_c a_{c1} y_{c1}) = p_c \left(\Delta a_{c1} y_{c0} + \Delta y_{c1} a_{c0} + \Delta a_{c1} \Delta y_{c1}\right) \qquad (8.6)$$

Summing across all crops and re-expressing in terms of growth rates gives:

$$\begin{aligned}\dot{Y}_1 &= \frac{1}{Y_0} \sum_{c \in \mathcal{C}} \Delta(p_c a_{c1} y_{c1}) \qquad (8.7) \\ &= \frac{1}{Y_0} \sum_{c \in \mathcal{C}} p_c \left(\dot{a}_{c1} a_{c0} y_{c0} + \dot{y}_{c1} y_{c0} a_{c0} + \dot{a}_{c1} \dot{y}_{c1} y_{c0} a_{c0}\right) \qquad (8.8) \\ &= \sum_{c \in \mathcal{C}} w_{c0} \left(\dot{a}_{c1} + \dot{y}_{c1} + \dot{a}_{c1} \dot{y}_{c1}\right) \qquad (8.9)\end{aligned}$$

where $w_{c0} = (p_c y_{c0} a_{c0})/Y_0$, which is just the proportional contribution of crop c to the aggregate yield.

So, bringing these expressions together we have:

$$\dot{V}_1 = \underbrace{\dot{A}_1}_{\text{Total area}} + \underbrace{\sum_{c \in \mathcal{C}} w_{c0} \dot{a}_{c1}}_{\text{Cropping pattern}} + \underbrace{\sum_{c \in \mathcal{C}} w_{c0} \dot{y}_{c1}}_{\text{Yields}} + \underbrace{\sum_{c \in \mathcal{C}} w_{c0} \dot{a}_{c1} \dot{y}_{c1} + \dot{A}_1 \dot{Y}_1}_{\text{Covariation}} \qquad (8.10)$$

An almost identical expression can be given for the change in the average value of production (per farming household), the only change to the RHS of equation (8.10) being that the mean land area farmed is substituted for the total area. Also, taking advantage of the linear nature of the decomposition, averages over multiple periods can be decomposed into period average growth rates for each component.

8.2.2 Results

Turning to implementation, we use the series of harmonized TIA/IAI micro-surveys, previously presented and discussed in Chapter 5. As noted therein, these surveys do not provide exhaustive data on all forms of agricultural production – e.g., consistent information on total quantities produced and/or areas allocated to

Table 8.2.1: Summary of data coverage, averages across all surveys

			Weights	
Crop	Area sh.	Yield	Monetary	Caloric
Maize	37.7	0.7	5.7	2.5
Cassava	17.4	6.0	4.7	1.1
Cowpea	7.1	0.2	9.8	2.9
Millet	6.9	0.4	7.0	3.6
Rice	6.6	0.3	12.1	3.6
Peanut (small)	6.0	0.3	12.8	5.9
Boer beans	4.2	0.4	8.8	3.3
Cotton	2.7	0.6	10.2	1.2
Sesame	2.4	0.4	20.7	2.5
Peanut (large)	2.4	0.3	12.8	5.9
Butter beans	2.1	0.5	16.8	2.9
Yoke beans	1.5	0.2	7.9	3.7
Tobacco	1.2	1.1	39.0	4.7
Pearl millet	1.1	0.4	5.3	3.8
Orange sweet potato	0.5	6.9	5.0	0.8
Sunflower	0.2	0.5	11.5	1.3

Source: Author's elaboration based on harmonized TIA/IAI dataset.
Note: Table summarizes the set of crops covered in the present component decomposition, including their respective land area shares; yields are in tonnes per hectare; monetary weights are 2012 constant prices; caloric weights are 10^3 calories per kilogram of raw produce; all values are survey weighted averages 2002–2020.

production are not available for some crops, such as vegetables. Also, production from livestock cannot be evaluated using the above framework. Nonetheless, for the present exercise there are adequate data from the ten surveys covering all primary staple crops, as well as some important cash crops.

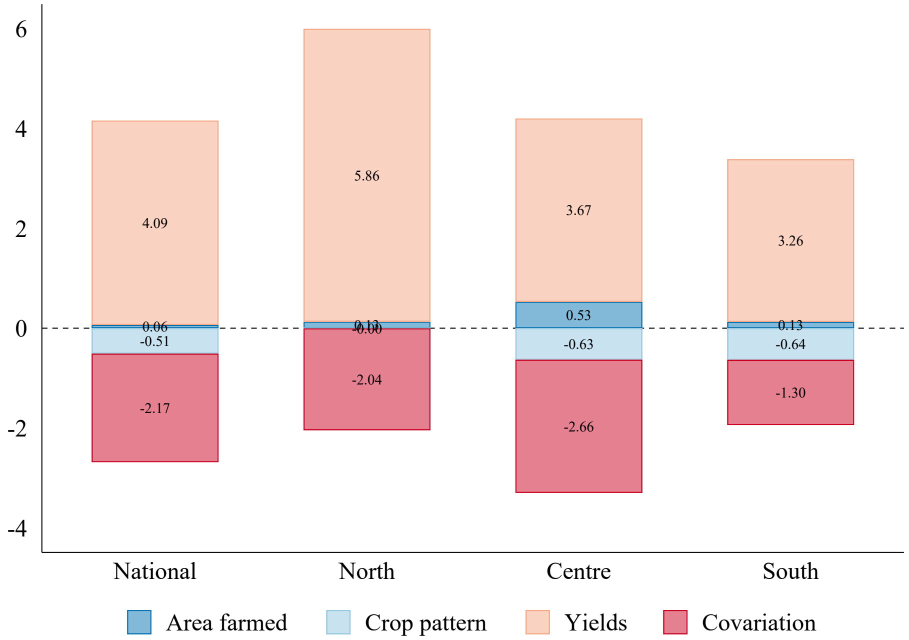
Table 8.2.1 summarizes the scope of the data used in this chapter, including the average share of land allocated to production of the selected crops, mean yields, and the (constant) monetary and caloric weights used to aggregate across crops. As indicated, we cover 16 crops from which the top five (by land share) represent around three-quarters of the total area allocated to production of the same crops. Also, while the two types of weights display a moderate positive association (Spearman rank correlation of 0.34), they are far from identical. Thus, we show results for both series; but, since a large share of production is not marketed, we focus principally on the caloric weights.

Figure 8.2.1 summarizes results from the decomposition at both the national and regional levels, showing the full period average of annualized changes in each component. The latter operation is necessary since the temporal spacing between observations (surveys) is uneven – e.g., the first observation covers the period 2002–2005, then the subsequent is for 2005–2006. Plot (a) shows results for caloric weights and (b) for monetary weights – evidently these are highly comparable. Table 8.2.2 summarizes the same information for caloric weights, including the aggregate average change in mean production per farm to which the four components sum. The same table adds corresponding provincial level estimates; and Table 8.2.3 reports period-specific national-level estimates, also reported on an annualized basis.

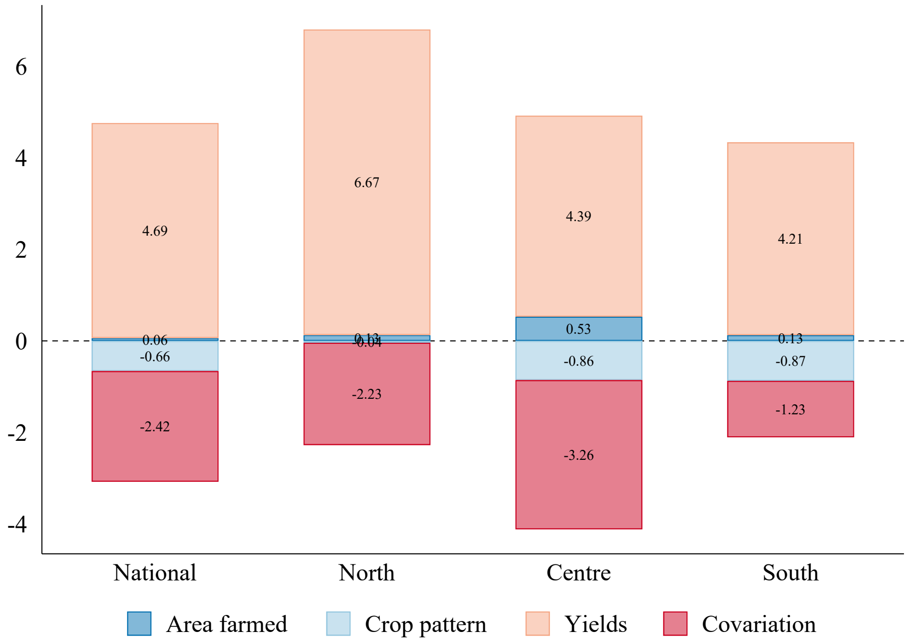
A number of main points merit highlighting. First, it is evident that variations in annual changes between periods *within* each component are substantial, particularly for measures of yields and (to a less extent) area farmed. This is not only apparent when viewed on aggregate (Table 8.2.3), but is even starker when we

Figure 8.2.1: Component decomposition of mean annualized changes in value produced per farm (2002–2020)

(a) Weighted by caloric values:



(b) Weighted by monetary prices:



Source: Author's elaboration based on harmonized TIA/IAI dataset.
Note: Figure shows component decomposition based on equation (8.10), using both monetary and caloric weights in panels (a) and (b), respectively.

Table 8.2.2: Annualized percentage changes in components of calories produced per farm (robust means), 2002–2020

	Components				
	Area	Pattern	Yields	Covar.	Calories
National	0.06	-0.51	4.09	-2.17	1.47
North	0.13	-0.00	5.86	-2.04	3.95
Centre	0.53	-0.63	3.67	-2.66	0.90
South	0.13	-0.64	3.26	-1.30	1.44
Niassa	-0.19	-0.42	4.49	-2.20	1.68
Cabo Delgado	-0.11	-1.20	7.12	-3.11	2.71
Nampula	1.19	0.62	6.97	-2.66	6.12
Zambezia	1.94	-0.54	4.80	-2.45	3.75
Tete	-0.64	-0.53	4.08	-3.12	-0.20
Manica	0.79	0.36	1.77	-1.03	1.89
Sofala	1.02	0.55	6.06	-7.26	0.38
Inhambane	-0.90	-0.83	6.85	-0.13	4.99
Gaza	1.48	-0.10	0.91	-2.43	-0.14
Maputo Prov.	3.10	1.40	5.46	-10.89	-0.93

Source: Author's elaboration based on harmonized TIA/IAI dataset.
Note: Table summarizes annualized percentage changes in components of calories produced per farm as per equation (8.10).

drill down to the regional estimates (Appendix Tables 8.A.1–8.A.3). For instance, in the Northern region we find the mean area farmed by each household increased by 9 per cent annually between 2002–2005, followed by a 4 per cent drop in 2005–2006 also accompanied by a 74 per cent increase in yields. Similarly, there is some degree of mean reversion, especially with respect to changes in yields, whereby large increases are often followed by large decreases (or *vice versa*). This variation poses two substantive challenges. On the one hand, it raises the concern that much of the variation we observe in the data may be noise, possibly driven by errors associated with outdated or problematic sample frames, as well as (systematic) measurement errors. We return to this below.

On the other hand, the simple average of (what may be) noisy observations is unlikely to provide a robust measure of central tendency. For this latter reason, we calculate adjusted means in which observations for each period are (re)weighted to reduce the influence of potential outliers.[2] These adjusted means are used in Figure 8.2.1 and Table 8.2.2; while the unadjusted (raw) national means are in Table 8.2.3 for comparison. As can be seen, differences are small but the adjusted estimates are somewhat shrunken toward zero.

A second main takeaway is that the evidence of moderate growth in mean caloric production per farm, equal to around 1.5 per cent per year at the national level, reflects two main yet opposing tendencies. Namely, changes in aggregate yields (the 'within'-crop effect) appear fairly solid at around 4 per cent per year, implying an almost doubling of average yields over the full period holding all other changes constant. In historical comparative terms, this would represent a strong performance – e.g., Briones and Felipe (2013) calculate land productivity grew by 2.24 per cent per annum between 1970 and 2009 across Asia. However, this positive contribution is offset by a negative covariation or interaction term, equal to -2.1 per cent, which

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[2] Concretely, for each crop-year-province combination we calculate the (annualized) change in yields and standardize the entire distribution, transforming to z-scores. Assuming normality, we weight each observation from this distribution by the probability it is observed by chance – e.g., a z-score of 0 attracts a weight of 1, a z-score of 0.5 attracts a weight of 0.63 and so on.

Table 8.2.3: Annualized changes in components of calories produced per farm, 2002–2020

	Components				
	Area	Pattern	Yields	Covar.	Calories
2005	7.39	1.96	-7.94	-3.15	-1.74
2006	-13.26	-6.13	85.49	-17.02	49.07
2007	5.16	4.60	-29.97	-3.67	-23.88
2008	-3.04	-1.80	-11.55	0.63	-15.77
2012	-2.69	-1.18	6.55	-0.88	1.80
2014	-2.93	1.28	9.77	0.03	8.16
2015	-1.27	-4.09	-21.10	1.61	-24.85
2017	-7.27	0.95	33.01	-4.54	22.16
2020	4.97	-2.96	-1.75	-1.58	-1.31
Mean	-0.36	-0.59	5.87	-2.51	2.40

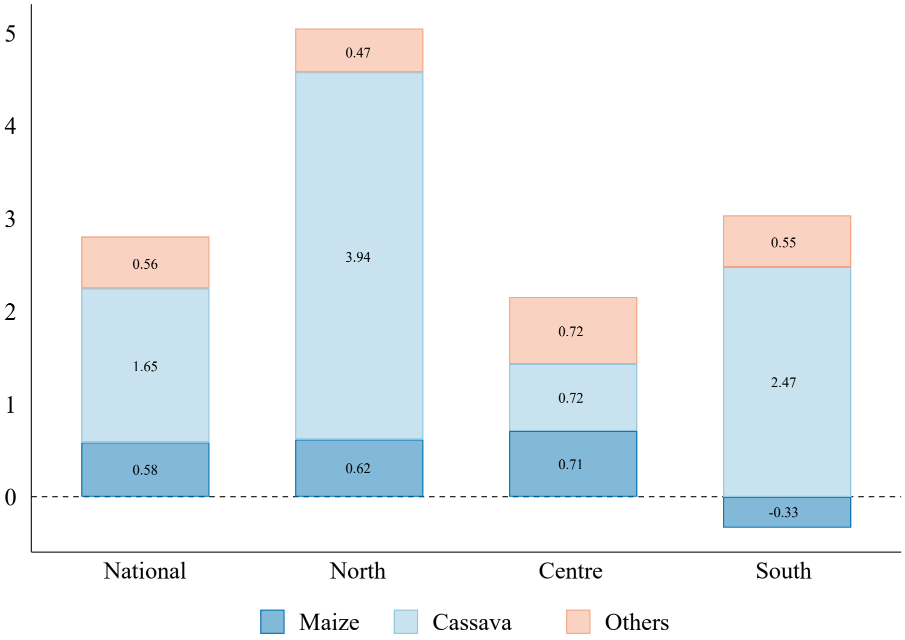
Source: Author's elaboration based on harmonized TIA/IAI dataset.

suggests that gains in yields have occurred primarily among crops that have become relatively less important in terms of their allocated area (or *vice versa*) – i.e., there have been negative dynamic reallocation effects. This may be indicative of different underlying tendencies, such as a conventional inverse size-productivity relationship. But, equally, this may well be a secondary consequence of measurement errors in plot size.

Third, there are marked regional differences. Confirming evidence from earlier chapters, long-run growth rates of agricultural production have been highest in the North, differing by around 2 percentage points from the Centre and South. In large measure, this is driven by higher yields in the North, as well as differences in cropping patterns. Outside the North we note a negative 'between' effect – indicating a relative shift toward lower yielding crops. Also, the Central region shows a large negative contribution of the covariance term.

An additional contribution of the component decomposition is to identify the role played by specific crops in average growth trends. Figure 8.2.2 summarizes the main results, showing the absolute contributions of each crop to net growth over the period 2002–2020, where changes in aggregate farm area are not taken into account. A central result is that gains in cassava yields have been fundamental to overall average yield gains, especially in the North and South. In part this reflects the significance of cassava in terms of allocated land share, but this is not the main explanation. Indeed, while maize represents over double the average share of farmed land compared to cassava, it makes a smaller overall contribution to long-run production growth. With earlier results, this insight suggests that 'within'-crop productivity gains for cassava have allowed households to allocate less land to this crop, freeing-up labour for other activities and/or other crops.

Figure 8.2.2: Mean crop-specific contributions to growth in caloric value produced per farm (2002–2020)



Source: Author's elaboration based on harmonized TIA/IAI dataset.
Note: Figure reports absolute contributions of each crop to net growth over the period 2002–2020; changes in aggregate farm area are not taken into account for simplicity.

8.3 Trend decomposition

8.3.1 Methodology

As a second exercise I turn to an econometric production function analysis. The basic point of departure is to define an aggregate measure of output (e.g., total caloric production per farm) as a function of inputs: $V_{it} = f(A_{it}, K_{it}, L_{it}, Z_{it})$, where i indexes farms; K, L are physical capital (machinery) and labour inputs, respectively; and Z captures other factors such as technology, climate, and soil quality. Since the full range of these inputs are rarely observed or measured directly, we follow Wollburg et al. (2023) and others and focus on an empirical reduced-form log-linear approximation:

$$\ln V_{ijt} = \mu_j + \delta t + C'_{it}\lambda_c + \beta_1 \ln A_{it} + K'_{it}\beta_2 + L'_{it}\beta_3 + Z'_{it}\beta_4 + \varepsilon_{it} \tag{8.11}$$

Here, j indexes locations such that μ_j captures all time-invariant unobserved factors in each location (provinces). The vector C is a set of dummy variables that take a value of one if a given product group represents the primary output of a farm (by production value), and where we distinguish between cereals, legumes, roots/tubers, and cash crops (fruit and livestock being the residual category). They include household characteristics, access to services, use of modern inputs, proxies for soil suitability, as well as climatic (weather) variables (namely, rainfall, temperature, and the Landsat Normalized Difference Vegetation Index [NDVI], expressed as standardized deviations from long-run trends). Last, ε captures the residual (unexplained) variation.

It is essential to note that equation (8.11) provides a basis for a conditional analysis or prediction of output –

i.e., *given* values of the RHS variables, we can use estimated parameter estimates to make a best prediction of the output level. In this sense, δ will indicate the trend rate of growth in output after controlling for variation in the observed covariates, which can be interpreted as a proxy for growth in TFP. This conditional trend stands in contrast to an unconditional model (e.g., Ayele et al., 2021):

$$\ln V_{ijt} = \mu_j + \delta^* t + \epsilon_{it} \tag{8.12}$$

in which δ^* will give an estimate for the raw (uncontrolled) mean rate of output growth in production.

The difference between these two estimates is of inherent interest, reflecting the net contribution of the included regressors to the unconditional trend in output. Put differently, the gap between the conditional and unconditional trend ($\delta^* - \delta$) effectively indicates the extent to which the former is driven by (linear) trends in the included covariates. Furthermore, as elaborated by Kremer et al. (2022) in the context of aggregate convergence in income across countries, the respective contributions of each individual regressor to the unconditional trend can be identified, yielding a complete decomposition of the same gap. To see the mechanics of this decomposition, consider a simplified 'true' conditional model:

$$\ln V_{it} = \mu + \delta t + \beta_0 x_{it} + \epsilon_{it} \tag{8.13}$$

$$x_{it} = x_{i0} + \gamma t + \phi_{it} \tag{8.14}$$

in which the second line partitions input x into an initial level, trend, and remaining orthogonal noise. Combining these two equations yields:

$$\ln V_{it} = (\mu + \beta_0 x_{i0}) + t(\delta + \beta_0 \gamma) + (\beta_0 \phi_{it} + \epsilon_{it}) \tag{8.15}$$

Comparing this to equation (8.12), one sees an equivalence: $\delta^* = \delta + \beta_0 \gamma$. That is, as per the formula for omitted variables bias in least squares regressions, in the absence of control variables that form part of the 'true' model, our estimate for the unconditional trend rate of growth will capture the contribution of TFP growth (the conditional trend) plus trend growth in each omitted factor weighted by its coefficient in the true production function (here, $\beta_0 \times \gamma$).

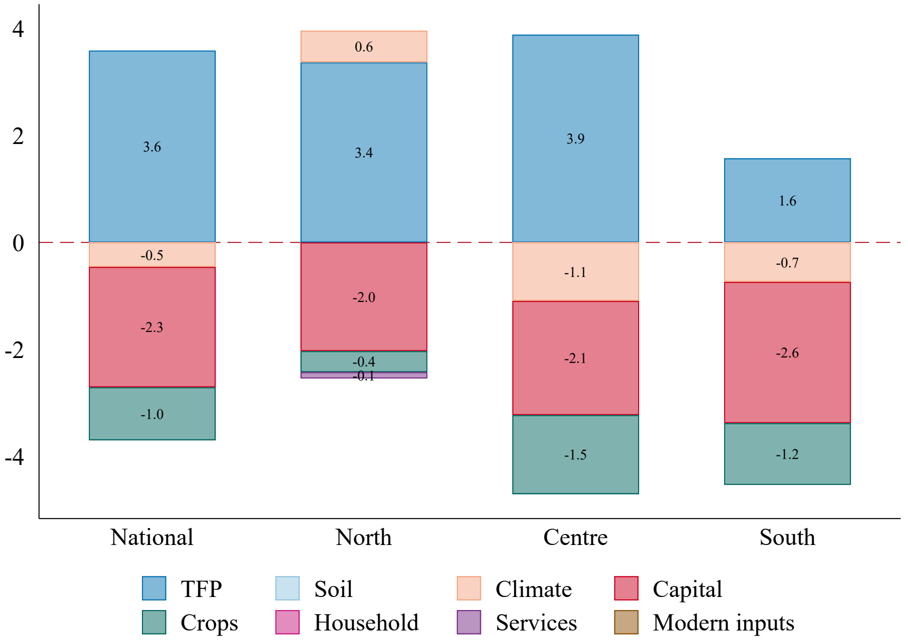
Empirical implementation of the above decomposition follows three steps. First, for each (time-varying) input factor included in the conditional model, one estimates separate regressions on the form of of equation (8.14), isolating their own trend components. Second, one estimates the complete unconditional model as per equation (8.11), indicating the effective weights of these inputs in the output function. Third, one combines these two estimates to calculate the contribution of each regressor to the unconditional trend.

8.3.2 Results

Table 8.3.1 sets out the main results pooling all data from the TIA/IAI survey (N = 72,917). The first row reports the estimate for the unconditional trend (δ^*), based on a simple OLS regression of output against a time trend and province fixed-effects. All such regressions are estimated using relevant household survey weights and standard errors are clustered at the district-by-survey level. Notably, this unconditional trend estimate is not different from zero, implying no clear sustained improvement over time in (mean) caloric production per household. This estimate differs slightly from the corresponding estimate in Table 8.2.2, primarily due to differences in the nature and focus of the analysis – i.e., here, we estimate the trend from observations in (log) levels, rather than from the more volatile growth rates. Also, compared to the previous analysis that aggregates the data, this analysis is undertaken using the farm-level micro-data.

The remaining rows of the table report results for the conditional analysis. The second row gives an estimate for the TFP growth rate (δ), which is simply the rate of growth in output after controlling for the included covariates. In line with the findings for changes in yields from the component decomposition, this is positive and significant (at about 3.66 per cent) indicating a negative unconditional-conditional growth gap, meaning that trends in observed covariates place a downward drag on output growth on a net basis. Rows three onwards decompose this gap showing individual trends in each covariate (column γ), their weight in the production function (β_0), their product and their relative contribution to the gap (final column). Figure 8.3.1 provides a visual summary of the same results, in which variables are grouped into sets and the total contribution of each group to the unconditional (net) growth rate is shown.

Figure 8.3.1: Decomposition of trend growth in caloric production per farm household, 2002–2020



Source: Author's elaboration based on harmonized TIA/IAI dataset.
Note: Figure summarizes results as per Table 8.3.1 for different geographical units, focusing on absolute growth contribution attributable to main factor groups, including TFP (the residual or unexplained component).

Focusing on the national-level results, a small number of variables explain the bulk of the growth rate gap. Principally, changes in capital inputs (physical and human) together explain 57 per cent of the gap, driven by declining trends in use of non-family labour and mean area farmed. This would be consistent with an intensification of farming – higher yields are achieved on moderately smaller plots, leading to no systematic gains in caloric output. The fact this also is achieved with less labour may indicate some shift toward non-farm activities or other challenges in securing non-family workers to support agricultural activity. A second factor dragging overall growth is changes in the choice of principal crops, namely a fall in the share of households that are dominant in the production of roots (cassava). As shown in Table 8.2.1, cassava appears to be a particularly important source of total calories – average per hectare yields for cassava are about 6 times that of major cereals and legumes, while the caloric value of cassava is only a third to one fourth of these alternatives. In other words, among alternative staples, cassava appears to offer the highest caloric

Table 8.3.1: Decomposition of trend growth in caloric production per farm household, 2002-2020

	Trend		Prod. coeff.		Growth contrib.		
	γ	(se)	$\delta^*, \delta, \beta_0$	(se)	$\beta_0 \times \gamma$	(se)	% gap
Uncond. trend	.	.	-0.26	(0.27)	.	.	.
TFP trend	.	.	3.59	(0.30)	.	.	.
Cowpea suitability	-0.01	(0.07)	0.59	(0.28)	-0.01	(0.04)	0.19
Cassava suitability	0.01	(0.09)	0.78	(0.17)	0.01	(0.07)	-0.27
Maize suitability	-0.01	(0.08)	-1.18	(0.27)	0.01	(0.10)	-0.32
Rice suitability	0.00	(0.07)	-0.07	(0.24)	-0.00	(0.01)	0.00
NDVI (z-score)	-4.40	(0.37)	0.24	(0.03)	-1.06	(0.14)	27.40
Rainfall (z-score)	-1.22	(0.24)	-0.10	(0.03)	0.12	(0.05)	-3.05
Temperature (z-score)	5.35	(0.28)	0.09	(0.03)	0.48	(0.15)	-12.43
Planted area (log.)	-1.61	(0.24)	0.44	(0.01)	-0.70	(0.11)	18.21
Planted area (log. sq.)	0.08	(0.14)	0.01	(0.01)	0.00	(0.00)	-0.02
No. of plots (log)	-2.17	(0.11)	0.07	(0.02)	-0.15	(0.04)	3.83
Tropical livestock units (log)	-2.09	(0.31)	0.08	(0.01)	-0.16	(0.03)	4.14
Trees units (log)	1.24	(0.80)	-0.00	(0.01)	-0.00	(0.01)	0.12
Uses non-family labour	-3.75	(0.18)	0.34	(0.02)	-1.26	(0.09)	32.70
Animal trans./traction	0.06	(0.13)	0.17	(0.02)	0.01	(0.02)	-0.25
Mechanical trans./traction	0.07	(0.03)	0.16	(0.06)	0.01	(0.00)	-0.30
Cereals (principal)	0.34	(0.16)	0.53	(0.11)	0.18	(0.09)	-4.71
Legumes (principal)	0.51	(0.07)	0.31	(0.11)	0.16	(0.06)	-4.11
Roots & tubers (principal)	-1.00	(0.18)	1.23	(0.11)	-1.22	(0.24)	31.71
Cash crops (principal)	0.05	(0.06)	0.56	(0.11)	0.03	(0.03)	-0.69
Diversity index	-0.17	(0.06)	0.70	(0.04)	-0.12	(0.04)	2.99
Has cash crops	-0.10	(0.11)	0.22	(0.02)	-0.02	(0.02)	0.56
Male household head	-0.57	(0.06)	0.18	(0.01)	-0.10	(0.01)	2.61
Age household head	0.17	(2.61)	-0.00	(0.00)	-0.00	(0.00)	0.00
Edu. household head	9.04	(0.52)	-0.01	(0.00)	-0.07	(0.02)	1.76
Highest edu. in household	13.54	(0.69)	0.01	(0.00)	0.14	(0.03)	-3.73
No. of adults	-0.81	(0.24)	0.01	(0.00)	-0.01	(0.01)	0.31
No. of dependents	-1.18	(0.22)	0.02	(0.00)	-0.02	(0.00)	0.50
Has land title	0.12	(0.02)	0.02	(0.04)	0.00	(0.00)	-0.08
Received price info.	-0.31	(0.14)	0.05	(0.01)	-0.01	(0.01)	0.39
Received extension	-0.41	(0.05)	0.06	(0.02)	-0.02	(0.01)	0.59
Member of a farmers org.	-0.17	(0.03)	0.04	(0.02)	-0.01	(0.00)	0.17
Received credit	-0.21	(0.02)	0.04	(0.03)	-0.01	(0.01)	0.21
Uses irrigation	-0.33	(0.07)	-0.01	(0.03)	0.00	(0.01)	-0.08
Uses fertilizer	0.09	(0.08)	0.24	(0.03)	0.02	(0.02)	-0.58
Uses pesticides	-0.11	(0.05)	-0.05	(0.02)	0.00	(0.00)	-0.13
Uses improved seeds	0.15	(0.05)	0.05	(0.02)	0.01	(0.00)	-0.17
Uses manure	-0.01	(0.05)	-0.00	(0.03)	0.00	(0.00)	-0.00
Rotates crops	-0.07	(0.09)	0.04	(0.02)	-0.00	(0.00)	0.07
Missing obs.	-5.92	(0.23)	0.02	(0.03)	-0.09	(0.13)	2.46

Source: Author's elaboration based on harmonized TIA/IAI dataset.

Note: Table summarizes trend growth decomposition based on separate linear regressions; 'growth contribution' is the product of the trend growth rate of each variable (γ) and the contribution of the same factor in a production function type regression (β_0); standard errors are in parentheses; final column gives the share of the differences between the conditional and unconditional growth rate attributable to each factor.

output per hectare. So, any shift away from production of this crop could well come at a loss for total caloric production. We reflect further on these findings below.

The third main explanatory factor for the growth gap are climate variables. Here we see a trend decline in the NDVI score, which is strongly associated with output. For instance, a one standard deviation increase in the NDVI score is associated with an approximate 24 per cent increase in caloric output. At the same time, temperature deviations – which are on an increasing trend (at five per cent per year) – are associated with higher output. But on a net basis the effect of trends in these climate indicators accounts for about 13 per cent of the growth gap. Finally, the absence of material contributions from other variables – e.g., access to services or use of modern inputs – is of note. On the one hand, this largely reflects the absence of clear growth trends in these variables. For instance, there is no significant trend in use of fertilizer, while the incidence of receipt of extension services has moderately declined. On the other hand, with some exceptions, these variables also do not appear to be of large import in the production function. For example, on average there is just a 5 per cent difference in expected output between households who do and who do not receive extension advice (holding all other factors constant).

Turning to the sub-national results summarized in Figure 8.3.1 (see also Tables 8.A.4–8.A.6 and Figure 8.A.3), distinctive regional patterns emerge. Notably, the combined effects of changes in capital inputs and cropping patterns are more marked in the Centre and South. In particular, these latter regions show a more marked decline in the choice of roots as a primary crop, as well as stronger declines in mean planted areas (e.g., more than 2 per cent per annum in the South). At the same time, while climatic factors also play a material role in all regions, they switch direction between the North and the rest of the country. In the former case, temperature increases are associated with positive output growth, which dominates the negative effect of NDVI changes. Minimally, this suggests a complex range of effects that are likely to emerge from climate change (see also Chapter 10).

8.4 Conclusion

This chapter provided two in-depth decompositions of growth trends in smallholder agricultural production in Mozambique over the period 2002–2020, based on a newly integrated and harmonized database of micro-surveys. The first approach represented an exact algebraic decomposition, splitting changes across survey periods into separate components associated (principally) with contributions of changes in farm size, crop allocations, yields, and their covariance. The most important insight from this analysis was that while average or long-run growth rates in the real value of agricultural production have been moderate, especially in light of continued rapid population growth, this masks two opposing features. On the one hand, yield growth has been robust, driven particularly by gains in cassava. On the other hand, there has been a decline in average farm areas as well as a systematic shift away from higher-yielding crops.

The second decomposition, which uses a reduced form log-linear approximation to a production function, supported the conclusion that while productivity growth (here, total factor productivity) has been positive, overall real production growth has been undermined by changes in other factors. These latter factors include changes to the climate but mainly refer to shifts in cropping patterns and declining farm sizes. At the same time, there is no clear evidence of changes in access to modern technologies or other support services that have supported productivity growth – i.e., the technology of production has remained broadly unchanged over the past 20 years, reflecting a predominance of only rudimentary techniques and basic equipment among smallholders. In fact, evidence suggests smallholder farmers now use less labour than before.

Taking stock, the deep or underlying causes behind these changes cannot be identified here. Nonetheless, an important candidate explanation is that farmers face major difficulties in exploiting opportunities to gain from surplus production – e.g., there are significant barriers to commercialization and/or insufficient incentives at higher levels in value chains (beyond the farm gate) to warrant investment of land and labour in additional production. Rather, rural communities may well consider off-farm activities to be *relatively* more lucrative. This conclusion certainly warrants more in-depth examination. As such, we recommend further analysis of constraints and opportunities in specific value chains in different regions, particularly for cassava, so as to explore how gains in yields can better translate into higher farm incomes.

Finally, it should be noted that the exact decomposition highlighted very large changes in component contributions between surveys. At best, this reflects the highly volatile and shock-prone nature of smallholder farming. At worst, it reflects significant measurement error in the data. Either way, echoing Chapter 6, sustained investment in robust statistical systems to support accurate monitoring of trends in the sector must be a priority.

Appendix

8.A Additional tables and figures

Table 8.A.1: Annualized changes in components of caloric value per farm, Northern region

	Components				
	Area	Pattern	Yields	Covar.	Value
2005	9.69	2.67	-13.54	-5.00	-6.18
2006	-3.95	-2.67	74.67	-6.45	61.59
2007	5.76	5.04	-46.34	-5.97	-41.50
2008	-3.14	0.73	-0.20	-0.41	-3.02
2012	-0.59	-1.64	13.17	-1.38	9.56
2014	-5.58	2.05	15.69	-1.12	11.04
2015	-6.20	-3.43	-26.81	2.94	-33.50
2017	-1.87	1.36	28.93	-0.41	28.02
2020	-1.32	-2.52	3.71	-1.11	-1.23
Mean	0.02	0.02	6.32	-2.04	4.32

Source: Author's estimates from harmonized TIA/IAI dataset.

Table 8.A.2: Annualized changes in components of caloric value per farm, Central region

	Components				
	Area	Pattern	Yields	Covar.	Value
2005	7.41	1.73	-3.96	-4.88	0.31
2006	-14.01	-6.29	98.26	-21.93	56.02
2007	-1.65	3.27	-15.33	-0.80	-14.51
2008	-0.51	-4.77	-14.86	0.65	-19.49
2012	-2.74	-0.89	0.18	0.14	-3.30
2014	-4.68	0.82	2.91	0.40	-0.55
2015	7.29	-3.12	-12.84	-0.54	-9.21
2017	-9.20	1.04	38.57	-7.45	22.96
2020	8.53	-2.73	-4.98	-2.21	-1.38
Mean	0.01	-0.76	6.23	-3.19	2.29

Source: Author's estimates from harmonized TIA/IAI dataset.

Table 8.A.3: Annualized changes in components of caloric value per farm, Southern region

	Components				
	Area	Pattern	Yields	Covar.	Value
2005	0.16	2.25	-1.63	0.78	1.56
2006	-15.88	-19.43	70.51	-13.99	21.20
2007	-2.41	4.68	-35.95	-0.96	-34.64
2008	-1.11	-1.89	-18.58	0.68	-20.90
2012	-4.97	0.53	16.18	-2.81	8.94
2014	11.17	-0.09	22.48	5.90	39.45
2015	-11.02	-3.56	-34.79	5.15	-44.23
2017	-11.95	-4.64	25.70	-5.98	3.12
2020	11.16	-1.58	-10.88	-4.90	-6.20
Mean	-0.99	-1.42	5.82	-1.83	1.58

Source: Author's estimates from harmonized TIA/IAI dataset.

Table 8.A.4: Decomposition of trend growth in caloric production per farm household, Northern region, 2002–2020

	Trend		Prod. coeff.		Growth contrib.		
	γ	(se)	$\delta^*, \delta, \beta_0$	(se)	$\beta_0 \times \gamma$	(se)	% gap
Uncond. trend	.	.	1.35	(0.42)	.	.	.
TFP trend	.	.	3.37	(0.38)	.	.	.
Cowpea suitability	-0.07	(0.10)	-0.46	(0.48)	0.03	(0.05)	-1.50
Cassava suitability	-0.09	(0.12)	1.12	(0.28)	-0.10	(0.14)	5.05
Maize suitability	-0.11	(0.10)	-0.40	(0.43)	0.05	(0.06)	-2.26
Rice suitability	-0.00	(0.08)	-0.34	(0.43)	0.00	(0.03)	-0.06
NDVI (z-score)	-4.08	(0.57)	0.10	(0.04)	-0.43	(0.12)	21.13
Rainfall (z-score)	-1.13	(0.44)	-0.15	(0.04)	0.17	(0.08)	-8.60
Temperature (z-score)	6.45	(0.43)	0.13	(0.04)	0.84	(0.20)	-41.89
Planted area (log.)	-0.94	(0.38)	0.40	(0.02)	-0.38	(0.16)	18.72
Planted area (log. sq.)	-0.31	(0.21)	0.03	(0.01)	-0.01	(0.01)	0.43
No. of plots (log)	-2.28	(0.17)	0.06	(0.02)	-0.14	(0.04)	7.14
Tropical livestock units (log)	-1.65	(0.24)	0.12	(0.01)	-0.19	(0.03)	9.53
Trees units (log)	0.61	(1.12)	-0.01	(0.01)	-0.01	(0.01)	0.30
Uses non-family labour	-3.76	(0.31)	0.35	(0.03)	-1.31	(0.14)	64.95
Animal trans./traction	0.02	(0.01)	-0.09	(0.17)	-0.00	(0.00)	0.06
Mechanical trans./traction	0.03	(0.01)	0.17	(0.08)	0.01	(0.00)	-0.28
Cereals (principal)	0.07	(0.20)	1.26	(0.22)	0.09	(0.25)	-4.45
Legumes (principal)	0.29	(0.11)	1.07	(0.22)	0.31	(0.13)	-15.53
Roots & tubers (principal)	-0.40	(0.25)	2.03	(0.22)	-0.81	(0.51)	40.09
Cash crops (principal)	-0.01	(0.09)	1.30	(0.22)	-0.02	(0.12)	0.83
Diversity index	0.10	(0.07)	0.71	(0.06)	0.07	(0.05)	-3.41
Has cash crops	-0.24	(0.19)	0.17	(0.03)	-0.04	(0.03)	1.99
Male household head	-0.46	(0.09)	0.21	(0.02)	-0.10	(0.02)	4.90
Age household head	-0.03	(3.25)	-0.00	(0.00)	0.00	(0.00)	-0.00
Edu. household head	9.19	(0.79)	-0.01	(0.00)	-0.06	(0.02)	2.96
Highest edu. in household	12.20	(0.81)	0.01	(0.00)	0.10	(0.03)	-4.76
No. of adults	-0.40	(0.23)	0.04	(0.01)	-0.01	(0.01)	0.72
No. of dependents	-0.20	(0.34)	0.01	(0.01)	-0.00	(0.01)	0.15
Has land title	0.08	(0.03)	-0.04	(0.08)	-0.00	(0.00)	0.15
Received price info.	-0.91	(0.21)	0.05	(0.02)	-0.05	(0.02)	2.24
Received extension	-0.55	(0.09)	0.11	(0.03)	-0.06	(0.01)	2.95
Member of a farmers org.	-0.26	(0.05)	0.04	(0.03)	-0.01	(0.01)	0.51
Received credit	-0.25	(0.02)	0.00	(0.05)	-0.00	(0.01)	0.06
Uses irrigation	-0.09	(0.05)	-0.05	(0.05)	0.00	(0.00)	-0.22
Uses fertilizer	0.01	(0.06)	0.18	(0.04)	0.00	(0.01)	-0.09
Uses pesticides	-0.21	(0.11)	0.01	(0.03)	-0.00	(0.00)	0.09
Uses improved seeds	0.15	(0.06)	0.04	(0.04)	0.01	(0.01)	-0.32
Uses manure	0.07	(0.04)	0.02	(0.06)	0.00	(0.00)	-0.07
Rotates crops	-0.43	(0.16)	0.02	(0.02)	-0.01	(0.01)	0.46
Missing obs.	-6.01	(0.37)	-0.01	(0.04)	0.04	(0.15)	-1.95

Source: Author's estimates from harmonized TIA/IAI dataset.

Table 8.A.5: Decomposition of trend growth in caloric production per farm household, Central region, 2002–2020

	Trend		Prod. coeff.		Growth contrib.		
	γ	(se)	$\delta^*, \delta, \beta_0$	(se)	$\beta_0 \times \gamma$	(se)	% gap
Uncond. trend	.	.	-0.83	(0.41)	.	.	.
TFP trend	.	.	3.89	(0.41)	.	.	.
Cowpea suitability	0.03	(0.10)	1.44	(0.38)	0.04	(0.14)	-0.77
Cassava suitability	0.09	(0.16)	0.45	(0.25)	0.04	(0.07)	-0.88
Maize suitability	0.04	(0.10)	-1.96	(0.41)	-0.08	(0.19)	1.69
Rice suitability	-0.00	(0.12)	0.28	(0.32)	-0.00	(0.03)	0.01
NDVI (z-score)	-5.06	(0.55)	0.30	(0.04)	-1.51	(0.23)	32.07
Rainfall (z-score)	-1.32	(0.29)	-0.00	(0.06)	0.01	(0.07)	-0.14
Temperature (z-score)	5.13	(0.39)	0.08	(0.05)	0.41	(0.21)	-8.73
Planted area (log.)	-1.92	(0.35)	0.49	(0.02)	-0.94	(0.18)	19.82
Planted area (log. sq.)	0.03	(0.20)	0.03	(0.01)	0.00	(0.01)	-0.02
No. of plots (log)	-1.93	(0.17)	0.00	(0.03)	-0.01	(0.05)	0.12
Tropical livestock units (log)	-2.59	(0.52)	0.08	(0.01)	-0.22	(0.05)	4.65
Trees units (log)	1.26	(1.12)	-0.00	(0.01)	-0.00	(0.01)	0.01
Uses non-family labour	-3.62	(0.27)	0.27	(0.03)	-0.99	(0.11)	21.02
Animal trans./traction	0.20	(0.19)	0.08	(0.03)	0.02	(0.02)	-0.34
Mechanical trans./traction	0.11	(0.06)	0.01	(0.10)	0.00	(0.01)	-0.02
Cereals (principal)	0.49	(0.24)	0.91	(0.13)	0.45	(0.22)	-9.46
Legumes (principal)	0.55	(0.10)	0.88	(0.14)	0.49	(0.12)	-10.29
Roots & tubers (principal)	-1.38	(0.27)	1.59	(0.13)	-2.19	(0.46)	46.48
Cash crops (principal)	0.11	(0.09)	0.94	(0.13)	0.11	(0.08)	-2.28
Diversity index	-0.44	(0.10)	0.73	(0.05)	-0.32	(0.07)	6.80
Has cash crops	-0.01	(0.14)	0.28	(0.03)	-0.00	(0.04)	0.07
Male household head	-0.69	(0.09)	0.17	(0.02)	-0.12	(0.02)	2.45
Age household head	0.79	(2.80)	-0.00	(0.00)	-0.00	(0.00)	0.01
Edu. household head	9.41	(0.79)	-0.01	(0.00)	-0.06	(0.04)	1.19
Highest edu. in household	14.11	(1.03)	0.01	(0.00)	0.17	(0.05)	-3.61
No. of adults	-0.62	(0.33)	0.01	(0.01)	-0.00	(0.00)	0.10
No. of dependents	-1.69	(0.33)	0.01	(0.00)	-0.02	(0.01)	0.47
Has land title	0.16	(0.04)	-0.01	(0.06)	-0.00	(0.01)	0.05
Received price info.	0.05	(0.18)	0.04	(0.02)	0.00	(0.01)	-0.04
Received extension	-0.31	(0.08)	0.01	(0.03)	-0.00	(0.01)	0.08
Member of a farmers org.	-0.08	(0.05)	0.08	(0.03)	-0.01	(0.00)	0.13
Received credit	-0.18	(0.03)	0.09	(0.05)	-0.02	(0.01)	0.35
Uses irrigation	-0.37	(0.11)	-0.06	(0.03)	0.02	(0.01)	-0.49
Uses fertilizer	0.17	(0.15)	0.27	(0.05)	0.05	(0.04)	-0.98
Uses pesticides	-0.05	(0.05)	-0.04	(0.05)	0.00	(0.00)	-0.04
Uses improved seeds	0.15	(0.09)	0.03	(0.03)	0.00	(0.00)	-0.09
Uses manure	0.05	(0.08)	-0.00	(0.04)	-0.00	(0.00)	0.00
Rotates crops	0.16	(0.13)	0.06	(0.02)	0.01	(0.01)	-0.21
Missing obs.	-5.86	(0.35)	0.01	(0.04)	-0.04	(0.18)	0.80

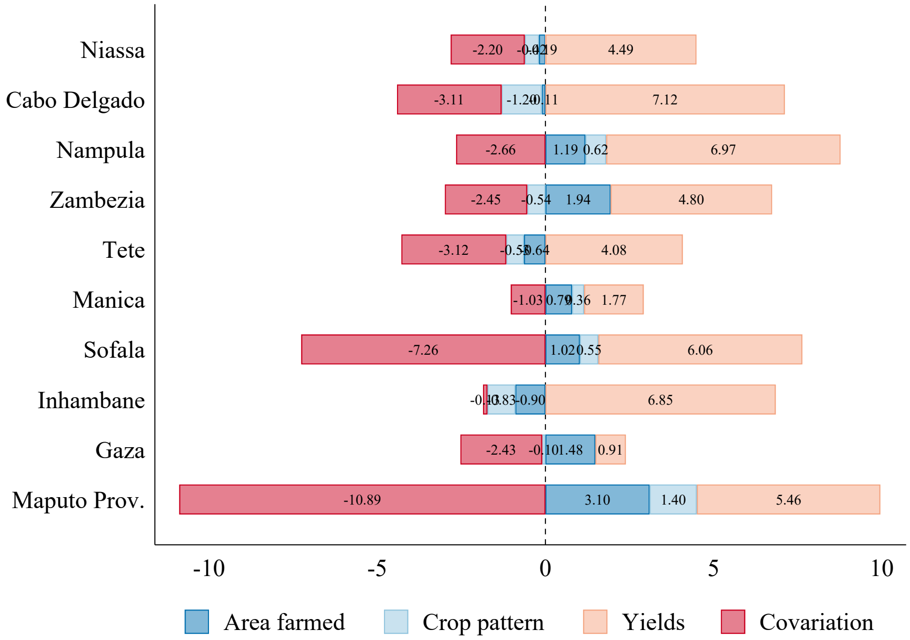
Source: Author's estimates from harmonized TIA/IAI dataset.

Table 8.A.6: Decomposition of trend growth in caloric production per farm household, Southern region, 2002–2020

	Trend		Prod. coeff.		Growth contrib.		
	γ	(se)	$\delta^*, \delta, \beta_0$	(se)	$\beta_0 \times \gamma$	(se)	% gap
Uncond. trend	.	.	-2.66	(0.66)	.	.	.
TFP trend	.	.	1.57	(0.88)	.	.	.
Cowpea suitability	0.01	(0.07)	-0.38	(0.71)	-0.00	(0.03)	0.07
Cassava suitability	0.03	(0.17)	1.02	(0.34)	0.03	(0.18)	-0.76
Maize suitability	0.09	(0.12)	-0.86	(0.49)	-0.08	(0.13)	1.92
Rice suitability	0.02	(0.06)	1.33	(1.04)	0.03	(0.09)	-0.60
NDVI (z-score)	-3.12	(1.00)	0.41	(0.10)	-1.27	(0.56)	29.88
Rainfall (z-score)	-1.11	(0.53)	0.10	(0.10)	-0.11	(0.16)	2.54
Temperature (z-score)	3.14	(0.93)	0.20	(0.09)	0.63	(0.45)	-14.96
Planted area (log.)	-2.38	(0.44)	0.33	(0.02)	-0.79	(0.17)	18.75
Planted area (log. sq.)	1.30	(0.38)	-0.06	(0.02)	-0.08	(0.04)	1.93
No. of plots (log)	-2.68	(0.21)	0.23	(0.04)	-0.62	(0.17)	14.69
Tropical livestock units (log)	-1.67	(0.56)	0.04	(0.01)	-0.07	(0.03)	1.69
Trees units (log)	2.83	(2.45)	0.03	(0.01)	0.07	(0.08)	-1.70
Uses non-family labour	-4.14	(0.35)	0.26	(0.05)	-1.09	(0.30)	25.65
Animal trans./traction	-0.30	(0.31)	0.26	(0.03)	-0.08	(0.08)	1.85
Mechanical trans./traction	0.07	(0.12)	0.31	(0.06)	0.02	(0.04)	-0.52
Cereals (principal)	0.59	(0.37)	0.36	(0.16)	0.21	(0.16)	-4.99
Legumes (principal)	0.95	(0.17)	-0.27	(0.14)	-0.25	(0.18)	5.96
Roots & tubers (principal)	-1.33	(0.30)	0.85	(0.14)	-1.13	(0.35)	26.72
Cash crops (principal)	-0.00	(0.00)	0.60	(0.39)	-0.00	(0.00)	0.06
Diversity index	0.03	(0.15)	0.46	(0.11)	0.01	(0.07)	-0.29
Has cash crops	0.02	(0.02)	0.36	(0.10)	0.01	(0.01)	-0.17
Male household head	-0.45	(0.10)	0.08	(0.03)	-0.04	(0.02)	0.84
Age household head	-1.27	(3.40)	0.00	(0.00)	-0.00	(0.01)	0.04
Edu. household head	7.47	(1.06)	-0.01	(0.01)	-0.05	(0.06)	1.22
Highest edu. in household	15.23	(1.09)	0.01	(0.01)	0.16	(0.12)	-3.69
No. of adults	-2.51	(0.46)	0.01	(0.01)	-0.02	(0.03)	0.49
No. of dependents	-2.13	(0.43)	0.02	(0.01)	-0.05	(0.02)	1.06
Has land title	0.12	(0.06)	0.15	(0.07)	0.02	(0.01)	-0.43
Received price info.	0.11	(0.19)	0.12	(0.03)	0.01	(0.02)	-0.32
Received extension	-0.36	(0.11)	-0.04	(0.05)	0.02	(0.03)	-0.36
Member of a farmers org.	-0.22	(0.09)	-0.08	(0.05)	0.02	(0.02)	-0.39
Received credit	-0.18	(0.02)	-0.00	(0.10)	0.00	(0.02)	-0.02
Uses irrigation	-0.80	(0.19)	0.04	(0.06)	-0.03	(0.06)	0.72
Uses fertilizer	0.07	(0.07)	0.11	(0.10)	0.01	(0.01)	-0.19
Uses pesticides	-0.02	(0.06)	0.02	(0.09)	-0.00	(0.00)	0.01
Uses improved seeds	0.12	(0.08)	0.16	(0.04)	0.02	(0.01)	-0.47
Uses manure	-0.40	(0.13)	-0.06	(0.05)	0.03	(0.03)	-0.61
Rotates crops	0.16	(0.13)	0.06	(0.04)	0.01	(0.01)	-0.24
Missing obs.	-5.86	(0.48)	-0.04	(0.09)	0.23	(0.70)	-5.39

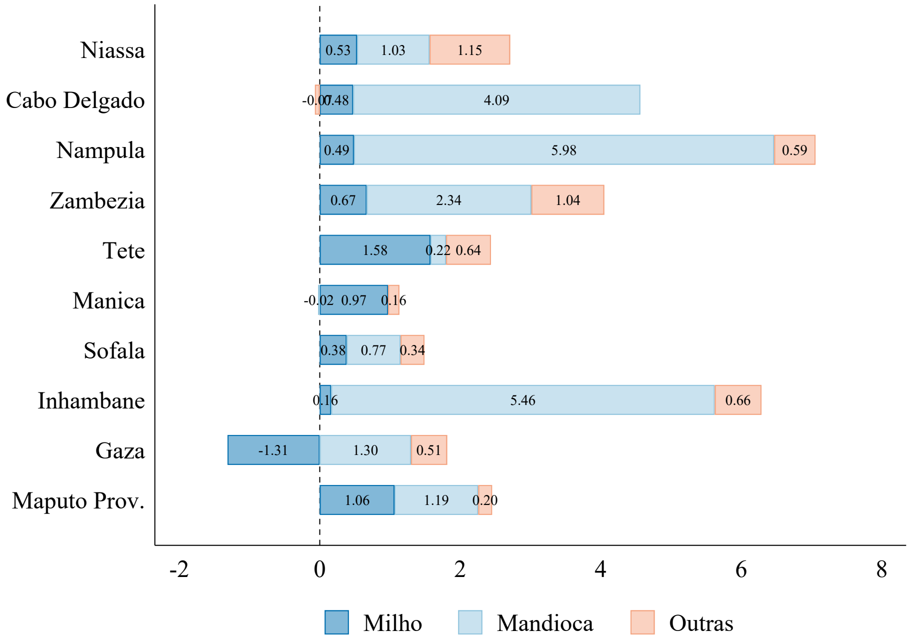
Source: Author's estimates from harmonized TIA/IAI dataset.

Figure 8.A.1: Component decomposition of mean annualized changes in caloric value produced per farm, by province (2002–2020)



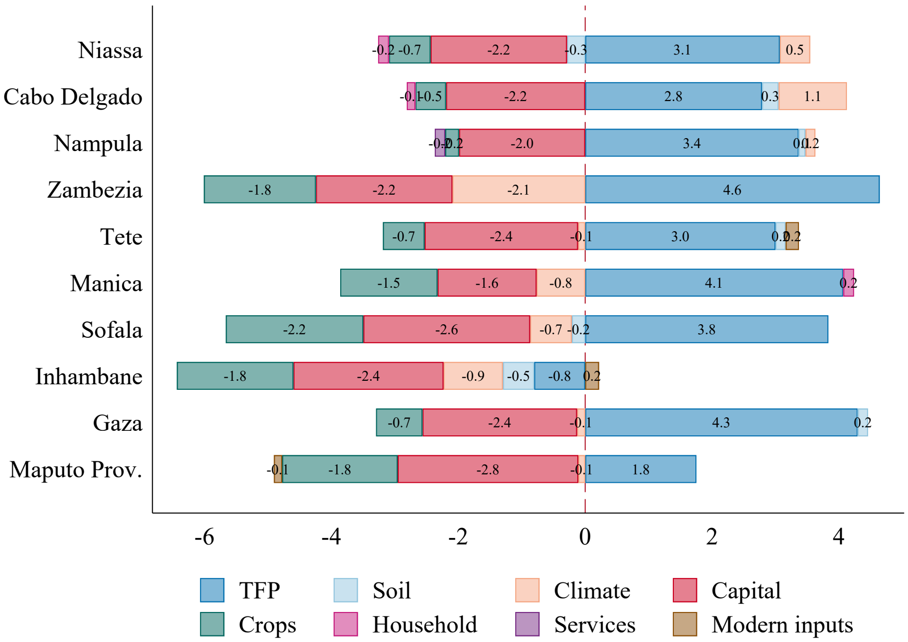
Source: Author's estimates from harmonized TIA/IAI dataset.

Figure 8.A.2: Mean contribution to changes in caloric value produced per farm, by crop & province (2002–2020)



Source: Author's estimates from harmonized TIA/IAI dataset.

Figure 8.A.3: Decomposition of trend growth in caloric production per farm household, 2002–2020



Source: Author's estimates from harmonized TIA/IAI dataset.

Chapter 9

What Do Successful Smallholder Farming Strategies Look Like?

9.1 Introduction

The fight against poverty is a central concern for the Government of Mozambique, where about one person in two is poor (Barletta et al., 2022; DEEF, 2016) and more than 40 per cent of the population is chronically poor (Baez Ramirez et al., 2018).[1] The prevalence of poverty is much higher in rural than in urban areas and in the north compared to the south of the country. The progress in poverty reduction is slow and it was further derailed by the COVID-19 pandemic (Barletta et al., 2022). As in many other African countries, agricultural households are disproportionately affected by poverty. The poverty rate of households whose head works in agriculture is 75 per cent, which is well above the national poverty level (Baez Ramirez et al., 2018). Despite agriculture being the most common source of livelihoods in the country, Mozambique is a net importer of food (IFAD, 2023) and agricultural households perceive food insecurity at a higher rate than their non-agricultural counterparts (FAO, 2021).

Agriculture is central to several government policies aiming to accelerate economic growth, reduce poverty, and improve food security. In 2007, Mozambique developed the Green Revolution Strategy, aimed at improving agricultural productivity through the National Plan for Agriculture Sector Investment (PNISA) and the Strategic Plan for the Development of the Agricultural Sector (PEDSA), which focused on improved inputs and technology packages (utilizing improved commercial seeds and chemical fertilizers, and investing in irrigation and mechanization) and on promoting agribusiness, nutritious food, and cash crops (Monjane et al., 2018; FAO, 2012). The main cash crops in Mozambique are tobacco, cotton, sugarcane, and cashew. As cash crops often have higher added value than food crops, cash crops production can increase household income and promote further aspects of well-being such as investment in health and education (Govereh and Jayne, 2003; Poulton et al., 2001). However, there is a concern over increased food insecurity and malnutrition when resources are inequitably used for cash crops instead of for food crops (Timmer, 1988; Achterbosch et al., 2014). More recent experiences from Malawi, Uganda, and Tanzania indicate that agricultural com-

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[1] Chronically poor households are identified as those who are unable to afford basic food and non-food baskets and also face deprivation in at least three other non-monetary measures of human welfare such as education, access to basic services, housing conditions, and ownership of basic assets.

mercialization tends to be increasingly driven by the sale of staple and other food crops and not necessarily by traditional cash crops (Carletto et al., 2017).

Agricultural commercialization can have positive impacts on household earnings, welfare, and nutritional status based on productivity improvements and indirect access to inputs and skills, which can be used to increase productivity in other household activities (von Braun, 1995; Barrett, 2008; Govereh and Jayne, 2003). Households' decision to participate in markets as sellers depends on numerous factors, including sale volume, price stability, technical skills, market imperfections, risk, agricultural policies, infrastructure (e.g., road and irrigation availability), and climatic conditions (Heltberg and Tarp, 2002; Rao and Qaim, 2011; Seng, 2015). These constraints vary by location and over time, resulting in a varying degree of market participation and commercial agriculture in the country. Farm households decide on the crop mix to produce, including both staple food crops and cash crops, and ultimately whether and how much of what they produce to sell. The resulting decisions define their livelihood strategies, which further determine their earnings and well-being.

Given that the costs and benefits of market participation fluctuate over time, we explore to what extent identifying and tracing changes in livelihood strategies can be a useful indicator of agricultural development. In this chapter, we first identified key livelihood strategies of smallholder households and described their evolution. We based the categorization of livelihood strategies on a handful of variables, including commercialization, crop portfolio, and the size of landholdings. We then investigated the contribution of key factors in determining the identified strategy choices. Finally, we explored how categorization of livelihood strategies can help us understand farmers' success outcomes such as income, yield, and food security relative to other types of performance estimations based on using extensive sets of control variables. The latter allows concluding whether the identified livelihood strategies are already an outcome of a farmer's decision-making and already capture the impact of endowments and production inputs. Thus, identifying the most common livelihood strategies based on a limited set of key variables (including the type of main crops produced, their share sold, share of area cultivated by the main crops, and the size of total cultivated area) could be an efficient way of describing and monitoring progress in agricultural development.

It is important to improve our understanding of livelihood strategies, particularly how commercialization and different combinations of food crops and cash crops influence various aspects of well-being of smallholder farming families. This can contribute to identifying sustainable development trajectories for agricultural production traditionally oriented towards subsistence. It can also help refine policies perpetually concerned about achieving balance between agricultural productivity modernization, goals, and smallholder participation and their livelihoods.

We identified five predominant livelihood strategies: cereals, legumes, roots/fruits, medium, and cash crops/livestock. We assessed how these relate to revenue from agriculture, overall yield, and food security and found that the well-being of farm households depends on a careful selection of the crop mix and inputs. The medium livelihood strategy based on larger landholdings is the only one with consistently better performance than the cereals strategy in terms of income, overall yields, and food security. This cluster achieves the highest revenue, overall yields, and food security but it comprises the smallest number of households. We found a limited role of cash crops and crop diversification in preventing poverty and food insecurity. However, improving efficiency in accessing production inputs is crucial for improving well-being of farm households. We also attempted to assess whether farmers' livelihood strategies can be used to measure progress in agricultural development and discovered that on their own they leave a large fraction of performance outcomes unexplained. Models with additional household and production controls had more explanatory power, which was, however, far from enviable. Consequently, increasing coverage and consistency of data collection is needed for better understanding of the key mechanisms for guiding sustainable agricultural development.

9.2 Methods

9.2.1 Key outcome and control variables

We estimate how key livelihood strategies are related to revenue from agriculture, productivity, and food security. Revenue from agriculture is obtained by summing the value of all crops sold and dividing the value by the number of household members. The value of all crops is obtained by multiplying the quantity sold with the price of a particular product. To account for inflation, prices are set to 2012 values. Productivity is measured as overall yield following Desiere et al. (2016), who calculate it as the energy content of total crop production (calculated as the total quantity of output per cultivated surface area) relative to the calorific content of maize, which is the main staple crop in Mozambique.

We assess the household's state of food security based on self-reported food availability, subjective experience of food security, and calorie production. The food availability variable was constructed based on the number of meals during the lean season. This variable takes value 1 if the household typically consumes more than three meals per day and 0 if less than that. The subjective measure of food security was obtained from the responses to the question *Did you struggle to feed all the household members in the last 12 months?* The subjective experience of food security is a binary variable taking value 1 if the respondent stated that there were no challenges related to feeding all household members in the past year and value 0 if otherwise.

The variable measuring the amount of calories produced per household member per day is constructed by multiplying the quantity of food crops produced in a year by the calorie content conversion factors obtained from the food composition tables (Leung et al., 1968) and dividing the amount by household size and 365 to obtain daily per capita amounts. Based on this, a binary *calories produced* variable is constructed by assigning the value 1 if the amount of produced calories per person per day is larger than 1800 calories and the value 0 if less than that.[2] When applying the calorie conversion factors, we specified that the beans calories are for dry beans and that the cashew calories are for raw cashew nuts. For maize, we used the mean value between food composition tables for Mozambique and Africa in general (Leung et al., 1968) given their huge variation. Moreover, as the data do not contain information about quantity of fruits, vegetables, and meat, we could not calculate calories for these product groups. For these and other products with missing calorie content information, we imputed the missing values with the average calories for the crop category.

Using these three variables, we predict two versions of the food security index using the two-parameter logistic (2PL) estimation model. This model is founded in the item response theory, allowing a consistent way of evaluating the contribution of an individual item (the three food security measures) to the latent measure being estimated (the food security index) (Charamba et al., 2023). The predicted value of food security is then converted to an index by centring around zero and multiplying by 100.

The crop diversification index is created as the inverse of the squared cultivated area for each crop. The technology index variables combines dummies for improved seeds, fertilizer, pesticides, manure, irrigation,

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[2] For detailed information on food composition tables for Mozambique, please refer to Korkalo et al. (2011).

land title, crop rotation, mechanized and manual equipment, receiving price information, extension services, having farmer organization membership, and credit. The index counts the number of different production practices or technologies are used. It is centred around zero.

9.2.2 Cluster analysis to identify main livelihood strategies

We used cluster analysis to identify five predominant types of households based on the main crop type produced, share of value sold of each of the main crop types, share of area cultivated by a specific crop type, and the total area cultivated by the household. Crops were grouped into the following main types: cereals, legumes, roots and tubers, fruits, and non-food cash crops. For each crop type, we calculated shares in total value sold and cultivated area (in hectares). Cluster analysis groups households based on similarities in the key measures, which we used to define different livelihood strategies, while at the same time it assures that the clusters be dissimilar to each other (Johnson and Wichern, 2007; Rencher and Christensen, 2012). Five household types were identified based on the five key measures, the absolute-value distance similarity (Minkowski with argument 1), and randomly choosing 2000 unique observations by each cluster as starting centres. The clusters were validated based on size, relevance, and prior research findings. For example, Manlosa et al. (2019) used the type of food and cash crops produced by Ethiopian households to identify five distinct livelihood strategy clusters, Oumer et al. (2013) and Iiyama et al. (2008) classified households in Ethiopia and Kenya, respectively based on the main crop type and the main type of income-earning activities, while Leonardo et al. (2015) grouped Mozambican households based on the size of cultivated area and the extent of hiring non-household labour for agricultural production.

9.2.3 Estimation of multinomial treatment effects

We use ordinary least square regressions to estimate correlations between our key outcome variables (revenue from agriculture, overall yield, and food security) and the main farm types pursuing five livelihood strategies using separate linear regressions for each dependent variable. We control for socio-economic characteristics of households, including gender, age, age squared, and level of education of the household head, single-woman household indicator, household size, and number of dependents. We also control for household endowments, in particular cultivated area, cultivated area squared, number of plots, number of trees, tropical livestock units, and crop diversity, as well as for agricultural production practices such as fertilizer use, improved seeds use, irrigation use, pesticides use, manure use, and whether a household hires farm labour. In addition, we control for the use of various services such as credit, extension, price information, and farmer organization membership, as well as for climate conditions, including average district temperature, precipitation level and the normalized difference vegetation index (NDVI) obtained from Landsat (Vermote et al., 2016) in the crop-growing period. All estimations include region fixed effects (North and Centre compared to South as the reference category) and region-year fixed effects.

Given that the choice of a livelihood strategy and consequently the farm type is not random, we use maximum simulated likelihood estimation with instrumental variables. Livelihood strategies are instrumented with district-level crop prices in the previous year.

9.3 Results

9.3.1 Livelihood strategy clusters

The cluster analysis grouped smallholder agricultural households in Mozambique into five distinct clusters, each characterized by a unique livelihood strategy. Table 9.3.1 shows the distribution of clusters by farm size category (micro, small, and medium). Slightly more than 40 per cent of farms are micro (below 1 hectare of cultivated area), about half are small (1–3 hectares), and just below 10 per cent are medium-sized cultivating above 3 hectares. The cereals cluster is mostly in the small farm size category, while the legumes and roots/fruits clusters are mostly micro-sized. The medium cluster is exclusively in the medium farm size category. The cash crops/livestock cluster mostly operates small farms, but there are also 20 per cent of micro- and 20 per cent of medium-sized farms in this cluster. This cluster has the second-highest prevalence of medium-sized farms.

Table 9.3.1 also shows the prevalence of each cluster in different parts of the country. All clusters are present in all regions, but there are clear regional differences. For example, most households from the cereals cluster are located in the Centre, from the legumes and cash crops/livestock clusters in the North, and from the roots/fruits cluster in the South. The medium cluster is located in the Centre.

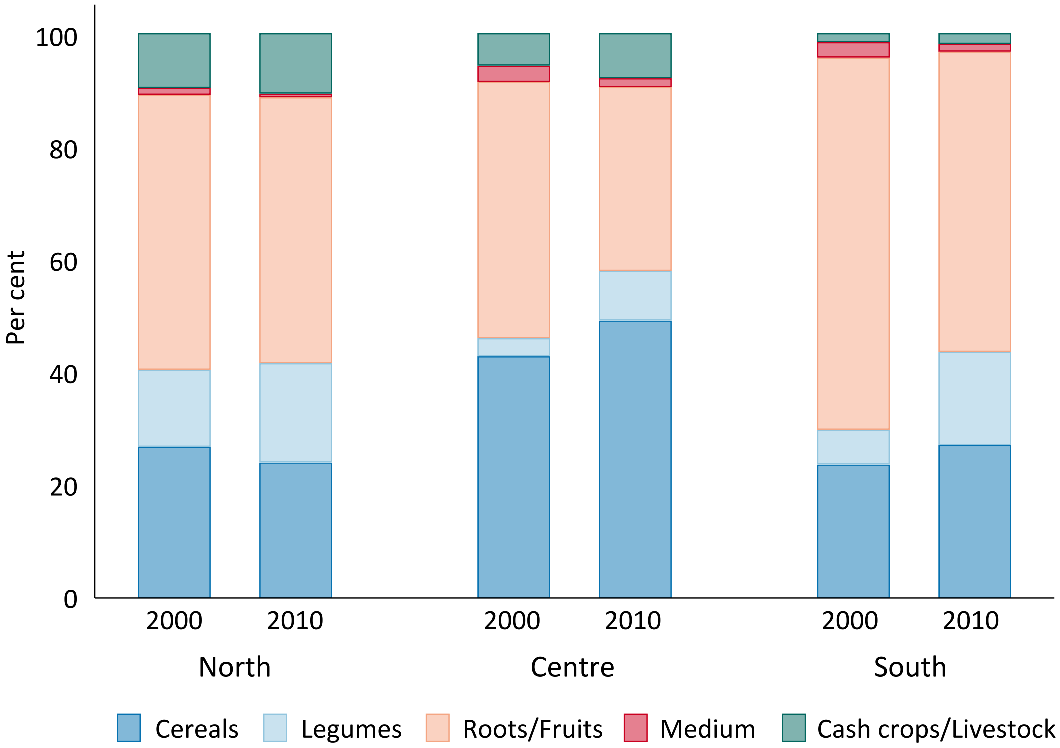
Table 9.3.1: Different clusters by location and size category

	Cereals	Legumes	Roots/Fruits	Medium	C. crops/Lives.	Total
Micro	39.6	48.0	47.7	0.0	20.4	42.0
Small	51.5	46.4	46.6	0.0	59.4	48.5
Medium	8.9	5.6	5.7	100.0	20.2	9.5
North	26.1	55.5	38.6	19.6	50.7	36.5
Centre	63.5	28.8	41.9	62.7	45.8	48.8
South	10.5	15.7	19.5	17.7	3.5	14.7

Source: Author's elaboration based on TIA/IAI harmonized dataset.

Figure 9.3.1 shows the spatio-temporal distribution of household clusters embodying five distinct livelihood strategies. Comparing the 2010–2020 (actual included survey years 2012, 2014, 2015, 2017, and 2020) and 2000–2010 decades (actual included survey years 2002, 2005, 2006, 2007, and 2008), we see an overall increasing trend to specialize in legumes over time in all parts of the country. We also see a tendency for lower specialization in combined roots and fruits production, a slightly increasing trend for cash crops/livestock production in North and Centre, and a declining share of medium farms across. The share of cereals producers has declined in the North but increased slightly in Centre and South.

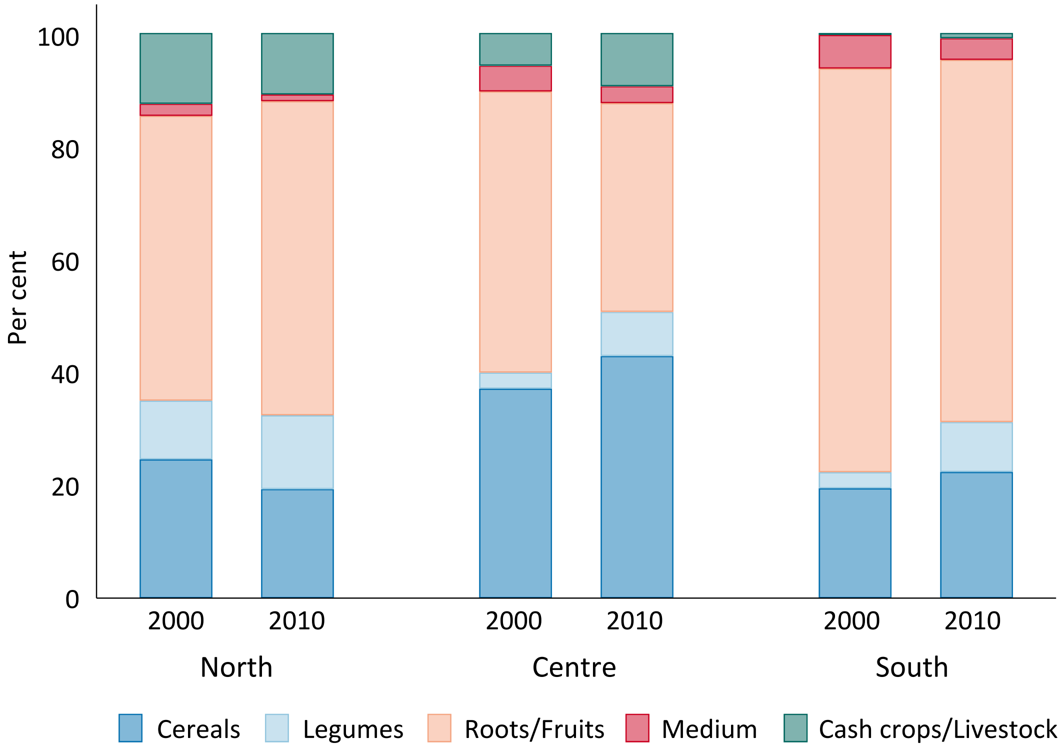
Figure 9.3.1: Spatio-temporal distribution of the main livelihood strategies



Source: Author's elaboration based on TIA/IAI harmonized dataset.

Defining success as above median in terms of yields, revenue, and food security, Figure 9.3.2 shows the distribution of successful farms by livelihood strategy. Looking over the entire time period, only the medium farm cluster has more than half of its households in the successful category. Comparing the second (2010–2020) and the first (2000–2010) decade, there has been an increase in successful farms in the cereals cluster in the Centre and the South, and a decrease in the North. There has been an expansion of successful legumes and cash crops/livestock farms, but the prevalence of successful cash crop/livestock farms is much lower in the South compared to other parts of the country. There has been a decrease in successful medium farms throughout the country. The successful part of the roots/fruits cluster increased in the North and decreased in the South and Centre.

Figure 9.3.2: Distribution of successful farms by cluster type



Source: Author's elaboration based on TIA/IAI harmonized dataset.

Table 9.3.2 shows production profiles of the five clusters. The first cluster comprises households pursuing a predominantly cereal-based livelihood strategy. This is the second-largest cluster, comprising 35 per cent of all households. The second identified cluster consists of households that mainly produce legumes. This cluster takes up about 10 per cent of all households. The third cluster is made up of households producing roots (97 per cent) and fruits (3 per cent). This is the largest cluster, comprising 45 per cent of all households. The fourth cluster contains medium-sized farms that produce a mix of crops, including cereals (43 per cent), legumes (11 per cent), roots (34 per cent), fruits (2 per cent), and cash crops (9 per cent). The fifth cluster is made of households focused on cash crops production (86 per cent), livestock (10 per cent), and some fruits (4 per cent). Livestock production in all apart from the last cluster is almost entirely absent. Clustering of households according to livelihood strategies thus indicates distinct roles of cereals, cash crops, and other food crops in sustaining household livelihoods.

Table 9.3.3 shows how average values of total cultivated area and area for different crops vary by cluster. As expected, the medium cluster cultivates the most land, 5.5 hectares on average. Of these, 51 per cent are dedicated to cereals, 22 per cent to legumes, about 11 per cent to cash crops, 9 per cent to roots, and 6 per cent to vegetables. The cash crops/livestock cluster cultivates 2 hectares on average, of which 43 per cent are under cereal grains, 30 per cent under cash crops, 15 per cent under legumes, 7 per cent under roots, and 4 per cent under vegetables. The cereals cluster cultivates 1.4 hectares on average, of which 66 per cent are dedicated to cereals, 16 per cent to legumes, 7 per cent to roots, 6 per cent to vegetables, and 3 per cent to cash crops. The legumes and roots/fruits cluster cultivate 1.2 hectares of land each. For the

Table 9.3.2: Production profiles of different clusters

	Cereals	Legumes	Roots/Fruits	Medium	C. crops/Lives.	Total
Cereals	100.0	0.8	0.0	42.7	0.0	36.3
Legumes	0.0	99.1	0.0	11.2	0.0	10.4
Roots	0.0	0.0	97.2	34.3	0.0	44.5
Fruits	0.0	0.0	2.8	2.3	4.0	1.6
Cash crops	0.0	0.0	0.0	9.3	85.5	6.4
Livestock	0.0	0.0	0.0	0.1	10.5	0.8
Sample percent	35.4	10.3	45.2	1.7	7.3	100.0

Note: Caloric production is per household member per day.
Source: Author's elaboration based on TIA/IAI harmonized dataset.

legumes cluster, 45 per cent of the cultivated area is dedicated to legumes, 33 per cent to cereal grains, and 16 per cent to root vegetables. The area under fruits and cash crops is under 2 hectares in this cluster. The roots/fruits cluster dedicates roughly one-third of their land to roots and cereals, and about one-quarter to legumes. The exact area under fruit trees is not recorded by TIA/IAI surveys systematically, so the small figure here is not a surprise. Area used for livestock rearing is also not recorded.

Looking at the level of commercialization of different clusters proxied by the share sold for each crop type, we see that the cereals cluster mostly sells cereals, the legumes cluster mostly sells legumes, the roots/fruits cluster mostly sells roots, and the cash crops/livestock cluster mostly sells cash crops. In the order of largest to lowest share sold, the medium cluster sells cereals, roots, legumes, and cash crops. These trends validate that the cluster analysis has grouped households reliably.

In terms of other household and production characteristics of the identified clusters, the medium cluster has the highest number of trees for fruit production, followed by the roots/fruits cluster. The medium cluster also has the highest number of tropical livestock units, the highest crop diversification index, and the highest number of hired farm workers. Households in the medium cluster tend to be larger and to be headed by older household heads than households in other clusters. The cash crops/livestock and the legumes clusters tend to have the youngest household heads. While all cluster types combine manual labour and machinery, the medium cluster seems to be most mechanized. Differences between clusters are statistically significant, except in a few cases. No significant differences were detected between the cereals cluster and the legumes and medium clusters in terms of the value share of livestock sold, between the cereals cluster and the legumes cluster in terms of hired labour, between the cereals cluster and the cash crops/livestock cluster in terms of household size, and between the cereals cluster and the roots/fruits cluster in terms of the household head's age.

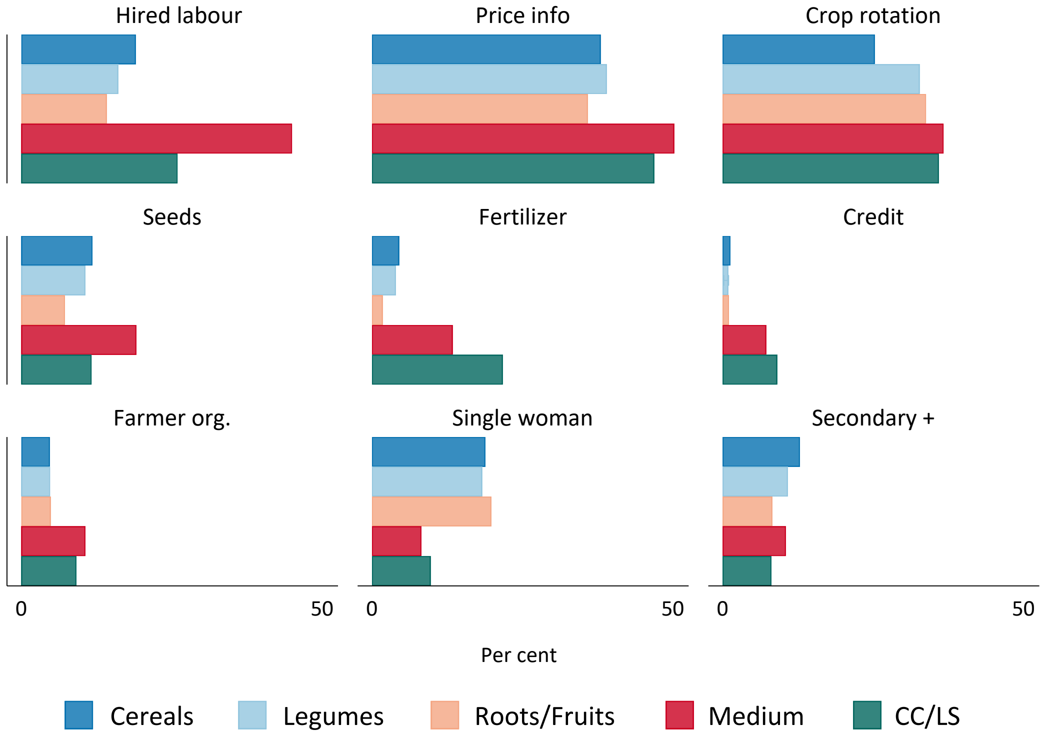
Table 9.3.3: Selected cluster characteristics

	Cereals	Legumes	Roots/Fruits	Medium	Cash crops/ Livestock
Area (ha)	1.4	1.2	1.2	5.5	2.0
Area cereals (%)	66.4	32.5	35.7	50.8	42.7
Area legumes (%)	16.5	45.1	23.4	21.8	15.5
Area roots (%)	7.4	15.8	33.4	9.4	7.0
Area vegetables (%)	5.8	2.8	2.5	6.5	3.6
Area fruits (%)	1.0	1.9	2.5	0.8	0.9
Area cash crops (%)	2.9	2.0	2.6	10.7	30.4
Area livestock (%)	0.0	0.0	0.0	0.0	0.0
Value sold cereals (%)	76.1	21.2	12.6	40.7	19.6
Value sold legumes (%)	11.5	62.0	9.1	15.6	7.0
Value roots (%)	7.5	11.4	72.3	26.9	7.0
Value fruits (%)	1.4	2.8	4.1	3.4	3.6
Value cash crops (%)	2.3	1.4	1.2	12.4	55.9
Value livestock (%)	1.1	1.2	0.6	1.1	7.0
Number of trees (sqrt.)	9.8	15.9	23.9	69.5	15.0
Livestock units	3.9	2.6	2.7	14.3	4.1
Crop diversification index	0.5	0.6	0.6	0.7	0.6
Technology index	0.0	-0.0	-0.1	0.9	0.7
Hired labour	2.1	2.3	1.6	9.5	3.9
Household size	5.7	5.3	5.5	7.6	5.6
Age household head	42.2	40.4	42.0	47.9	39.9
Manual labour (%)	17.7	10.7	10.0	35.4	12.1
Machinery use (%)	3.1	1.2	1.5	5.6	2.2
Caloric production	726.7	860.5	2275.4	2137.8	1077.6
More than 3 meals (%)	24.7	18.5	14.4	33.4	21.7
Perceived food security (%)	65.9	66.0	62.5	72.1	67.4

Source: Author's elaboration based on TIA/IAI harmonized dataset.

Figure 9.3.3 shows a comparison between clusters in terms of additional selected household and production characteristics. The cash crop/livestock and the medium clusters rely on extension services, use formal credit, have farmer organization membership, and have male heads of households more commonly than three other clusters. They also tend to have more input-intensive production, including a higher tendency for using fertilizer, irrigation, and improved seeds, but are not more educated. Differences between clusters are statistically significant, except for a few variables and only between specific rather than all clusters. No significant differences were detected between the cereals cluster and the legumes in terms of the use of fertilizer and the share of single-woman households, as well as between the cereals cluster and the legumes and roots/fruits cluster in terms of farmer organization membership.

Figure 9.3.3: Selected characteristics of key clusters



Source: Author's elaboration based on TIA/IAI harmonized dataset.

9.3.2 Factors explaining the livelihood strategy choices

In this section, we focus on the factors that explain the adoption of particular livelihood strategies. As Table 9.3.4 shows, the livelihood strategies are determined by several indicators of human, social, and physical capital of Mozambican farmers. The results are based on the multinomial logistic regression. The cereals cluster is taken as a baseline.

Production inputs such as fertilizer, seeds, irrigation, pesticides, manure, and hired labour significantly increase probability of non-cereals livelihood styles. However, their individual effects can be positive for some and negative for other livelihoods. For example, while the use of fertilizer shows a positive association with the medium and cash crops/livestock livelihood strategies, it is negatively associated with the roots/fruits strategy. The use of seeds is also negatively associated with this one and the cash crops/livestock strategy, while it contributes positively to adopting the legumes-based livelihood strategy. The use of pesticides is negatively associated with legumes and roots/fruits, while it is positively associated with the medium and cash crops/livestock clusters. The same holds true for the use of manure and hired labour.

In terms of the institutional engagement, we obtain that credit has a negative association with legumes and roots/fruits strategies and that it has a positive association with medium and cash crops/livestock clusters. Price information is negatively associated with the roots/fruits cluster, while extension services positively contribute to the cash crops/livestock cluster.

Table 9.3.4: Determinants of key livelihood strategies

	(1) Legumes	(2) Roots/Fruits	(3) Medium	(4) Cash crops/Lives.
Fertilizer	0.01	-0.68***	0.54***	1.26***
	(0.12)	(0.09)	(0.17)	(0.10)
Seeds	0.14*	-0.32***	0.15	-0.26***
	(0.08)	(0.05)	(0.12)	(0.09)
Irrigation	-0.38***	-0.33***	-0.46**	-0.62***
	(0.12)	(0.07)	(0.19)	(0.13)
Pesticides	-0.41***	-0.28***	0.90***	1.83***
	(0.14)	(0.09)	(0.18)	(0.09)
Use of manure	0.25*	0.21**	-0.21	-0.89***
	(0.13)	(0.08)	(0.23)	(0.16)
Hired labour	-0.05	-0.38***	0.74***	0.19***
	(0.07)	(0.04)	(0.11)	(0.07)
Price information	0.03	-0.13***	0.05	-0.07
	(0.05)	(0.03)	(0.10)	(0.06)
Extension	-0.13	0.00	0.15	0.16*
	(0.09)	(0.05)	(0.13)	(0.08)
Farmer organization	0.04	-0.01	-0.03	0.13
	(0.11)	(0.07)	(0.17)	(0.11)
Credit	-0.42**	-0.27**	0.51**	1.07***
	(0.19)	(0.11)	(0.21)	(0.12)
Male	-0.01	0.06	0.30	0.28***
	(0.09)	(0.06)	(0.21)	(0.11)
Single woman	-0.05	0.05	-0.18	-0.33**
	(0.10)	(0.07)	(0.25)	(0.13)
Age household head	-0.01	0.01**	0.03	-0.02
	(0.01)	(0.01)	(0.02)	(0.01)
Household size	-0.05***	-0.05***	0.12***	-0.02
	(0.01)	(0.01)	(0.02)	(0.01)
Dependency ratio	0.00	0.00***	0.00	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
Primary	0.14**	0.17***	-0.08	-0.11*
	(0.05)	(0.03)	(0.10)	(0.06)
Secondary	-0.06	-0.15**	-0.18	-0.79***
	(0.09)	(0.06)	(0.19)	(0.12)
University	0.54	0.53**	-1.17	-0.89*
	(0.38)	(0.26)	(0.93)	(0.51)
No. of plots	0.14***	0.36***	0.60***	0.30***
	(0.02)	(0.02)	(0.04)	(0.03)
Number of trees (sqrt.)	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Livestock units	-0.02***	-0.03***	0.02***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Crop diversification index	2.30***	1.65***	4.17***	1.86***
	(0.12)	(0.08)	(0.30)	(0.15)
Growing period NDVI z-score	-0.27***	-0.26***	0.39**	0.11
	(0.06)	(0.04)	(0.17)	(0.08)
Growing period rainfall z-score	0.38***	-0.20***	0.72***	0.07
	(0.10)	(0.06)	(0.23)	(0.10)
Growing period temperature z-score	0.23***	-0.18***	1.20***	0.06
	(0.09)	(0.06)	(0.21)	(0.11)
Region-Year FE	Yes	Yes	Yes	Yes
Obs.	56,025	56,025	56,025	56,025

Note: Marginal effects from multinomial logit estimation. NDVI stands for normalized difference vegetation index. Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.
Source: Author's elaboration based on TIA/IAI harmonized dataset.

Socio-economic attributes at household level such as education, gender, and asset ownership per capita also have mixed effects on the probability of adopting particular livelihood strategy. Male-headed households have a positive while single-woman households have a negative probability of pursuing the cash crops/livestock livelihood strategy. Older household heads have a higher probability of engaging in roots/fruits production. Larger households have a lower probability of cultivating legumes and roots/fruits, while their probability of operating medium farms is higher. Those with primary school have a higher probability of adopting the legumes and roots/fruits strategy. The latter is, however, higher with university-level education. Any formal education decreases the probability of adopting the cash crops/livestock strategy.

A higher number of plots for cultivation and trees and a higher crop diversification index are positively correlated with all non-cereals strategies. More livestock is a negative predictor of the legumes and roots/fruits strategies, while it is a positive predictor of the other two.

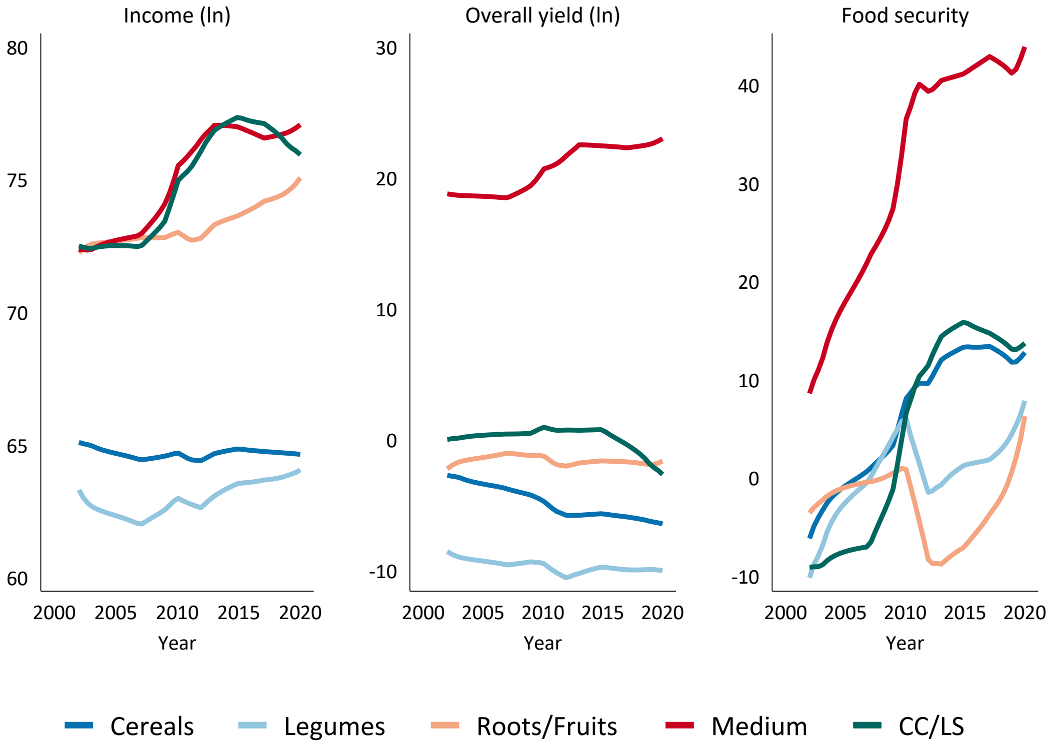
Climate conditions play a decisive role in the choice of all livelihood strategies, except for the cash crops/livestock strategy. Warmer and wetter conditions are positively associated with the probability of pursuing the legumes and medium strategies, while they decrease the probability of the roots/fruits strategy.

9.3.3 Indicators of success

Figure 9.3.4 shows unconditional relationships between our selected indicators of success and clusters. Revenue from agriculture per household member is higher in the roots/fruits, medium, and cash crops/livestock clusters than in the cereals and legumes clusters. The first group of clusters achieves 3–4 times the revenue of the second group. For example, the medium cluster has four times higher revenue per household member than cereals and legumes clusters. The medium and cash crops/livestock clusters have increased their income since 2010 more than the roots/fruits cluster. Differences in revenue between all clusters are statistically significant.

The medium cluster has the highest overall yield and food security scores evaluated in terms of calorie production. Whereas the cash crops/livestock and the roots/fruits cluster are very close in terms of overall yield, the cereals cluster is more similar to the the cash crops/livestock cluster in terms of food security. The legumes cluster shows the lowest overall yield level. In terms of food security, it is statistically indistinguishable from the roots/fruits cluster, which has had the lowest food security scores since 2012. Before 2012, the cash crops/livestock cluster had the lowest scores, but it has surpassed the legumes and roots/fruits clusters in the past decade.

Figure 9.3.4: Success indicators by cluster type



Source: Author's elaboration based on TIA/IAI harmonized dataset.

Note: Income and yields in natural logarithm multiplied by 10 for comparable scale illustration.

Table 9.3.5 shows the linear regression estimates of the relationship between the four clusters and the key indicators of success. The results shown in Figure 9.3.4 are broadly confirmed in estimations without the addition of any control variables, while the estimation with an extended set of controls show slightly different results for the cash crops/livestock cluster. All clusters apart from the legumes have significantly higher revenue from agriculture than the cereals cluster. Whereas the roots/fruits and medium clusters benefit from higher yields more than the cereals cluster, the legumes and cash crops/livestock clusters do not. After controlling for key farm, household, and other characteristics, we obtain that all clusters apart from the medium cluster fare worse in terms of food security than the cereals cluster. This was expected from Figure 9.3.4 for the roots/fruits and the legumes cluster, but not for the cash crops/livestock cluster, which does not have a different food security performance from the cereals cluster. Adding control variables has mostly reduced the size of coefficients for the key livelihood strategies in all estimations. An exception is the coefficient for the cash crops/livestock cluster in food security estimations in column 6.

In terms of the key control variables, the important predictors of all observed farm performance outcomes include inputs use, having a male household head, and some education. Higher levels of education particularly contribute to better food security. Despite additional controls, which include other farm and household characteristics, as well as location and time effects, we are left with a large part of unexplained variation in farm performance. It is particularly large in food security estimations.

Table 9.3.5: Linear estimates of success outcomes

	Income		Overall yield		Food security	
	(1)	(2)	(3)	(4)	(5)	(6)
Legumes	-0.06**	-0.05**	-0.31***	-0.34***	-4.42**	-7.57***
	(0.03)	(0.02)	(0.04)	(0.03)	(2.17)	(2.32)
Roots/Fruits	0.89***	0.93***	0.48***	0.46***	-5.84***	-5.69***
	(0.01)	(0.01)	(0.02)	(0.02)	(1.30)	(1.47)
Medium	1.23***	0.98***	2.71***	1.62***	27.79***	13.65***
	(0.04)	(0.04)	(0.04)	(0.05)	(4.09)	(4.58)
Cash crops/Livestock	1.16***	0.83***	0.55***	-0.02	3.18	-9.45***
	(0.02)	(0.02)	(0.03)	(0.03)	(2.38)	(2.70)
Fertilizer		0.47***		0.33***		25.53***
		(0.03)		(0.03)		(3.14)
Seeds		0.05**		0.09***		1.34
		(0.02)		(0.03)		(2.19)
Pesticides		0.12***		0.11***		0.45
		(0.02)		(0.03)		(3.14)
Extension		0.07***		0.08***		0.42
		(0.02)		(0.03)		(2.21)
Credit		0.09**		0.03		3.79
		(0.04)		(0.05)		(3.97)
Male		0.15***		0.20***		5.42**
		(0.02)		(0.04)		(2.53)
Household size		-0.14***		0.05***		-1.07***
		(0.00)		(0.00)		(0.31)
Primary		0.02*		0.02		9.00***
		(0.01)		(0.02)		(1.42)
Secondary		-0.08***		-0.16***		32.63***
		(0.03)		(0.04)		(2.62)
University		-0.25*		-0.56***		69.05***
		(0.14)		(0.18)		(8.60)
Region FE	No	Yes	No	Yes	No	Yes
Region-Year FE	No	Yes	No	Yes	No	Yes
Other controls	No	Yes	No	Yes	No	Yes
Obs.	60,065	56,025	60,065	56,025	60,065	56,025
R^2	0.16	0.37	0.07	0.32	0.00	0.07

Note: Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Source: Author's elaboration based on TIA/IAI harmonized dataset.

Table 9.3.6 shows the results of multinomial treatment effects regressions with instrumental variables, which are broadly consistent with linear regressions in Table 9.3.5. We obtain again that the medium cluster performs significantly better in terms of income, yield, and food security than the cereals cluster. There roots/fruits cluster now does not have a different food security level from the cereals clusters, whereas the linear regression estimates showed a significantly lower food security outcome for this cluster.

Table 9.3.6: Treatment effects of clusters on success outcomes

	(1) Income (ln)	(2) Overall yield (ln)	(3) Food security
Legumes	-1.12	-2.75*	-78.05***
	(0.91)	(1.44)	(3.11)
Roots/Fruits	11.87***	9.18***	21.99***
	(0.55)	(0.99)	(3.68)
Medium	4.53***	1.54**	-13.51**
	(0.53)	(0.60)	(5.32)
Cash crops/Livestock	9.12***	-1.03	-13.36***
	(0.50)	(0.72)	(3.71)
Region FE	Yes	Yes	Yes
Region-Year FE	Yes	Yes	Yes
Other controls	Yes	Yes	Yes
Obs.	56,555	56,025	56,555

Note: Maximum simulated likelihood estimates of multinomial treatment effects with instrumental variables. 100 Halton sequence-based quasi-random draws per observation. Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Source: Author's elaboration based on TIA/IAI harmonized dataset.

Table 9.3.7 explores the contribution of crop diversification and the use of advanced production technology in influencing income, overall yield, and food security. All results are relative to the cereals cluster, for which we obtain a positive contribution of the technology index for all outcomes and a positive contribution of crop diversification for income and yield, but not for food security. We obtain that only for the livelihood strategy based on cash crops/livestock does the crop diversification contribute positively to the overall yield. It otherwise contributes negatively to income for the roots/fruits cluster and to food security of the legumes and medium clusters. In terms of technology modernization, it seems that it is potentially beneficial only for the cash crops/livestock cluster in terms of income. Otherwise, it is correlated negatively with yield and food security of the roots/fruits and medium clusters.

Table 9.3.7: The role of crop diversification and modern technology

	Income (1)	Overall yield (2)	Food security (3)
Legumes	0.07	-0.11	9.71
	(0.10)	(0.15)	(7.98)
Roots/Fruits	1.01***	0.36***	-9.13**
	(0.04)	(0.06)	(3.87)
Medium	1.41***	3.05***	62.84***
	(0.17)	(0.20)	(17.20)
Cash crops/Livestock	0.74***	-0.53***	-21.11**
	(0.09)	(0.16)	(9.88)
Crop diversification index	1.05***	1.41***	12.30***
	(0.04)	(0.06)	(4.10)
Legumes × Crop diversification index	-0.25*	-0.40*	-27.83**
	(0.15)	(0.22)	(12.07)
Roots/Fruits × Crop diversification index	-0.24***	0.03	4.98
	(0.07)	(0.09)	(6.19)
Medium × Crop diversification index	-0.61**	-1.81***	-62.30**
	(0.25)	(0.29)	(25.87)
Cash crops/Livestock × Crop diversification index	0.06	0.78***	21.97
	(0.13)	(0.23)	(14.83)
Tech. index	0.12***	0.18***	8.50***
	(0.01)	(0.01)	(0.93)
Legumes × Tech. index	0.01	0.02	-0.21
	(0.02)	(0.03)	(2.09)
Roots/Fruits × Tech. index	0.00	-0.03*	-4.45***
	(0.01)	(0.02)	(1.27)
Medium × Tech. index	-0.00	-0.18***	-6.72**
	(0.03)	(0.03)	(2.77)
Cash crops/Livestock × Tech. index	0.12***	-0.01	-0.60
	(0.02)	(0.02)	(1.60)
Region FE	Yes	Yes	Yes
Region-Year FE	Yes	Yes	Yes
Other controls	Yes	Yes	Yes
Obs.	60,059	60,059	60,059
R^2	0.35	0.30	0.05

Note: Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Source: Author's elaboration based on TIA/IAI harmonized dataset.

9.4 Conclusion

This chapter investigated how different livelihood strategies smallholder households pursue play out in terms of their well-being. Using cluster analysis, we identified five household types with substantial differences in livelihood strategies, farm endowments, production practices, and institutional engagement (e.g., use of extension services, farmers organization membership). All clusters are present in different geographical regions, albeit in different proportions, downplaying the role of location as a key identifier of farm and livelihood profiles. Over time, the share of households pursuing the cereals and cash crops/livestock livelihood strategies has increased, while others have declined. Defining successful farms as those having above median yields, revenue, and food security, we note the highest increase in the legumes cluster over the past two decades. We then explored whether the strategies that are on the rise are also the most beneficial ones in terms of household well-being. A caveat is that our food security measure does not include purchased calories as we do not observe household consumption expenditures. We also do not subtract calories from food sold. In this way, our results are downward-biased for clusters that are net food buyers.

The five clusters representing five distinct livelihood strategies show substantial variation in income levels, overall yield, and food security. The highest performance is registered for the medium cluster, which pursues a diversified livelihood strategy that combines cereals, legumes and roots, and, to a smaller extent, cash crops production with comparatively higher fruit trees and livestock ownership, and the use of extension services, credit, production machinery, and inputs. The legumes cluster has lower overall yields and food security than the cereals cluster. The roots/fruits cluster shows a better performance than the cereals cluster in terms of income and yield at the same level of food security. The cash crops/livestock cluster has a significantly higher income and overall yield but lower food security than the cereals cluster. The results based on pooled least squares and multinomial treatment effects estimations with instrumental variables were highly aligned.

It is traditionally considered that cash crops contribute positively to food security in particular when produced jointly with staple crops. The picture from Mozambique is different given that only the medium cluster shows higher food security than the cereals cluster based entirely on staple crops. A possible explanation could be that risks inherent in the production and commercialization of cash crops are not well insured against, including, for example, crop failure due to weather shocks or unexpected drop in world prices for cash crops. Accordingly, the role assigned to the agricultural sector for addressing food insecurity challenge in Mozambique cannot rest entirely on the production of cash crops.

Compared to earlier studies (Herrera et al., 2021), our results also downplay the role of crop diversification in improving food security, as we obtained declining food security outcomes for more diversified legumes and medium clusters. Diversification appeared beneficial only for the cash crops/livestock cluster in terms of overall yield, whereas modern technology contributed positively to this cluster's revenue from agriculture, but neither diversification nor technology were significant factors in improving food security for this cluster. Our findings thus highlight a need for a better understanding of heterogeneity in farmers' livelihood strategies with respect to different performance outcomes, as that could help develop policies that better align performance targets and livelihoods.

In all analyses, production inputs are important predictors of income and yield. Fertilizer use and and access to extension services are also key factors determining improved food security. This points to sustainable agricultural intensification of inputs use combined with a carefully made crop choice as a potential way of addressing poverty and food insecurity challenges in Mozambique. Improving policies related to access to inputs and services could thus play a vital role in mitigating these challenges.

We also attempted to assess the extent to which the identified livelihood strategies could be an efficient indicator for guiding agricultural development policy. To achieve this, we regressed the key outcomes on the livelihood strategy variables only and then regressed the key outcome variables on the livelihood strategies and numerous farm, household, geographical, and climate controls. The estimations with additional controls had a higher explanatory power of the outcome variables compared to when the models included the livelihood strategies only, but the overall explanatory power of our models remained modest. This could imply two things. First, the identified livelihood strategies alone do not capture the impact of household endowments and production inputs and therefore cannot be used to efficiently inform about agricultural development.

Second, the available dataset does not contain all the variables needed to explain agricultural productivity and food security very well. For example, we cannot control for some of the key determinants, such as investment in agriculture, hours spent working on the farm by family members and hired workers, wages of the hired labour, soil quality, amount of food purchased, using insurance, off-farm work, product quantity (in case of vegetables), access to government programmes and services, and a number of other characteristics that have not been measured consistently each survey year. Moreover, instead of collecting simple information about the presence or absence of a particular activity, future surveys could include more details, such as the information about the amounts (for example, instead of asking whether a household uses fertilizer, the questionnaire can also ask about the amount used and its value) or the types of seeds used. Consequently, resolving the constraints posed by data limitations requires increasing the data collection effort by the relevant authorities, as this is the only way to obtain unbiased estimates useful in guiding policy.

Chapter 10

Simulating the Impact of Climate Change

10.1 Introduction

Mozambique ranks among the top 10 countries most vulnerable to natural hazards, while also being among the least prepared to adapt. Historically, the nation has always grappled with extreme fluctuations in temperature and rainfall. However, in recent decades, the frequency and severity of floods, droughts, and cyclones have escalated due to climate change (BEHI, 2022; CIAT and World Bank, 2017). This chapter scrutinizes the impact of climate change on Mozambican agriculture. To begin, it provides an overview of how climate change affects agriculture globally and in Africa. Subsequently, it delves into the specific implications for Mozambique. The subsequent section adopts a more technical approach, introducing climate change simulations and utilizing a comparative static computable general equilibrium (CGE) model. This is done to forecast potential future impacts on Mozambican agriculture before concluding.

10.2 Climate Change and Agriculture

10.2.1 Worldwide

"Climate change refers to long-term shifts in temperatures and weather patterns. [S]ince the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas. Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures" (United Nations, 2023). Since the 19th century, the average temperature has increased by 0.9°C and it is projected to rise to at least 1.5°C by 2050. The consequences of a higher temperature are, among others, an increase in natural hazards such as droughts, floods, and cyclones (Arora, 2019).

The agricultural sector faces significant challenges from climate change due to its scale and susceptibility to weather variations (Malhi et al., 2021). Presently, the altered climate adversely impacts crop yields to such an extent that global food security is under threat. Projections suggest that if the current trajectory of climate change persists, major cereal crops will be severely impacted by 2100. Expected decreases range from 20–45 per cent in maize yields, 5–50 per cent in wheat yields, and 20–30 per cent in rice yields (FAO, 2016). Certain crops, like coffee, may struggle to recover from future natural disasters (Grigorieva et al., 2023). This could potentially initiate a detrimental cycle of food insecurity, illness, and increased crime rates (Arora, 2019).

The effects of higher temperatures, alterations in precipitation patterns, and CO2 fertilization vary depending on the crop, location, and the degree of change (Adams et al., 1998). While in some regions, particularly in the northern hemisphere, a combination of elevated temperatures and increased CO2 levels may positively influence crop yields, the overall impact of climate change is expected to be negative. Tropical regions are especially vulnerable due to the lower stress resilience of tropical crops to temperature fluctuations, coupled with the heightened prevalence of pests and diseases in warm and humid climates (Malhi et al., 2021). Weather patterns are already erratic and projected to become increasingly unpredictable, posing challenges for agricultural planning and activities such as sowing, planting, and fertilizing (Watanabe et al., 2018).

To effectively address the present and future challenges posed by climate change, adaptation strategies must be implemented at multiple levels, encompassing global, national, regional, local, and individual farmer levels, utilizing innovative and interdisciplinary approaches (Malhi et al., 2021; Grigorieva et al., 2023). The specific adaptation strategies deemed most pertinent will vary depending on the unique contextual factors within each country and region. Urgent action is required for farmers and their communities to adopt measures aimed at reducing vulnerability while capitalizing on opportunities presented by current and anticipated climate shifts (Malhi et al., 2021). This underscores the importance of tailoring agricultural recommendations to align with the climate realities specific to agricultural households, rather than applying broad national-level approaches. Adaptation strategies at the regional and local levels, as outlined by Grigorieva et al. (2023), include:

- crop varieties and management, including land use change
- water and soil management, including agronomic practices
- farmer training and knowledge transfer

Adaptation strategies at regional and national level as summarized by Grigorieva et al. (2023) include:

- governmental support programmes, financial schemes, and insurance
- agricultural and meteorological services
- R&D, including the development of early warning systems

Adaptation measures have proven most effective when they integrate the traditional knowledge held by communities. This traditional wisdom should be complemented with climate-smart agricultural practices (Grigorieva et al., 2023). Climate-smart agriculture addresses climate change within the agri-food system, recognizing the interplay between productivity, adaptation, and mitigation efforts. It emphasizes practices tailored to specific agro-ecological conditions and socio-economic contexts, while also considering the synergies and trade-offs inherent in these approaches (World Bank, 2023). There remains a pressing need for further research into adaptation options and the readiness of farmers and societies to adapt, particularly within the diverse contexts found within individual countries (Grigorieva et al., 2023).

10.2.2 Africa

Despite contributing only 3 per cent of total historical emissions since 1751, the African continent faces disproportionate vulnerability to climate change, contrasting sharply with the USA, which has contributed 25 per cent of emissions (Arora, 2019). This heightened vulnerability arises not just from the impacts of a changing climate but also from challenging socio-economic conditions, compounded by a lack of prioritization of agriculture on the policy agendas of African governments (Pereira, 2017). While global temperatures are projected to rise to at least 1.5°C by 2050, estimates for southern Africa suggest an increase of at least 3.5°C by the same year (Arora, 2019; Holtz and Golubski, 2021). However, it is important to note that temperature and precipitation patterns will vary significantly across different regions of Africa. Presently, droughts are already more severe, and their intensity is expected to exacerbate in the coming decades (Grigorieva et al., 2023).

Agriculture holds paramount significance on the African continent, employing approximately 70 per cent of the labour force and contributing over 25 per cent to the GDP, on average (UNECA, 2009, as cited by Pereira, 2017). The primary climatic variables impacting agriculture in Africa are rising temperatures, particularly the extremely hot days, and alterations in precipitation patterns (Pereira, 2017). Agricultural productivity is facing a downward trend due to these extreme conditions (Kalimba and Culas, 2020), leading to an escalation in food crises across Africa caused by heightened occurrences of droughts, crop pests, and deteriorating soil fertility as a consequence of climate change (Grigorieva et al., 2023).

The majority of households in sub-Saharan Africa rely on small-scale farming for sustenance and income, with a significant proportion of African farmers being smallholders (Abegunde et al., 2019). These smallholders face constraints such as limited financial resources and restricted access to essential infrastructure and information. Consequently, much of African farming relies heavily on rain-fed agriculture, heightening vulnerability to the impacts of climate change.

On average, crop yields are anticipated to decline by over 10 per cent by 2055, with wheat expected to suffer the most significant negative impact (a projected 15 per cent decline by 2050). However, it is worth noting that Africa's wheat production is relatively minimal (Gachene et al., 2015; Pequeno et al., 2021). Maize, one of the primary staple crops in Africa, occupies approximately 30 per cent of the total cereal production area (Gachene et al., 2015). Despite its importance, maize yields exhibit high volatility, and current yields are relatively low (less than 200 grams per square meter) compared to other global regions such as China and India (600 grams per square meter). The reasons for these low yields include drought, poor soil fertility, nutrient depletion, pest and disease pressure, limited input availability and use, and inadequate access to improved seeds, among other factors (Gachene et al., 2015). While increased rainfall in the future may potentially benefit maize production, higher temperatures and decreased precipitation could have adverse effects (Holtz and Golubski, 2021). Conversely, millet and sorghum yields are expected to rise due to their greater tolerance to elevated temperatures and drought stress (Gachene et al., 2015). However, precise projections are challenging due to the intricate interplay between climatic and socio-economic factors, alongside the limitations inherent in climate models (see also Section 10.3.1).

Climate-smart agricultural practices are deemed essential for mitigating both current and future impacts of climate change on agriculture, with particular emphasis on supporting smallholders to bolster the productivity of African agriculture (Kalimba and Culas, 2020). Predominant adaptation strategies on the African continent include crop diversification, the cultivation of drought-tolerant varieties, adjusting planting dates, opting for early-maturing crops, implementing irrigation techniques, and enhancing extension services (Grigorieva et al., 2023; Kalimba and Culas, 2020). However, the adoption of these (climate-smart) agricultural practices remains notably low, especially among smallholders, owing to the multitude of constraints they encounter. Research indicates that membership in farmer groups, access to credit facilities, and the provision of improved climate information significantly enhance adaptation efforts among smallholders (Shikuku et al., 2017). It is imperative for African governments to allocate more resources towards agriculture, while also considering the development of national seed sectors with active community participation (Cacho et al., 2020).

10.2.3 Mozambique

In recent years, agriculture has accounted for over 27 per cent of Mozambique's GDP, a notably higher contribution compared to the 18 per cent of GDP attributed to agriculture in other sub-Saharan African countries (Jones et al., 2022; CIAT and World Bank, 2017). The primary crops cultivated in Mozambique include maize, pulses, and sorghum, with tobacco, vegetables, fruits, and nuts (including cashew) also being significant contributors. Of all the cultivated land, more than 80 per cent is dedicated to the production of staple crops (CIAT and World Bank, 2017).

Two of Mozambique's primary development challenges revolve around low agricultural productivity and the impacts of changing weather patterns, including natural hazards. Mozambican agriculture is predominantly composed of subsistence-based smallholders, who, despite their low productivity levels, play a pivotal role by generating approximately 90 per cent of the total agricultural output (IFAD, 2011). However, due to the myriad constraints they face, it remains difficult for smallholders to significantly enhance their productivity in the coming decades. Moreover, changing weather patterns are poised to exacerbate their challenges. Across all regions of Mozambique, projections indicate a temperature increase of at least 1–2°C and a decrease in average precipitation of 3.2 per cent by 2050 (Arndt et al., 2011; CIAT and World Bank, 2017).

Already today, Mozambique ranks as noted among the top 10 countries most impacted by and least equipped to handle natural hazards (BEHI, 2022; CIAT and World Bank, 2017). Events like floods and cyclones have historically afflicted Mozambique, but projections suggest they will become more frequent and severe in the future, partially attributed to climate change (Ritchie et al., 2022). Disasters exacerbate poverty, with the most severe repercussions felt by poorer households, particularly those residing in rural areas (Salvucci and Santos, 2020).

Various studies have examined the potential impacts of climate change on future maize yields in Mozambique. Amaral et al. (2020) highlight that Mozambique currently falls short of its maize production targets, with the yield gap between Mozambique and neighbouring countries widening over time. The area allocated to maize cultivation, as well as its production and yield, fluctuates significantly over time due to the existing high variability in rainfall. Notably, there is an upward trend in the total area allocated to maize, primarily driven by the establishment of new maize plots rather than an expansion of cultivation in existing maize-growing households. With climate change, the geographical volatility of maize production is projected to increase, posing challenges to food security (Holtz and Golubski, 2021). Manuel et al. (2021) estimate a reduction of 6–10 per cent in maize production in the coming decades, with more pronounced declines anticipated in the Southern region (more than 10 per cent) compared to the Central (3.5 per cent) and Northern regions (1.5 per cent).[1]

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[1] *South:* Gaza, Inhambane, Maputo City, Maputo Province; *Centre:* Manica, Sofala, Tete; *North:* Cabo Delgado, Nampula, Niassa, Zambezia

In addition to maize, other crops such as cassava and coffee are also projected to face negative impacts in the future (Manuel et al., 2021; Cassamo et al., 2023). Conversely, cotton yields are expected to increase, albeit these gains are unlikely to offset the losses in other crop yields (Holtz and Golubski, 2021). Consequently, Mozambique may struggle to meet the food needs of its population solely through its national agricultural system (Ferrão et al., 2018). Moreover, creating precise estimations of future climate change impacts on specific crops poses significant challenges. Climate change scenarios offer estimates rather than definitive outcomes, necessitating further research to refine predictions.

While few studies have delved into climate change adaptation strategies within Mozambique's agricultural sector, those that did provide evidence that smallholders are cognizant of shifting weather patterns (Monjane et al., 2018). However, the coping mechanisms adopted by farming households following climate shocks are often unsustainable for long-term well-being (Baez et al., 2020; Salazar-Espinoza et al., 2015). Notably, households may resort to increasing child labour or selling durable assets in response to multiple shocks (Baez et al., 2020). Moreover, there is a tendency for households to transition from permanent crops to short-term crops, aiming to establish a buffer stock of food (Salazar-Espinoza et al., 2015). Among the potential and more sustainable adaptation strategies identified by Arndt et al. (2011), CIAT and World Bank (2017), and Zorrilla-Miras et al. (2024), are the following:

- climate-smart agriculture such as crop residue management, mulching, composting and rotations, and use of short season varieties
- contextualized coordination in adaptation strategies, including more information sharing between all actors involved in the adaptation efforts
- investments in agricultural research and extension, especially in climate-smart agriculture
- education
- sealed (rural) roads
- land use planning

Ultimately, Arndt et al. (2011) outline that “the best adaptation to climate change may prove to be more rapid development leading to a more flexible and resilient society. An effective adaptation strategy should therefore reinforce existing development objectives” (p.18ff.).

10.3 Climate change simulations

10.3.1 Climate change simulations and what they can do

Climate models are instrumental in simulating the dynamics and interactions of various climate determinants, including the atmosphere, oceans, land surface, and ice (IPCC, 2014). They “rely on certain assumptions when calculating the future development of the climate. These assumptions are combined into greenhouse gas scenarios, resulting in climate projections. Projections are not forecasts or predictions (‘this will happen’), but rather ‘if-then’ statements: if this scenario occurs, then this could happen... They form the basis for assessing the risks and opportunities of future climate change and for developing adaptation measures” (Umweltbundesamt, 2022). One crucial application is examining how climate changes may influence agricultural yields in the future.

There are many challenges associated with the use of CGE models in assessing the impact of climate change on yields. First, differences in results among models arise due to different underlying assumptions. Climate models relate to global dynamics such as population growth, economic and social developments, technological changes, consumption of resources, and environmental management (Umweltbundesamt, 2022). Differences in assumptions regarding these dimensions lead to different projections. Second, insufficient data further complicate the assessment of long-term climate change effects on crop yields in most Sub-Saharan African (SSA) countries. Third, on a global scale, climate models have a highly coarse resolution (100*100km), meaning they are somewhat imprecise (Umweltbundesamt, 2022). Thus, the majority of models lack the capacity to assess impacts at the household level, and no single approach is deemed sufficient.

10.3.2 Climate change and agriculture simulations for Mozambique

In this section, we provide projections for potential impacts of climate change on agricultural yields and suitable agricultural land in Mozambique. However, this analysis is not exhaustive; it serves as a preliminary step, highlighting the need for further in-depth research on the topic. We use nine scenarios as depicted in Table 10.3.2 to discuss how climate change might impact on agricultural yields in Mozambique in the future. In a second step, we analyse how the changes in agricultural yield might as a result affect the Mozambican economy in the aggregate. We use the FAO results of Representative Concentration Pathways (RCPs) 2.6 and 8.5. The former can broadly be interpreted as a pathway with strong reduction in greenhouse gas emissions, while the latter is characterized by the highest emissions considered by FAO. These scenarios are available from the FAO GAEZ (2022) data portal's country profile for Mozambique. They are presented for 41 crops in terms of changes to suitable land area and crop yields for the period 2040–2070 under high input level and rain-fed conditions without CO2 fertilization. This is compared with baseline climate results for the period 1981–2010. It may be possible that accounting for irrigation, low input scenarios and alternative CO2 fertilization could alter the results.

Model and detailed assumptions for model drivers

A comparative static computable general equilibrium (CGE) model is used to explore the economy-wide implications of these crop scenarios. The key data input into the CGE is the social accounting matrix (SAM), and the reference year is 2019. The CGE model is described by Lofgren et al. (2002), and is not discussed in detail here other than to mention that it is a standard neoclassical framework which allows for unemployed factors of production, various economic equilibrium identities as well as cost minimisation, utility optimisation, and movement of relative prices. FAO GAEZ climate change results for the 41 crops are aggregated up to 16 crop groups identified in the SAM as shown in Table 10.A of the Appendix. The key drivers of impact in the CGE model are:

- The shift parameters of the crop production functions for changes in crop yields
- The supply of crop land for changes in suitable land area

The latter will lead to upper bound estimates since the suitable land area does not necessarily translate in harvested area. Also note that the non-crop industries (livestock and other productions) are not affected by these climate change scenarios in the economic modelling.

According to Jones et al. (2022), the contribution of agriculture to Mozambican GDP was more than 27 per cent in 2019. Shares of crops in total crop value added are shown in the last column of Table 10.A of the Appendix. Maize, pulses, and sorghum are the main crops, followed by tobacco, vegetables, and fruits and nuts (including cashew). At this stage, the agricultural household data (TIA) production value shares are used to weigh the FAO climate change yield changes in order to consolidate them for SAM crops. As mentioned before, the FAO climate change shocks refer to the period 2040–2070 as compared to FAO's baseline climate period 1981–2010. In the comparative static CGE context modelled here, the climate shocks are imposed on the 2019 economy of Mozambique as captured by the SAM. This is not FAO's baseline climate period 1981–2010. Nevertheless, it may still be instructive to consider as if it is.

Other assumptions regarding the modelled economy are as follows:

- Labour is unemployed, except for tertiary educated workers, who are assumed to be fully employed
- Capital is fully employed and sector specific, it cannot move to be used in other production (tractors cannot be used as dentist chairs or the other way around)
- Investment is held fixed in quantity terms, the savings rates adjustment to maintain balance
- The budget deficit is allowed to adjust
- The exchange rate is flexible, while the current account of the balance of payment (BoP) is held fixed

Scenarios and results

We start examining two outcomes for the 16 groups of crops: percentage change in crop yields relative to historical yields and percentage change in suitable area for the specific crop compared to historically suitable area are shown in Table 10.3.1. Interestingly, maize and sorghum are expected to experience slight increases in both their yields as well as in the suitable area for maize and sorghum. Yet, it is important to note that the models do not account for various changes that could alter these results. This is in line with previous studies showing that maize yields might be positively impacted due to different reasons. First, carbon dioxide emissions by themselves are positively correlated with maize production (Rehman et al., 2020). Second, there may be increased production in one region, while there is a decline in production in different regions, which jointly add up to a positive change in yields (Neupane et al., 2022). Third, a combination of changes in temperature and precipitation can either bring positive or negative effects on maize yields. Specifically, under extreme climate change scenarios such as a temperature increase of 1.46 °C and a 30 per cent precipitation increase, maize yields might increase (Li et al., 2011).

Pulses, vegetables, sugar cane, tobacco, and fruits and nuts are projected to be impacted negatively. A particularly negative change in yields of more than 10 per cent is estimated for vegetables, sugar cane, and coffee and tea. The negative changes for vegetables can be explained by vegetables being particularly sensitive to heat stress (Bisbis et al., 2018). Regarding coffee and tea, these will be strongly affected by reduction in suitable areas due to temperature increase (Adhikari et al., 2015). The conditions for rice, cassava, tobacco, and fruits and nuts will be negative as well but to a smaller extent. A negative change in yields of between 5 to 10 per cent can be expected. For Eastern Africa, it has been estimated that root crops will be less affected by climate change than grain crops because the former are more robust to changes in temperature and precipitation (Adhikari et al., 2015).

The change in suitable area can be incorporated into the modelled economy in a number of ways. The supply of land can either be assumed to be fully used, allowing for crop-switching, or crop specific. The former

Table 10.3.1: Shocks imposed on the 2019 economy of Mozambique (percentage change to historical)

		Percentage Change in Yield		Percentage Change in Suitable Area	
		RCP 2.6	RCP 8.5	RCP 2.6	RCP 8.5
1	Maize	6.6	4.7	2.8	2.7
2	Sorghum and millet	7.0	6.2	4.1	4.0
3	Rice	-5.0	-8.2	0.1	-1.8
4	Other cereals	-5.3	-8.9	-24.9	-57.5
5	Pulses	-3.2	-7.0	1.5	0.0
6	Groundnuts	-4.0	-8.7	1.9	-1.2
7	Other oilseeds	-3.8	-10.4	-9.1	-19.9
8	Cassava	-6.8	-10.7	1.3	0.3
9	Other roots	-3.6	-8.6	-1.3	-7.1
10	Vegetables	-11.1	-18.6	-1.8	-13.4
11	Sugar cane	-10.3	-8.3	-24.6	-34.3
12	Tobacco	-8.4	-18.2	-2.8	-8.9
13	Cotton and fibres	-3.8	-6.5	3.0	1.5
14	Fruits and nuts	-5.5	-6.1	-12.7	-20.4
15	Coffee and tea	-10.4	-13.9	-22.1	-27.0
16	Other crops	-7.7	-9.3	-5.8	-15.1
	Total	-1.0	-4.2	-2.3	-7.9

Source: FAO GAEZ (2022) and author's calculations.

implies that that the land is fully used and market forces potentially lead to crop switches. In that case, the total supply of land is forced to change according to the economy-wide average shown in the last row of Table 10.3.1. In the latter case, no switching of crops is allowed. In other words, the land remains associated with the crop as in the base.

The scenarios explored with the CGE are set out in Table 10.3.2 and some initial results are shown in the subsequent tables, starting with a macro-economic overview of demand-side GDP. The columns follow the scenarios set out in Table 10.3.2 and report real – i.e., quantity – changes. Since this class of CGEs model is characterised by relative as opposed to absolute price movement, the results are by default measured in real terms. However, the results can still be expressed in terms of the relative prices associated with the relevant scenarios or in terms of base level relative prices.

On the whole, if a pathway with strong reduction in greenhouse gas emissions materializes (RCP2.6, columns 2, 4, 6, and 8 of Table 10.3.3), a very small negative yield impact can be expected. The impacts on GDP and those of its components that are allowed to change in real terms become more pronounced under the climate change scenario with the highest emissions. GDP is modelled to be 1.3 per cent lower than its base 2019 level if only the crop yield impacts are considered (cell 7.3). If, on top of that, the change in land area suitable for crops is also taken into account, the negative impact rises slightly to 1.5 per cent (cell 7.7) and with crop switching allowed for this rises to 1.6 per cent. The latter suggests that although market changes lead to switching, this may not necessarily benefit other producers and consumers. However, it can also be seen that the difference is very small.

Looking at the components of GDP, investment, stocks and government expenditure are not impacted since they are kept constant in quantity terms by design. Consumption, including what is "own produced", is hit

Table 10.3.2: Scenarios explored in the CGE model

Scenario	Shared Socio-economic Pathway	Description	Land Closure
1	2.6	Change in crop yields of RCP2.6	Crop specific
2	8.5	Change in crop yields of RCP8.5	Crop specific
3	2.6	Change in suitable area of RCP2.6	Crop specific
4	8.5	Change in suitable area of RCP8.5	Crop specific
5	2.6	Change in crop yields and suitable area of RCP2.6	Crop specific
6	8.5	Change in crop yields and suitable area of RCP8.5	Crop specific
7	Mobile area 2.6	Change in suitable area of RCP2.6	Crop switching
8	Mobile area 8.5	Change in suitable area of RCP8.5	Crop switching
9	Mobile area 8.5	Change in crop yields and suitable area of RCP8.5	Crop switching

Note: RCP stands for Representative Concentration Pathway. The pathways describe different climate change scenarios, and vary by the amount of assumed emission of greenhouse gases.
Source: FAO GAEZ (2022) and author's calculations.

the hardest. With GDP at a lower level, imports are expected to be lower as well. The negative impact on exports appears to be exaggerated when compared to imports but this can be attributed to its low share (cell 5,1) and the assumption of holding the current account of the BoP fixed. With lower economic activity, imports will decline and the exchange rate appreciates. Exports will decline due to the exchange rate appreciation such as to keep the current account at the base level.

Selected industry detail is shown in Table 10.3.4. The second and third rows show that maize and sorghum GDP increase due to yield increase (see third entries), with shocks shown in Table 10.3.1, but the positive land supply shock has a (very small) negative impact. This can be attributed to the negative impacts on GDP for most other crops and the direct and indirect negative impacts on household income earning this may cause. Agriculture as a whole is for the same reason negatively impacted by the climate change shocks. The crops that contribute mostly to this negative impact on agriculture as a whole are higher value crops such as pulses, vegetables, fruits and nuts, and sugar. Due to forward linkages, food processing is therefore also negatively impacted to a significant degree, as can be seen in row 19. Manufacturing and services are affected to a lesser degree due to more indirect linkages to crop production.

The impact on employment is shown in Table 10.3.5. The last three rows summarize the results for rural, urban and total employment. Rural employment benefits slightly in the main because of the high labour intensity of maize and sorghum. Urban employment suffers since it is indirectly linked to crop production, not necessarily through the industry linkages as such, which have been described as limited in Mozambique (see Jones et al., 2022, p.9) but more through the household income–expenditure loop.

It can also be seen that the positive impacts on rural employment reduce at higher education levels. More

Table 10.3.3: Demand-side GDP Results

		Initial share	Change from base (%) Alpha ssp 2.6	Alpha ssp 8.6	Area ssp 2.6	Area ssp 8.6	A&A ssp 2.6	A&A ssp 8.6	Area mob 2.6	Area mob 8.5	A&A mob 8.6
1	Consumption	64.6	-0.3	-2.0	-0.1	-0.3	-0.4	-2.3	-0.1	-0.3	-2.4
2	Investment	44.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Stocks	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Government	22.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	Exports	32.6	-0.5	-1.6	-0.1	-0.2	-0.6	-1.8	-0.1	-0.2	-1.9
6	Imports	-80.1	-0.2	-0.7	0.0	-0.1	-0.2	-0.7	0.0	-0.1	-0.8
7	GDP at market prices	100.0	-0.2	-1.3	-0.1	-0.2	-0.3	-1.5	-0.1	-0.2	-1.6
8	Ex. rate (real)	100.0	0.3	-0.5	0.0	0.0	0.3	-0.5	0.0	-0.1	-0.6

Source: Author's calculations.

highly educated labour is less likely to be employed directly and indirectly in crop production that benefits from climate change, but more likely to be employed by supporting industries that suffer due to the negative impact of climate change on higher value crops. The opposite appears to be the case in urban areas. Note that per assumption, tertiary educated labour is not impacted since it is assumed to be fully employed. For total employment, the impacts then appear to wash out. As an alternative, it could be assumed that all labour is fully employed. The argument for changing the labour market closure for unemployed labour with attainment levels less than tertiary education is that the time frame of the shocks is of such a long term nature that wage rates can adjust downwards for industries that suffer and adjust upwards for those that benefit. Running the model with the same shocks in this way suggests (but not shown here) that the pattern of impacts on wage rates is similar to those reported in Table 10.3.5.

Table 10.3.4: Detailed GDP Results

			Change from base (%)								
		1 Initial share	2 Alpha ssp 2.6	3 Alpha ssp 8.6	4 Area ssp 2.6	5 Area ssp 8.6	6 A&A ssp 2.6	7 A&A ssp 8.6	8 Area mob 2.6	9 Area mob 8.5	10 A&A mob 8.6
1	Agriculture	27.3	-0.4	-2.8	-0.2	-0.5	-0.5	-3.2	-0.2	-0.5	-3.4
2	Maize	7.0	4.2	1.8	0.0	-0.2	4.2	1.6	-0.2	-0.6	0.9
3	Sorghum and millet	2.5	5.0	3.3	0.0	-0.2	5.1	3.1	-0.2	-0.6	2.4
4	Rice	0.6	-2.2	-4.5	-0.1	-0.3	-2.3	-4.8	-0.1	-0.5	-5.0
5		0.3	-14.4	-24.7	-3.8	-9.3	-17.4	-30.9	-0.5	-1.8	-28.0
6	Pulses	3.3	-2.7	-6.5	0.0	-0.2	-2.7	-6.7	-0.2	-0.7	-7.2
7	Groundnuts 0.6	-3.4	-8.2	0.0	-0.3	-3.4	-8.4	-0.2	-0.6	-8.8	
8	Other oilseeds	0.1	-1.9	-5.8	-0.2	-0.5	-2.1	-6.3	-0.1	-0.4	-6.2
9	Cassava	0.2	-3.0	-5.3	-0.1	-0.3	-3.1	-5.6	-0.1	-0.5	-5.7
10	Other roots	1.0	-1.7	-4.8	-0.1	-0.4	-1.8	-5.2	-0.1	-0.4	-5.1
11	Vegetables	1.8	-7.4	-13.3	-0.1	-0.6	-7.5	-13.8	-0.1	-0.5	-13.7
12	Sugar cane	0.8	-1.8	-2.3	-0.2	-0.4	-2.0	-2.6	-0.1	-0.2	-2.5
13	Tobacco	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	Cotton and fibres	0.2	-2.4	-4.8	0.4	0.3	-2.0	-4.6	-0.2	-0.8	-5.2
15	Fruits and nuts	1.7	-5.5	-7.0	-1.2	-2.1	-6.6	-8.9	-0.3	-0.9	-8.1
16	Coffee and tea	0.0	-2.8	-4.3	-0.4	-0.7	-3.3	-5.0	-0.1	-0.4	-4.6
17	Other crops	0.5	-14.6	-18.4	-0.7	-1.9	-15.2	-19.8	-0.4	-1.3	-20.2
18	Mining	12.1	0.4	-0.1	0.0	0.1	0.4	-0.1	0.0	-0.1	-0.2
19	Food Processing	3.0	-0.9	-2.0	-0.1	-0.3	-1.0	-2.3	-0.1	-0.2	-2.3
20	Manufacturing	9.9	0.0	-0.8	0.0	0.0	0.0	-0.9	0.0	-0.1	-1.0
21	Private Services	32.8	-0.3	-1.2	0.0	-0.1	-0.4	-1.4	0.0	-0.1	-1.4
22	Public Services	13.3	-0.1	-0.3	0.0	0.0	-0.1	-0.3	0.0	0.0	-0.4
23	GDP	100.0	-0.2	-1.3	-0.1	-0.2	-0.2	-1.5	-0.1	-0.2	-1.6

Source: Author's calculations.

Note: Shares in column 1 do not add to 100 per cent due to selective reporting.

Table 10.3.5: Detailed employment results

			Change from base (%)								
		1 Initial share	2 Alpha ssp 2.6	3 Alpha ssp 8.6	4 Area ssp 2.6	5 Area ssp 8.6	6 A&A ssp 2.6	7 A&A ssp 8.6	8 Area mob 2.6	9 Area mob 8.5	10 A&A mob 8.6
1	labour-rural not completed primary	5,986.7	0.4	0.9	0.0	0.2	0.4	1.1	0.1	0.5	1.2
2	labour-rural completed primary	1,577.7	1.0	1.7	0.2	0.4	1.2	2.2	0.1	0.5	1.8
3	labour-rural completed secondary	283.9	0.5	0.4	0.1	0.2	0.6	0.7	0.1	0.3	0.4
4	labour-rural completed tertiary	75.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	labour-urban not completed primary	1,684.1	-0.1	-0.5	-0.1	0.0	-0.1	-0.5	0.1	0.2	-0.5
6	labour-urban completed primary	1,678.8	-0.5	-2.2	-0.1	-0.2	-0.5	-2.3	0.0	-0.2	-2.5
7	labour-urban completed secondary	958.8	-0.8	-3.0	-0.2	-0.3	-0.9	-3.3	-0.1	-0.3	-3.4
8	labour-urban completed tertiary	619.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	labour-rural	7,924	0.5	1.0	0.0	0.2	0.6	1.3	0.1	0.5	1.3
10	labour-urban	4,942	-0.3	-1.5	-0.1	-0.1	-0.4	-1.6	0.0	0.0	-1.7
11	labour-total	12,865	0.2	0.1	0.0	0.1	0.2	0.2	0.1	0.3	0.1

Source: Author's calculations.

10.4 Conclusion

Globally, the anticipated impact of climate change on agriculture is predominantly negative. Africa, including Mozambique, is already experiencing disproportionate vulnerability to climate change. This vulnerability stems not only from the direct impacts of a changing climate but also from challenging socio-economic conditions, exacerbated by the lack of prioritization of agriculture on the policy agendas of African governments. Mozambique is among the top 10 countries most affected by and least prepared to handle natural hazards (BEHI, 2022; CIAT and World Bank, 2017). Present climate change adaptation strategies are proving unsustainable, highlighting the urgent need for more context-specific and climate-smart measures.

Climate models play an informative role in assessing how climate change may affect agricultural yields in the future. Projections specific to Mozambique indicate a bleak outlook, with estimates suggesting a negative change in yields exceeding 10 per cent for crops such as vegetables, sugar cane, coffee, and tea by 2040–2070. Similarly, a decrease in yields ranging from 5 to 10 per cent is anticipated for rice, cassava, tobacco, fruits, and nuts. Moreover, these adverse effects are expected to translate into an overall negative impact on the Mozambican GDP, estimated to range between 1.3 to 1.6 per cent.

While it is certain that climate change will exert negative impacts on Mozambican agriculture, it is crucial to acknowledge that different assumptions in various models can imply different results. Therefore, more refined research is imperative to enhance the accuracy of climate projections for Mozambique and beyond. This underscores the importance of continuous efforts to improve climate modelling and refine projections to better inform adaptation strategies and policy decisions. At the same time, sustainable (and climate-smart) adaptation to climate change is urgent, and should be part of all development policies.

Appendix

10.A Details about FAO GAEZ data

Table 10.A.1: 41 FAO GAEZ crops and aggregation into 16 crop groups (as used in SAM)

	Crop group	**Crop**
1	Maize	Maize
2	Sorghum and millet	Biomass sorghum, foxtail millet, pearl millet, sorghum
3	Rice	Dryland rice, wetland rice
4	Other cereals	Barley, wheat
5	Pulses	Chickpea, cowpea, gram, dry pea, phaseolus bean, pigeonpea, soybean
6	Groundnuts	Groundnut
7	Other oilseeds	Jatropha, miscanthus, rapeseed, sunflower
8	Cassava	Cassava
9	Other roots	Sweet potato, white potato, yam
10	Vegetables	Alfalfa, cabbage, carrot, onion, tomato
11	Sugar cane	Sugar cane
12	Tobacco	Tobacco
13	Cotton and fibres	Cotton
14	Fruits and nuts	Banana, citrus, coconut
15	Coffee and tea	Cocoa, coffee, tea
16	Other crops	Napier grass, rubber

Source: FAO GAEZ (2022) and own mappings.

Table 10.A.2: Comparison of FAO GAEZ harvested area and TIA data for SAM crops

		2020 FAO Area	**2020 TIA Area**	**TIA/FAO (%)**	**2020 %sh in tot diff (%)**	**2019 SAM VA Shares**
1	Maize	2,286,362	2,136,300	-6.6	9.5	31.0
2	Sorghum and millet	316,056	302,570	-4.3	0.8	11.4
3	Rice	283,919	240,087	-15.4	2.8	2.6
4	Other cereals	13,000	23	-99.8	0.8	1.5
5	Pulses	1,552,349	884,401	-43.0	42.1	14.5
6	Groundnuts	347,000	340,222	-2.0	0.4	2.8
7	Other oilseeds	741,972	345,226	-53.5	25.0	0.4
8	Cassava	556,000	572,544	3.0	-1.0	0.8
9	Other roots	105,731	79,507	-24.8	1.7	4.5
10	Vegetables	75,340	267,716	255.3	-12.1	8.0
11	Sugar cane	47,351	19,438	-58.9	1.8	3.8
12	Tobacco	56,164	39,584	-29.5	1.0	8.1
13	Cotton and fibres	144,098	47,471	-67.1	6.1	0.7
14	Fruits and nuts	319,243	17,756	-94.4	19.0	7.6
15	Coffee and tea	34,879	0	-100.0	2.2	0.0
16	Other crops	0	0		0.0	2.3
	Total	6,879,464	5,292,845	-341.0		100.0

Source: FAOSTAT, Crops and livestock products and TIA.

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