Food for Growth: A Diagnostics of Namibia's Agriculture Sector

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Executive Summary

This growth diagnostic report analyzes the economic constraints that explain the underperformance of the agriculture sector in Namibia. Section 1 starts by showing why Namibia's agricultural challenge is unique when compared to the rest of the world. We then describe the sector's key features, recent trajectory, and growth potential across different relevant dimensions in Section 2. In Section 3, we provide an adaptation of the growth diagnostic framework to the case of agriculture in Namibia and a detailed analysis of its economic constraints. Finally, Section 4 presents policy guidelines for addressing the challenges described in this report and prioritizing policy interventions accordingly.

Since the 1990s, Namibia's agriculture sector has expanded farmland without significantly increasing yields, while peer countries have experienced agricultural growth thanks to productivity gains. Section 1 notes that all agriculture activities in Namibia that experienced growth in the past two decades have increased land and water use but are severely constrained by their low productivity levels. This is the case for cereal crops but also for fruits and vegetables –even for grapes, representing almost 80% of Namibia's exports in agriculture outside of the fishing, livestock, and meat industries. It is also the case for the meat sector, where value added per animal declines as weaner exports substitute in-country slaughtering. This broad pattern of land expansion under low productivity indicates that the sector has not acquired the capabilities required to converge to the trajectory of agriculture in the rest of the world. As Namibia continues expanding farmland extension, the country faces productivity barriers to increasing agricultural output.

This growth diagnostic report of agriculture in Namibia asks what the binding constraints are for increasing agricultural output through productivity growth. This is a central question when considering the prospects of agriculture in Namibia, as the sector is either not growing or growing in a way that has proven unsustainable. Section 3 finds that human capital and access to finance are not binding constraints for agricultural development. Similarly, although infrastructure is essential for developing irrigation-based agriculture in Namibia, it is not a binding constraint in the short term, given its levels of underutilization. The most pressing problem producers face is the scarcity of vital productive inputs due to problems with the provision of public inputs (land tenure and plant variety protection policies). The sector also faces binding coordination problems linked to diversification, innovation, and the development of place-based agricultural know-how. Additionally, the livestock industries face a scarcity of animal feed that hampers their productivity and profitability. More so, the effect of the economic constraints is aggravated by adverse natural conditions –which generate major production setbacks year after year.

The analysis indicates that Namibia's agriculture sector faces a syndrome of "adaptive know-how gap" where the private sector finds it challenging to develop productive capabilities and technologies that adapt to the specificity of Namibia's natural environment. The use of modern inputs in commercial agriculture shows a pattern where agents are trying to overcome the constraint of coordination problems in agriculture innovation. The farmers who require complex know-how to address farming challenges are not able to thrive, whereas those who require less complex know-how perform better. Additionally, the few farmers who managed to bypass these problems and invest in modern inputs show higher productivity levels.

The report concludes with a policy framework that aims to provide insights for designing a strategy for the agriculture sector. The framework categorizes policy interventions according to the problems they aim to address and their scope. The results of the growth diagnostic analysis indicate that the most binding constraints for agriculture are public input provision and coordination problems, so these areas of intervention appear as priorities for a strategy of agriculture development. On the other hand, policy interventions can take different forms depending on whether they target specific industries or address cross-cutting issues.

1. Introduction: Namibia’s Agriculture Challenge in Global Context

The world experienced a technological revolution in agriculture during the 1960s that was later named the “green revolution” and had long-lasting effects on agricultural productivity. The green revolution started with the incorporation of modern technologies into the agriculture sector in developed economies and later expanded to developing countries. Some of the key technologies that contributed to the Green Revolution include:

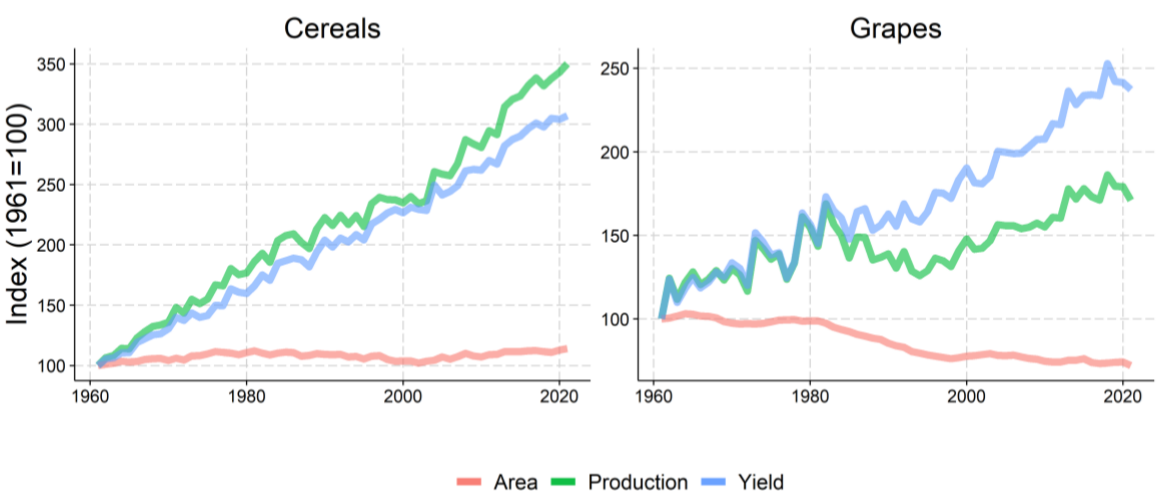
- High-yielding crop varieties (HYVs) of crops such as wheat, rice, and maize produce more grain per acre than traditional varieties. These HYVs were bred through hybridization and selection, resulting in crops that were more resistant to disease and pests and could grow faster and produce higher yields.
- Irrigation systems such as sprinkler and drip irrigation allowed farmers to water their crops more efficiently and effectively, reducing water waste and increasing yields.
- Fertilizers and pesticides boost crop growth and protect plants from pests and diseases, reducing crop losses and increasing yields.
- Farming machinery like tractors, harvesters, and others enabled farmers to cultivate more land, harvest crops more efficiently, and reduce labor costs.
- Management practices, such as crop rotation, soil conservation, and integrated pest management

The Green Revolution not only helped developing countries increase their agricultural productivity but also had enduring effects on economic development. Technology adoption resulted in a significant reduction in child mortality (Bharadwaj et al., 2020; Von Der Goltz et al., 2020), higher crop yields, increased income per capita, and a reduction in population growth across the world (Gollin et al., 2021). Norman Borlaug, who was one of the leading champions of the green revolution and a Nobel Peace Prize laureate, formulated what was later known as the “Borlaug Hypothesis”: He thought that the implementation of high-yielding crop varieties (HYVs), along with modern agricultural techniques, is the main road towards increasing food production and reducing hunger in the world (Angelsen & Kaimowitz, 2001).

While high-yielding varieties (HYVs) significantly impacted agricultural productivity, their influence varied across different crops. Gollin et al. (2021) find that the Green Revolution had a greater impact on wheat and rice yields than other important crops- cassava and sorghum – relevant to Namibia’s agriculture and consumption patterns. This is partly because wheat and rice high-yielding varieties (HYVs) became available earlier, whereas cassava and sorghum were only available later. Additionally, the impact of HYVs on cassava and sorghum yields was not as significant. Furthermore, outside of the big three staple crops (maize, rice, and wheat), many plant varieties that are an essential part of the food consumption baskets in Africa, including Namibia, have not experienced gains from HYVs. This fact remains a crucial challenge for agriculture policy (Pingali, 2023).

As a result of the productivity gains of the Green Revolution, the world increased agricultural output by raising the value per hectare of existing cropland rather than by expanding the amount of land under cultivation. As shown in Figure 1, the pattern holds for cereals and some crops relevant to Namibia's agriculture sector, like grapes. The total production of cereals in the world increased by 3.5 times in 60 years, while the area under cultivation remained roughly the same. In turn, grapes almost doubled their production, while the total area under cultivation decreased significantly. In this sense, the grape yields grew by a factor of 2.5. The productivity gains from the Green Revolution were particularly advantageous for developing countries as they were the primary commodity exporters of several crops. While countries like the United States, Canada, and Ukraine are major cereal exporters, the export of grapes in 2020 was concentrated in Latin America (60%) and Africa (30%). In the case of cereals, several developing countries like Argentina, Brazil, India, and Thailand were able to join the productivity boom in cereal production and significantly increase their global exports share.

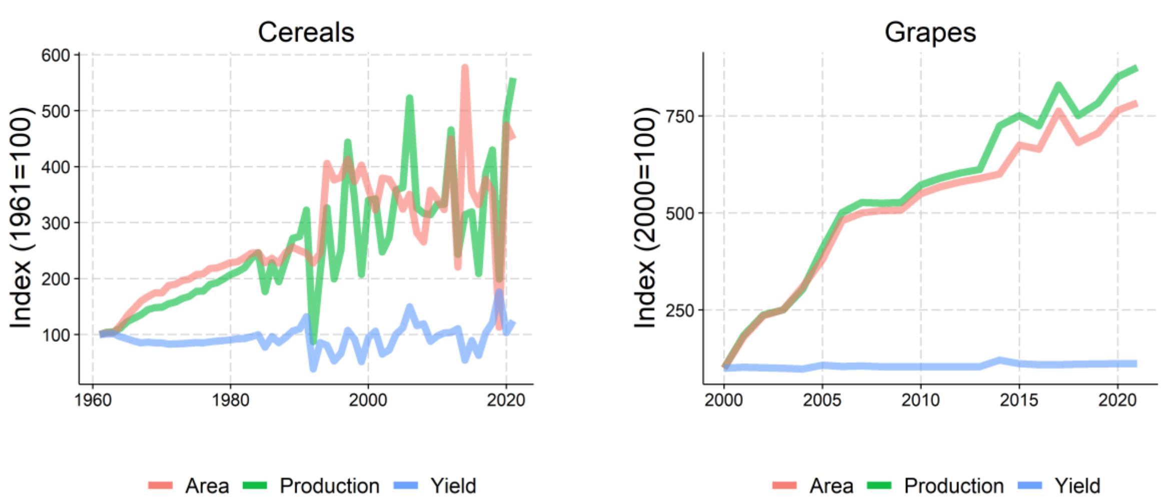
Figure 1: Cereal and Grapes Production (tonnes), land (has), and yields (tonnes per ha) in the world. Index (1961=100)



Sources: World Bank and FAO data, idea from OurWorldinData.org

In Namibia, the agriculture sector has only been able to increase output by expanding cropland rather than by incorporating global productivity gains. Figure 2 shows that Namibia's production pattern is opposite to that of the global trend. Cereal production increased fourfold between the 1960s and Namibia's independence and has since remained stable. This production pattern closely follows the trajectory of the area under cultivation, which also increased during the same period. However, yields have remained at the same level as in the 1960s, indicating a lack of improvement in productivity. Furthermore, Namibia's cereal production exhibits greater variability compared to its peer countries. While many developing nations encounter fluctuations in their rain-fed agricultural output, Namibia's situation is particularly noteworthy. This can be attributed to the impact of droughts and adverse weather conditions that have significantly hampered crop yields and production. The cultivation of grapes also displays a similar trend, albeit without significant volatility, as it is an irrigated crop. Despite cropland expansion, grape yields remain low and have only seen a marginal increase. These two crops are the most productive of Namibia's agriculture (farmers from the Maize triangle and grape growers from the Orange River Basin), but the same pattern of low productivity through cropland expansion can be observed across the rest of agriculture. The small horticulture farmers who have managed to move out of subsistence agriculture are struggling to improve productivity. Meanwhile, the livestock and meat sector has not fully modernized production standards or added more value to their products.

Figure 2: Cereal and Grapes Production (tonnes), land (has), and yields (tonnes per ha) in Namibia. Index (1961=100 for cereals and 2000=100 for grapes)



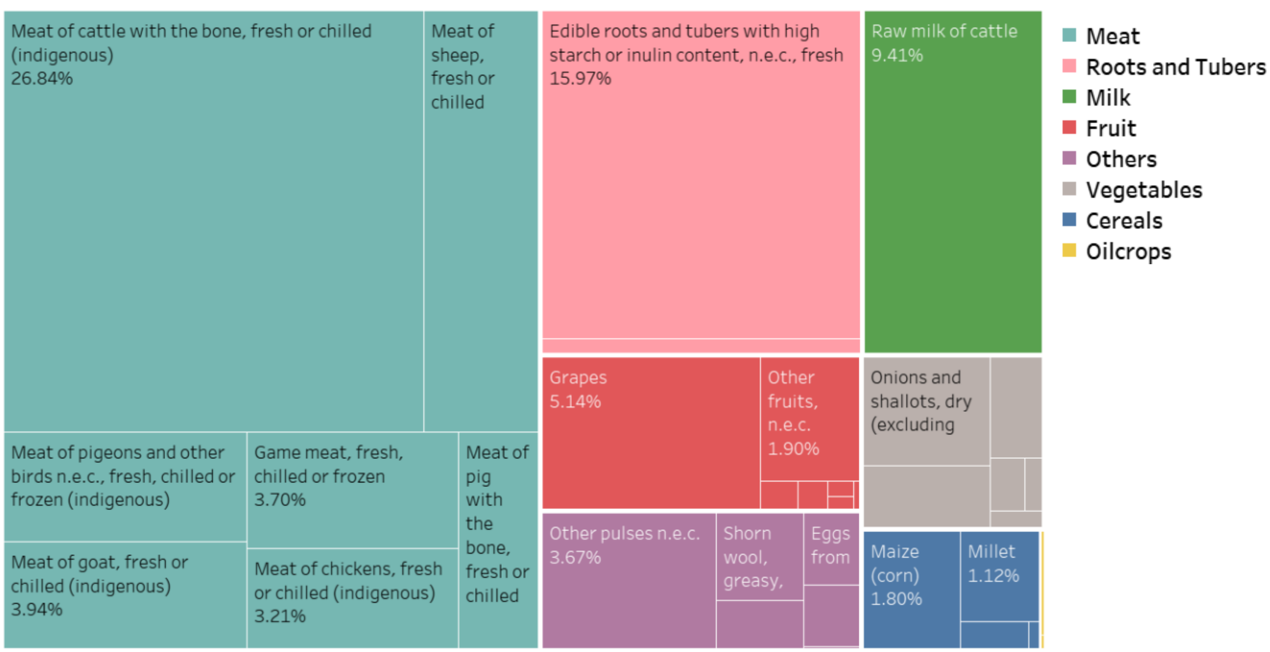
Sources: World Bank and FAO data, idea from OurWorldinData.org

The central focus of this report is to investigate why Namibia's agriculture sector has failed to achieve productivity gains. In the subsequent sections, we delve into a detailed analysis of the factors contributing to this phenomenon. Agriculture can grow either by expanding the utilization of land and water resources or by increasing output per hectare. Despite the volatility and slow pace of farmland expansion compared to other countries, Namibia has experienced increased agricultural land use over the last two decades. This has occurred through the expansion of green schemes, the emergence of new commercial farms in the south, and the development of small farmers in the north. Nevertheless, what distinguishes Namibia's agricultural trajectory is its inability to solve the productivity problem, which should be a top priority. As we will elaborate in subsequent sections, this issue also constrains farmland expansion, discouraging investments in the agriculture sector. Thus, to achieve sustainable agricultural growth, Namibia needs to address the challenge of increasing productivity that would enable farmland expansion.

2. Trajectory and Features of Namibia's Agriculture

Namibia's agriculture has historically been comprised of animal farming, an export-oriented fruit industry, small-scale horticulture farmers, subsistence farming, and cereal producers. In 2019, the animal and meat industries were over 50% of the total gross production value (Figure 3). According to FAO data, the second most significant agricultural activity in Namibia in terms of production value is the farming of roots and tubers by subsistence farmers. Interestingly, this activity surpasses grape production (which accounts for only 5% of the total output), which shows that in terms of production value, the volume of subsistence agriculture in Namibia is notably high. The remaining agricultural activities in Namibia consist of cereals (3%), vegetables (5%), and dairy (9%).

Figure 3: Namibia's Gross Production Value of Agriculture (2019)
(Constant 2014-2016 thousand I$)

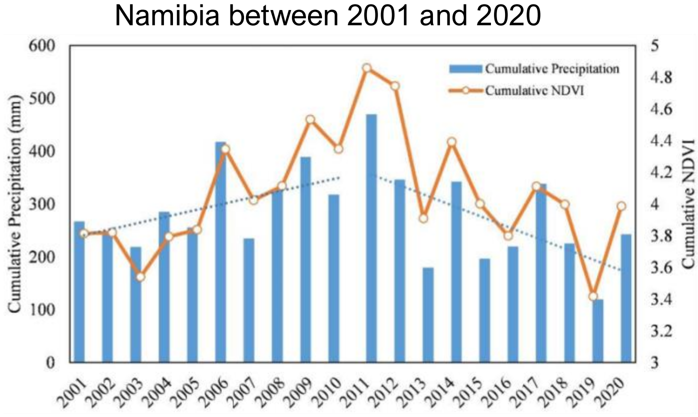


Source: FAOSTAT

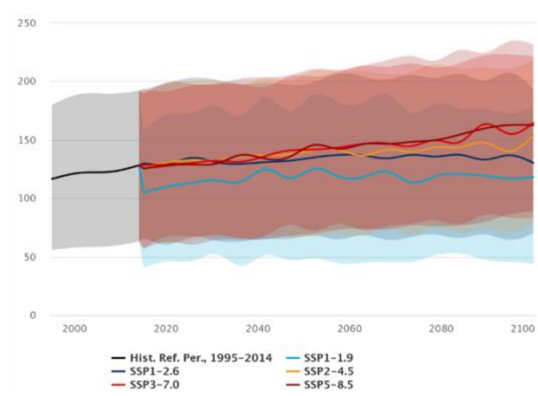
Namibia, the driest country in Sub-Saharan Africa, faces severe limitations in developing its agriculture due to natural conditions. Long-term factors such as land degradation and bush encroachment have significantly reduced the land's carrying capacity and fertility. Climate disasters like floods and droughts have also resulted in substantial losses in various agricultural activities, particularly in livestock farming. Additionally, the elevated temperatures in northern Namibia pose a challenge to developing varieties that might be more productive in other types of environments. These factors severely hamper land productivity in Namibia and increase the risk of engaging in agricultural businesses in the country. Furthermore, Figure 4 shows that natural conditions have become worse in time and are projected to become harsher in the future. Panel A presents the trends in cumulative precipitation and NDVI in Namibia, with a decline after 2011 (Liu & Zhou, 2021). Similarly, Panel B shows that the maximum number of consecutive dry days are expected to increase in 2020-2100. Although this is a limiting factor, there are several examples of places that have developed productive agriculture in arid land or with extreme conditions, two of the most prominent ones being Egypt and Israel. The latter has less than half of Namibia's arable land area, but over three times more agricultural exports. This report does not provide analyses of the role of environmental conditions in agriculture development in Namibia. Instead, we focus on the economic constraints that can be addressed to increase agricultural output considering the natural conditions as given. Furthermore, it is important to note that Namibia's adverse natural conditions highlight the need to develop a highly productive agriculture industry capable of withstanding climate risks, sustaining yield levels with lower rainfall, and adapting to local weather and soil conditions.

Figure 4: Climate Change Variation and Projections

A. Inter-annual variation of cumulative precipitation and cumulative vegetation during the growing season in Namibia between 2001 and 2020



B: Projected Max Number of Consecutive Dry Days in Namibia



Notes: Vegetation based on Normalized Different Vegetation Index (NDVI) in the left. The reference period for the right-hand side graph is 1995-2014 and it is based on a multi-model ensemble. Sources: World Bank Climate Change Knowledge Portal (right) & Liu, X., & Zhou, J. (2021). Assessment of the Continuous Extreme Drought Events in Namibia during the Last Decade. Water, 13(20), 2942. https://doi.org/10.3390/w13202942 (left).

A crucial factor that has shaped Namibia's agriculture both in the past and present is the divide between the north and the rest of the country. Paradoxically, some of the regions in the north possess the most favorable natural conditions for agriculture, with three times more median annual rainfall than the south (Figure 5). Nevertheless, despite having the best conditions for agriculture and the largest working-age population available for work, the northern regions have no significant productive agricultural development. In contrast, the development of irrigation projects in the south, facilitated by the Orange River Basin, has made agriculture a more profitable venture. Thus, while the north of Namibia is primarily home to subsistence farmers, the south has evolved into a commercial agriculture hub. Moreover, the veterinary cordon fence (VCF) constitutes a fundamental limitation for advancing a market-driven livestock and meat sector in the north, which still relies heavily on cattle rearing (Figure 7). Finally, the rural regions in the north of Namibia exhibit significantly higher population densities (Figure 6) compared to the south and even other rural areas in developing countries. Due to its history as a former homeland, the north of Namibia shares similarities with rural regions of the former homelands of South Africa, where population densities are too high for typical rural areas in other developing countries but too low to be considered urban settlements. In contrast, The Southern regions have the lowest population density in the country and a private property system of land tenure. The low population density is a long-term effect of the Herero and Namaqua genocide done by the German army in 1904-1908, during the German colonization of Namibia (Melber, 2014).

Figure 5: Median rainfall, 2000

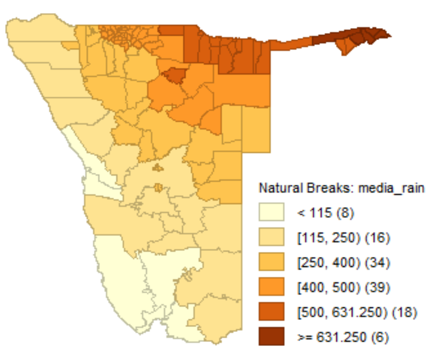


Figure 6: Population density, 1991

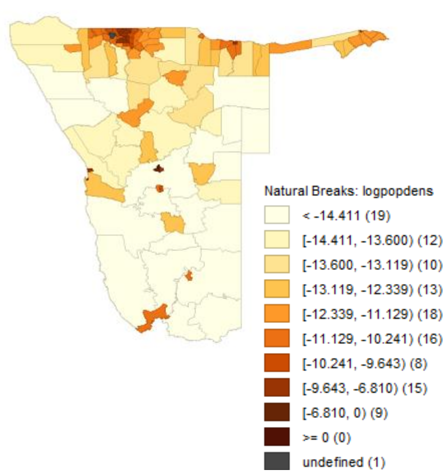
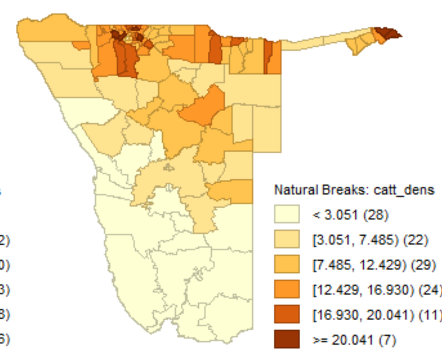


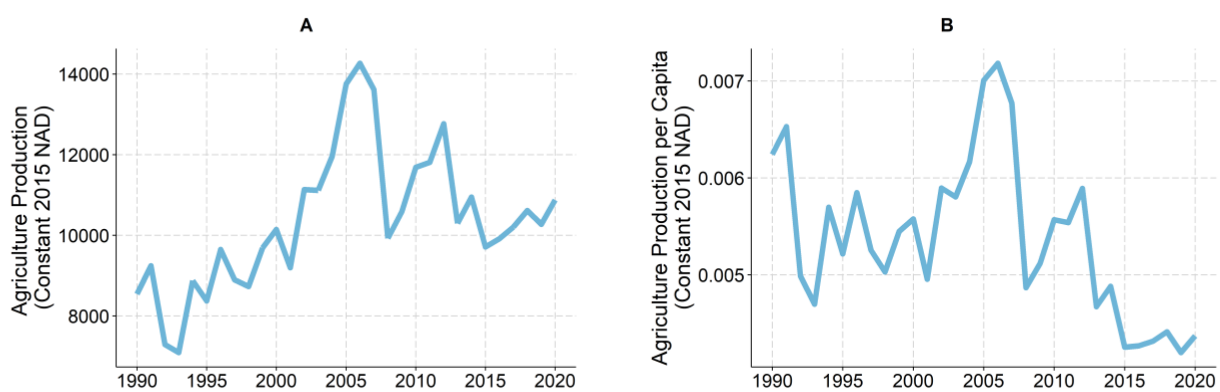
Figure 7: Density of cattle (Heads per Km2), 2000



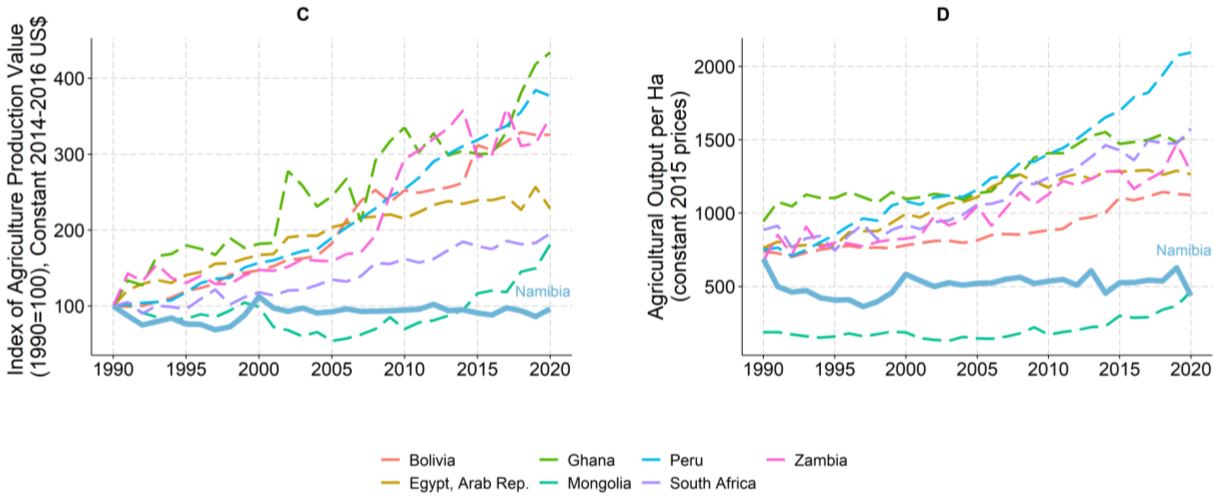
Source: Namibia GeoPortal

The agriculture sector in Namibia has shown a dismal trajectory over the past two decades, a fact that is at the core of its primary challenge. Figure 8 shows the trajectory of Namibia's agriculture production from different perspectives. According to the Namibia Statistics Agency (NSA), the total GDP of agriculture increased significantly between 1990 and 2006, only to sharply decrease after that (Panel A). The sector started to recover in 2015, and more recent data from NSA shows that this holds for 2021 and 2022, where agriculture GDP saw a 2% increase each year (NSA's National Accounts). However, the recovery is far from reaching the levels of 2006. Furthermore, the agriculture GDP per capita (Panel B) shows a different trend: there is no sustained increase during the first period (only in 2002-2006), and the decline is even sharper after 2006 -without a recovery post-2015. When compared to peer countries,[1] the overall underperformance is even starker. Peer countries saw a significant upward trend in agriculture production during 1990-2020 (Panel C). Agriculture production was nearly 100% higher in 2020 than in 1990 in South Africa and Mongolia. In Bolivia, Peru, and Zambia, it was more than 200% higher, and Ghana managed to increase the agriculture GDP by over 300% during the same period. According to FAO data, Namibia's agriculture GDP in 2020 was only 96% of what it used to be in 1990. In 2000, Namibia's agriculture gross production value per capita was higher than South Africa, Peru, and Bolivia. Still, by 2020, it was 30% lower than the average of the three countries. The same pattern applies to output per hectare (Panel D). All peer countries experienced a sustained increase during the period, but Namibia has the same levels as the country had in 1990.

Figure 8: Namibia's agriculture trajectory in perspective



[1] See Appendix 1 for a detailed explanation of the methodology for peer selection.



Sources: NSA (Panels A and B), FAOSTAT (Panel C), Economic Research Unit at US Department of Agriculture (Panel D).

The livestock and meat industries, which have suffered severe drought shocks, drive the agriculture decline. Crops, fruits, vegetables, and non-animal farming activities contributed positively to overall growth in production value between 2000 and 2020, according to data from FAO. Livestock and meat, on the other hand, contributed to a reduction of total agriculture value at a compounded annualized rate of 0.66% and 0.72%, respectively. The National Accounts data from NSA shows a similar trend: the livestock and meat sector positively contributed to overall agricultural growth in 1990-2005, which became negative in 2005-2020. Additionally, the industry could not recover from recurrent droughts in 2013, 2016, and 2019. Figure 9 shows the exports of livestock and processed meat products after 2000. The years with low exports coincide with droughts, which have severely affected the animal industry's overall production. As a result, the exporters of livestock and meat products have been unable to regain their promising growth path before 2013.

Figure 9: Exports of Livestock & Processed Meat

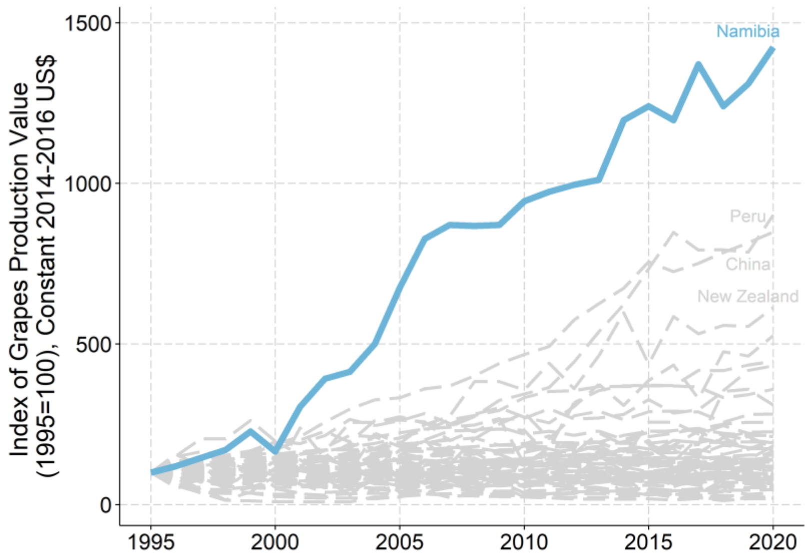
Source: International trade data from Atlas of Economic Complexity

The only crop demonstrating competitive and significant growth in Namibia is table grapes. Figure 10 shows the production value of grapes[2] in Namibia compared to the rest of the world (indexed to 1995). According to data from FAO, Namibia is the country with the highest growth in grape production in the world during the past three decades. The growth rate is extraordinary: between 1995 and 2020, it increased by a factor of fourteen. Over the whole period, grape production in Namibia grew over 50% faster than in the largest grape producers in the world. This reflects the successful establishment of a competitive grape industry from scratch. However, as Figure 11 illustrates, Namibia's share in global table grape exports in 2021 was 0.5%. This is a considerable share given Namibia's industry size, but it also implies that there is potential for this sector to expand and gain a larger global market share. However, it is essential to note that grape exports peaked in 2014 and have not recovered since, both in terms of total value and market share. This suggests that challenges may prevent the industry from fully reaching its potential. As we will show in the following sections of this report, the case of grape production is useful to understand the binding constraints of the agriculture sector. By analyzing the grape industry as an outlier, we can understand the unique factors that enabled its growth. In that sense, we can see whether the grape growers overcame constraints affecting the rest of the agricultural

[2] The data includes grapes for wine production, which explains the trajectory of New Zealand.

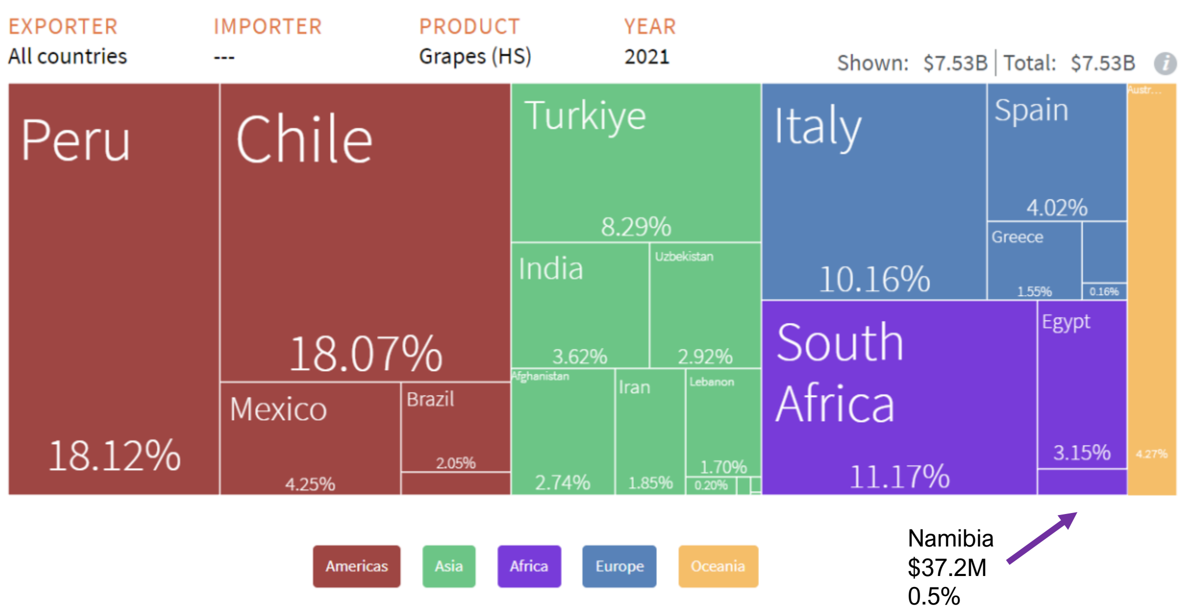
industries or are less intensive in using specific scarce inputs. This type of analysis can help identify the inputs that prevent the development of other industries that are more intensive in them.

Figure 10: Index of Grape Production Value (1995=100)



Source: FAOSTAT

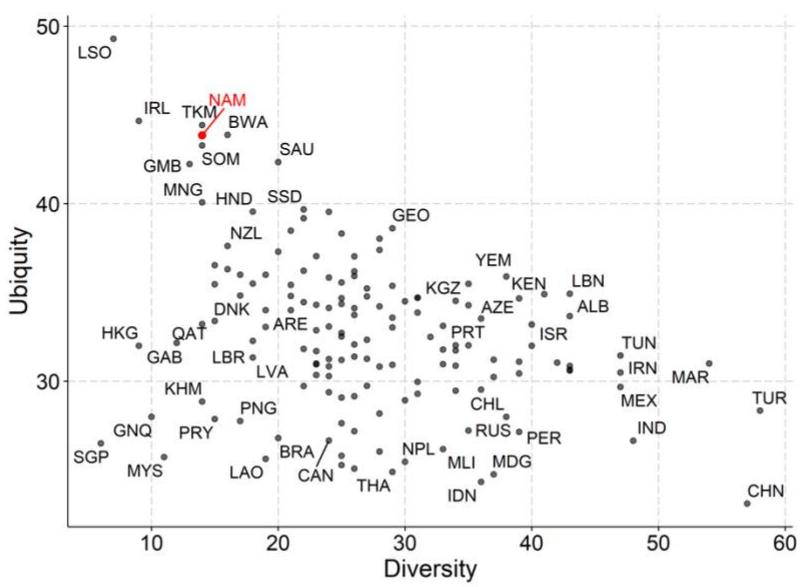
Figure 11: Net Exports of Table Grapes (2021)



Source: Atlas of Economic Complexity

Another crucial factor for understanding Namibia's agriculture growth challenge is that the sector is not diverse and comprises non-specialized crops. Figure 12 shows broad estimates of the diversity and ubiquity of crop production worldwide using production values from FAOSTAT. The diversity of countries is calculated by counting the number of crops in which each country has a comparative advantage.[3] On the other hand, the ubiquity of crops represents how common these are worldwide, and it is calculated by counting the number of countries that produce them with RCA higher than one. The figure shows the average ubiquity of crop production by country, indicating if they have crops that tend to show a comparative advantage in the rest of the world or more unusual crops. The figure also shows a pattern that holds for international trade and is at the core of economic complexity theory: more diverse places tend to produce specialized goods on average, and less diverse places tend to produce more ubiquitous goods (Hausmann et al., 2014). Namibia is in the upper-left area of the distribution, which indicates that the country's crop diversity is much lower than the rest of the world, and its average ubiquity tends to be higher.

Figure 12: Diversity Vs. Ubiquity of Crop Production (2019)

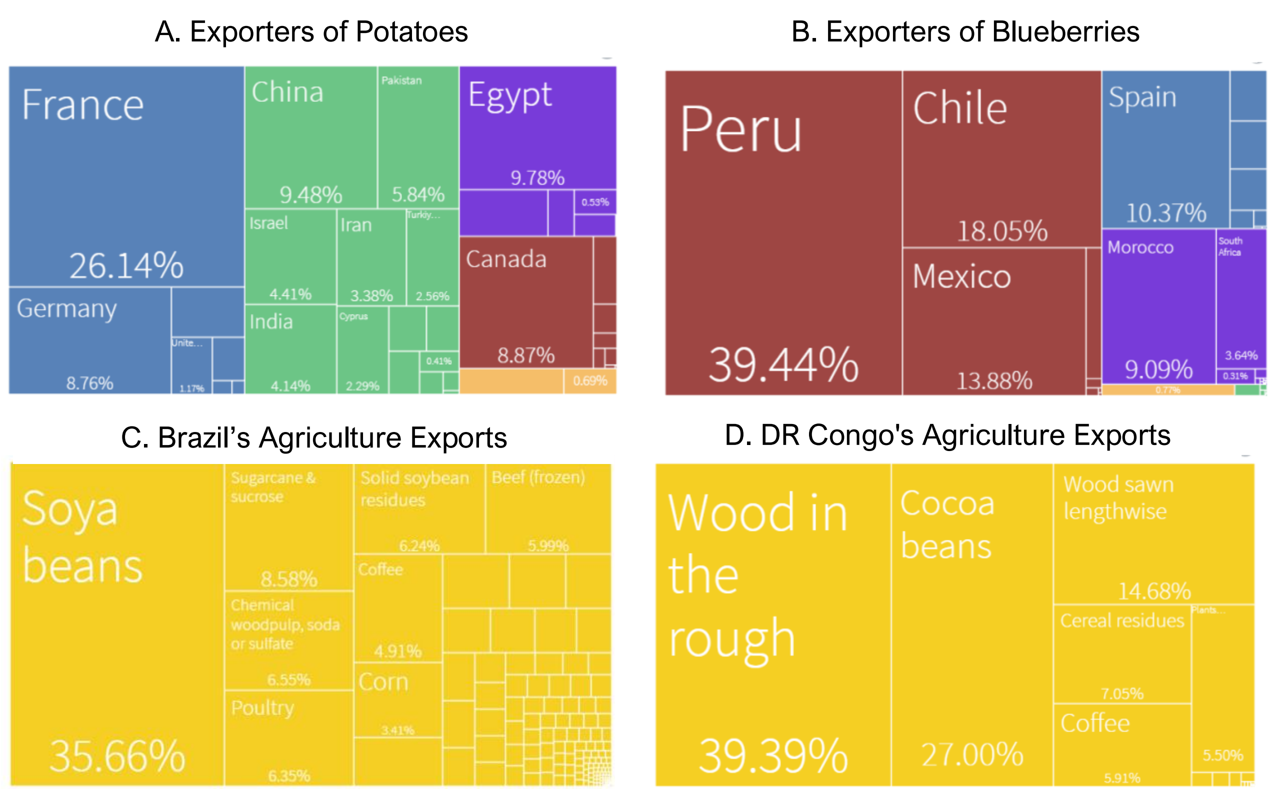


Source: FAOSTAT

[3] We can use the Balassa index to see a country's revealed comparative advantage (RCA) in each crop. The RCA is calculated by comparing how much of a crop a country produces out of all its production to the amount of that same crop being produced worldwide. Essentially, it tells us if a country is producing more (RCA > 1) or less (RCA < 1) of that crop than what we might expect given its portion in global production.

Namibia's agricultural sector lacks diversity and struggles even in its most competitive industries, illustrating a significant challenge in cultivating necessary know-how. Figure 13 shows patterns of diversification in agricultural exports. The agricultural goods known to be more complex, like blueberries, tend to be exported by fewer countries than goods known to be less complex, like potatoes (Panels A and B).[4] In turn, the countries that have developed highly competitive agricultural know-how, like Brazil, have also been able to diversify their exports of agricultural products (Panel A), whereas countries without a solid commercial agriculture sector, like DR Congo, show low levels of diversification. Namibia developed specific agricultural know-how in livestock, meat, and grape industries, but these industries are not reaching their full potential, and the country has not seen positive spillovers on other crops and industries. The challenge lies in expanding the necessary know-how base to boost the sector's diversity and productivity.

Figure 13: Patterns of Agricultural Diversification in 2021

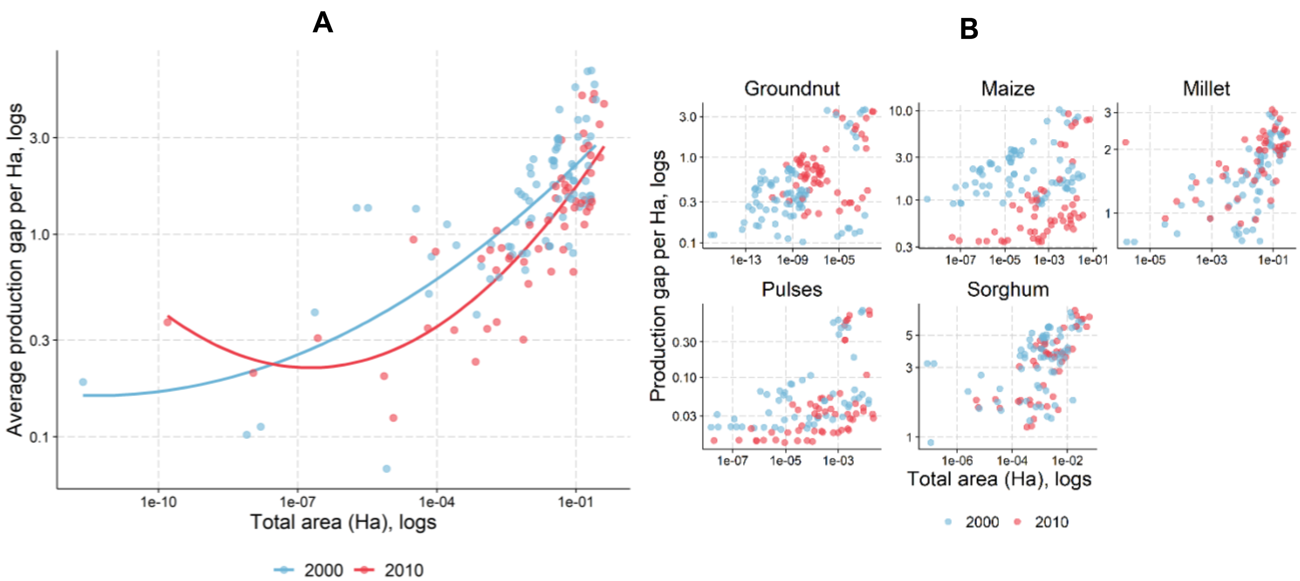


Source: Atlas of Economic Complexity

[4] We consider only generic potatoes and blueberries. There are over 5,000 varieties of potatoes and over 150 varieties of blueberries.

Despite the sector's complex challenges, signs point toward growth potential. FAO has developed a Global Agro-Ecological Zones (GAEZ) model based on satellite imagery data to identify land use types and evaluate the agricultural potential of geographical areas in the world.[5] The GAEZ data includes an estimation of the production gaps by location, that is, the difference between the actual and potential yields.[6] Figure 14 presents the production gaps against the total agricultural production area by constituency. Panel A shows the average production gaps for all crops, while panel B presents them by crop (only those most present in Namibia). In all the cases, we observe that the constituencies with the largest production areas show the highest yield gaps. These areas have better natural conditions for agriculture, hence higher potential yields, partly because they have the largest production areas. Thus, the constituencies of Namibia that show better conditions for agriculture have the potential to increase their production significantly.

Figure 14: Crop Potential by constituency (2000 & 2010)



Source: Global Agro-Ecological Zones, FAOSTAT

[5] FAO and IIASA. Global Agro Ecological Zones version 4 (GAEZ v4). URL: http://www.fao.org/gaez/
[6] The potential yields are calculated assuming low input requirements (e.g., fertilizers) and rainfed production.

3. Growth Diagnostic Analysis

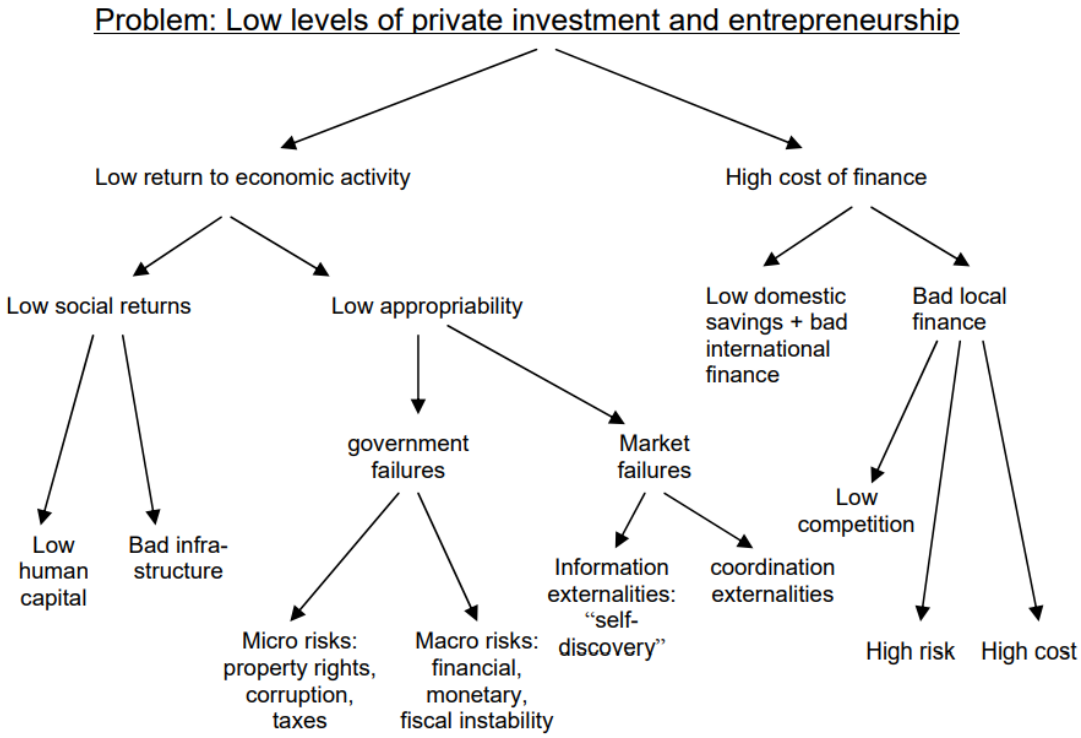
The Growth Diagnostics Framework emerged as an alternative approach to the conventional policy reforms inspired by the Washington Consensus (Hausmann et al., 2005; Hausmann et al., 2008). These typical reform tactics often adopted one-size-fits-all solutions or sought wholesale reforms encompassing numerous policy issues. The downfall of such blanket solutions lies in their failure to account for unique problems needing diverse solutions, as countries have distinct challenges. In contrast, laundry-list reforms could prove inefficient and expensive, primarily if they do not concentrate on the most pressing issues for a specific place. Moreover, policies that work in Region X might not only not work in Region Y but have adverse effects. The Growth Diagnostics Framework (GDF) is a strategy for identifying the binding constraints for economic activity in a specific location and the corresponding policy priorities that can address those constraints. In that sense, the strategy aims at securing “the biggest bang for the reform buck” (Hausmann et al., 2005).

Identifying constraints starts by analyzing the inputs required for the production process. Any economic activity requires a series of inputs to grow dynamically. These can be public inputs (i.e., public infrastructure, rule of law, etc.) or market inputs (i.e., labor, capital, technology, etc.). However, these inputs are not substitutes. They are complementary. Take, for example, the case of the manufacturing industry in South Africa, which, during 2008-2023, has been losing competitiveness and growth prospects due to problems in the supply of electricity. It is impossible to substitute the provision of electricity with other inputs required for the sector to grow. For example, suppose the government attempts to increase the supply of other inputs, like facilitating access to finance or investing in skills development programs. In that case, the interventions will not influence the sector’s dynamics if the electricity crisis persists. The fact that inputs are complementary means that some are more problematic than others, thus pointing toward binding constraints. It also implies that relaxing the binding constraints that affect the most problematic inputs has significant effects on economic activity, whereas working on non-binding constraints or the least problematic inputs has little to no results.

The original GDF presented a decision tree to guide the identification of constraints. Figure 15 shows the original decision tree. It starts with a growth question: Why are there low private investment and entrepreneurship levels? The tree branches are guides for analyzing symptoms of the constraints that explain the growth question. In that sense, the low levels of investment and entrepreneurship can be due to factors that increase the cost of finance, thus negatively affecting the capacity of firms to access credit (right side of the tree), or because there are factors that reduce the returns to economic activity (left side of the tree):

- **Access to finance**. If savings problems or distortions exist in the local financial markets, finance can be a binding constraint. If there is a savings problem, then there must be symptoms of domestic savings being limited and restrictions in accessing foreign borrowing. If, on the other hand, there are problems in local finance, then there must be symptoms of low competition amongst banking institutions, high risks, or costs of borrowing.
- **Low returns to economic activity**. An economy faces low returns to economic activity either because there are factors that reduce the returns to economic activity or because there are factors that distort the appropriability of the firms' returns. In the first instance, the decision tree calls "social returns" to issues with inputs that affect economic activity, like human capital or infrastructure, and an individual firm is not able to produce on its own. The low availability of skilled labor or key infrastructure like roads or electricity can be binding constraints affecting the returns to economic activity. In the second case, the decision tree characterizes as "appropriability" issues situations that affect the firms' capacity to get the returns to their economic activity or those that affect the expectations on the appropriability of the returns. There can be several constraints affecting appropriability. On the one hand, there can be government failures in the form of micro risks like an inadequate regulatory environment or red tape affecting firms' profitability or macro risks or policy uncertainty affecting the expected returns or increasing the risk of economic activity. On the other hand, there can be market failures that distort the expected appropriability of economic activity, like insufficient information about the market that disallows firms to invest in potentially profitable activities or coordination failures of different that might require several stakeholders to organize themselves to invest in missing inputs. For example, if there are not enough crop scientists, it is unlikely that commercial crop production would succeed in a country, but if there is no commercial crop production, there would not be incentives for people to study crop science.

Figure 15: The Original Growth Diagnostics Tree



Source: Hausmann et al., 2005; 2008

There are four standard ways of testing for binding constraints. The tests are straightforward ways of identifying binding constraints in local contexts where data is often limited, and the main purpose of the analysis is to inform policymaking. They are not meant to be econometric analyses in search of precise causal inference. If a constraint is binding, then:

- **The constraint shows a high (shadow) price**. A high shadow price is a signal of unmet demand, and although it is often expressed by actual market prices, it can also be signaled by other factors. For example, if there is a high demand for the expansion of road infrastructure in a region with recently discovered natural resources, but there is no supply for it, then the shadow price of road infrastructure is incredibly high -regardless of actual market prices for that type of infrastructure development.
- **Movements in the constraint should produce significant movements in economic activity.** If a binding constraint is relaxed, then there should be evidence of increasing economic activity. However, it might be the case that there have not been attempts to relax the binding constraints, and consequently, there are no observable movements to show proof of it. When there is enough data to show movements in constraints, this test can help

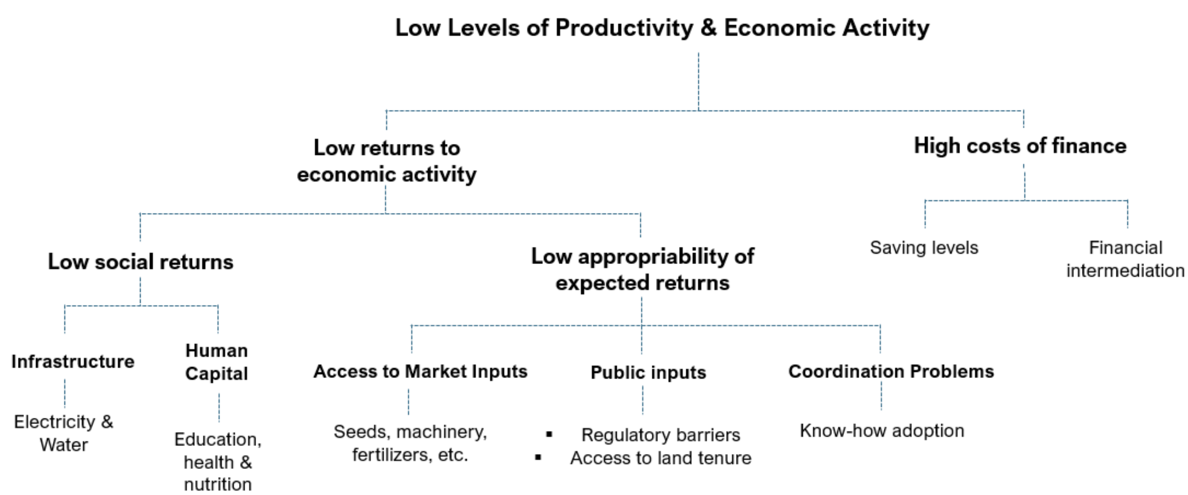
identify whether they are binding. Hausmann et al. (2008) provide an illustrative example: when analyzing whether access to finance is a constraint, a reduction in interest rates should positively impact investment, given that they would be relaxing the cost of finance. During 2000-2003 in Mexico, investment fell while real interest rates were also decreasing, and it started rising in 2003-2007 while interest rates moderately rose. This indicates that access to finance was not a binding constraint for investment or economic activity in Mexico during that period.

- **Agents less intensive in that constraint should be more likely to survive and thrive.** Looking at what type of firms or industries are thriving or growing vis-à-vis what type of firms or industries are not can lead to strong indications of where the binding constraints are. Hausmann et al. (2008) use the metaphor of camels and hippos in the desert: camels can thrive in the desert because they are less intensive in the use of water, while hippos are rarely found in that type of environment, which indicates that water is a binding constraint for the development of animal life in the desert. For example, suppose import tariffs on capital goods are a binding constraint. In that case, the firms that are less dependent on foreign capital goods (camels) will show normal signs of economic activity, while those that are dependent (hippos) will be struggling.
- **Agents are overcoming the constraint.** The way markets react to problems in the availability of inputs or binding constraints is relevant information to test for them. For example, suppose the formal sector is declining while the informal sector is expanding within the same industry. In that case, this is a symptom of labor regulations being a binding constraint for growth within that industry. Firms are managing to overcome the constraint of labor regulations by producing the same as the formal sector firms but with informal workers.

3.1 An Adaptation to Namibia's Agriculture Sector

The GDF was designed to analyze the economic dynamics of countries, but it is still useful when pursuing industry-specific analyses. However, the original diagnosis tree must be adapted to the sector's characteristics. One of our modifications was removing potential constraints or factors relevant to the national economy, like macroeconomic risks, but not informative in the sector. These might be binding at the sector level for a different country with severe macroeconomic turbulences (e.g., the financial sector in Argentina), but may not add as much information for analyzing agriculture in a country like Namibia. On the other hand, we reframed the branches of the decision tree to address sector-specific issues. The "access to finance" branch looks at the cost of finance, intermediation issues, and overall credit considering the specificities of the sector and the prevalence of Namibia's state-owned bank for agriculture, AgriBank. In turn, there would be a problem of low social returns that affects agriculture productivity if the infrastructure that is relevant for the sector acts as a constraint or if there are constraints affecting labor productivity that could be categorized under the broad umbrella of human capital, like education, health, and nutrition. Finally, the appropriability of returns would become a problem in agriculture if firms were not able to access key modern inputs that they need, if public inputs are missing (government failures), or if there are market failures that prevent the market from capitalizing on potential returns because of coordination problems.

Figure 16: The Growth Diagnostics Tree for Agriculture



Source: Own elaboration

The following subsections provide an analytical perspective on whether each potential constraint is binding. We start with the branch of access to finance and then follow with returns to economic activity. We conduct the standard growth diagnostics tests for each of the constraints.

Box 1: Summary of Growth Lab's Research on Agriculture

The growth diagnostic of agriculture is a byproduct of a three-year research engagement with the Government of Namibia. The research engagement addressed the country's triple challenge of economic diversification, social inclusion, and fiscal consolidation (Hausmann et al., 2022). In that context, the agriculture sector plays a key role for several reasons. First, it is essential for promoting labor inclusion in a country with exceptionally high unemployment rates and a high share of the population living in rural areas. Second, some of Namibia's most feasible diversification opportunities are in the agriculture & food industries (Hausmann et al., 2022b). Finally, increasing economic activity and productivity in agriculture can help the country reduce its reliance on tax revenues from mining.

Discussions with policymakers and interviews with private and public sector stakeholders informed this growth diagnostic report. We supported the development of two productivity taskforces focused on two critical agricultural sectors: High-value fruits and livestock and meat industries. We provided research inputs for reviewing the Rural Development Policy & Strategy, the Green Schemes policy, and Namibia's ascension to the International Union for the Protection of New Varieties of Plants (UPOV). These engagements contributed significantly to understanding the agriculture sector and productivity constraints. Additionally, we conducted multiple interviews with individuals from relevant public and private sector organizations. During 2022, we also did two field visits to the central north of Namibia (Oshana, Ohangwena, Omusati, and Oshikoto) and one to the south (Stampriet), which included visits to:

- Research Development Centers
- Etunda Irrigation Scheme
- Etaka Small Farmers Association
- UNAM Ogongo Campus
- Agro-Marketing and Trade Agency (AMTA)
- Ongwediva Rural Development Center
- Asparagus Farm Industrias Alimentarias de Navarra (Otjimbele Agriculture)
- Roots Agri-Village and Farm
- Namibian Agronomic Board
- Namibia Industrial Development Agency (NIDA)

3.2 Access to Finance

Farmers' access to finance can enable investments in technology and equipment, modern inputs, and access to new markets, all of which can boost productivity. Financial services to save, borrow, make payments, and buy insurance aid producers and investors in agriculture to access and better manage working capital and daily transactions, fund investments, market, and transport produce, and mitigate risks including weather events, pests, diseases, and market volatility (Khandker, 2021). As such, useful and affordable finance has the potential to increase farmer productivity, income, consumption, and nutrition for farmers (Cull et al, 2014; Karlan et al, 2014), with large implications for contexts like Namibia where agriculture represents a major source of livelihood. Nevertheless, in many developing countries, and in Sub-Saharan Africa, credit for agriculture is insufficient despite the sector's large contribution to GDP. The inherent risks of the sector stem from production seasonality, weather variability, and a lack of sufficient collateral, all of which combine to make production and crop prices uncertain and lending potentially difficult to repay.

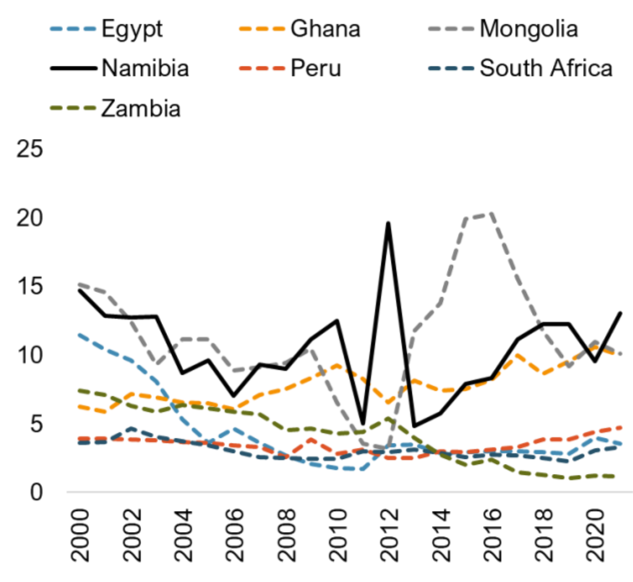
Credit for agriculture across Namibia is crucial for productive and social reasons. Credit can compensate for the country's exposure to droughts and global climate change, as described in section 2. Weather variability place disproportionately heavy burdens on small and community farming as the uncertainty of harvests, input availability, and income flows create financial constraints to raise investments and smooth consumption that can contribute to the national priority of food security (see Karlan et al, 2014 for field experiment findings in northern Ghana).[7] But also, broader access to credit requires dealing with large transaction costs of covering rural areas with poor infrastructure and limited connectivity, which further reduces the incentives for commercial banking to meet the demand in remote regions. With 9.3 commercial bank branches per 100,000 adults, Namibia is slightly above the SSA average of 8.0, but the country still underperforms other least densely populated countries (WDI, 2021).

Poor access to finance would be a binding constraint for productivity if profitable agricultural ideas and entrepreneurship cannot materialize due to a lack of savings or the inability to deploy these resources. At the national level, the Growth Lab documented low levels

[7] The importance of sustained food and nutrition is underscored by different government development plans. See the Fifth National Development Plan (NDP5), the Zero Hunger Strategic Review (ZHSR), and the recent Harambee Prosperity Plan.

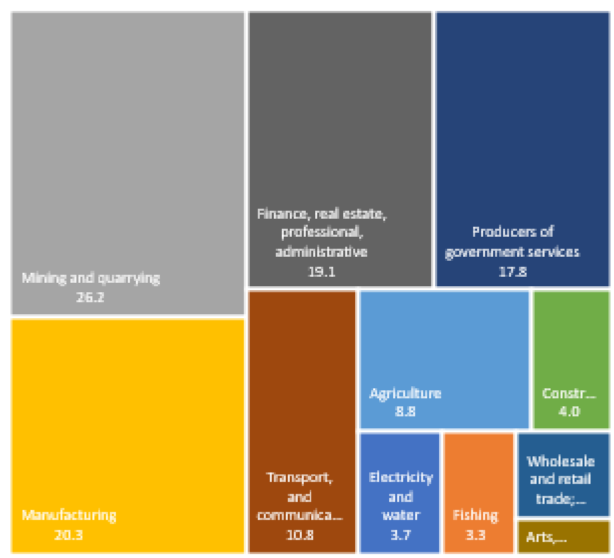
of domestic savings being compensated by unrestricted access to external finance at low and even decreasing rates and a relatively efficient process of financial intermediation to mobilize overall savings. To further study the extent to which these domestic and international savings flow towards agriculture, we can see how much investment and credit materialize in this sector. Since the early 2000s, Namibia's investment in agriculture as a share of GDP, proxied by the gross formation of fixed capital, performed better than its peers (see Figure 17). Agriculture was also the sixth sector to capture investment from 2017 to 2021 (see Figure 18**Error! Reference source not found.**). In addition, the country's levels of total credit to the private sector ranked near the median of the benchmark countries, reaching 7% of GDP in 2021 (see Figure 19). However, when adjusting credit rates by the sector's share in GDP, data shows that agriculture received a lower share of credit relative to the sector's GDP contribution and that this low share has mostly remained stagnant (see Figure 20).[8]

Figure 17: Gross Fixed Capital Formation in agriculture (% of total, US$ 2015 prices)



Notes: Agriculture includes forestry and fishing. There is no data available for agriculture only (crops and livestock) for Namibia. Source: FAOstat

Figure 18: Gross Fixed Capital Formation in Namibia by sector, 2017-2021 (2015 prices - N$ billion)



Source: Bank of Namibia, Annual Report 2021

[8] FAOstat reports cross-country data to allow for international comparisons, and some indicators are unavailable for all countries. To study and compare Namibia, investment and credit available data for agriculture include forestry and fishing, besides crops and livestock -the subsectors study for this report. Given the large weight of fishing in the Namibian economy, we acknowledge that this affects the reading of the cross-country figures.

Figure 19 Credit to Agriculture (% of total credit)

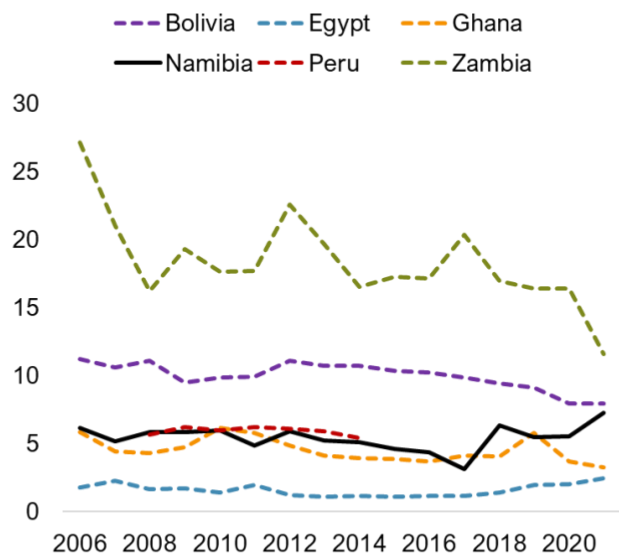
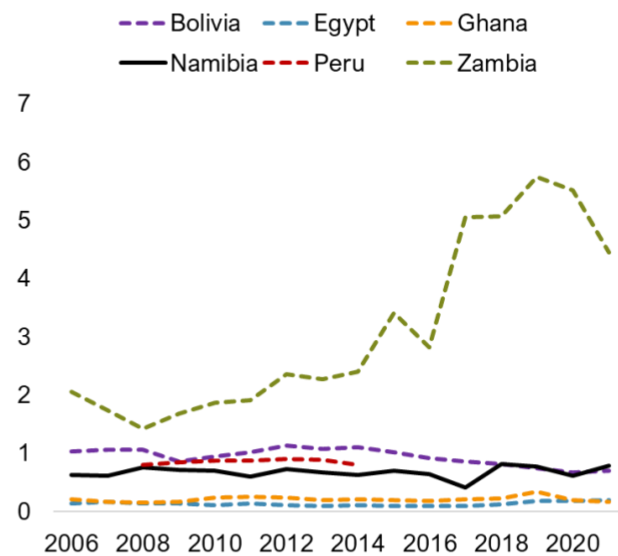


Figure 20: Agriculture orientation index of credit to agriculture



Notes: Agriculture includes forestry and fishing. There is no data available for agriculture only (crops and livestock) for Namibia. An index higher than 1 means the agriculture sector receives a higher share of credit relative to its economic value. An index lower than 1 reflects a lower orientation to agriculture. Source: FAOstat

Financial intermediation in Agriculture is influenced by Agribank, the state-owned agricultural bank. In Namibia, commercial banks lend primarily to individuals and housing loans. Agriculture took only 4% of the overall loans and advances granted by private banks between 2017 and 2021 (Bank of Namibia, 2021). As such credit to the sector is largely supplied by Agribank and the Development Bank of Namibia to a lower extent. These public financial institutions target farmers, agribusinesses, and other stakeholders in the agricultural value chain. In 2021, Agribank recorded a market share of 43%. Following concurrent government priorities on economic development, food security, land reform and rural development, the SOE offers subsidized interest rates on agricultural loans to make credit more affordable to communal farmers under the National Agricultural Credit Programme (NACP) and resettled farmers under the Post Settlement Support Fund (PSSF).[9] Agribank also complements its services with technical assistance, extension services, and financial literacy programs to enhance the capacity of farmers to manage credit effectively. As such, the SOE disbursed 61% of all credit for land purchase and

[9] Interest rates for subsidized credit set in May 2020 are 4% for communal farmers (half the aggregate rate) and 8.75-9.25% for commercial farmers (see Agribank website).

livestock, and 62% to groups and companies (Agribank, 2021).[10] Overall, agriculture plays a significant role in the government's purpose of mitigating the risk for lenders and mobilizing funding for productive ends. As such, agriculture has increasingly represented most of the government's domestic loan guarantees. It reached more than a third of the total stock in 2021/2022 (0.4% of GDP).

While it seems that Namibia lacks symptoms of restricted funds for investment in agriculture, assessing the demand for credit would permit determining if access to finance is productivity-binding. During the fieldwork trips to the central north of Namibia (Oshana, Ohangwena, Omusati, and Oshikoto regions) and to the south (Stampriet), the Growth Lab asked local stakeholders about farming needs and outcomes. Small as well as large farmers often cited the lack of finance as the reason behind the low investment. This topic also came up often during the Productivity Taskforces set up by the NIPDB. To better assess the way supply and demand of credit interact, this section explores the Namibian Census of Agriculture 2013/2014. It takes advantage of the microdata at a farmer/household level to better study applications and approvals to credit, whether formal or informal, the purpose, the sources, and the type of collateral used. Moreover, it distinguishes between communal and commercial farmers to reflect differences in their endowments, capacities, and needs.

In commercial agriculture, the demand for credit is low, and almost all the applicants access it. Data shows that only 24% of commercial farmers applied for credit in the previous 12 months and that 94% of all applicants were approved to receive the funds. Moreover, credit fundamentally comes from formal institutions. While 49% of farmers resorted to private intermediaries such as banks and microfinance institutions[11], 47% of farmers received loans from public institutions including Agribank, the Development Bank of Namibia, other government agencies, and Non-Government Organizations (NGOs). With varying degrees of territorial penetration, private intermediaries are more relevant credit suppliers in regions such as Khomas (60% of farmers), Otjozondjupa (55%), and Erongo (53%). Meanwhile, public intermediaries were reported to be the

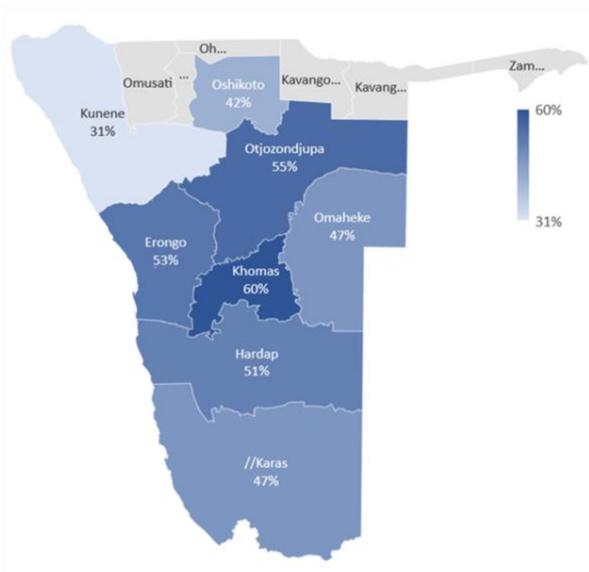
[10] An existing special finance scheme, Etunda Green Scheme allows small farmers to access Agribank vouchers with a value between 50,000N$ and 100,000N$ and exchange them for farming inputs. Farmers who repay the loan after two years may apply for a further loan while defaulting farmers are evicted (Fiebiger et al, 2011).

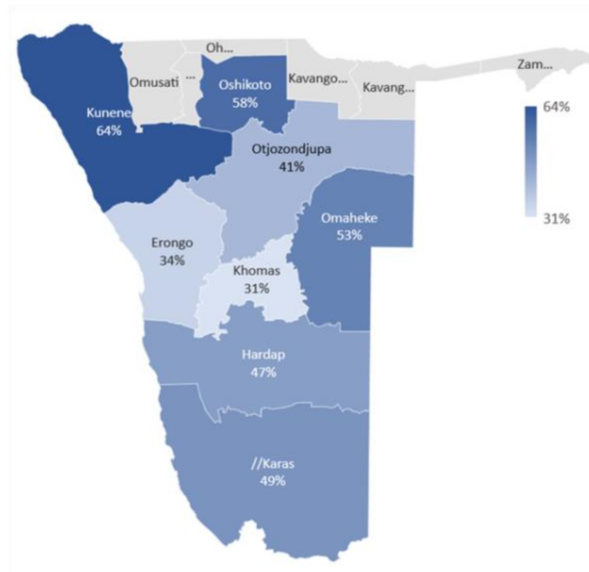
[11] Microcredit is almost inexistent in Namibia. One of the few microfinance institutions is Fides Bank, which operates in Ovamboland. Fides requires the constitution of credit groups and assesses the motivation of small entrepreneurs and their potential to generate income as a condition of access to credit in the range of 500 and 7,500N$ and weekly or monthly repayments (Fiebiger et al, 2011).

leading credit suppliers in northern regions such as Kunene (64% of farmers) and Oshikoto (58%) (see Figure21).

Figure 21: Loans by type of lender in commercial land

a. Private intermediaries   b. Public intermediaries





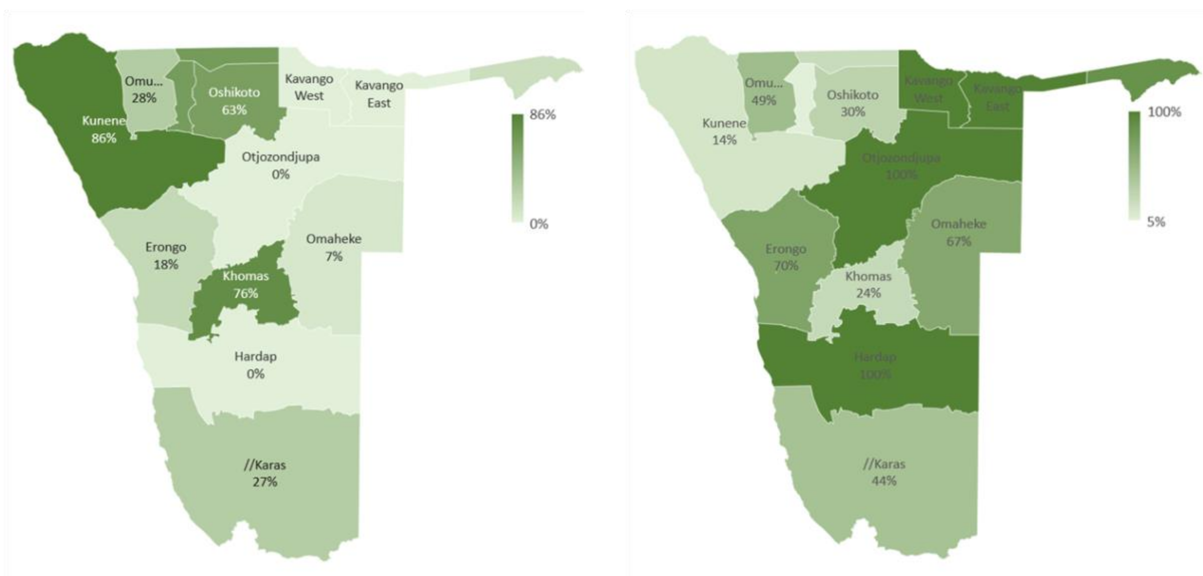
Source: Census of Commercial and Communal Agriculture 2013/2014

Commercial farmers with higher productivity have a lower risk profile that explains their high approval rates for credit. We take the average yields of all crops harvested on each farm as a proxy for farm productivity. We show that farmers who did not apply for loans are 24% more productive than those who applied, signaling whether they are more productive are also productivity differences. Farmers who applied for a loan and did receive it were 27% more productive than those whose applications were rejected. These figures may reflect that credit-constrained farmers are precisely those with larger productivity problems, which nonetheless are sorted out by farmers that signal their capacity to better face production and price risks and have more regular repayment schedules. Overall, these facts are indicative of finance not being a binding constraint for commercial farmers.

Meanwhile, credit for communal farmers is less likely to be granted. It also largely comes from informal sources. Not only 72% of them were able to get credit, in contrast to the 94% registered for commercial farmers. More importantly, 47% of these approved credits were informally supplied by self-help groups, under shelter, family, and friends. Meanwhile, 39% of farmers received loans from public institutions, which shows a relatively high demand for credit that is not being fully met by formal financial intermediaries. As in the case of commercial land, in communal land, the penetration of credit by type of lender changes across the territory. Informal credit reached farmers in Kunene (86%), Khomas (76%) and Ohangwena (66%) to a larger extent. Meanwhile, public intermediaries were reported to be the only credit supplier in Hardap, Kavango East, Kavango West, and Otjozondjupa (see Figure 22). Informal credit has the advantage of lower transaction costs and can be readily available on short-term notice. However, this flexibility that comes from contracting with social networks, can come at the expense of unproductive or costly credit. Informal credit tends to be insufficient to cover broader access to modern technologies and other inputs. Moreover, as lending social networks potentially face similar risk levels to borrowing farmers, informal credit has limits in leveraging resources or pooling risks (Ardic et al, 2013) necessary to further investments.

Figure 22: Loans by type of lender in communal land

a. Informal intermediaries b. Public intermediaries

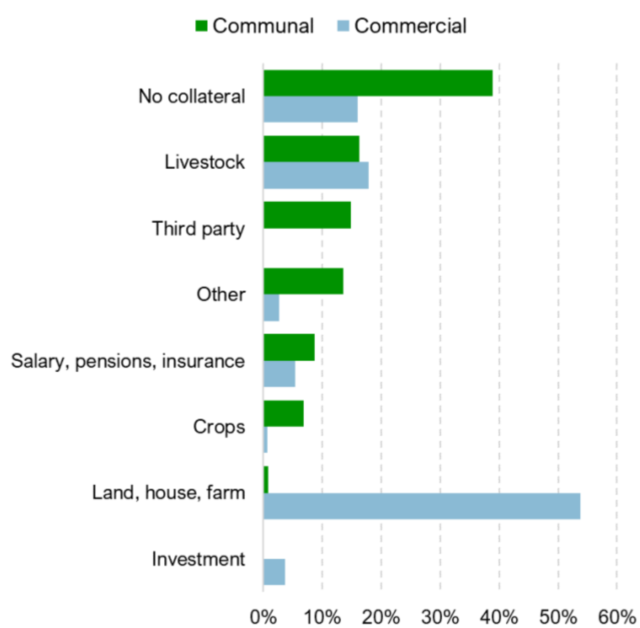


Source: Census of Commercial and Communal Agriculture 2013/2014

The communal farmer's inability to use land as collateral makes them resort to their productive assets to access credit. In part because these farmers do not own the land they are cultivating and use it as collateral and because of their risk profile, they are less likely to access formal credit. In contrast to commercial farmers that in the majority used their land, houses, or farms when applying for a loan (54%), communal farmers depended more on their livestock (16%),

third parties (15%), and other resources (14%) to employ them as collaterals (see Figure 23**Figure**
).[12] The Growth Lab's in-person interviews with small and medium farmers in northern Namibia further revealed that farmers find the information on the availability and conditions of formal credit very unclear, that the requirements to access credit are burdensome and seem hard to fulfil, and that regional officers are not sufficiently present in the field to understand local needs. Moreover, the untitled land provided by the government to small-scale farmers in Green Schemes such as Etunda seems to keep holding an elevated risk for communal farmers. This comes from uncertainties on the length of the land leasing and the possibility of growing as medium-scale farmers able to better access optimal credit conditions (Amadhila and Ikhide, 2016). Bilateral meetings with senior officials from Agribank underscored that collateral is a pre-requisite for most loans in this part of the country and that the amount of capital provided is small. Moreover, they confirmed that loans to small farmers were not a significant part of their lending portfolio given the risks and challenges in enforceability associated with the lack of land to be used as collateral[13].

Figure 23: Source of collateral by type of land



Source: Census of Commercial and Communal Agriculture 2013/2014

Communal farmers use the credit to cover current expenditures rather than capital investments or another type of productivity-enhancing expenditure. Credit is mostly used to

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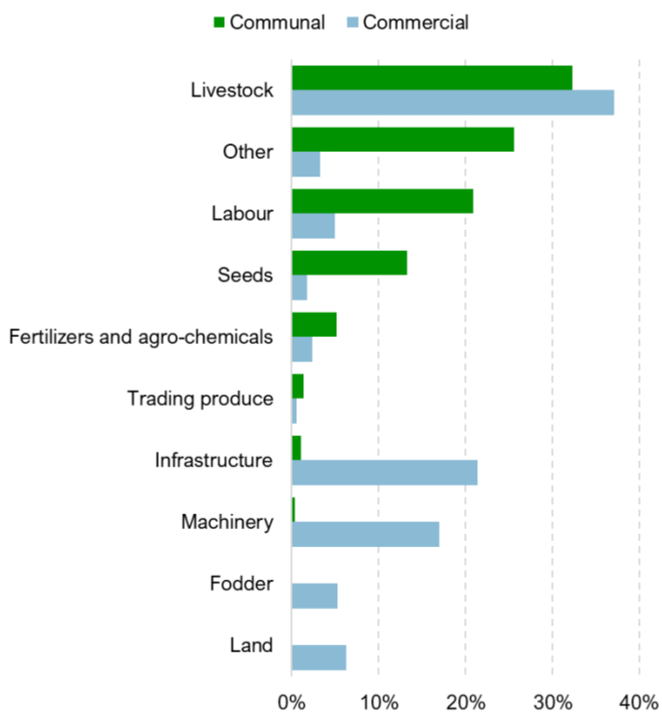
[12] 38% of land in Namibia falls under the communal land tenure, where 50% of the population lives. Customary rights have with their own registration system. See here.

[13] Officials also highlighted that outdated, incomplete, and untimely data for optimal targeting and monitoring inhibits a better risk screening necessary for better risk assessment and credit targeting.

purchase livestock and cover cash needs for labor, seeds, and fertilizers, instead of physical capital or other productive investments (see Figure 24). This pattern highly contrasts with the credit purpose of commercial farmers, who tend to invest in infrastructure and machinery. On aggregate, Namibia's levels of savings are low, but they are seemingly enough to cover the small demand for productivity-enhancing credit in agriculture. While data presented above show that commercial farmers, in fact, find ways to access credit, this is not the case for communal farmers. Nevertheless, the source and use of credit for the latter reflect low levels of productivity and expected profitability. As such, farmers' demand for formal credit has lower returns than necessary to compensate for the cost of capital, which implies that the binding constraint relies on other branches of the Growth Diagnostics tree.

Figure 24: Use of credit by type of land



Notes: Infrastructure includes irrigation structures, debushing, and storage dams. Others include apiculture, aquaculture, and housing for commercial land, and it is not specified in communal land. Source: Census of Commercial and Communal Agriculture 2013/2014

In conclusion, access to finance for farmers can facilitate investments in key inputs like machinery and equipment and foster agricultural productivity but this issue is not constraining the sector the most. Credit in agriculture, especially, is crucial because it can compensate for seasonality and irregularity of cash flows and weather variability. Evidence for Namibia shows that demand for credit by commercial farmers is low as their good risk profile, in part associated with higher productivity, allows them to either not be cash-constrained or have credit applications approved and supplied by formal institutions. In the case of communal farmers, the figure is the opposite. More of them demand credit and end up accessing informal sources, which might signal they are credit constrained. Moreover, their inability to use land as collateral makes them resort to third parties and own produce to access credit. However, farm-level data shows that credit is mostly used to purchase livestock and cover cash needs for labor, seeds, and fertilizers, instead of physical capital or other productive investments. This points to the issue of access to finance not being a binding constraint. The source and use of credit by communal farmers reflect instead low levels of productivity mostly constrained by other factors such as their inability to access land tenure.

3.3 Infrastructure

Transport infrastructure is not a constraint for agriculture, although it is a sensitive input for the sector. The two types of transport infrastructure relevant to Namibia's agriculture sector are ports and roads. Although specific products like blueberries are transported in airplanes, this does not constitute a key means of transportation in Namibia. Nevertheless, given that the transportation of agricultural goods tends to have specific standards, this is a crucial area for developing the sector. For example, fruit farmers have tight schedules, and transport disruptions can change their business altogether. The transport of livestock and processed meat also follows specific standards essential for the country to access international markets.

Rather than a constraint, road infrastructure is a comparative advantage in Namibia. Previous research (Hausmann et al., 2022) shows that the quality and supply of road infrastructure in Namibia are respectively high and extensive. The rate of road area to population is high compared to regional peers, and the country ranked among the top ten countries with the best road connectivity in the world in 2018, according to the World Economic Forum. Nevertheless, in our field trips to Northern Namibia, we have learned that small-scale farmers face serious hurdles when it comes to solving the logistics of reaching markets and consumers. One of the reasons why this happens is that there is not enough supply of logistic services for that type of economic activity in those areas. In that sense, Northern Namibia is not seizing its comparative advantage in roads.

The current state of port infrastructure does not appear to serve as an active constraint (Hausmann et al., 2022), but if agricultural industries were to scale up significantly, it could become a concern. Although Namibia's ports have low capacity relative to the global average, they are adequate for the country's level of economic activity. The quality of the Walvis Bay port is well-suited for the country's needs, and firms have not reported having issues using it. However, Southern fruit farmers export their produce through the Cape Town port instead of Lüderitz, which would take over 40% less total freight time if it were functional. During interviews with the Growth Lab's research team, fruit farmers mentioned that they resort to Cape Town because of a lack of economies of scale. There is not enough produce in Namibia to fill the vessels' cargo in Walvis Bay or Lüderitz and then ship directly to the destination (e.g., Rotterdam). The vessels from Namibia would need to make more port calls on their way to Rotterdam to add cargo, adding a considerable number of days to the transport time, which is not feasible in industries like grapes and other high-value fruits. Although the fruit growers would benefit from using Namibian ports because it would reduce freight time, the lack of economies of scale does not make it feasible. Additionally, if they were to gain a larger scale in the future, utilizing Lüderitz might not be reasonable because of the state of its current infrastructure[14], but also because the port's capacity to operate only with small ships has resulted in a termination of international freight feeder services (Goddard, 2022). In that case, they would have to resort to Walvis Bay, which might produce an excess demand for its port services and the roads connecting them.

The type of infrastructure that matters the most for agricultural development is the one that allows access to electricity and water. Farmers of all types need water to grow their produce. Livestock farmers also need water for their animals and to grow fodder or other types of animal feed. Farmers also require electricity to pump water from the ground or power their storage facilities. Moreover, the type of water and electricity infrastructure that agriculture requires differs from the one destined for cities and rural human settlements. In the first case, the population density of cities allows for much higher cost-effectiveness in service delivery. As a result,

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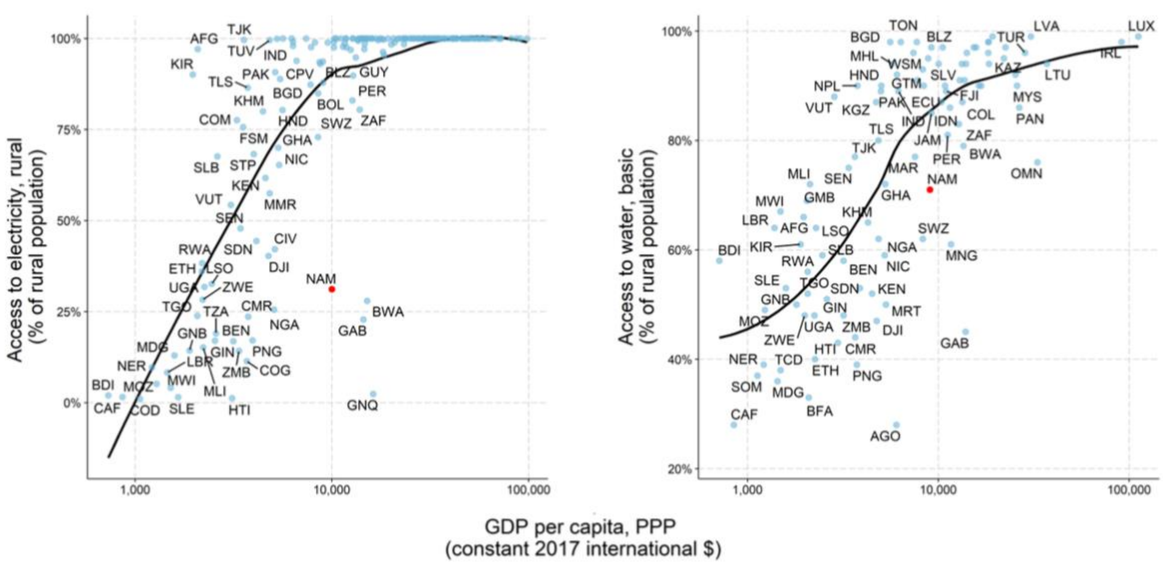
[14] The farmers also mentioned that, according to their estimates, using Lüderitz adds over 30% to the cost of transportation. According to the farmers, the difference is mainly driven by an inefficient system in Lüderitz that requires vessels to make two port calls each time they operate and a tax on cabotage with foreign vehicles.

developing this type of service in urban areas is less challenging in terms of its economic viability. The establishment of water, sanitation, and electricity services in rural areas, on the other hand, is much less cost-effective, given that the costs are much higher and the returns much lower (rural population tends to be lower income and have lower economic activity overall, as is the case in Namibia). Besides, the water points or canals that serve rural households are enablers of small-scale farming but would not allow for the development of medium- to large-scale agriculture. Numerous subsistence and small commercial farmers in Northern Namibia utilize water points and canals to set up their irrigation systems. Yet, they might not be able to coexist with large-scale farms if they were to establish in the same area and utilize the same water sources. Other types of infrastructure are designed to serve large-scale farming efficiently, like irrigation dams.

Access to electricity and water is problematic in rural Namibia. Figure 25 shows the percentage of the rural population with access to electricity (left) and basic water services (right) against GDP per capita in 2019. Electricity access is exceptionally low. It is lower than in Rwanda, a low-income economy with 80% less GDP per Capita than Namibia. Electricity access in Namibia is also uniquely low when compared to South Africa. Although South Africa is currently facing a dramatic electricity crisis, the national government has implemented a policy of expanding access to electricity since 1994. Namibia, on the other hand, is in a different position. The renewable energy projects in the country's pipeline show promising potential for expanding energy generation, but the electricity grid extension is far from its ideal. Access to water, on the other

Figure 25: Access to Electricity and Water in Rural Areas (2019)

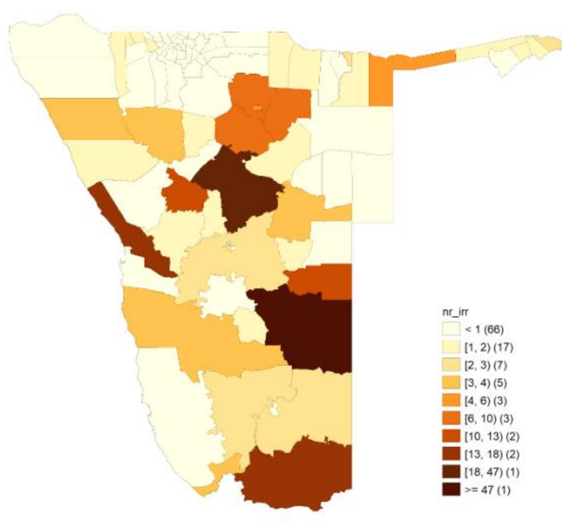


Source: World Bank Data & UNESCO

hand, is also low but closer to the average. Nevertheless, the quality of water that a considerable number of rural households can access is not fit for human consumption, and half of the water points are not functional (Salom & Khumalo, 2022). This has led to dire situations where households are forced to sell livestock to fix the public boreholes themselves (Kooper, 2023).

The farmers in communal areas of Namibia display an extremely limited utilization of water and electricity for irrigation. According to the Namibia Census of Agriculture in Communal Areas (2013-2014), only 1.3% of the communal land area was irrigated, and 1.2% of farmers utilized irrigation techniques —moreover, only 26% of the farmers that used irrigation paid for it. Figure 26 shows the number of irrigation areas for agricultural use by constituency in 2001 as registered by the Ministry of Agriculture and Forestry. The constituencies in southern Namibia show the highest numbers of irrigation projects, led by Mariental in Hardap and Karas in !Karas. On the other hand, the communal areas in northern Namibia have very few of them. The Guinas constituency in Oshikoto had the most irrigation areas (seven). There is a major gap between Namibia's south and north and the communal and commercial areas regarding irrigation infrastructure.

Figure 26: Irrigation Areas by Constituency (2001)

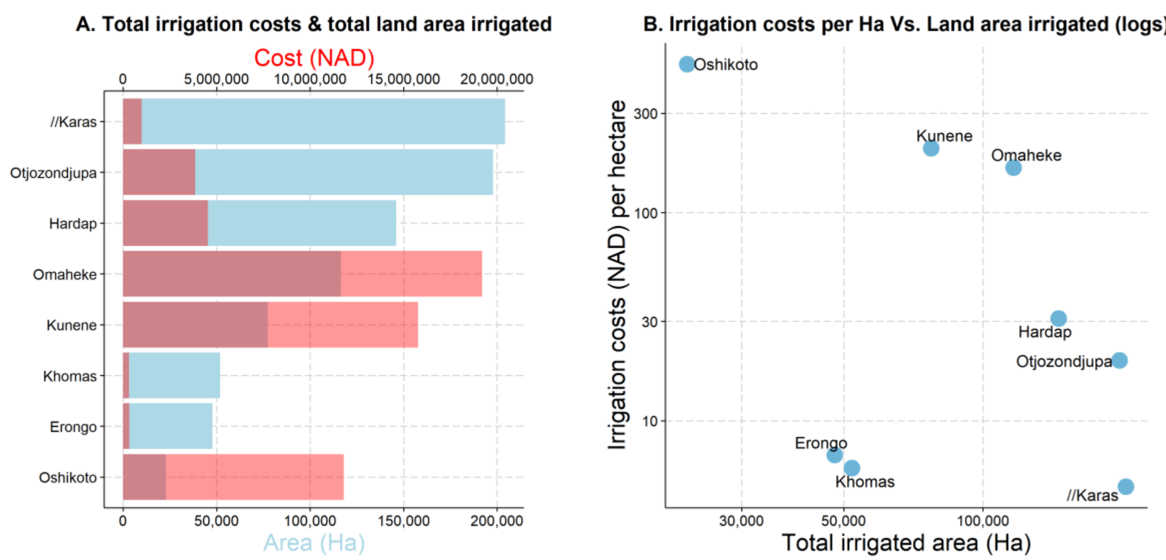


Source: Namibia GeoPortal

The cost of irrigation in northern and southern Namibia is also indicative of how infrastructure affects agriculture development. Figure 27 shows key facts about the cost of irrigation in different regions. Panel A presents the total area irrigated (blue) and total cost of irrigation (red). Panel B presents the irrigation costs per Ha Vs. the total land area under irrigation.

We observe that six of the eight regions follow a pattern where the southern areas with more irrigation agriculture tend to face lower costs than the northern areas with less irrigation. The exceptions are Erongo and Khomas, where the cost of irrigation might be lower due to the availability of urban water infrastructure. A plausible explanation for the difference in the irrigation costs between the south and the north lies in the scale levels. It makes sense that irrigation is more costly in the north where the scale is much lower than in the south. Another explanation might be that irrigation infrastructure is scarce in the north, which disallows agricultural development. Does the difference in costs reflect a high shadow price? If demand is high, but supply is low and costly, then this might be a symptom of irrigation infrastructure being a binding constraint for agriculture in the north. As a point of comparison, the southern areas would not be facing a constraint in irrigation infrastructure, which would be reflected in the low cost of irrigation in tandem with their higher productivity and overall growth. As we will explain next, it is not the case that irrigation infrastructure is a binding constraint in the short-term, though it may function as a constraint for agriculture growth in the medium- to long-term.

Figure 27: Irrigation costs in commercial farms per region (2013-2014)



Source: Commercial Agriculture Census (2013-2014), NSA.

Farmers that utilize irrigation tend to be more productive, but other factors are important to explain the differences in productivity gains. Namibia's low precipitations and rain variability make it difficult for rain-fed agriculture to thrive. Figure 4 showed how precipitation levels and the vegetation index have been declining, and the probability of droughts is expected to increase in the future. Moreover, the recent droughts in Namibia have evidenced that rain-fed agriculture is a risky business. In that context, it is only natural that irrigation becomes a much more viable, if not the only viable, option for crop production. It is also natural that the productivity and yields of farms that utilize irrigation are much higher than those that do not. Table 1 shows the results of a regression analysis using the communal and commercial sections of the agriculture sector. In the dataset of communal farmers, we selected over 240 households that reported using or not using irrigation techniques and have farms of under 200 hectares. We ran a linear regression to understand in what measure irrigation is correlated with higher yields. In this case, the dependent variable is the yield log in terms of quantity (Kg) of crops per area (Ha). We controlled by region, total farm area, crop type,[15] whether the farm was affected by drought in recent times (severe, moderate, slight, or no damage), and types of equipment.[16] In the case of the dataset of commercial farms, we ran a regression on over 90 farms with the same dependent variable and, in this case, controlling for total farm area, crop type,[17] type of machinery utilization, and region. The results show informative patterns:

1- As expected, the farms that utilized irrigation techniques have higher yields. The positive correlation between irrigation and yields is significant, and the coefficients are high for both communal and commercial farmers. In the first case, using irrigation comes with a 49% increase in crop yields, and in the second case, with a 116% increase.
2- The effects of irrigation are much higher in commercial than communal farms. The difference makes sense because one would expect that commercial farms are in a much better position to take full advantage of irrigation gains. Additionally, communal farmers might face other types of hurdles that diminish their returns to using irrigation.
3- The regression analysis shows relevant information but lacks explanatory power. Table 1 shows that the R^2 is low in both cases but is particularly low for the commercial section. This does not mean irrigation does not have a positive and significant effect on yields, as one would expect in Namibia. In turn, it reveals that irrigation and the specified control variables cannot really explain the variance of productivity across farms, which is an interesting finding. There are likely other factors that explain why some farms are thriving

[15] The types are Maize, cabbages, pumpkin, other vegetables, groundnuts, millets, sorghum, beans, sweet potatoes, soya beans, watermelons, and wheat.
[16] There are 23 types of equipment registered in the census that ranges from rudimentary instruments like axes to modern machinery like tractors.
[17] In the case of the subset of commercial farmers we selected, the crops were White maize, yellow maize, wheat, fodder, rice, beans, sunflower, olives, sorghum, and groundnuts.

more than others and, consequently, what is constraining those that are unable to increase their productivity.

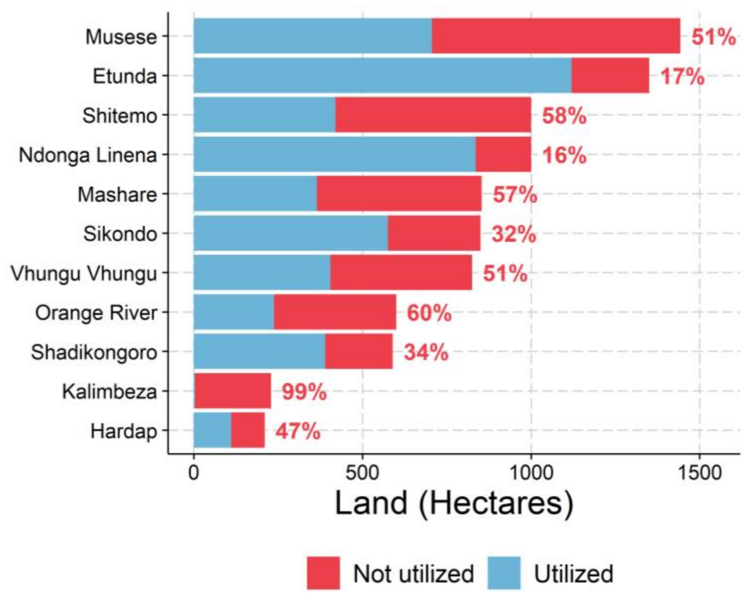
Table 1: Correlation between yields and irrigation in communal and commercial farms (2013-2014)

Communal section					Commercial section				
Term	Coefficient	SE	Statistic	P Value	Term	Coefficient	SE	Statistic	P Value
Intercept	9.81	0.67	14.4	0.000	Intercept	3.16	2.7	1.7	0.244
Farm area (Ha)	-0.009	0.00	-23.2	0.000	Farm area (Ha)	-0.002	0.00	-2.7	0.007
Utilized irrigation	1.22	0.12	9.4	0.000	Utilized irrigation	1.47	0.5	2.9	0.004
Residual SE: 1.35 on 6016 degrees of freedom. Adjusted R^2: 0.39					Residual SE: 2.074 on 96 degrees of freedom. Adjusted R^2: 0.08				

Source: Communal and Commercial Agriculture Census (2013-2014), NSA.

The government's introduction of the Green Schemes Policy in 2008 led to a broader reach of irrigation infrastructure in rural Namibia, but the facilities remain vastly underutilized. Figure 28 shows the extension in hectares of each green scheme and its share under cultivation in 2020, as documented by the National Planning Commission (NPC, 2020). The total area in the control of green schemes in 2020 was 8,952 hectares (Ibidem), of which 42% is not used for any

Figure 28: Land area in Green Schemes (2020)



Source: NPC, 2020

economic activity. If we consider that the area in the green schemes destined for commercial activities is underutilized, the total available land is even higher. A significant share of the "commercial" land in green schemes was managed by AgriBusDev[18] and destined to produce staple crops (maize and wheat) to supply the national food security fund. However, wheat production peaked in 2013-2014, and maize in 2015-2016. During the 2017-2018 harvest, wheat production was already 67% lower than in 2013-2014 (Ibidem). Maize production, on the other hand, is expected to yield 6,732 tons in 2023-2024 (Matthys, 2023), representing a 61% decrease from its peak. Fixed capital is also underutilized. Figure 29 shows pictures of equipment and installations taken during the Growth Lab's field visit to Etunda Green Scheme. One of the green schemes policy's main goals was to provide irrigation infrastructure for productive agricultural development. Their underutilization reveals that goal was not achieved.

Figure 29: Underutilized capital in Etunda (April 2022)

Source: Growth Lab's field visit in April 2021

The irrigation infrastructure in the green schemes can make significant contributions to agricultural development. The extension of land available for economic activity in the green schemes allows for scalable agriculture projects. Commercial agriculture projects could make productive use of existing and functioning infrastructure. Table 2 shows back-of-the-envelope

[18] AgriBusDev is Namibia's state-owned enterprise for the agriculture sector. It was created in 2008 by the Green Schemes Policy to administer the green schemes. See here: http://www.agribusdev.org.na/

projections of the potential to produce blueberries in the green schemes as an example of a potentially strategic high-value fruit. The projections are not predictive but illustrative. They are meant to provide a sense of how the infrastructure already in place has the potential to significantly impact agriculture growth, if following realistic parameters. The parameters are the price of blueberries at the farm gate, the yields of the blueberry farms, and the number of jobs created by those farms in South Africa, as reported by the industry association and the Western Cape Government in 2019 (Pienaar et al., 2019). In a conservative scenario where Namibia allocates one thousand hectares of green schemes to blueberry production, the farm sales would represent 0.5% of GDP when reaching the full potential of the farms and the orchards. This would result in the creation of 2,500 jobs (both seasonal and permanent). In an ambitious scenario where Namibia makes a strategic bet and allocates six thousand hectares to blueberry production, the impact becomes significantly higher. Blueberry sales would represent 2.7% of GDP, and job creation would be 1.6% of the labor force and 9% of total agriculture employment. The parameters from

South Africa are conservative relative to those from Peru. If we were to take the same measures in Peru, the projections would be more impactful. The yields of blueberry farms in Peru are 15-20 MT per hectare, and the export price in 2021-2022 was $5.7 (Camacho, 2023), although prices are in decline due to the expansion of supply.

Table 2: Irrigation Potential of Green Schemes

Scenarios		Parameters			Illustrative Projections				
	Ha	Price in SA at the farm gate	Yields in SA	Job creation in SA	Sales (USD Mil)	% of GDP	Job creation	% of Labor Force	% of Agriculture Employment
Conservative	1000	R80 per Kg	10 MT	2.5 jobs per Ha	$56	0.5%	2,500	0.3%	1.5%
Competitive	4000				$222	1.8%	10,000	1.1%	6.1%
Strategic bet	6000				$333	2.7%	15,000	1.6%	9.2%

Source: Own elaboration. The parameters of South Africa (SA) were taken from Pienaar et al. (2019), and they are all from 2019. The GDP of Namibia (2019) comes from World Bank Data, the labor force from ILOSTAT, and agriculture employment from Namibia's LFS.

While there are evident challenges and disparities in accessing infrastructure in Namibia, our findings suggest that these issues do not pose an immediate or short-term constraint. The importance of water and electricity infrastructure in Namibia's agricultural sector cannot be overstated. These inputs are vital for the country's agricultural development, particularly in the context of Namibia's unique environmental conditions. Section 2 of this report highlights how Namibia's natural conditions significantly elevate the risks associated with rainfed crop production and livestock farming while negatively impacting yields. Given this scenario, the implementation of efficient water systems becomes imperative. Such systems can enhance water availability for agricultural purposes and boost farm productivity, thereby mitigating environmental risks. Irrigation systems could be a pathway for Namibia to develop a comparative advantage in agriculture. A comparison between the grape and livestock industries in the country illustrates this potential. While Namibia has a robust history of cattle farming, this industry has been hindered by its dependence on rainfall. Conversely, the recent growth of the grape industry demonstrates that irrigation-based agriculture is not only feasible in Namibia but can also be a source of competitive advantage. This observation is further supported by the success of other nations with similar environmental characteristics, such as Israel, which has managed to develop a thriving agricultural sector. However, although water and electricity infrastructure may pose challenges for all types of agriculture in the medium to long term, our research indicates that these are not immediate or binding constraints. To realize the ambition of creating larger-scale and competitive agricultural industries, Namibia must invest in fixing, expanding, and enhancing its existing water and electricity infrastructure. Yet, according to our findings, this is not currently the most binding constraint for increasing agriculture productivity. There are three main reasons why we understand this is the case:

1- Most farms that manage to access irrigation infrastructure are currently facing other bottlenecks. When looking at the agriculture census, we observe that utilizing irrigation infrastructure is associated with higher yields, but other complementary inputs are crucial to explain the variation in yields. Furthermore, the yields vary a lot amongst the farms that utilize irrigation. If infrastructure were a constraint, one would expect to see a much stronger relationship between growth and irrigation intensity of crop production in the style of the camels and hippos' test. The camels in Namibia's agriculture sector (i.e., industries with low rainfall dependency like grapes) are not really thriving. As a case in point, grape exports reached their peak in 2014 but have been on a downward trend since then. In 2021, they hit their lowest volume since 2007.
2- The current state of infrastructure allows for higher utilization in the agriculture sector. Although household access to water and electricity infrastructure is low in Namibia, as reflected by Figure 18, agriculture-specific infrastructure is underutilized. The most

compelling sign supporting this is the extensive idle capacity in the green schemes. The land area that is available with access to infrastructure in the green schemes is large enough to make a significant impact on agricultural development, as pointed out in Table 2. Furthermore, the government has recently acquired 11,000 hectares of land serviced by the Neckartal Dam (The Namibian, 2022; The Brief, 2023). This strategic acquisition enhances the potential for higher utilization of existing infrastructure. In sum, there is a need to fix the current state of water infrastructure and expand electricity generation and access in rural areas for small farmers and households, but there is not yet an excess demand coming from agriculture.

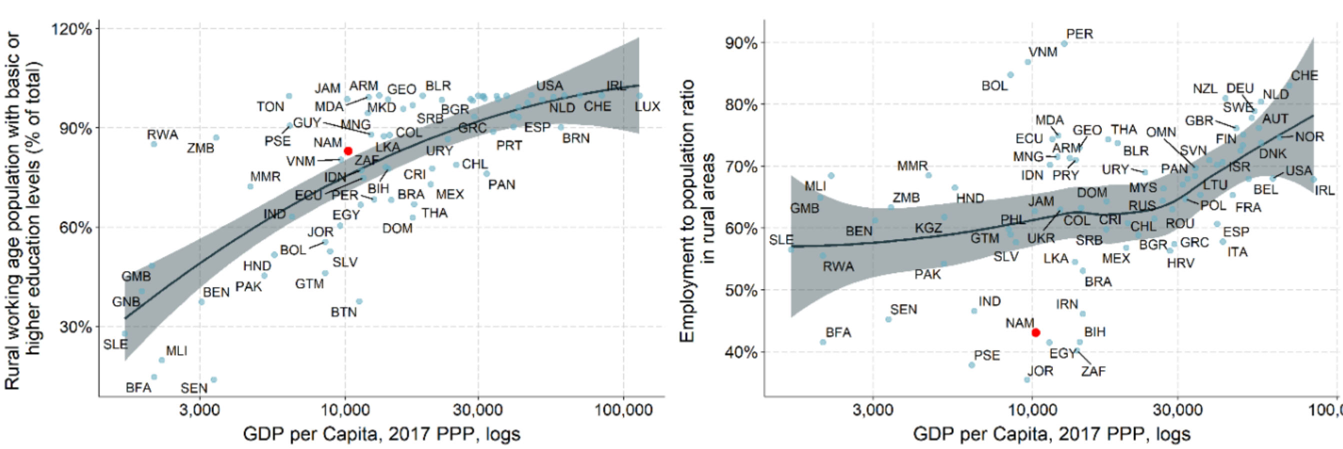
3- The investments in infrastructure done by the government have not produced major movements in the productivity or economic dynamics of the sector. Since the start of the Green Schemes Policy in 2008, the extension of land available for agriculture under irrigation has significantly expanded. However, this expansion has not translated into an increase in productive agriculture. One major factor contributing to this lack of dynamism was the failed role of AgriBusDev as the central administrator of the green schemes. Additionally, a considerable portion of land was allocated to small farmers, but this did not yield scalable results. The small farmers participating in the green schemes have faced substantial obstacles, preventing them from increasing their volumes and productivity. The challenges they encounter highlight the complexity of transforming investments in infrastructure into tangible growth within the sector, and they underscore the need for a more comprehensive and effective approach to agricultural development in Namibia.

3.4 Human Capital

Human capital could become a binding constraint for economic growth if the prevailing skill set in the country leads to returns on investment that are so low that they deter economic activity. As defined by Santos & Hani (2021), the question of whether human capital is a binding constraint can be addressed by evaluating whether there is a sufficient stock of skills (e.g. if there is enough supply of skills both in terms of quantity and quality) or by identifying whether there is skills misallocation (e.g. if there are barriers to an efficient allocation of skills like, for example, cultural norms preventing women from working in certain industries). The growth diagnostics conducted for Namibia by Hausmann et al. (2021) reveal that human capital derived from education does not pose a constraint to the country's economic growth. However, a scarcity of specialized skills and know-how has been identified as a limiting factor for Namibia's growth potential. In the initial meetings of the High-Value Fruits Productivity Task Force, commercial farmers emphasized the negative impact of low education levels and living standards in rural areas on labor productivity. They expressed the concern that these factors act as constraints, hindering firms from investing in activities that demand higher labor productivity at the spectrum of low-skills or general farm laborers. In the following section, we will delve into an analysis to determine whether the human capital analysis at the national level is equally applicable to the specific context of the agriculture sector or if there are unique considerations that need to be addressed.

In Namibia, employment levels in rural areas are notably low, mirroring the situation at the national level, yet the country stands out positively in terms of access to basic education. Figure 30 shows access to at least basic education and employment levels in rural Namibia relative to other rural areas in the world in 2018. Two facts stand out from this comparison: Namibia’s employment levels are exceptionally low, while its basic education levels are above average. In the first case, Namibia’s situation is akin to countries like South Africa, where rural areas experience spatial barriers to economic activity (Lochmann, 2022). This similarity can be traced back to a shared history, leading to a pattern where insufficient business activity reduces labor demand. Additionally, the agriculture sector, both in South Africa and Namibia, faces complex coordination challenges among traditional authorities, the private sector, and the national government (Klinger et al., 2022). However, it is worth noting that the underlying causes of low labor demand may differ from those in South Africa, where rural areas often struggle with infrastructure connectivity to

Figure 30: Access to Education and Employment in Rural Namibia (2018)



Source: ILOSTAT & World Bank Data. Note: Basic education is at least primary or lower secondary education.

markets (Lochmann, 2022). In turn, the basic education levels of the working-age population in rural Namibia are higher than those in South Africa or even countries with higher income per capita, like Chile. When evaluating the impact of education on labor productivity, we find that, in terms of quantity, education does not seem to pose a constraint, particularly at the low-skills level. On the other hand, the quality of education might be problematic, but assessing this aspect is more challenging, as it requires a deeper examination of educational content and outcomes.

The relatively high access to basic education in rural Namibia is a result of improvements made in expanding educational opportunities. Table 3 shows the unemployment rate and the share of the working age population without formal education in rural and urban areas as registered by the 2011 National Census and the 2018 Labor Force Survey. The observed decline in both variables may be partially explained by Namibia's substantial rural-urban migration during the period in question. As individuals within the working-age population relocate to cities, there is a corresponding increase in the proportion of graduated students from primary and pre-secondary schools in rural regions that enter the working-age population. However, this migration, marked by a seven-percentage point drop in the rural population, cannot be the only explanation for the change in rural access to education. The unemployment rate in rural Namibia may not have genuinely improved, as there are no significant indications of major shifts in economic activity during this time. Yet, the fact that the share of the working-age population without formal education decreased by 22 percentage points suggests a change too substantial to be attributed solely to rural-urban migration.

Table 3: The shift in employment and education levels in rural Namibia (2011-2018)

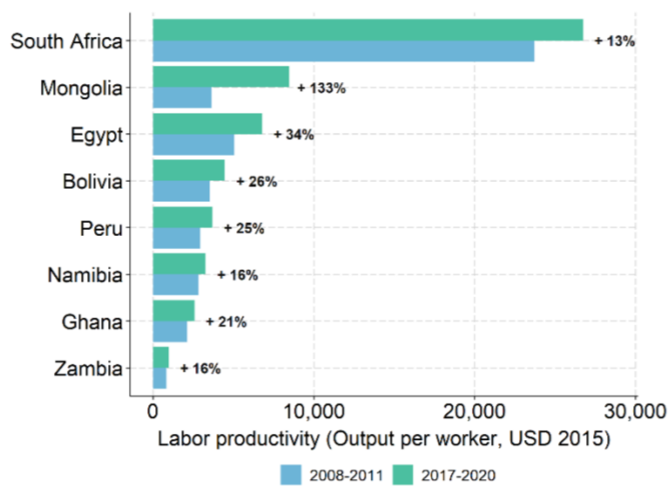
	Unemployment Rate			Working Age Population without Formal Education (% of Total)		
	2011		2018	2011		2018
Urban	35.8%		33.4%	18.0%		7.0%
Rural	38.4%	-5.1pp →	33.5%	40.3%	-22pp →	18.3%

Source: National Population Census (2011) & Labor Force Survey (2018).

The progress in access to basic education was not followed by a significant increase in labor productivity. Figure 31 shows the change in labor productivity of crop and livestock farming in

Namibia and peer countries according to estimates by the International Agricultural Productivity dataset compiled by the US Department of Agriculture. The data shows that labor productivity is low in Namibia, comparable to Peru, Ghana, or Zambia. It also shows that between 2011 and 2018, Namibia's increase in labor productivity was the lowest along with Zambia's. If human capital were to be a binding constraint for productivity growth in agriculture, we would expect to see a relation between the significant improvements in terms of educational access in rural areas and labor productivity.

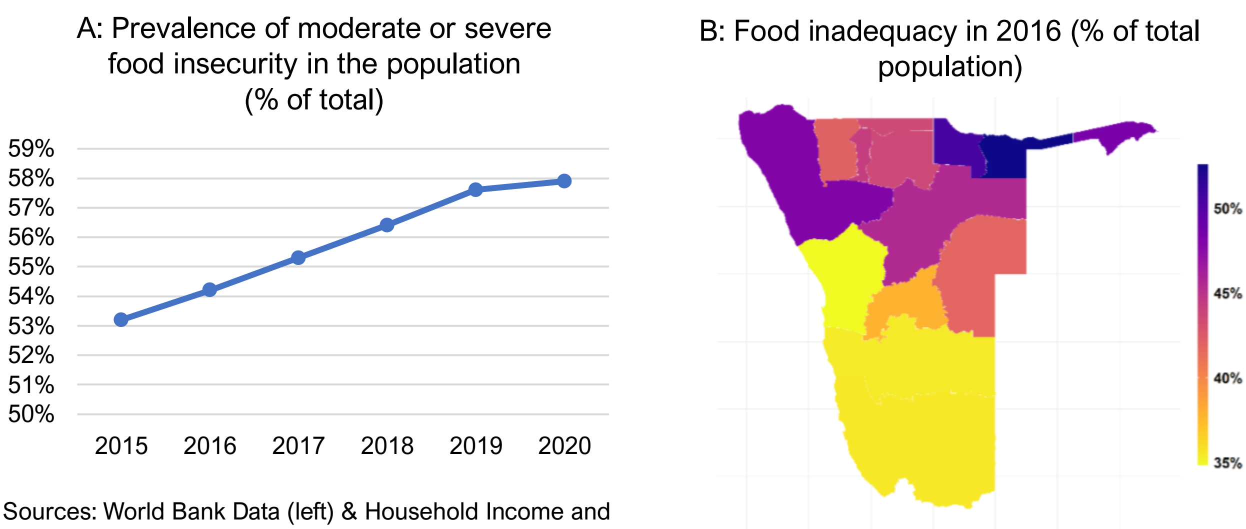
Figure 31: Agriculture labor productivity in Namibia and peers (2008-2011 Vs. 2017-2020)



Source: International Agricultural Productivity dataset, US Department of Agriculture

While rural Namibia has seen progress in enhancing access to basic education, this improvement has not been mirrored in the living standards for most of the population. Figure 32 shows the prevalence of food insecurity in Namibia in 2015-2020 and by region in 2016. Poverty and food adequacy has been worsening, especially in northern Namibia where a significant share of the rural population reside. Furthermore, the negative effects of droughts on the population's capacity to source food have made the situation even worse. While the availability or adequacy of skills may not directly correlate with food adequacy, the latter plays a vital role in maintaining the overall well-being of the labor force in rural areas. Food adequacy ensures that the workforce is nourished and healthy, but we find that it is not a constraint for labor productivity. Instead, it is a consequence, rather than a cause, of the substantial underutilization of labor supply in rural Namibia. The scarcity of jobs in rural Namibia is more likely associated with labor demand issues than supply-side problems. The 2018 Labor Force Survey revealed that over 56% of the unemployed in rural Namibia had either ceased looking for work, failed to find employment, or simply grown weary of the search. This statistic, however, does not reflect a lack of willingness to work. When informed about job opportunities, the rural population actively applies. A recent example can be seen in the developments at the Etunda Green Scheme. The new grape farm project attracted an overwhelming demand for jobs, with over a thousand applicants registering for positions. In this first stage, only 53 were hired, illustrating the stark contrast between the demand for employment and the availability of jobs in rural Namibia (Kaapanda, 2023). This example holds significance as it illustrates the presence of excess labor supply, or 'slack,' in rural Namibia's labor market. If human capital were a binding constraint, it would lead to a tight labor market, characterized by a scarcity of available workers. In such a scenario, firms would find it challenging to locate employees who are both willing and able to adhere to specific work standards.

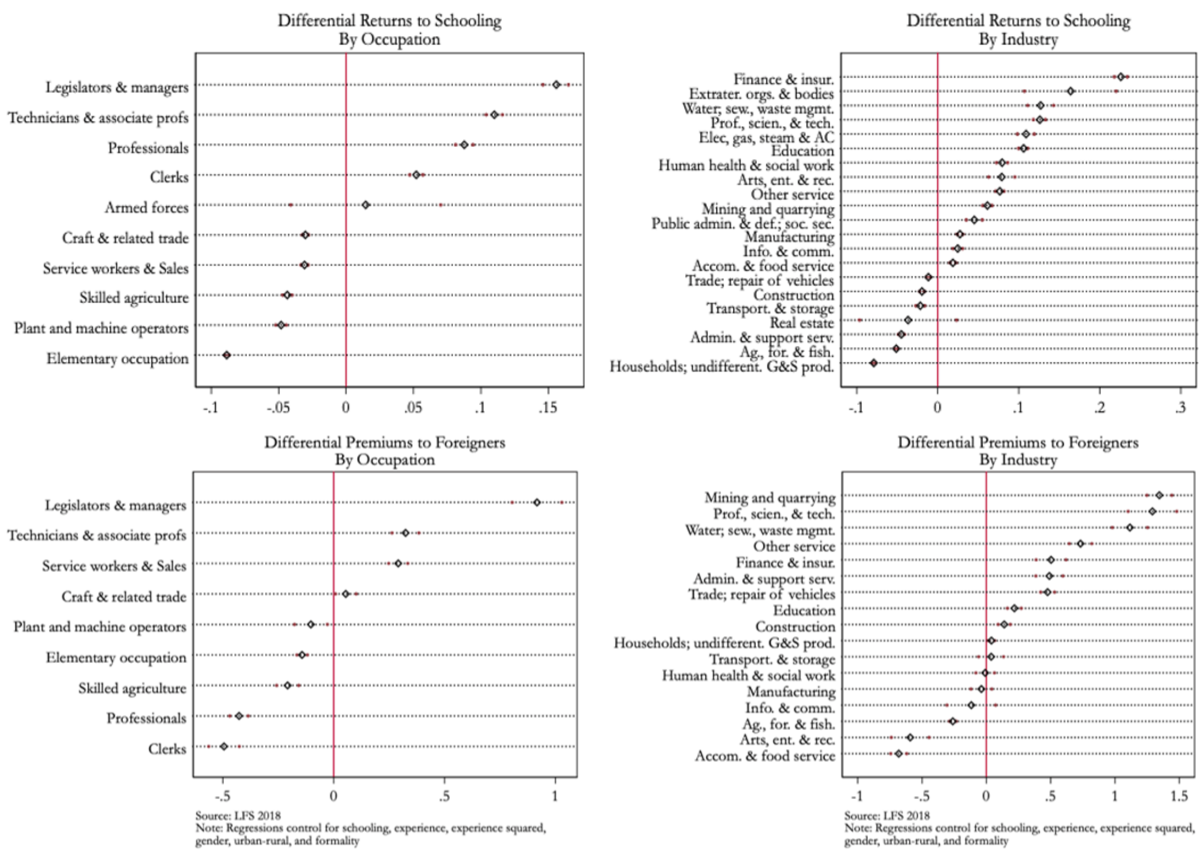
Figure 32: Food Insecurity in Namibia



Sources: World Bank Data (left) & Household Income and Expenditure Survey (right).

Finally, the availability of high skilled labor does not seem to be constraining agriculture development. The returns to schooling in agriculture are negative and rank among the lowest when compared to other industries (Figure 33). Even occupations classified as "skilled agriculture" show negative and minimal returns. Additionally, high-skilled foreign workers in agriculture perceive lower wage premiums than those in other sectors as shown in the bottom left panel of Figure 33 (premium to foreigners in skilled agriculture). These findings suggest that existing firms in agriculture do not face shortages of skilled workers, whether foreign or national. The growth diagnostic of Namibia emphasized that the "challenges in accessing specialized knowhow are exacerbated by the difficulties of hiring and retaining foreign labor" (Hausmann et al., 2022: 33). The analysis of schooling and foreign labor premiums suggests that might not apply to the agriculture sector. However, this situation may not be reflective of the entire agricultural landscape. While the analysis of schooling and foreign labor premiums indicates that these challenges might not apply to the core agriculture sector, they could still be relevant to firms outside of crop or animal farming. These might include essential areas for agricultural development such as seed breeding, food manufacturing, agronomic services, biotechnology, and other food- and agriculture-related technologies or industries. While the traditional agricultural sector in Namibia may not face issues related to skilled labor shortages, the broader ecosystem that supports agriculture might still encounter these challenges. We address issues with the ecosystem of innovation in Section 3.6.2. Furthermore, challenges in developing the skills that are required for innovation may act as constraints for the development of new crops or agricultural activities that require significant investments in research and innovation. For instance, the creation of crop

Figure 33: Returns to schooling and premiums to foreigners. by industry and occupation (2018)



Source: Hausmann et al., 2022

varieties specifically adapted to Namibia's unique ecological characteristics exemplifies this situation.

In conclusion, the rural workforce's levels and type of human capital do not constrain agricultural productivity or growth. We find evidence that shows that the improvements in access to education in rural Namibia were not accompanied by increases in labor productivity, which should be the case if human capital was constraining the sector. We find that the concern about human capital being a constraint does not hold and should not be a major obstacle to expanding productive agriculture or increasing the productivity of existing farms. In turn, the living standards of the rural population in Namibia are low and have worsened over time. This is a result of the low levels of economic activity that characterize the rural regions but should not be preventing workers from fulfilling their tasks. We see strong signs of labor market slack, meaning firms should not face obstacles in finding available laborers. Finally, although the high-skilled occupations in crop and animal farming do not show high shadow prices, there might be a scarcity of critical skills and know-how, even though this cannot be gleaned from the data.

3.5 Access to Market Inputs

The access to critical market inputs plays a vital role in developing productive and competitive agriculture value chains. However, recent global events, such as the pandemic and the conflict in Ukraine, have demonstrated that disruptions in the supply chain can pose serious challenges to countries that rely on importing specific inputs. In this section, we analyze whether the availability of market inputs is a binding constraint in the agriculture sector of Namibia. We will focus our analysis on two primary types of inputs within the two most emblematic sectors of Namibian agriculture. The first includes modern inputs—such as machinery, fertilizers, and seeds—integral to crop production. The second involves animal feed, a key component in the livestock and meat industries.

3.5.1 Modern Inputs

Modern inputs can significantly boost agriculture productivity. Modern inputs, understood as technologies including mechanized equipment, chemical fertilizers, improved seeds, and agrochemicals, are essential for enhancing productivity and overall growth in agriculture (Sheahan and Barrett, 2014). Mechanized equipment can replace human-powered planting and harvesting.

This could improve the promptness of land preparation and allow farms to grow in scale while employing fewer people (Sims and Zienzle, 2006). Similarly, organic fertilizers can sustain and enhance yields by adding nutrients to the soil and enabling crops to grow, which can have larger benefits in areas where soil productivity is low.[19] Improved seeds, meanwhile, can help promote production efficiency, adapt to local-specific agroecological conditions, decrease production risks, and meet high-quality standards and requirements by foreign markets. Altogether, improved seeds would make yields higher and more stable. Finally, agrochemicals such as pesticides, herbicides, fungicides, and insecticides also have a positive effect on crop productivity by protecting plants from pests, diseases, and weeds. Overall, the benefits of these inputs create incentives for farmers to purchase and use them to boost production.

Although modern inputs offer numerous advantages, their adoption in Namibia is significantly low. As mentioned in Section 1, modern technologies in Asia and Latin America contributed to a significant improvement in agricultural productivity during the Green Revolution. However, in contrast to these regions, farmers in countries within Sub-Saharan Africa often lag in the utilization of these modern inputs, despite the associated benefits (Johnson et al, 2003). Through anecdotal evidence gathered during numerous field visits and policy research conducted by the Growth Lab in support of the NIPDB and their Productivity Taskforces, as well as the Ministry of Agriculture, Water, and Land Reform (MAWLR) and their rural development strategy, it has become evident that an analogous situation exists in Namibia. It has been claimed that the limited availability of these inputs across the board may be hindering farmers' ability to expand their operations and enhance production efficiency.

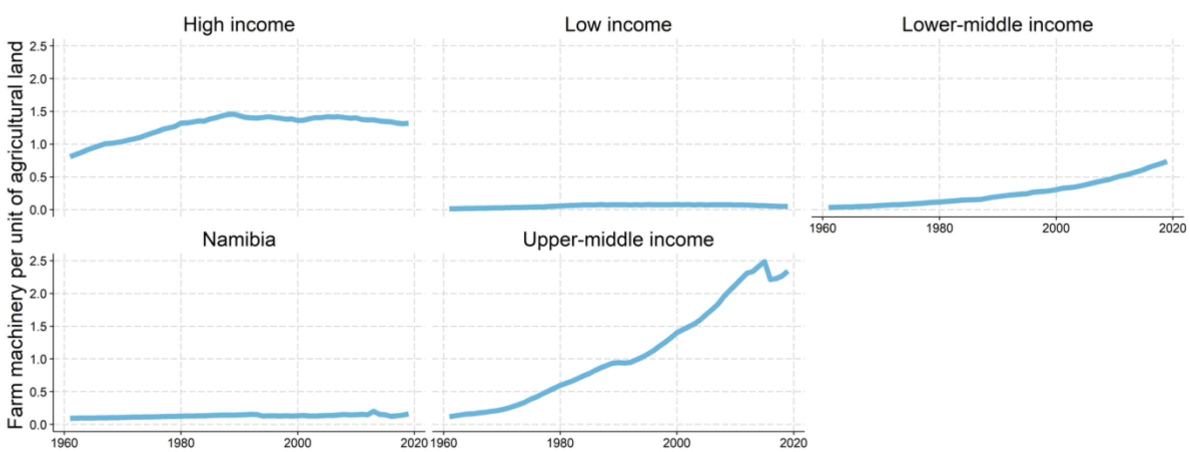
If the scarcity of supply is the underlying cause, access to modern inputs can become a binding constraint for productivity as it leads to increased input prices and diminished returns on investments to purchase these technologies. This scarcity can stem from a range of factors, such as high transaction costs to reach input retailers, weak contract enforcement, and significant output risk, which are prevalent in many Sub-Saharan African (SSA) countries, including Namibia (Dillon and Barrett, 2017). When the level of scarcity reaches a point where there is a substantial mismatch between the supply and demand of inputs, it can discourage productive investments in the sector despite the potential for productivity gains. To evaluate the

[19] Fertilizers can also be organic, namely come from manure and compost. While it provides different benefits, and thus can be used complementarily with chemical fertilizers, in this report we focus the attention on the latter.

adequacy of the supply of modern inputs in Namibia, we assess macro-level statistics for cross-country comparisons and complement them with farm-level microdata, which provides insights into input utilization patterns. This approach allows us to capture more effectively the diverse conditions within the country, while also distinguishing between the practices of commercial and communal farmers.[20]

The use of machinery in Namibia is as low as in a low-income country and has not changed since the 1960s. There was 0.2 machinery per unit of agricultural land, a level comparable to that in low-income countries and well below the prevalence of machinery in high-income economies (see Figure 34). Moreover, the prevalence has not progressed since the 1960s, in contrast to the pattern observed in lower-middle- and upper-middle-income countries. This result may be partly explained by the fact that export-oriented agriculture in Namibia, concentrated in a few entrepreneurs, started only two decades ago. Furthermore, it may also be explained by the fact that this type of agriculture is not capital-intensive.

Figure 34: Farm machinery per unit of agricultural land (1961-2020)



Source: United States Department for Agriculture (USDA) Economic Research Service, FAOstat

Although commercial farmers use increasingly diverse mechanized equipment, the figure is still low compared to other countries. Reliance on human power for agriculture is still hugely dominant. Commercial and communal farmers tend to use hand tools like axes, pangas,

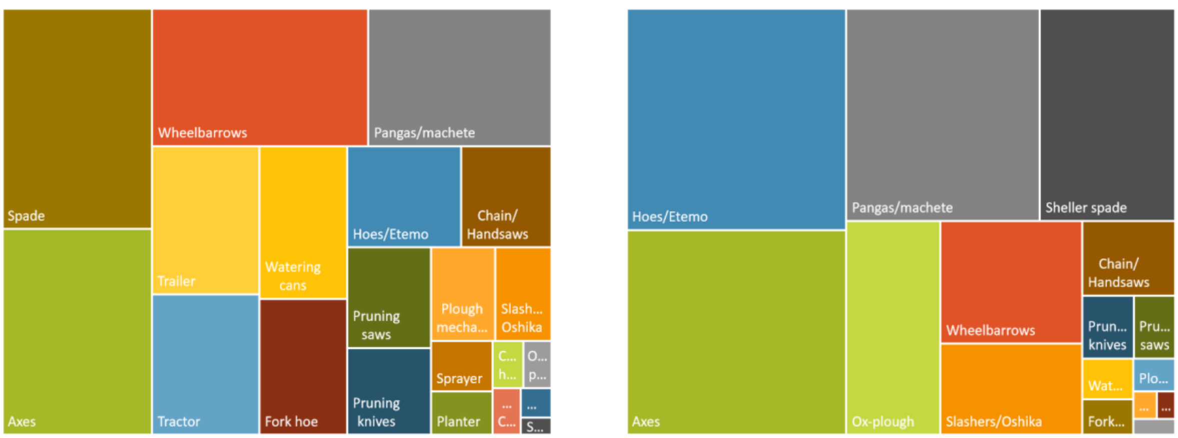
[20] However, common data limitations in this type of analysis include the input use intensity, namely the quantity used, its frequency, the area of cultivated land under the use of modern inputs, as well as the differential use by types of soil, land size, among others.

wheelbarrows, and spades when planting and harvesting (see Figure 35). Only 28% of commercial farmers used trailers and tractors and 11% used mechanical ploughs. Meanwhile, practically none of this mechanized equipment was used by communal farmers. For instance, they rely more on ox-ploughs (40% of farmers) than on mechanical ploughs (3% of farmers). These numbers highly differ from figures from other countries such as Nigeria, where 27% of cultivating households used animal traction and 25% used machines (Sheahan and Barret, 2014). In Nigeria, there is also a complementarity of methods: 47% of households use both animal traction and machines. On the other hand, commercial farmers in Namibia use more varied -although not necessarily more modern- machinery, which reflects more advanced methods of production.

Figure 35: Types of machinery used

a. By commercial farmers

b. By communal farmers



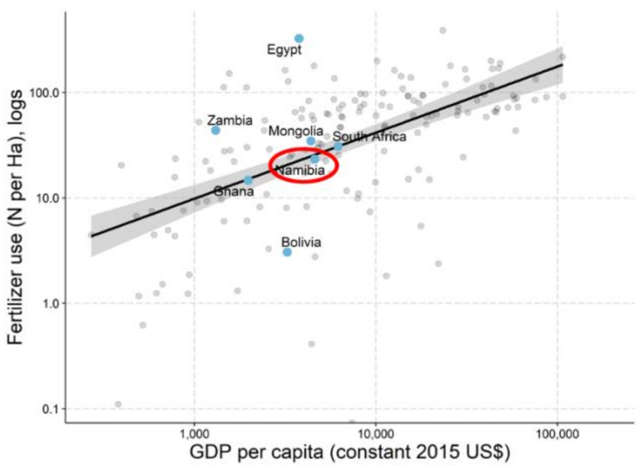
Source: Census of Commercial and Communal Agriculture 2013/2014

Similarly, the use of fertilizers is very low across the board. Farmers apply an average 6.7 kilograms of chemical fertilizer per hectare of cultivated land in Namibia. While at an aggregate level, fertilizer use is high and is close to the global average (see Figure 36), micro-data reveals that only 3.7% of commercial farmers used chemical fertilizers and less than 7% of communal farmers that grow the top-three crops used them (see Figure 37)[21]. Data for other countries from Sub-Saharan Africa show that 35% of all farmers used chemical fertilizers, although with some heterogeneity across countries: Ethiopia (56%), Malawi (77%), Nigeria (41%), Niger (17%),

[21] Millet is cultivated by 85% of communal farmers, sorghum by 16%, and maize by 12%. Nitrogen nutrient fertilizer is the most used in Namibia: 92% of overall consumption in 2020 (FAOstat, 2022).

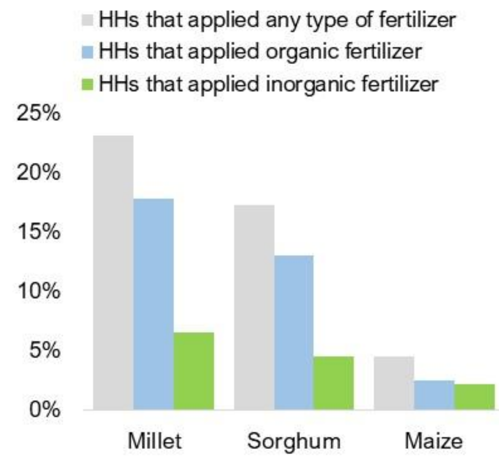
Tanzania (17%), and Uganda (3%). While different crops may rely more on chemical fertilizers than others, in Namibia the low use is for all the crops cultivated by communal farmers. Moreover, the high use of fertilizers at the aggregate level but extremely low at the farmer level may explain the extreme levels of demand concentration in a few farmers.

Figure 36: Fertilizer consumption vs GDP per Capita, 2019



Sources: FAOstat

Figure 37: Fertilizer use by communal farmers for most cultivated crops



Source: Census of Communal Agriculture 2013/2014

The low use of fertilizers may be explained by increasing demand unmet by suppliers, associated with higher prices. In Africa, more than half of chemical fertilizers are imported as the number of domestic suppliers is very low and the region only contributes 5% of global production. In 2021, only 135 fertilizer plants were registered in Sub-Saharan Africa, excluding South Africa, the largest producer in the region. This results from high transport costs and the low population density that make fertilizers more costly to access. As such, higher prices reduce the profitability of fertilizers and may discourage their adoption by farmers (Suri and Udry, 2022).[22] This is more constraining in Namibia, where broad government programs that subsidize prices have been non-existent and low density inhibits access to markets.[23] Moreover, none of the fertilizer plants are in the country, which makes farmers fully dependent on imports, which have registered increasing prices globally (Malpass, 2022).[24] In Namibia, the average price jumped from

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[22] See AfricaFertilizer.org

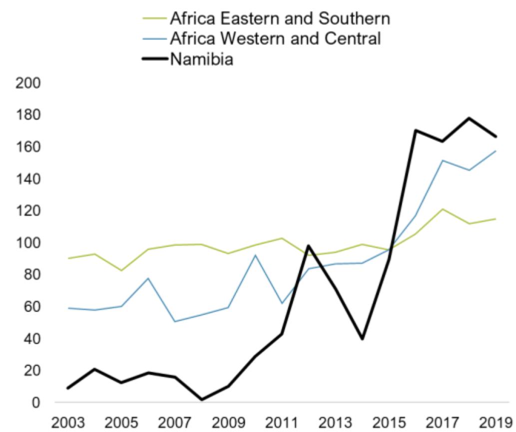
[23] In many African agricultural economies, the government provides financial assistance or subsidies to farmers to help them access fertilizers. Eligible farmers receive vouchers, direct payments, or discounted prices.

[24] Imports thus are largely influenced by international prices, currency exchanges, market political conflicts, and shipping costs. Namibia imported 90% of chemical fertilizers from South Africa in 2021.

0.75 US$ per kg in 2017 to 1.73 in 2019 (see Figure 38). This is in a context where the demand has been steadily increasing since 2008 (see Figure 39), with a more pronounced trend than other countries in the region.[25]

Figure 38: Price of imported fertilizers in Namibia (US$ per Kg)

Figure 39: Fertilizer consumption in Africa (Kg per Ha, 2014-2016=100)



Notes: Figure on the left corresponds to fertilizers most imported by Namibia (code 4030). Source: WDI, FAOstat

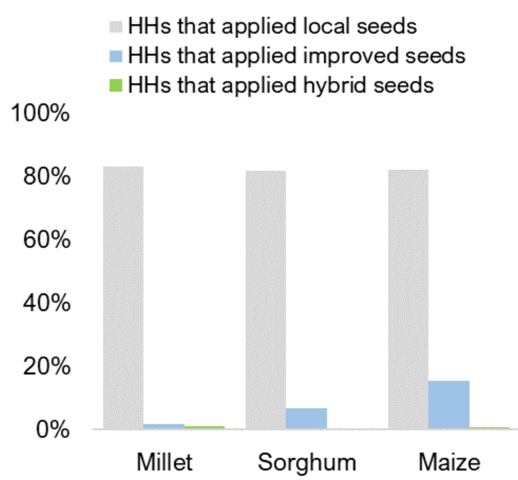
The use of improved seeds is also low. Only 4% of commercial farmers used improved seeds and only 2% and 7% of millet and sorghum growers in communal land, respectively used them. More than 80% of these farmers still rely on local seeds, which tend to be stored for different crop seasons and informally traded (see Figure 40). The use of improved seeds for maize is higher (15%) but is still well below the numbers for other SSA countries. In Malawi, over half of the maize-cultivating households use a modern variety while only 22% use local seeds. In Ethiopia, 25% of maize farmers use improved seeds while 51% use local seeds. Importantly, in contrast to these countries, in Namibia, farmers do not seem to show some degree of on-farm diversification in seed choice despite the benefits that the diversity in seed attributes offers (Lunduka, Fisher, Snapp 2012).

The production of improved seeds is non-existent, and even the utilization of certified seeds remains low, same with fertilizers. Improved seeds are those that have undergone selection or breeding processes to enhance their efficiency in terms of yields or resistance to climate

[25] This factor has been recognized by the NAB in different reports. See one report here.

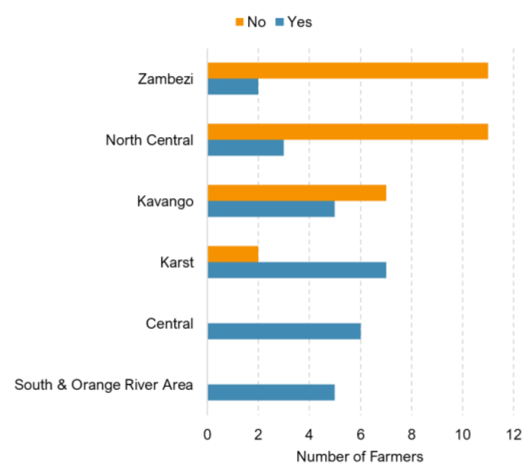
conditions (temperature or water intake variability), surpassing local seed varieties. On the other hand, certified seeds meet stringent quality standards and receive official certification from regulatory bodies or seed certification agencies to ensure high quality, genetic purity, and freedom from contaminants or diseases. Improved seeds are developed through various scientific methods, such as traditional breeding techniques or advanced biotechnology approaches like genetic modification. Certified seeds are produced and distributed by authorized seed companies or institutions that adhere to stringent protocols and quality control measures throughout the seed production process. However, despite their quality assurance and standardization, the adoption of certified and improved seeds in Namibia is limited. For instance, a sizable portion (63%) of planted fruit trees lack certification. Farmers in Zambezi, North-Central, and Kavango regions primarily acquire fruit trees from non-accredited nurseries (see Figure 41). The inadequate use of certified seeds could be attributed to the absence of local seed nurseries or breeders, with only one regional horticulture firm in operation. Consequently, all trees are sourced from foreign companies or traders, mirroring the situation with fertilizers. This overall scenario contributes to the scarcity of land dedicated to fruit production (15%) and the small share of fruit production in the country's total trade (4%).

Figure 40: Seed use by communal farmers for most cultivated crops



Notes: HHs = households. Source: Census of Communal Agriculture 2013/2014

Figure 41: Were the fruit trees sourced from an accredited nursery?

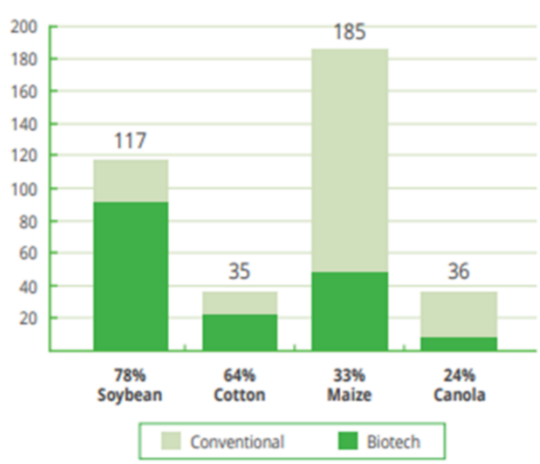


Source: NAB (2022), Baseline Study Regarding the Status Quo of Fruits Production in Namibia; Census of Commercial and Communal Agriculture 2013/2014.

The limited availability of appropriate high-yield and high-quality plant varieties is a current constraint for productivity growth in export-oriented agriculture and will become binding

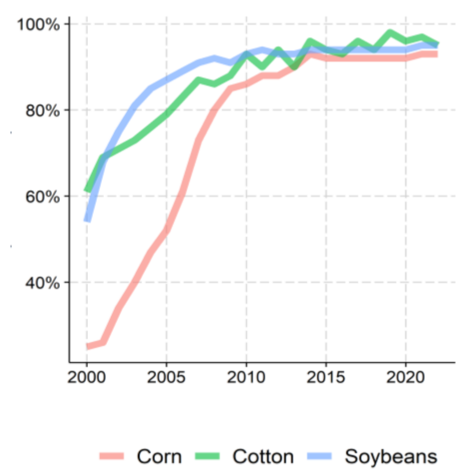
eventually for the rest of the farmers as they increment their productive capabilities. Export-oriented high-value fruit producers require specific cultivars to access different international markets that would allow them to reach higher levels of scale in the short run –thus increasing their productivity (they are starting from low scale levels). In the case of small-scale horticulture and cereal production, the unavailability of bioengineered varieties is a binding constraint in the medium to long term as they still massively use local seeds. The access to certified and improved seeds is crucial for different reasons. Firstly, it is a way to overcome adverse effects of local natural conditions in Namibia, like low precipitation, rainfall variability, elevated temperatures, or local pests. Secondly, it is essential for diversifying the production of crops. As Namibia gains improved access to seed varieties, the country will be able to develop tests of what types of crops work best for its local context. Finally, accessing certified seeds is crucial for expanding Namibia's market access, as countries tend to demand specific varieties of crops. There is overwhelming global evidence of how the incorporation of bioengineered crops has increased yields worldwide (see Figure 42 and Figure 43), with even more benefits for water-stressed places like Namibia. But the use of biotech seeds is also rapidly growing in Africa. 11 countries have commercial approval for GM crops or are under ongoing trials for extensive crops that Namibia produces such as sorghum, maize, potatoes, cowpeas, cassava, among others (ISAAA, 2016).[26]

Figure 42: Global adoption rates of improved seeds, 2016 (Million Ha)



Sources and elaboration: ISAAA (2016)

Figure 43: Genetically Engineered Varieties in the United States (% of total)



Source: USDA Economic Research Service

[26] Includes Sudan, Ethiopia, Kenya, Uganda, Mozambique, Malawi, South Africa, Eswatini, Nigeria, Ghana, and Burkina Faso.

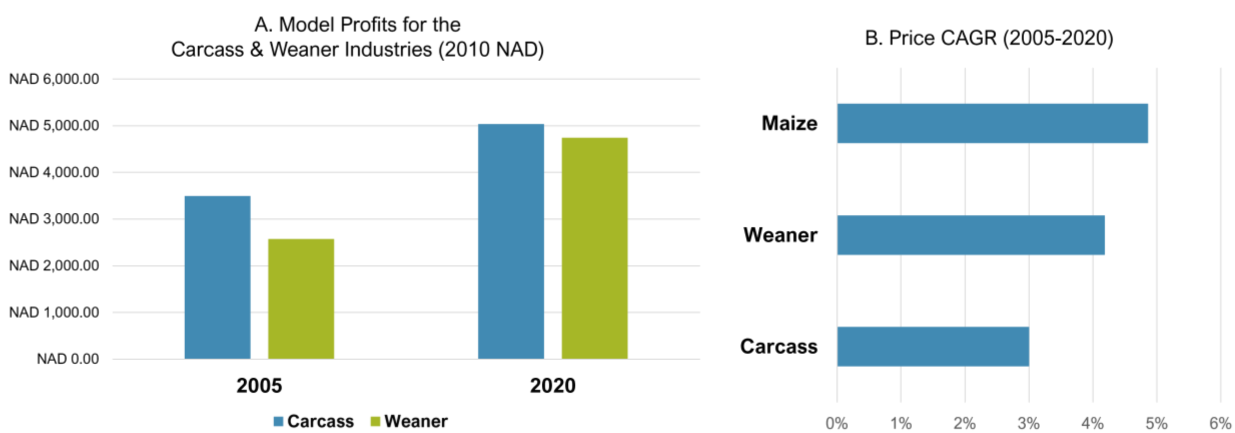
In conclusion, despite the large gains from using modern inputs to drive agriculture, its use is low in Namibia, although the causes may be different. Modern technologies can make labor more efficient, sustain and enhance yields, adapt to varying agroecological conditions, drive environmental resiliency, access markets, and altogether promote productivity and the competitiveness of the sector in Namibia. Altogether, improved seeds would make yields higher and more stable. Despite these benefits, in Namibia, all figures show that the replacement of traditional inputs by more industrialized and technological options has evolved at a minimal pace across the board. It has been shown that both fertilizers and certified seeds are imported at costly prices and unevenly used. Specifically, extensive crops access more certified plant varieties, but this is not the case for horticulture, for which there are no tree nurseries or local seed breeders. Meanwhile, use of improved seeds is almost inexistent. Following Dillon and Barrett (2017), in the case of fertilizers and certified seeds, policies to extend their use may aim to reduce the costs of their production locally through investment in public goods and services such as infrastructure and connectivity. Meanwhile, policies for higher use of improved seeds may require creating a market to assign property rights, remove restrictions to current (limited) ways of exchange, or provide complementary public goods.

3.5.2 Animal Feed

Although Namibia's livestock and meat industries are amongst the largest in Sub-Saharan Africa, they are losing competitiveness. In 2010-2019, Namibia's share of beef exports in the region constituted 27% of the total, which reflects the country's ability to develop to develop a competitive industry that complies with strict international animal health protocols. However, the situation has taken a downturn. As previously reported in Figure 10, the exports of livestock and meat products have not recovered from recent droughts. Moreover, Namibia has been losing global market share in those industries. If the country had kept the highest global share in the past decade, exports would be significantly higher. Exports of bovine live animals in 2021 were over 14% lower than in 2010. What explains this underperformance? What are the immediate constraints the sector is facing that resulted in a collapse in production and productivity?

The industry's stakeholders agree on the negative effects of droughts on the industry's performance. These natural phenomena affect the sector because it is particularly dependent on rainfed pastures, maize, or fodder production. In that sense, the sector faces a serious scarcity of an essential market input: animal feed. Panel A in Figure 44 shows an estimation of profits for producing weaner and carcasses in Namibia in 2005 and 2020 using a simple model accounting only for feeding costs and the prices of carcasses and weaners. The cost of feeding is the largest operating cost for bovine producers. According to the Economic Research Service at the US Department of Agriculture (Commodity cost and return estimates), feeding costs were over 60% of operating costs in the 1990s and up to 75% in 2021.[27] The production of carcasses requires much more animal feed than weaners because weaners are typically sold during their first year, whereas cows take two to three years to produce carcasses. In turn, carcasses production is more complex and involves higher value addition than weaners. Most countries with a comparative advantage in livestock farming export more beef or downstream products (carcasses) than live bovine animals. However, Figure 44 shows that carcasses production has lost profitability because of the rise in animal feed cost. In 2005, the carcass industry was over 35% more profitable than the weaner industry, whereas in 2020 it is only 6% more profitable. The collapse in carcass profitability can be traced to the rising cost of animal feed. Panel B shows the Compounded Annualized Growth Rate (CAGR) of the price of maize, which is a fair proxy of the price of animal feed since maize is one of its principal components. Notably, the escalation in feed costs has outpaced the price increase of both weaners and carcasses, leading to a disproportionately negative impact on carcass production. The demand for weaners is primarily driven by South

Figure 44: Profits of Livestock Industries & Change in Prices (2005-2020)



Source: Data from the Meat Board of Namibia & FAO. Note: The model profits were elaborated following a model developed by Chiriboga, K. et al. (2008).

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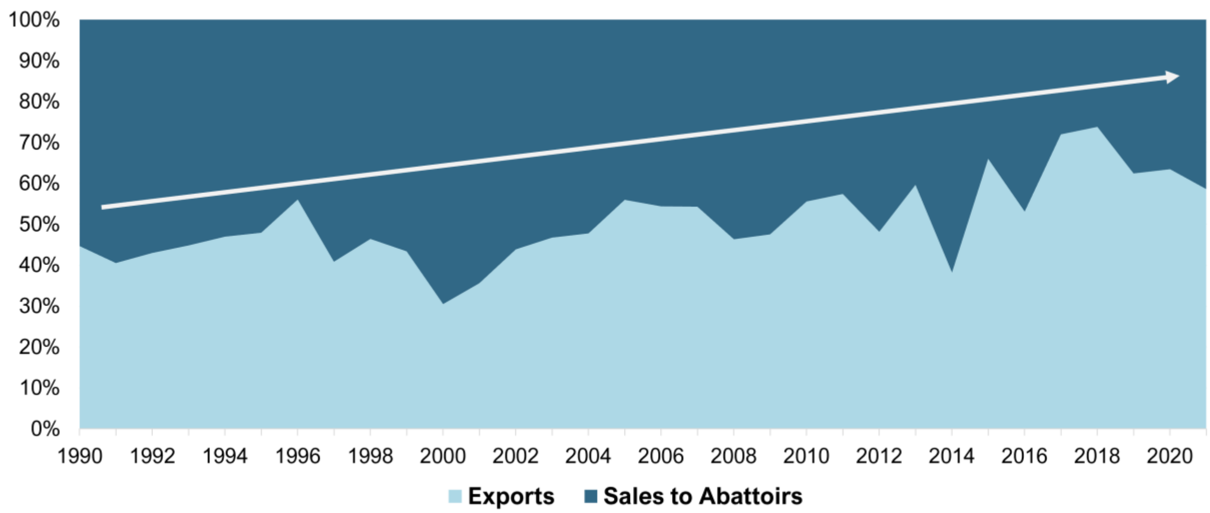
[27] See https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=104424 and https://www.ers.usda.gov/data-products/commodity-costs-and-returns/commodity-costs-and-returns/#Historical%20Costs%20and%20Returns:%20Cow-Calf

African feedlots, which, in turn, market carcasses and beef both domestically and internationally. As a result, the sector shows a tendency to substitute the sales of abattoirs with exports of live animals (Figure 45). The exports of live animals went from 42% of total production in 2000-2004 to 67% in 2017-2021 (Meat Board Cattle Marketing data).

Figure 45: Livestock Exports & Abattoir Sales (1990-2020)

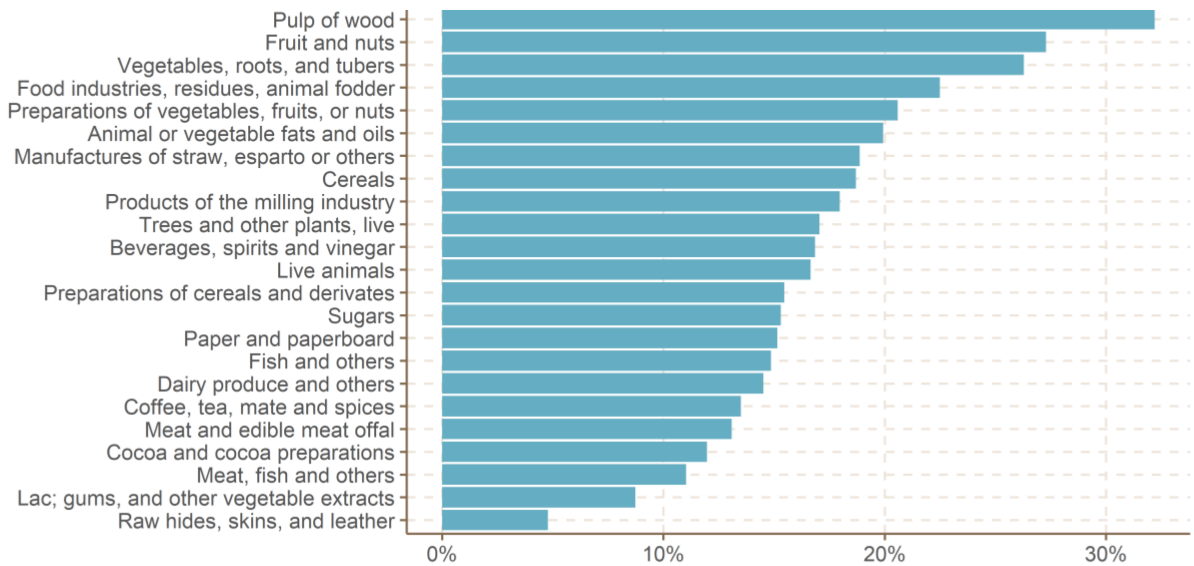


Source: Meat Board of Namibia

The challenge in accessing animal feed is an immediate problem for the productivity of the livestock and meat industries in Namibia. As noted in Figure 3 in Section 2, the sector represents over 50% of the total value of agriculture production. Furthermore, if Namibia manages to solve the constraint of the veterinary cordon fence that disallows exports beef and bovine exports in the northern regions, the country would be able develop a high-scale, competitive and export-oriented livestock farming sector. However, the high shadow price of animal feed indicates that it has become an immediate constraint for the sector.

Namibia has the potential to increase its resiliency to droughts in livestock production – both for communal and commercial areas – by producing commercial feed, as an alternative to imported feed. It is estimated that road transport costs represent 20% of the value of imported feed, which is a high rate when considering the aggregated weight of transport costs in agriculture imports of Namibia (Figure 46). This implies that the Namibian livestock sector has a considerable disadvantage vis-à-vis countries that produce animal feed domestically and are able to do so at international standards of productivity. In turn, it also implies that it might give Namibian feed producers a margin to remain competitive against imports from South Africa even at a lower level of efficiency – at least until larger scales needed to be competitive at the export level are achieved and if the domestic costs of transportation is lower. There is a market for animal feed in Namibia, where most of the livestock farmers use their own feeding material (Figure 47), and Angola, a country with 66% more cattle than Namibia.

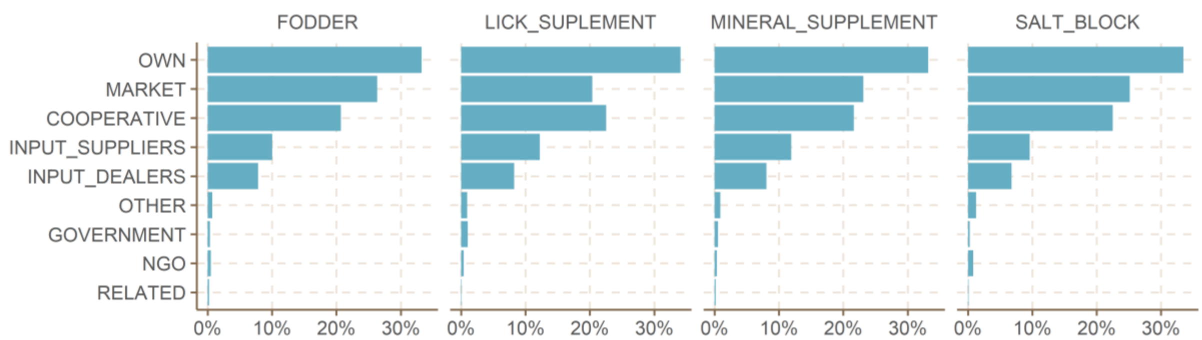
Figure 46: Estimation of Road Transport Costs (% of import values for Namibia's agriculture products, 2019)



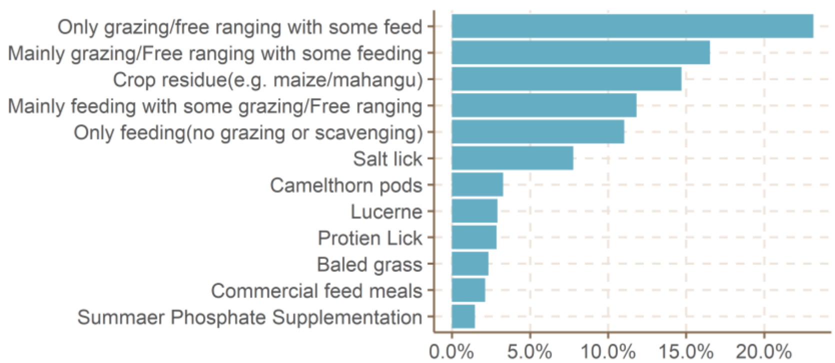
Source: UN COMTRADE Database. Note: The road transport costs estimation is the difference between the Free on Board (FOB) import values and the Cost, insurance, and freight (CIF) values, over the FOB values at the HS 2-digit level. This is not an accurate estimation because the CIF-FOB differentials reflect cross-country discrepancies in measurement (Hoffmeister et al., 2022), yet it is an indicative measure of transport costs as a rate of the products'

Figure 47: Animal Feed in Commercial and Communal Farms (2013-2014)

A. Animal Feed Sources in Commercial Livestock Farms



B. Feeding Practices in Communal Livestock Farms



Source: Agriculture Census of Namibia (2013-2014)

3.6 Provision of Public Inputs: Regulatory Environment

Agricultural development requires specific public goods that cannot be supplied by individual economic agents. This consideration extends to many other industries and is a crucial consideration for industrial policy (Rodrik et al., 2023; Crespi et al., 2014). It is unlikely that a country would be able to develop a comparative advantage in car exports without compliance with minimum port infrastructure standards. Conversely, it would be impossible for a country to expand renewable energy generation if it lacks appropriate regulation. In the case of agriculture, there are several inputs that are essential and could become binding constraints. Section 3.3 of this report has already covered one of them: Infrastructure. In this section we cover two other types of public inputs: land tenure and appropriate regulation.

3.6.1 Land Tenure

Research shows that the prevalence of customary or communal land tenure systems is associated with lower agricultural productivity. While natural suitability and land quality for agriculture vary among countries, the disparity in agricultural productivity is even more pronounced. As Adamoupoulos & Restuccia (2018) show, a more efficient resource allocation in lower-yielding countries could dramatically reduce the agricultural yield gap between rich and poor nations from 214% to a mere 5%. But communal land tenure is predominant in developing nations with lower agricultural productivity. In Southern Africa, the proportion of communal lands to total land area is substantial, with Namibia and South Africa having comparably lower rates at 36% and 14%, respectively. In contrast, Tanzania has an overwhelming 86% of its lands under communal tenure. These systems can inadvertently hamper productivity by leading to resource misallocation. Essential agricultural resources include land, capital, labor, and technology. Misallocation might occur when, for instance, more capital or labor is allocated to less productive farms. There is evidence of land institutions being a factor of resource misallocation in agriculture in multiple countries: Philippines (Adamopoulos & Restuccia, 2019), Malawi (Chaoran et al., 2023), Ethiopia (Chen et al., 2017), China (Adamopoulos et al., 2017), and Vietnam (Le, 2020), among others. Customary land institutions often restrict the expansion of the most capable farmers or the allocation of productive farms in areas abundant with essential inputs like water or electricity.

The customary land tenure system presents significant challenges for the development of productive agriculture in northern Namibia. The country's land ownership is primarily categorized into two systems: freehold tenure prevalent in urban regions and commercial farms, and customary tenure on communal lands. In communal land regions, low productivity household-level agriculture is prevalent. Are the institutions of land tenure in northern Namibia a constraint for the development of productive agriculture? Until the Communal Land Reform Amendment Act of 2005 (Act No. 11 of 2005), the law established that any plot of communal land used for commercial purposes had to be registered as a leasehold. The procedures to transition the customary rights to leasehold were cumbersome and deterred communal farmers from engaging in commercial farming. In that sense, there was a direct legal constraint for the expansion of productive agriculture in the north at least until 2005. The 2005 reform established a system of registration of customary land rights and leasehold rights that intended to reduce the barriers to economic activity. Nevertheless, under the current legal framework, land rights in communal areas cannot be registered as legal deeds. As a result, they cannot be used as collateral for credit applications. This results in areas of "dead capital" (Shiimi, 2011), that could otherwise contribute to economic growth. Research shows that improving land property rights can have a significant impact on agriculture growth and financial inclusion by enabling access to finance (Manysheva, 2022). In that sense, the communal land tenure system can be a barrier to agricultural development (Mendelsohn, et al., 2012). Furthermore, as shown by Mendelsohn et al. (2012), the current system allows for expanding informal occupations of land undertaken by resourceful groups in collaboration with local authorities. The creation of a regulated market for land rights would benefit the inhabitants of communal land areas, as it would facilitate its tradability and the development of productive agriculture. Additionally, it would make it easier to control and regulate informal and illegal fencing.

The impossibility of using land tenure or leasehold rights as collateral could be binding constraint for attracting investment in northern Namibia's agriculture sector. As shown in Section 3.2, access to finance is not a constraint for the type of agriculture that currently exists in Namibia. The fact that the farmers that manage to get credit use it for covering current expenditure items instead of capital investments is a strong indication of access to finance not being a constraint. Instead, as we will show next, the farmers in communal land areas face coordination problems that lead to a lack of scale and low levels of agricultural know-how. In that scenario, increasing access to finance per se would not lead to a more efficient allocation of resources, productivity growth, or sustainable output growth. The small-scale and subsistence farmers that populate communal land areas lack other complementary inputs that would enable more direct effects on output. In turn, the legal barrier to using leaseholds as collateral could constrain capital-intensive and high-scale industries that currently do not exist in northern Namibia, because they require much higher upfront investments. According to interviews with stakeholders done by the Growth Lab, two of the commercial crop farms in the north, Otjimbele (asparagus) and Mashare Berries (blueberries), were developed in an area of under 500 hectares. The extension of the farms allows for equity investments for covering project development, but larger projects would require higher levels of capital in absolute and per hectare terms. In that sense, the legal provisions that disallow the use of leaseholds for collateral are a binding constraint for capital-intensive projects that currently do not exist because it is impossible to gather the capital they would require. Nevertheless, this is not the only type of agriculture with potential in the northern communal areas.

Streamlining access to land tenure and regulating leasehold rights as collateral primarily involves addressing coordination challenges. A land reform promoting the privatization of property rights in communal areas would allow land to be collateralized for more capital-intensive farming. But this would make community land seizable by lenders, which is often in direct opposition to the interests of community members for whom secure land rights are necessary for own-consumption agriculture, and to whom communal ownership provides deeper cultural value. Instead of insisting on land reform and privatization, an alternative is for the government to facilitate partnerships between communities and the private sector which coordinate the provision of know-how and inputs within existing land institutions. Klinger et al. (2023) delve into the emergence of this type of partnership in South Africa. Their study reveals various organizational designs employed in selected cases, elucidating how these models effectively navigated coordination challenges. The partnerships allowed the local communities to generate consistent income sources, create job opportunities, and start a process of learning by doing. In turn, the private sector could access land and resources that would not be accessible to them otherwise. The authors also document a series of key areas that this type of partnership needs to explore in

Figure 48: Summary of Case Studies of Business Partnerships in Communal Areas in South Africa

Summary chart	AMADLELO AGRI TOGETHER WE GROW • TOGETHER WE REAP	WIPHOLD	ZAMUKELE PART OF THE SCHOEMAN GROUP
Property framework with the community	Shared property between Private Party and community at holding and company level	Shared property of the operating company	No property sharing as it is an out-grower model
Governance	Board of trustees with a majority for the community while Amadlelo´s management make everyday operational decisions	Wiphold oversees both strategic and operational decisions	Local farmers in full charge of strategic and operational decision only advised by Zamukele
Plot consolidation	Communal land owned by the community consolidates in a single plot	Communal land owned by the community consolidates in a single plot	There is no plot consolidation, each farmer operates its plot by its own
Compensation to local community	Land lease linked to fixed sum and dividend distribution based on the operation performance	Land lease linked to fixed sum and cash distribution following a performance score	Farmer's individual profits on its operation
Trust building	By making decision process transparent and including the community in it as well as payment of fixed rent	By paying a fixed rent to farmers plus using own money to honor that guarantee	Based on knowledge of Schoeman in the area
Risk sharing between private party and local community	Farmers reduce risk by sharing it with private party and by receiving a fixed compensation for land use	Farmers reduce risk by sharing it with private party and by receiving a fixed compensation for land use	Farmers reduce risk by rolling over with private party their debt obligations
Risk sharing between communities	There is risk sharing between subsidiary companies through Amadlelo shares in subsidiaries, but local communities absorb the impact of the performance of their company in their community	Significant, since all communities are part owners of the single company in charge of CMAI, but cash distributions may have a penalty in individual landowners according to performance of each plot	None, since each farmer is responsible for its own operation
Involvement of community in farming activities	Large share of employees work directly in dairy farms in core chores	Communal landowners perform non-core farming chores	Local farmers oversee production decisions and crop management and hire farm contractors on their own, assisted by Zamukele
Knowhow diffusion	Significant as local communities employed in its different operations climb in the company's organizational chart	Even though Wiphold executes a training program for the local community there is little "learning by doing" of farming chores	Significant as farmers adopt not only a new crop, but also a management approach that relies on data
Technological upgrade	Significant as private partner brings in machinery, know-how and management skills	Relevant as through consolidation allows for mechanized extensive agriculture	Significant in terms of commercialization, financing and the use of digital apps
Profitability	Profitable for both, private party and community	Farms are not profitable after 7 years of operation	Profitable for both, private party and community

Source: Klinger et al. (2023)

Namibia as well: i- mechanisms to building trust at scale, ii- the creation of a market between communities and firms, iii- transferring technology to smaller farms, and iv- reducing risk through parametric climate insurance. Figure 48 summarizes the takeaways from each case study documented by Klinger et al. (2023).

3.6.2 Plant Variety Regulations & Innovation Ecosystem

Improved seeds are essential for modern and productive agriculture. These seeds refer to plant varieties developed or selected through breeding techniques to possess desirable traits that can offer a wide range of benefits for farmers (McMullen, N., 1987) Improved seeds are often engineered to resist diseases, pests, and pathogens for specific locations and crops. They also can be designed to develop crops with shorter growth cycles and offer high-quality standards and to withstand droughts, floods, and other extreme weather events. By allowing for multiple harvests in a year, easier access to international markets, lower production costs, higher yields, and more predictable food production, farmers can benefit from adopting these technologies. On aggregate, countries with broader access to and use of improved seeds can witness the modernization of their agriculture. Productivity gains can be recorded and reliance on agricultural land can be eased, optimizing water and land use, reducing land degradation, fostering resilience to climate change, and improving food security (Lanaerts et al., 2019).

The benefits of high-yielding crop varieties on productivity can drive their broad adoption by farmers. Gollin et al. (2021) study the impact of the Green Revolution in the developing world. The authors estimate that the breeding and release of new varieties arising from modern crop-breeding techniques increased aggregate yields of food crops by 49% between 1965 and 2010. Some crops, such as wheat and rice, recorded the highest yield increases, in contrast to the marginal improvements for crops such as cassava and sorghum, for which new varieties appeared late, which potentially explains the divergence between agriculture in Southeast Asia and Africa happening over the past half-century (Evenson and Gollin, 2003). There's also complementary evidence on adoption and productivity gains being explained by the improved genetics of the modern seed itself and by the behavioral labor response of the farmers, who spend more time taking care of their plots having certainty about the benefits of modern seeds, in terms of their quality (Bulte et al., 2023).

The utilization of enhanced seeds may be limited in cases where there is a lack of a domestic private market that necessitates the establishment of property rights for these innovations. The advancement of enhanced seeds demands individuals who possess the capacity to invest and engage in innovative practices. Nevertheless, innovation is frequently distinguished by its inherent non-excludability, as it poses challenges in restricting farmers from utilizing and reaping the benefits of the invention without contributing to its development and provision. Establishing property rights of discoveries can effectively address the "free rider" problem. This approach creates incentives for investment in innovation, hence allowing the accessibility of these discoveries to meet farmers' diverse demands. The justification for government intervention, especially through regulation that establishes a protective regime for these rights (Crespi et al., 2014), would lay the groundwork for a novel market wherein plant breeding activities might take place to fulfill the market's need for enhanced seeds.

This is the case in Namibia, where the regulatory environment for innovation in breeding is incipient and has hampered the potential appropriability of these returns. Beyond the challenge of an underdeveloped legal system for certified seeds, aimed at setting out minimum standards of genetic seed design to guarantee cultivars' quality and protection, which was described in the previous sections,[28] Namibia lacks a legal system of plant variety protection. There's no valid regulatory framework to protect plant breeding rights (PBP), contrasting the situation in other 28 countries, such as Kenya, Zimbabwe, Zambia, Tanzania, Malawi, and South Africa, all of which have highly developed seed industries (Cochrane & Kahn, 2021). These frameworks grant the breeders the property right on the plant varieties they design, thus allowing them to authorize (or not) the utilization of the plant varieties they own and receive a royalty for it. The right applies only to plant varieties that, in addition to being new, are distinct compared to other plant types, are uniform across their kind, and are stable with characteristics that remain similar through generations. As such, PBPs create incentives for know-how diffusion and capital investments in breeding because it allows the breeders to offer plant varieties in other countries. But in Namibia, this lacking system has prevented the introduction of foreign varieties and disincentivized the development of local ones. Despite the relevance and its application in

[28] The corresponding Seed and Seed Varieties Act 23 did well in creating the Namibia Seed Council, responsible for advising, monitoring, and coordinating the national seed policy. However, this Act has not been put into practice yet.

Namibia, the legal framework started to be discussed through the Plant Breeders' and Farmers' Rights Bill in 2009 and it has not been approved yet.

Namibia is also absent in international systems for plant breeders' rights. The Union for the Protection of New Varieties of Plants (UPOV) is the largest global convention that provides the international Plant Variety Protection (PVP) system that codifies and oversees the intellectual property rights of plant breeders in the country members. By 2021, 21 countries in Africa belonged to UPOV, in contrast to Namibia. [29] This country's strategy for cultivar access and plant protection primarily relied on regional initiatives with altogether have not materialized. This includes the African Regional Intellectual Property Organization (ARIPO), which started its application to UPOV in 2009, the Arusha Protocol (2015), which created a regional system for plant variety protection that created a single legal framework with uniform and clearly defined principles applicable to member countries. And the Protocol for the Protection of New Varieties of Plants, which created a regional framework with eight other nations from the Southern African Development Community (SADC).[30]

The problems in the supply of improved seeds became symptomatic when export-oriented high-value fruit producers demanded the adherence of Namibia to UPOV. The farmers participating in the Productivity Taskforce on High-Value Fruits expressed that the lack of modern seeds and access to international cultivars as a significant constraint for productivity. These producers have found ways to address this binding constraint in the short term by signing bilateral agreements with foreign breeders to guarantee the protection of genetic resources. Nonetheless, these solutions have been claimed to be costly and limited in scale. A specific policy action demanded by these farmers was the adherence of Namibia to UPOV as it would permit the implementation of a regulatory framework following international norms and the establishment of formal channels for exchanging and disseminating plant varieties with seed developers in country members.

The adherence to UPOV can foster the availability of improved seeds and increase crop yields. Evidence shows that countries like Argentina, China, and Kenya saw a significant increase

[29] 78 countries that have aligned their PBP systems to the UPOV Convention, including Kenya, Tanzania, South Africa, Zimbabwe, and the 17 African Intellectual Property Organization (OAPI) members.

[30] Regarding the Arusha Protocol, only four Tanzania. Sao Tome e Principe, Gambia, Ghana, and Mozambique have signed the Arusha protocol. Meanwhile, Namibia recently signed the Protocol for the Protection of New Varieties of Plants with eight other nations from the Southern African Development Community (SADC). Nevertheless, the protocol has no validity until two-thirds of the SADC members sign it.

in the number of applications and rights granted for the development of new plant varieties following their membership to UPOV (UPOV, 2005). Foreign and, to a lesser extent, domestic breeders introduced new varieties with improved traits, resulting in faster varietal turnover in a variety of crops. The demand for improved seeds gradually drove the expansion of plant breeding capacities and seed industries. It also encouraged more participation from the private sector, public-private partnerships, and national-foreign partnerships in breeding. For example, after becoming a member in 2006, Vietnam reported increases in the registration and use of new plant varieties. The number of applications for PBR titles experienced a shift from under 50 in 2007 to over 150 in 2017, as noted by Noleppa (2017). The advancement in the plant breeding sector led to notable growth in yields for key crops such as rice, maize, and sweet potato. From 2005 to 2016, the annual average increase in yield was 1.4% for rice, 1.8% for maize, and 4% for sweet potato, as stated in the same source. Consequently, only these three crops underwent a remarkable rise in value enhancement. Overall, plant breeding developments are believed to have prevented an 8% reduction in agricultural gross value added in Vietnam.[31]

However, it is necessary to acknowledge that the impacts of UPOV are complex as other factors simultaneously condition and influence the effects on commercial agriculture. Relevant factors comprise differences in the provision of additional public goods, the seeds and farming systems, the quality of institutions, the target market, and the extent of Government participation in agriculture. As a result, evidence for specific countries and/or crops necessitates careful extrapolation of the findings to the Namibian context. For example, in some countries, such as Mexico and Colombia, the strengthening of intellectual property rights for plant breeding on its own was documented not to be accompanied by significant industry investment or the release of new plant varieties. Other factors influencing the confidence and perception of an adequate business environment to ensure PBR appropriability contributed to this. In Colombia, for example, breeders were responsible for overseeing and detecting any infringement of the rights rather than the PBP office and found penalties for violations to be vague.

Namibia does not suffer from limited resources for innovation but from a more optimal allocation of resources that can accompany the relevance of crops and livestock farming. The United Nations Food and Agriculture Organization, based on data from ASTI (IFPRI), estimates that spending per farmer on R&D in Namibia has been around $143 (in US dollars at purchasing

[31] See Annex 2 on the Peruvian experience as a UPOV member.

power parity). This figure is higher than what most peers spend, except for South Africa ($264), and contrasts the region's low spending levels. Similarly, Namibia does not underperform peers in the number of researchers per 100 thousand farmers. Figure 49 shows that the indicator jumped from 28 to 38 between 2001 and 2014, while Bolivia, Ghana, Peru, and Zambia recorded unchanged, lower numbers over the period. However, both financial and human capital resources have not increased to accompany productivity gains in agriculture and most of them are oted toward the fishing subsector. Figure 50 shows the number of researchers by type of agricultural activity for all peers in this analysis. The number of researchers for crops and livestock represents half of the total, while in Bolivia, the figure reaches 82%, 67% in Egypt, and 62% in Peru.[32]

Figure 49: Number of researchers (FTEs per 100,000 farmers)

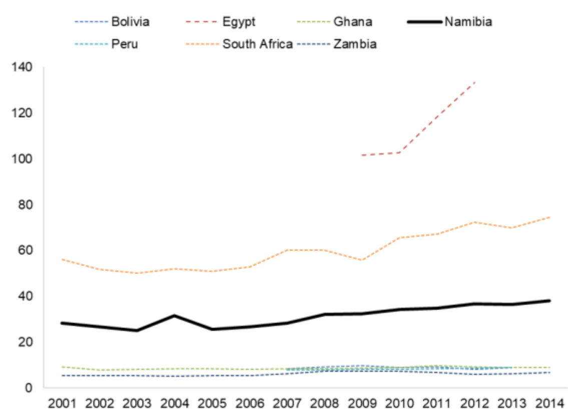
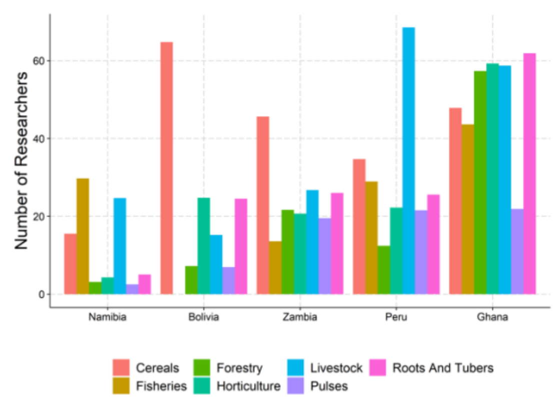


Figure 50: Number of Researchers by Topic (2012-2018)



Note: FTE = Full Time equivalent researchers. Source: Agricultural Science and Technology Indicators (ASTI CGIAR) Database. Source: Agricultural Science and Technology Indicators (ASTI-CGIAR) Database

A fully conducive ecosystem for innovation in seeds goes beyond the regulatory landscape. It demands solid and functioning institutions. There is agreement that innovation policies necessitate significant institutional capabilities, such as engaging with the private sector, coordinating among public agencies, and ensuring policy continuity. Namibia's Research, Science, and Technology Act of 2004 recognizes that science and technology (S&T) interventions are critical to both promoting and optimizing niches and opportunities in the agricultural sector. Meanwhile, the National Development Plan (NDP) stresses, among many other things, the importance of agricultural R&D in driving technological progress and addressing the sustainability

[32] Not available information for the rest of the country peers.

of the country's agricultural sector. Nevertheless, Namibia's research institution for agriculture, the Department of Agriculture Research and Development has been pending its restructuration since 2016, with restrained reforms that could drive its semi-autonomy to recruit and train high-skilled staff that could altogether lead the efforts for a strong innovation ecosystem. Even if the discovery of new varieties is resorted to outside technological support from domestic or foreign private universities or research centers, public institutions, such as agricultural technology centers or research centers and universities, require the resources to promote broader access to improved seeds, whether just by adapting varieties to local conditions or by further improving and developing new varieties (Ghezzi et al, 2022). Complementarily, Namibia also requires a solid enforcement agency for safeguarding property rights. Strengthening the enforcement capacity of PBP by the Business and IP Registrations, Administration, and Regulation (BIPA) should accompany the improved R&D efforts. This agency must be responsible for strengthening intellectual property protection and implementing effective licensing, management, and collection of royalties for creators.

A stronger ecosystem for innovation can also boost the utility and effectiveness of extension services promoted by the MAWRL. The sensitivity of agricultural technologies to local circumstances limits the extent of the potential impact, making private research more costly (Suri and Udry, 2022). Extension services help alleviate part of this problem by providing information to the demand side, namely farmers, regarding the performance of the technology for their specific circumstances and the adequate use in terms of proportion, timing, complementarity with other inputs, among others. Farmer field schools, demonstration plots, and other mechanisms can be optimal channels to provide small producers with information and training. Namibia still faces challenges in the reach and effectiveness of its extension services. According to the Census 2013/14, only 10% of communal farmers and 29% of private farmers accessed these services, and, in most cases, the knowledge was transmitted through radio and newspapers, which inhibits the feedback loop of what techniques and technologies work for every different set of needs reported by farmers.

In conclusion, our findings suggest that the incipient Plant Variety Protection System represents a short-term binding constraint for export-oriented agriculture, which has the highest potential for productivity gains and employment generation. While there are specific regulations already developed that need to be put into force and that can give direction to national agriculture policy, the availability of improved seeds requires a comprehensively conducive ecosystem for innovation. Particularly important is the existence of a strong innovation agriculture center that can leverage local knowledge to provide information and resources to create modern seeds that adapt to the time- and region-varying agroecological conditions in Namibia. This includes, for example, varieties that can resist local pests and grow more efficiently considering the local needs of land quality. This institution must count on predictable and enough financial resources and technical capacities to test varieties. Therefore, the Government can start by broadening and consolidating the domestic R&D capabilities. As it is currently happening with the strengthening of the Plants Health Division, this effort will require investments in human and capital resources for R&D. This would facilitate the field and laboratory seed inspection and testing that can promote the participation of breeders from the private sector. Moreover, the Government should continue relying on joint work with national universities and other agricultural research centers to expand domestic innovation and access to improved seeds for more crops.

3.7 Coordination Problems

Coordination problems typically appear in tradable goods and services (Cherif et al., 2022; Cherif & Hasanof, 2019). This happens because they tend to have higher learning externalities, which arise from the fact that they are more intense in R&D and have experienced steep productivity growth in the past decades of globalization. When attempting to diversify into new agriculture industries, different types of coordination problems might arise:

- **Self-discovery**. Hausmann & Rodrik (2002) provide a framework to understand what this type of coordination problems are, how they affect economic development, and what are their policy implications. The key to self-discovery is the concept of learning externalities. Learning externalities are those externalities associated with discovering a new productive and competitive activity. There is no way of predicting what products or businesses will thrive in specific settings with 100% accuracy. As Cherif et al. (2022) explain, when a firm ventures into a new business, it pays the cost of discovering the cost structure and viability of its business. If the company succeeds, competitors can emulate its model and reap the benefits –hence the externalities. Conversely, if the firm fails, it absorbs the full financial brunt of this trial. As a result, such isolated actions might lead to less-than-optimal market entries and insufficient self-discovery.

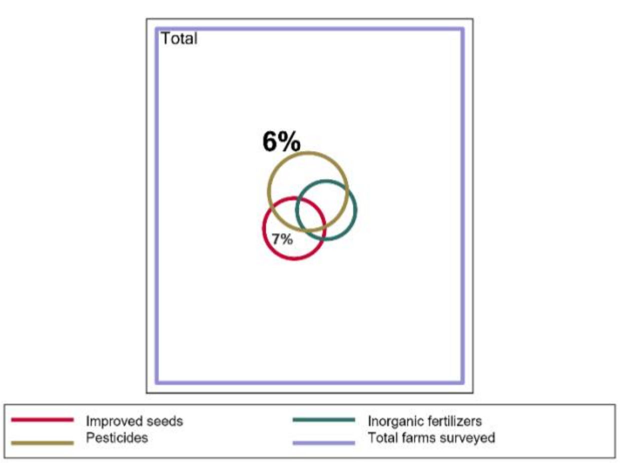
- **Chicken & egg problems.** In a landmark growth diagnostic study, Hausman, Espinoza & Santos (2015) describe the chicken & egg challenges that the region of Chiapas in Mexico faces as part of a "low-productivity trap". In Chiapas, a series of factors (federal transfers, high costs of transportation, and low education level) negatively affect returns to investment. At the same time, the region's economy is not diversified, has low complexity, and shows few "proximate" opportunities in terms of its product space. In that sense, the region faces a chicken-and-egg coordination problem where the complementary inputs that are required for new industries to thrive are, in turn, not thriving because there is no demand for them (which would come from new industries). The case of the public transport system is illustrative: "There needs to be a minimum operational scale for the creation of an efficient public transport system, which in turn will not be possible until there is enough demand for transportation." (Hausmann et al., 2015: 3).
- **Small-scale farmers aggregation**. Smallholders typically face challenges that are associated with lack of economies of scale. Two of the most common ones are high input costs and inconsistency of production. When smallholders attempt to buy inputs like fertilizers or pesticides individually, they often find that the costs are too high for them. In turn, they also struggle with achieving the sustainable and consistent volumes of production that supermarkets or other vendors require to buy from them. These problems are inherent to the levels of scale the farmers have. If they were to increase their scale, they would find lower input costs both as a share of total costs and in absolute terms, because they would be able to negotiate with the suppliers and buy in bulk. Additionally, achieving higher levels of scale requires specific organizational know-how that allows farmers to solve their inconsistency problem. In sum, the coordination problem of small farmers presents them with two scenarios: either they do not coordinate amongst them and continue to produce individually, or they associate to establish a joint production enterprise. Moving from the first scenario to the second one requires hard coordination work.

The agriculture sector faces several instances of coordination that constrain productivity growth through a misalignment between productive know-how and Namibia's local conditions. The remainder of the section describes what these are and what is their role in the three most prominent types of agriculture in Namibia: livestock farming, smallholders, and export-oriented crop production. The coordination problems this report identified as binding constraints are directly connected to the challenges described in previous sections: the difficulties in accessing market inputs and the provision of public inputs. These factors exacerbate the problems the sector faces when developing the productive know-how required for increasing productivity. When farmers have limited access to modern inputs or land tenure because of inappropriate regulations or inefficient public goods, they also have limited space to learn how to develop context-specific agricultural practices. Conversely, when livestock farmers face animal feed shortages, the returns to investments are so low that it is not reasonable to expand their productive capabilities or add value to their production. As a result, agriculture in Namibia faces a syndrome of “adaptive know-how gap,” where the sector experiences barriers to developing the context-specific know-how required to increase productivity and converge with the global trends in agriculture.

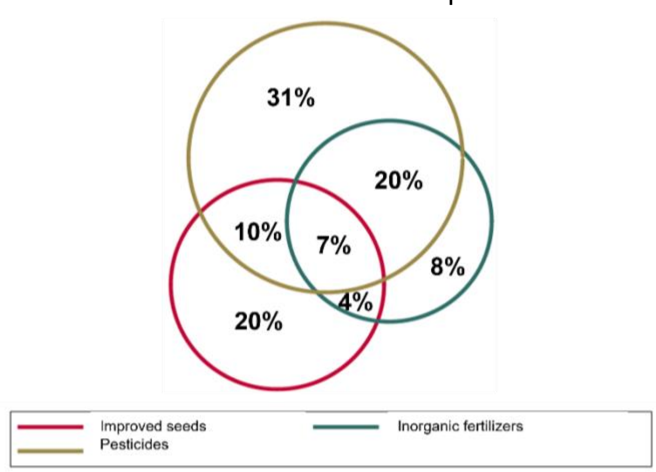
The farmers who utilize modern inputs more extensively typically achieve higher productivity. In Namibia, this pattern holds for a subset of commercial farmers. Figure 51 shows the commercial farmers that utilized modern inputs as a share of total (Panel A), how many of them utilize each input (Panel B), and input expenditure per hectare versus crop yields by farm (Panel C). A limited number of commercial farmers utilize modern inputs, and an even smaller subset employs more than one of them in a complementary way. However, those who invest in inputs tend to experience higher productivity. This shows a pattern where agents are trying to overcome the constraint of coordination problems in agriculture innovation, business development, and utilization of modern inputs. The few farmers who bypass the coordination problems and invest in modern inputs show higher productivity levels.

Figure 51: Modern inputs in commercial farms (2013-2014)

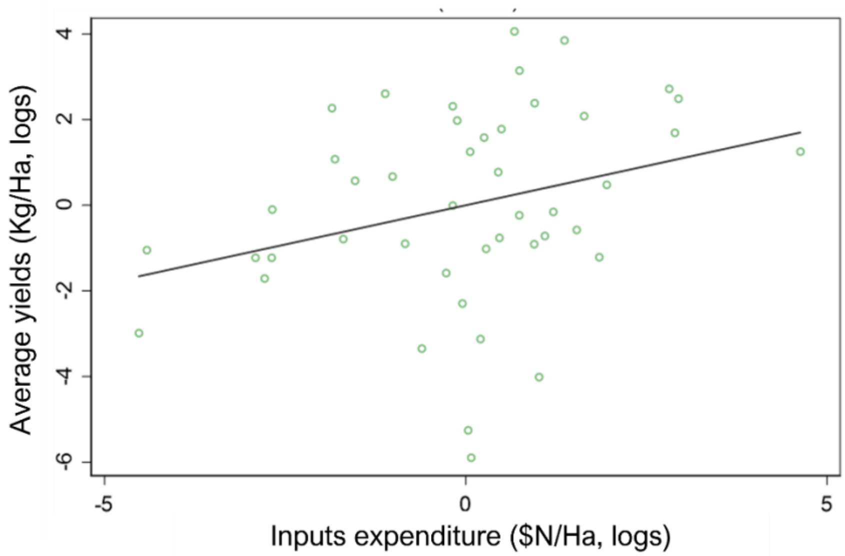
A. Use of modern inputs (% of total)



B. Use of modern inputs



C. Input expenditure per Ha, logs, Vs.
Yield (Kg/Ha), logs, by farm



Source: Agriculture Census, Commercial Section (2013-2014). Note: The same venn diagrams can be found in Sheehan et al., 2014, only for Ethiopia and Niger. Their paper on the utilization of modern inputs in Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda is a point of reference for this analysis.

Other signs indicate that commercial agriculture shows a "Camels & Hippos" pattern where only the farmers with lower technology-intensity are thriving. While a few farmers are able bypass constraints in utilizing modern inputs, the patterns of production in Namibia show that those that require more complex technological solutions for farming problems are not able to thrive. Although we were not able to find empirical evidence of this pattern, we do find strong signs that indicate this is the case:

- The cultivation of rain-dependent crops in northern Namibia has consistently underperformed when compared to those cultivated under irrigation both in terms of productivity and overall economic growth. One of the most pressing challenges has been the recurring droughts that the region has experienced since 2013. However, there are multiple issues that require the development of place-based know-how. One key challenge is the management of local pests. Effective pest control requires specific know-how that starts with the utilization of modern inputs at minimum but can also include more advanced solutions like the development of genetically modified crops designed to be more resistant to these pests. Examples of such rainfall- and technology- dependent crops include Maize, Pearl Millet, and animal feed crops.

- The case of the asparagus project in Etunda shows that, even within irrigation crops, those that require more complex technological solutions are not able to thrive. In 2017, Industrias Alimentarias de Navarra (IAN) decided to invest in an asparagus farm to export premium-quality produce to Spain, capitalizing on Namibia's comparative advantage in terms of seasonality. The company started a trial in 2017 and decided to invest in the farm and a facility for producing preserved asparagus. However, by 2022, the company decided to terminate the project (Tuukondjele, 2022). Interviews with the Growth Lab research team revealed that one of the key factors that determined the company's decision was the negative effects of pests and extreme temperatures on yields. Addressing these challenges would have required creating context-specific technological solutions, a venture that demanded time and financial resources that exceeded IAN's initial plans.
- One of the key takeaways from the high-value fruits productivity task force in Namibia is that access to seeds and plant varieties presented a serious bottleneck to the sector. Yet, if farmers find it difficult to access the plant varieties they need, how have the grape growers managed to develop a thriving industry? There are two plausible reasons: either the farmers are finding ways of bypassing the constraint, or they are focusing on cultivars that are more readily available. In any case, the fact that the access to seeds is constraining even the farms that are thriving the most is illustrative of the coordination problems that affect agriculture. The development and utilization of plant varieties is a key component of adaptive know-how because it allows farmers to test new crops and different varieties of existing crops, which in turn strengthens their understanding of place-specific problems.

3.7.2 Self-discovery

As previously mentioned, self-discovery issues are one type of coordination problems that affect Namibian agriculture. The cost of investing or discovering new business areas is too high for individual farmers and too high when considering that other potential farmers might take advantage of the discovery. There are two illustrative examples of this problem: the lack of an animal feed industry, and the lack of diversification in plant varieties.

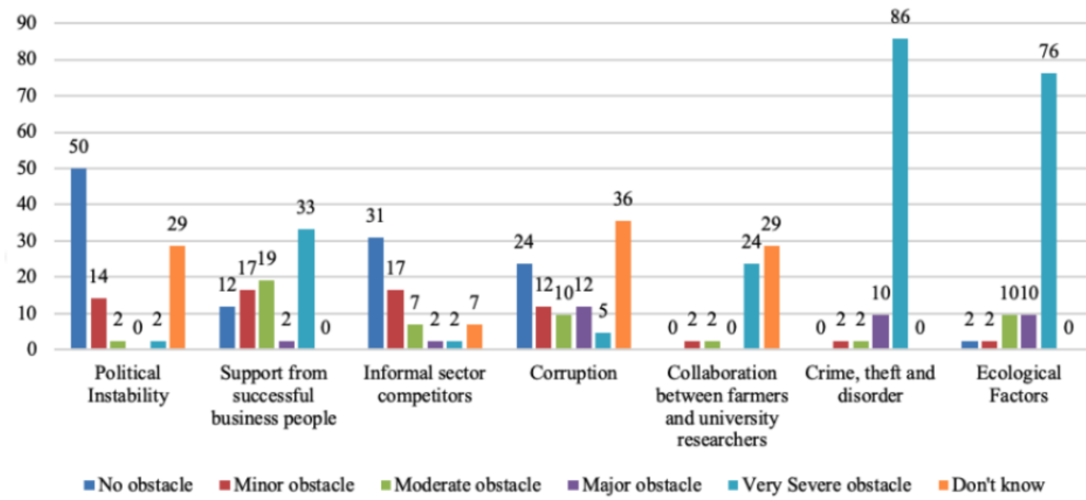
Yellow maize, fodder, and crops for animal feed stand out as a strategic opportunity in Namibia. The Economic Complexity Report of Namibia identified animal feed as one of the products with strategic value and export-potential (Hausmann et al., 2022). Furthermore, as described in Section 5.5.2, Namibia faces high demand and low supply of animal feed, given the relevance of the livestock industries in the country. Most of the livestock farmers rely on their own feed production, which has caused serious disruptions given recurrent droughts. Additionally, it is estimated that road transport costs represent 20% of the value of imported feed, which is a high rate when considering the aggregated weight of transport costs in agriculture imports of Namibia (Figure 46 in Section 3.5.2). This present potential Namibian feed producers with a competitive advantage vis a vis South African imports. Furthermore, cultivating animal feed crops under irrigation could be a profitable activity in Namibia, as it is in other countries. For example, most of the irrigation resources in the United States are utilized for animal feed crops (Ruess et al., 2023).

The development of an animal feed industry would require solving self-discovery issues. Technology is a key component for animal feed, as illustrated by the case of South Africa. South Africa's significant increases in the yields of white and yellow maize are in stark contrast to the stagnation of Namibia's since the early 2000s (FAOSTAT). These productivity improvements were achieved with genetically modified cultivars that helped reduce food insecurity (Ala-Kokko et al, 2021) and expand the animal feed industry. The investments that are required to untap the business of animal feed in Namibia are currently too high for potential individual investors.

The problems farmers face in accessing plant varieties exacerbate issues of self-discovery in developing context-specific know-how. As mentioned before, the high-value fruits productivity task force identified that problems in the access to plant varieties were a bottleneck for fruit producers, both in terms of expanding current production and diversifying into new crops. The lack of a system for plant variety protection and a developed market for seeds disallows for testing new varieties that could work in different regions of Namibia. As mentioned, this negatively affects crop diversification and production of existing crops as farmers cannot improve their varieties.

Self-discovery issues also affect small farmers when it comes to addressing the challenges addressing agro-ecological conditions. In a recent survey of small farmers in Etunda Irrigation Schemes, Neema & Kalitanyi (2023) find that over 75% of farmers classified ecological factors such as pests and temperature as a "very severe obstacle" (Figure 52). In turn, this reflects a deeper issue of self-discovery: Ecological factors are an obstacle because the agriculture sector has a deficit of context-specific know-how that is required to address them.

Figure 52: The business environment obstacles of small farmers in Etunda (2023)



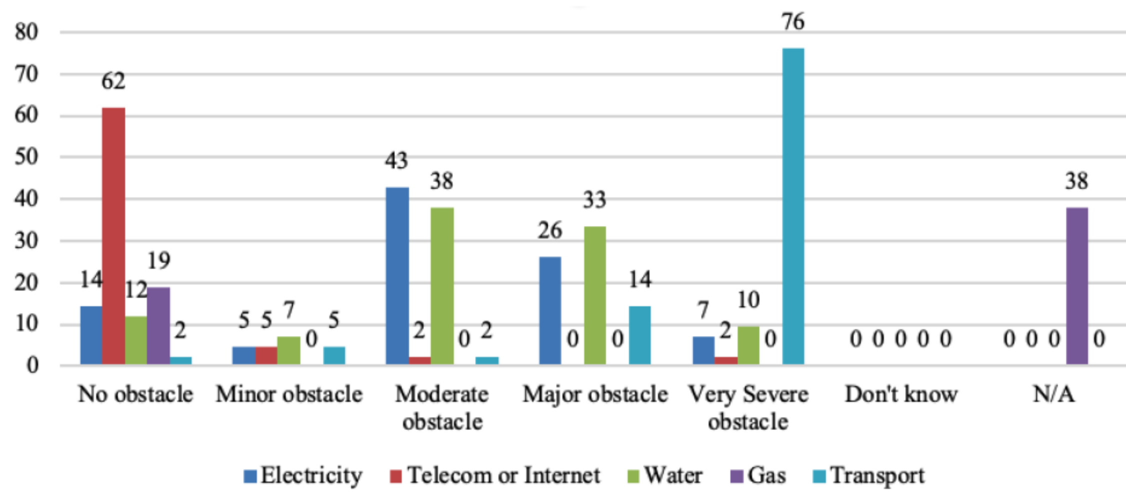
Source: Figure from Neema & Katinayi, 2023.

3.7.3 Chicken & egg problems

The agriculture sector in Namibia also faces coordination problems of the "chicken & egg" type. These problems arise because the development of a new industry requires a set of inputs that, in turn, require the industry to be established for its development. In the case of the growth diagnostic of Chiapas (Hausmann et al., 2015), the transportation system was an example of a chicken & egg problem because the lack of economic development resulted in low demand of transportation, and the high cost of transportation had negative effects on returns to investments. The small farmers in Namibia seem to be facing a similar conundrum.

Although road infrastructure is a comparative advantage of Namibia when compared to international peers, small farmers in northern regions face a scarcity of logistics services. In interviews during Growth Lab's field visit to northern Namibia, the small farmers expressed that the cost of inputs was problematic for them. Furthermore, Neema & Kalitanyi (2023) report that over 75% of small farmers in Etunda find that transport is a very severe obstacle (Figure 53).[33] This reflects a chicken & egg problem. The development of logistics services in rural areas requires consistent and reliable demand from farmers to be profitable. In turn, farmers need logistics services to access markets and consumers.

Figure 53: Infrastructure obstacles of small farmers in Etunda (2023)



Source: Figure from Neema & Katinayi, 2023.

3.7.4 Small-scale farmers aggregation

The aggregation of small farmers into a coordinating group is a key step towards solving problems that are inherent to small-scale farming. In interviews with small farmers, managers at the Etunda green scheme, and policy officials working in the field, the Growth Lab team uncovered some of the most important constraints small farmers are facing: (a) high prices and availability of inputs; (b) inconsistency and low quality of produce; (c) logistics; and (d) market access. These are common problems for small farmers that face low levels of scale. If small farmers achieved economies of scale – by working on cooperatives or aggregating production under a coordinating entity – they would face lower input costs, standardize their production, and be able to solve logistics challenges.

[33] Although Neema & Kalitanyi (2023) refer to transportation infrastructure, we understand that the survey responses reflect a scarcity in logistic services. The road infrastructure of northern Namibia allows for much higher levels of freight or transportation in general. As mentioned before, the state of roads is not particularly problematic compared to international peers.

The aggregation of small farms involves solving coordination problems between individual farmers. A crucial component of this type of coordination problem lies in the capacity of farmers to work together. The case of the Etaka farmers association in northern Namibia shows an example of agents trying to overcome this coordination problem and achieving higher levels of production both in terms of volume and quality. At least by the time of the Growth Lab's last field visit (June 2022), the farmers were on a path of developing productive irrigation agriculture. In turn, working as an association they find it easier to sort out the problems of accessing markets, finding logistics services, or even facing input costs.

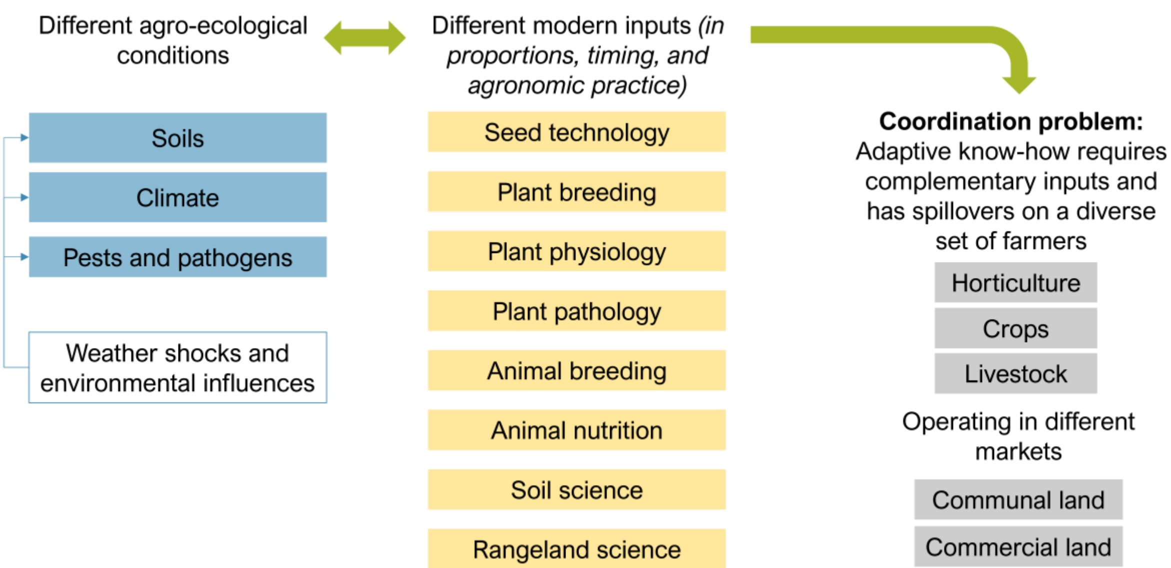
However, the most challenging coordination problem lies in bridging the gap between small farmers, the private sector, and local authorities. Coordination with the private sector is essential for small farmers to optimize their learning by doing process. The farmers can become providers of larger companies that, in turn, can supply them with essential services or inputs such as logistics or seeds. There are multiple mechanisms that can be explored to expand these types of partnerships. Klinger et al. (2023) provide valuable insights from South African case studies.

3.8. A Syndrome of Adaptive Know-How Gap

A large share of agricultural productivity differences in the world can be explained by technological inappropriateness. As described in Section 1, the Green Revolution changed global crop production. Biotechnology has become a key element in global agriculture development, yet it is context specific. Biotechnology companies have developed crops that are resilient to location-specific pests, temperature variability, and climate conditions. Nevertheless, recent research (Moscona & Sastry, 2022) has shown how frontier agricultural technologies are biased towards the local conditions of high-income countries. Moscona & Sastry (Ibidem) describe how the United States hold 25% of global innovation in crop genetics, the EU over 20% and Africa and Asia together hold less than 4%. The authors show how dissimilarities in crop genetics reduce average global agriculture productivity by 40-50%. A substantial share of the disparities between countries can be explained by the fact that agricultural technology is not appropriate for the context of low-income and developing countries. Furthermore, the dissimilarities in terms of biotechnology also affect international technology transfer. The genetically modified Maize that works for the Western Corn Rootworm is ineffective when solving the problem of the African Maize Stock Borer.

Agriculture development requires context-specific or adaptive know-how and the resolution of coordination problems. Figure 54 shows the mechanism behind how adaptive know-how works in agriculture. Firstly, the context is a fundamental factor for determining the profile of agricultural development. Although the production of vegetables happens both in South America and Southeast Asia, the way producers use technology is significantly different in both cases. The context is determined by multiple agro-ecological conditions like soils, climate, and, especially, the type of prevalent pests. Modern inputs, in turn, encompass multiple technologies and research areas like plant breeding or soil science. Know-how in agriculture involved more than the utilization of modern inputs, yet a key part of it lies in the selection of the optimal mix of modern inputs. Another crucial element is the identification of opportunities in specific crops or goods. Yet it does not end there, the farmers also need the capacity to test the suitability of crops, successfully implement business projects, and many other capabilities, like accessing foreign or domestic markets. To develop agricultural know-how that responds to specific agro-ecological conditions, the farmers face two layers of coordination problems. Firstly, there is a chicken and egg problem where the farmers need modern inputs to develop adaptive know-how, but the modern inputs suppliers need adaptive know-how in the sector to invest in making those inputs available. Secondly, farmers face self-discovery problems when it comes to developing adaptive know-how. This involves discerning the right combination of modern inputs, say, to cultivate crops resilient to the temperature fluctuations of northern Namibia. However, if others replicate the efforts of first movers, the initial cost of innovation might outweigh potential returns, which would decrease because of competition. This imbalance could deter businesses from backing crucial innovations tailored to address the unique agricultural challenges faced across Namibia's diverse regions.

Figure 54: Development of Adaptive Know-How



Source: Own elaboration.

4. Agricultural Policy: Increasing Productivity while Reducing Food Insecurity

"If we have to make advancement in agriculture, it has to be based on science and technology."
Chidambaram Subramaniam
Minister for Food and Agriculture of India, 1967

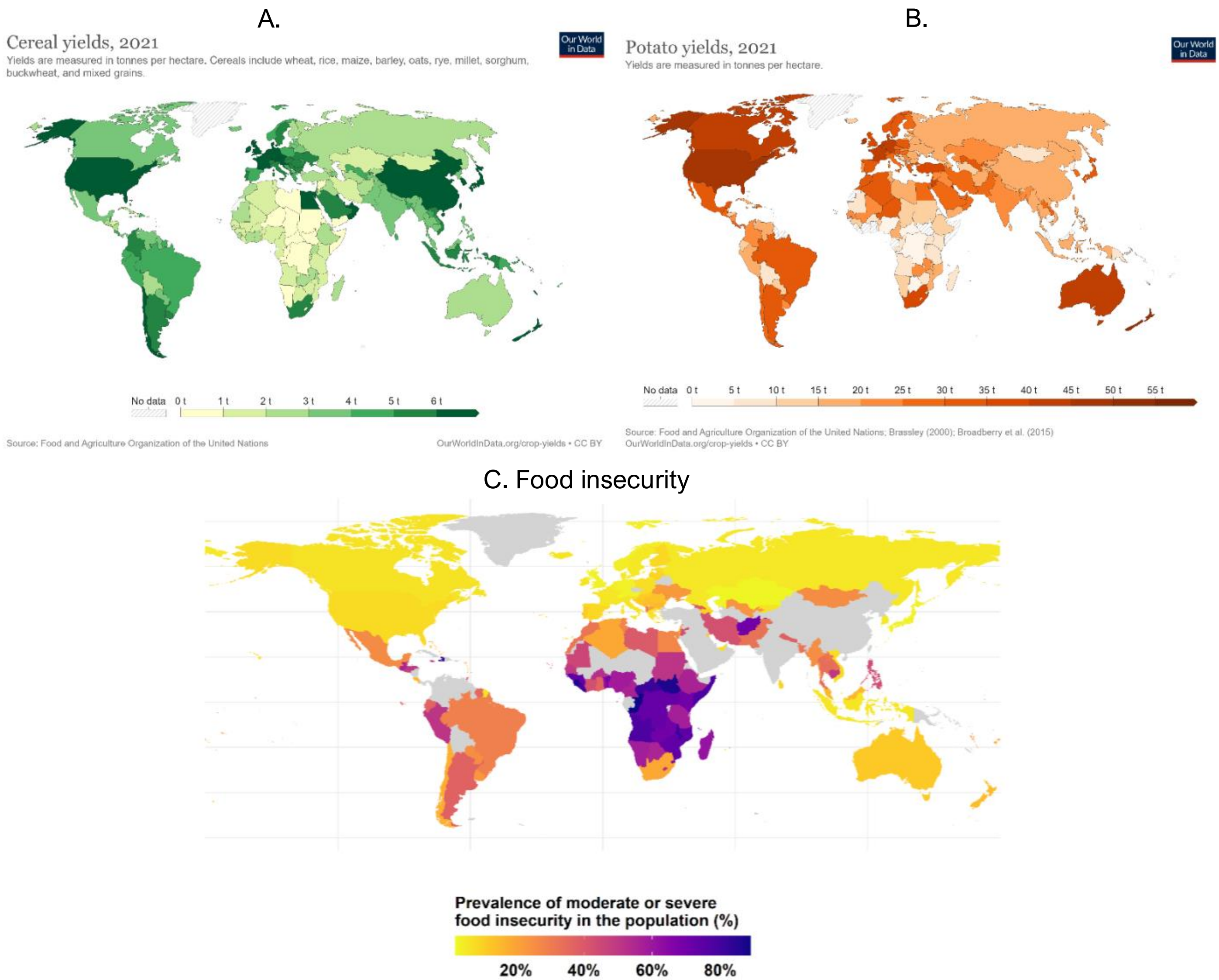
The core objective of Namibia's agricultural policy is to create an institutional environment that stimulates increased production and enhances productivity. The 1995 and the 2015 National Agriculture Policy documents embrace this core objective. Nevertheless, as this report shows, the sector has underperformed since Namibia's independence in 1990. The sector's past trajectory begs the question of whether the government is utilizing the right set of policy instruments or has defined the correct group of priorities for achieving its core objectives regarding agricultural policy.

Reducing food insecurity is another primary component of Namibia's policy towards the sector. A significant share of the rural population relies on subsistence farming for food consumption, so it makes sense to target food insecurity through agriculture policy. The farmers in communal land areas experience a poverty trap that is challenging to overcome without policy intervention. However, Namibia has not significantly reduced food insecurity in the past decade. The prevalence of moderate and severe food insecurity in the population has increased by around five percentage points between 2015 and 2020. The levels of food insecurity are exceptionally high for Namibia's GDP per capita and compared to peer countries.

Several countries significantly reduced food insecurity in the 1960s and 1970s by increasing food production via technology adoption in the context of the Green Revolution. There is widespread literature documenting the effects of the Green Revolution in the reduction of food insecurity. Evidence shows that the Green Revolution had a significant negative impact on child mortality in the developing world (Von der Goltz et al., 2021). Gollin et al. (2021) also show that the Green Revolution had a negative effect on fertility in developing countries, which was associated with lower population growth and a rise in the relative size of the working-age population. This resulted in a demographic dividend for developing countries that accounted for one-fifth of the authors' estimated effect on GDP per capita. Asia played a pivotal role in this transformation, and among the Asian countries that present valuable lessons for agriculture policy, the case of India is noteworthy.

But the Green Revolution has not yet arrived in most regions of Sub-Saharan Africa, including Namibia. Panels A and B in Figure 55 show the average yields of cereals and potatoes by country in 2021. As noted in the Figure, cereals include several relevant crops in Namibia's food consumption basket: maize, wheat, barley, millet, and sorghum, among others. Apart from countries like Egypt and South Africa, most African countries show low yields, which is due to a lack of technology adoption. Furthermore, the research done by Moscona & Sastry (2022)

Figure 55: Crop yields & food security (2021)



Source: OurWorldInData.org & World Bank Data indicates that modern plant varieties are inappropriate for addressing the pest and climate challenges of most African countries. As a result, food production in Africa is much lower than in other continents. At the same time, while Asian and Latin American countries managed to increase food production thanks to technology adoption and now show lower levels of food insecurity, Africa still suffers a challenging food scarcity problem. Namibia is no exception in that sense.

The government can play a vital role in kickstarting agricultural development by promoting the adoption of productive technology. The case of India in the 1960s presents valuable lessons when designing agricultural policy. Varshney (1980) documented the policymaking process that led to India's agricultural growth in the 1960s. One of the political leaders behind this institutional change was Chidambaram Subramaniam, who at the time was acting as Minister for Food and Agriculture. Varshney (Ibidem) describes the two main pillars in Subramaniam's agrarian model:

- **Economic policy**. The model's economic policy was shaped by the perspective that farmers would be driven to produce more if they were given the right price incentives because it would be more profitable to do so. For this to work, India aimed to raise producers' prices while keeping consumer prices at a reasonable level to safeguard food availability while increasing profitability. Such a delicate balance demanded robust institutional support. To ensure the effective functioning of this system, food subsidies were provided alongside establishing two pivotal institutions. The Agricultural Prices Commission (APC) was instituted to determine and recommend reasonable producer prices, and the Food Corporation of India (FCI) was tasked with buying and selling grains based on these recommendations. Whenever there were unexpected price hikes due to production shortfalls, the government intervened by releasing food stocks to stabilize the prices. Conversely, in times of abundant harvests leading to price drops, the government, through FCI, would purchase large quantities of grains to ensure that producer prices remained protected. The combined efforts of APC and FCI thus formed the linchpin of India's agricultural price strategy during that era.
- **Technology policy**. In the 1960s, India's agricultural policy focused on modernizing and optimizing farming practices. Key objectives included the widespread introduction and promotion of hybrid seeds, enhancing the use of chemical fertilizers, ensuring plant protection through pesticides, and expanding irrigation facilities. As in economic policy, this pillar also required the creation of organizations and institutional change. As Varshney

stated, “Subramaniam placed the highest emphasis on research and extension. If his first cabinet paper was on price policy, his second (Subramaniam, 1979: 12) was on the importance of strengthening scientific research institutions and of giving 'financial inducements' to agricultural scientists 'so that proper men of quality (are) attracted to these professions' (Subramaniam, 1972: 11)” (Varshney, 1989: 297-298). Consequently, research institutions underwent a reorganization. A novel agricultural research service was inaugurated, collaborations with global agricultural research entities were promoted, and the remunerations for agricultural scientists were revised upwards. To bridge the gap between research and its real-world application, the extension service was revamped. The “Village Level Workers” (extension services) were designated a multifaceted role encompassing education, healthcare, sanitation, plant care, and dissemination of new scientific research. However, Subramaniam refined this approach, minimizing the generalist role of these agents. Instead, he advocated for their specialized training at agricultural universities and bolstered their numbers to ensure every village received the necessary technical know-how.

India’s agricultural strategy in the 1960s offers insightful takeaways for shaping Namibia's agricultural policy, encompassing both its successes and shortcomings. A thorough review of India’s strategy lies outside of the scope of this report, but a revision of the existing literature offers valuable ideas for Namibia:

- **Strengthening state capacity is crucial**. The technology adoption process and consequent agriculture growth in India was essentially state-led. This required strong technical capabilities in the public sector, but also administrative muscle that can establish functioning institutions. It also requires political support to create new organizations or reorganize existing ones.
- **Striking the right balance between profitability, productivity, and consumer prices is challenging but important.** Although Varshney (1989) highlighted that price incentives in India had a key role in increasing agriculture production by making it more profitable, this can also cause productivity losses. Ensuring profitability through subsidies or tax breaks can disincentivize firms from investing, adopting technology, or increasing their efficiency. However, a minimum profitability level is required, as evidenced by the case of cereals production in the green schemes in Namibia. The price ceilings imposed by the

government on maize produced in the green schemes aimed to make food available in times of need, but also made the green schemes unprofitable. Another case worth revisiting is the policy towards domestic staple crop production outside of the green schemes. The producers in the maize triangle have captive demand because of import quotas imposed on food retailers and commerce, yet although this ensures domestic production, it has not resulted in higher productivity. In that sense, applying the type of economic policy that worked in India might not work in Namibia. One key consideration is that price incentives might work better for small farmers than for larger commercial farms, because the former face much harder profitability challenges than the latter.

- **The focus on developing adaptive know-how is essential**. The adoption of modern inputs and the adaptation to the local context was essential for India to become self-sufficient in food production. As mentioned above, the country's strategy was centered on the development of technology both in terms of promoting innovation and extending the adoption of technology by all types of farmers. Although Namibia's Agriculture Policy of 2015 highlights the role of R&D, there does not seem to be a big push on this field like in the case of India or other countries that underwent significant agricultural transformation (e.g., Egypt or Israel).
- **Modern technologies are not necessarily applicable to indigenous crops that are relevant for regional markets.** India's Green Revolution had a negative impact on indigenous crops (Eliazer et al., 2019). The country focused on increasing the production of staple crops with high-yielding varieties like rice at the expense of other crops like millet. As a result, the production of indigenous crops declined. Namibia can avoid these negative externalities by taking a different strategy than India's in the 1960s. It is not about applying modern technologies that have worked in other countries but adapting agricultural know-how to the local context. In that sense, there might be economic opportunities in developing other crops that are not necessarily those with more high-yielding varieties like rice, maize, or wheat.

Targeting agricultural productivity in communal and commercial land areas can help develop new sources of comparative advantage and reduce food insecurity in Namibia. In addition to contributing to agriculture diversification and production growth, the focus on productivity through know-how development can have a positive effect on food security for the following reasons:

- **Food availability**. The expansion of the domestic production of staple crops, animal feed, fruits, and vegetables would have a direct effect on food availability, which is a problem in Namibia, given the frequency of droughts and other natural disasters.
- **Productivity of small farmers.** The households that now rely on their produce for food consumption can play a key role in developing competitive value chains. If they manage to incorporate know-how and technology that increase their yields, they will be able to take part in the development of a productive agriculture sector, as is the case in countries like India, Indonesia, or Egypt. The share of agricultural land area occupied by farms of under-five hectares in these countries is much higher than Namibia's,[34] but the small farms are much more integrated in competitive value chains.
- **Demographic transition**. Research shows (Gollin et al., 2021) that the Green Revolution contributed to the demographic transition in developing countries. The communal land areas of Namibia experience a demographic challenge that could be solved by developing productive agriculture. According to the Namibia Demographic and Health Survey of 2013, the rural areas face significantly higher levels of fertility rates than the national average, which are especially high in the northern communal areas. If these regions experience growth in productive agriculture, they will face lower fertility rates.
- **Inter-industry linkages**. Not every rural household prefers to dedicate their skills to agriculture. Many do it because it is the only way to procure food. Developing a competitive agriculture sector in communal land areas would also create demand for other types of jobs that are not directly involved with farming. Examples of upstream services that a competitive agriculture sector might demand include logistics, security, or construction. On the downstream side, food manufacturing, transport, and storage jobs might benefit from expanding agriculture.

In the following subsection we present a policy framework that aims to help design a strategic approach towards agriculture, in addition to a summary of potential policy interventions to address the binding constraints that were described in this report.

[34] 55% in Egypt, 55% in Indonesia, 39% in India, and 16% in Namibia. Data taken from OurWorldInData.org/farm-size. The original source is Lowder et al. (2016).

4.1 A Policy Framework for Agriculture

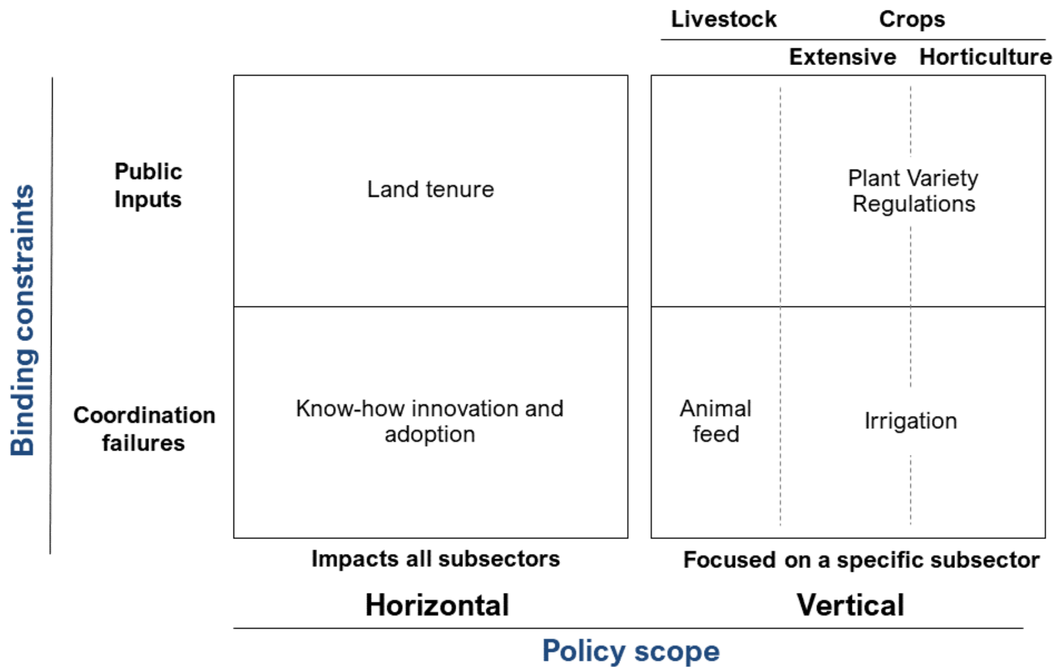
The resolution of Namibia's binding constraints in agriculture requires policy intervention. Although producers are finding ways to bypass challenges and the sector has seen the appearance of new industries such as blueberries or dates, addressing its binding constraints is essential for untapping the sector's potential. This section presents a policy framework to help guide the strategy towards the agriculture sector by prioritizing key areas of interventions.

The agriculture sector in Namibia faces binding constraints in the provision of public inputs, and coordination problems that prevent diversification, innovation, and developing place-based know-how. These constraints are also associated with immediate challenges in accessing key market inputs, like animal feed in the case of the livestock industries. The low supply of animal feed in Namibia is an example of the type of coordination problems that the sector faces. In this case, there seems to be a self-discovery issue that prevents investors from developing an industry for which there is demand and growth potential.

A policy framework is not a comprehensive list of policies but rather a guide to prioritize interventions according to the problems they aim to address. Namibia's Agriculture Policy contains multiple areas of interventions that range from agro-financing to international cooperation. Although some of these do not address the most pressing constraints, they are still vital as public inputs –like agro-financing or extension services for communal land areas. However, the policy does not define the most binding constraints in the sector nor gives a sense of the most pressing areas of interventions that the government should prioritize.

Two dimensions are essential for designing a strategy for the agriculture sector: industry specificity and types of binding constraints. Figure 56 shows a policy framework for agriculture based on the framework for productive development policies developed by Crespi et al. (2014). The X-axis represents the level of specificity of problems or the scope of policy interventions. Are these targeting problems affecting the agriculture sector as a whole, or are they specific to certain crops or industries? As shown in Figure 56, if the problems are crosscutting, they are "horizontal," and if they are industry-specific, they are "vertical." In turn, the Y-axis represents the problems the policies aim to address. Different types of binding constraints require different types of policy interventions. Fixing the provision of public inputs requires capabilities different from those needed for solving coordination problems.

Figure 56: Agriculture Policy Framework



Source: Own elaboration based on Crespi et al., 2014.

The agriculture growth diagnostic analysis suggests areas of improvements that fall under these dimensions. In the upper left quadrant of Figure 56, we find the public inputs that affect all agriculture industries. As mentioned in Section 4.6, this includes issues with access to land tenure that affect all types of farmers, but especially partnerships between the private sector and the local communities. The upper right quadrant involves public inputs that are industry-specific, like plant variety regulations that prevent the access to improved seeds for crop production. The lower right quadrant is comprised of coordination failures that affect a specific subsector, thus requiring vertical interventions. These can be increasing the utilization of existing infrastructure by expanding the adoption of irrigation techniques or promoting the developing of an animal feed industry. Finally, the lower left quadrant includes coordination failures that affect all agriculture industries like know-how adaptation and development.

Namibia needs to address issues with access to water and electricity in rural areas to promote scalable irrigation agriculture in the long term. Although infrastructure is not a binding constraint in the short term, it would become a bottleneck for expanding and adopting irrigation techniques if there are no improvements in current infrastructure policy. Firstly, there is much work to do in terms of using existing infrastructure. Section 3.3 showed that existing water and electricity infrastructure in the Green Schemes is widely underutilized, which indicates that there is a lot to do before planning large new infrastructure projects like expanding the electricity transmission lines or developing new dams. The MAWLR already started with a process of leasing out the land within the Green Schemes to commercial projects. This is a key step towards involving the private sector in communal land areas. Yet strengthening the presence of small local farmers in the Green Schemes is also essential to develop partnerships with the private sector and promote know-how diffusion. This policy area demands vertical interventions targeted at solving coordination problems that are specific to places (how to incentivize the productive use of existing infrastructure), but not necessarily to industries or types of agriculture. Secondly, improving access to water in rural areas through public infrastructure planning is essential for promoting irrigation agriculture outside of the Green Schemes. This demands a strategy for providing public inputs that enable the development of water points across rural Namibia.

Although a revision of the laws pertaining to the communal land system is underway, there is a need for an active strategy to facilitate access to land tenure. The ongoing discussions on land reform focus on reviewing the regulations of land leasing and the procedures to utilize communal land tenure as collateral. However, access to land tenure ultimately depends on the local authorities, the communal land boards, and the national government. Furthermore, the soil and climate characteristics of arable land differ a lot across Namibia, which makes the process of allocating land more complex because, ideally the most fertile land would be allocated to the most productive land use types. Yet there are also other important factors to consider, like local community development or political issues. All of this requires a capable state and efficient public-public coordination to facilitate access to land tenure in communal land areas.

A review of the economic policy towards agriculture is necessary to leverage incentives in the right direction. The current set of price incentives and import quotas designed by the Namibian Agronomic Board aims to achieve self-sufficiency in food consumption at least in the long term. Yet the current growth path in domestic food production is not sustainable due to the reasons explained in this report. Additionally, Namibia still faces severe food insecurity, which is worsened by the frequency of droughts. Developing price incentives for small famers might help them solve their profitability problems, in addition to assist them in reaching marketplaces. A subsidy or tax break on food produced by small farmers might enable access to retail markets that currently prefer to import produce that can be farmed domestically. This type of market interventions needs to be vertical policies aimed at solving coordination failures like profitability problems the small farmers face. They should be evaluated on a case-by-case basis and should not be designed to be permanent but rather to achieve specific goals.

Finally, the sector demands a strategy for crop diversification and know-how adoption that relies on the development of a domestic innovation ecosystem. As described in Section 3.6.2, one essential step for this to happen is establishing domestic plant variety protection regulations. The Seed and Seed Varieties Act (No. 23 of 2018) has been passed by Parliament, but it has not yet been brought into force. This would enable the development of a market for seeds and plant varieties that is comprised by foreign seed providers but also local ones. In turn, it would also promote the development of varieties that are most appropriate for the Namibian natural conditions, as the breeders and seed developers can capitalize on their outcomes because they are able to register their property rights. It would also allow for farmers to access a wider range of cultivars, thus removing barriers for experimentation with different crops. In sum, plant variety regulations are essential for the development of a domestic innovation ecosystem and require horizontal interventions to ensure an appropriate regulatory environment. However, a broader strategy for efficiently providing public inputs is required to incentivize research in this field. One key element would be developing an independent research institution. The Department of Agriculture Research & Development (DARD) is in a pending restructuration process since 2016. The institution also lacks semi-autonomy to recruit and train high-skilled staff. Another key factor would be strengthening extension services. These can promote the uptake of modern inputs. According to the agriculture census, only 10% of communal farmers and 29% of commercial farmers was in contact with an extension services provider in 2013-2014.

5. References

Adamopoulos, T., Brandt, L., Leight, J., & Restuccia, D. (2017). Misallocation, Selection and Productivity: A Quantitative Analysis with Panel Data from China (w23039; p. w23039). National Bureau of Economic Research. https://doi.org/10.3386/w23039

Adamopoulos, T., & Restuccia, D. (2018). Geography and Agricultural Productivity: Cross-Country Evidence from Micro Plot-Level Data (w24532; p. w24532). National Bureau of Economic Research. https://doi.org/10.3386/w24532

Adamopoulos, T., & Restuccia, D. (2019). Land Reform and Productivity: A Quantitative Analysis with Micro Data (w25780; p. w25780). National Bureau of Economic Research. https://doi.org/10.3386/w25780

Agribank of Namibia (2021). Annual Report. Available in: https://agribank.com.na/page/annual-reports/

Abdel-Dayem, S., Abdel-Gawad, S. and Fahmy, H. (2007), "Drainage in Egypt: a story of determination, continuity, and success". Irrigation and Drainage., 56: S101-S111.

Ala-Kokko, K., Lanier Nalley, L., Shew, A. M., Tack, J. B., Chaminuka, P., Matlock, M. D., & D'Haese, M. (2021). Economic and ecosystem impacts of GM maize in South Africa. Global Food Security, 29, 100544. https://doi.org/10.1016/j.gfs.2021.100544

Amadhila, E., & Ikhide, S. (2016). Unfulfilled loan demand among agro SMEs in Namibia. South African Journal of Economic and Management Sciences, 19(2), 282-301.

Angelsen, A., & Kaimowitz, D. (Eds.). (2001). Agricultural technologies and tropical deforestation (1st ed.). CAB International. https://doi.org/10.1079/9780851994512.0000

Ardic Alper, Oya Pinar; Hommes, Martin; Stein, Peer Benno Walter (2013). Closing the credit gap for formal and informal micro, small, and medium enterprises (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/804871468140039172/Closing-the-credit-gap-for-formal-and-informal-micro-small-and-medium-enterprises

Agricultural Science and Technology Indicators (2023). ASTI-CGIAR Database. https://www.asti.cgiar.org/

Bank of Namibia (2021). Annual Report. Available in: https://www.bon.com.na/Economic-information/Annual-Reports.aspx

Bharadwaj, P., Fenske, J., Kala, N., & Mirza, R. A. (2020). The Green revolution and infant mortality in India. Journal of Health Economics, 71, 102314. https://doi.org/10.1016/j.jhealeco.2020.102314

Bulte, E, S di Falco, M Kassie, and X Vollenweider (2023), “Low quality seeds, labor supply and economic returns: Experimental evidence from Tanzania.” The Review of Economics & Statistics, In Press.

Chen, C., Restuccia, D., & Santaeulàlia-Llopis, R. (2017). The Effects of Land Markets on Resource Allocation and Agricultural Productivity (w24034; p. w24034). National Bureau of Economic Research. https://doi.org/10.3386/w24034

Chen, C., Restuccia, D., & Santaeulàlia-Llopis, R. (2023). Land Misallocation and Productivity. American Economic Journal: Macroeconomics, 15(2), 441–465. https://doi.org/10.1257/mac.20170229

Cherif, R. and Hasanov, F. (2019) “The Return of the Policy That Shall Not Be Named: Principles of Industrial Policy.” IMF Working Paper 19/74, International Monetary Fund, Washington, DC. https://www.imf.org/en/Publications/WP/Issues/2019/03/26/The-Return-of-the-Policy-That-Shall-Not-Be-Named-Principles-of-Industrial-Policy-46710

Cherif, R., Hasanov, F., Spatafora, N., Giri, R., Mikov, D., Quayyum, S., Salinas, G., Warner A. (2022) *Industrial Policy for Growth and Diversification. A Conceptual Framework.* African Department and Institute for Capacity Development. IMF Departamental Paper. International Monetary Fund, Washington, DC.

https://www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2022/09/28/Industrial-Policy-for-Growth-and-Diversification-A-Conceptual-Framework-519714

Chhabra, V. (2020). Studies On Use of Biofertilizers in Agricultural Production. European Journal of Molecular & Clinical Medicine, 7(7), 2335-2339.

Chiriboga, L., Kilmer, C., Fan, R., Gawande, K. (2008), *Does Namibia have a Comparative Advantage in Beef Production?*, Bush School of Government and Public Service, Texas A&M University https://bush.tamu.edu/wp-content/uploads/2020/02/Gawande_2008.pdf

Cochrane, D. & Kahn, C (2021), "Plant Breeders' Rights Developments in Africa", Spoor & Fisher, https://www.spoor.com/wp-content/uploads/2021/09/plant-breeders-rights-developments-in-africa-pdf.pdf

Crespi, G., Fernández-Arias, E., & Stein, E. (Eds.). (2014). *Rethinking Productive Development*.

Palgrave Macmillan US. https://doi.org/10.1057/9781137393999

Cull, R., T. Ehrbeck, and N. Holle. 2014. "Financial Inclusion and Development: Recent Impact Evidence." CGAP Focus Note 92. World Bank, Washington, DC.

Dillon, B., & Barrett, C. B. (2017). Agricultural factor markets in Sub-Saharan Africa: An updated view with formal tests for market failure. Food policy, 67, 64-77.

Eliazer Nelson, A.R.L., Ravichandran, K. & Antony, U. The impact of the Green Revolution on indigenous crops of India. J. Ethn. Food 6, 8 (2019). https://doi.org/10.1186/s42779-019-0011-9

Evenson, R E, & Gollin, D. (2003). Assessing the impact of the Green Revolution, 1960 to 2000. Science, 300, 758–762.

Fiebiger, M., Behmanesh, S., Dreuße, M., Huhn, N., Schnabel, S., & Weber, A. K. (2011). The Small-Scale Irrigation Farming Sector in the Communal Areas of Northern Namibia. Albrecht Daniel Thaer-Institut für Agrar-und Gartenbauwissenschaften.

Ghezzi, P., Hallak, J. C., Stein, E., Ordoñez, R., & Salazar, L. (2022) Competing in Agribusiness Corporate Strategies and Public Policies for the Challenges of the 21st Century. Inter-American Development Bank. http://dx.doi.org/10.18235/0004347

Goddard, E. (2022). "Namibia's southern port loses feeder service" in *Southern Africa's Freight News.* April 12, 2022. https://www.freightnews.co.za/article/namibias-southern-port-loses-feeder-service

Gollin, D., Hansen, C. W., & Wingender, A. M. (2021). Two Blades of Grass: The Impact of the Green Revolution. Journal of Political Economy, 129(8), 2344–2384. https://doi.org/10.1086/714444

Haggblade, Steven and Hazell, Peter B.R. (Eds.). 2010. *Successes in African agriculture: lessons for the future*. Baltimore, MD: Published for the International Food Policy Research Institute (IFPRI) by Johns Hopkins University Press.

Hausmann, R., Rodrik, D., & Velasco, A. (2006). *Growth diagnostics. The Washington consensus reconsidered: Towards a new global governance*, 2008, 324-355. https://growthlab.hks.harvard.edu/sites/projects.iq.harvard.edu/files/growthlab/files/serra8.pdf

Hausmann, R., Klinger, B., & Wagner, R. (2008). *Doing growth diagnostics in practice: a 'Mindbook'*. CID Working Paper Series. https://growthlab.hks.harvard.edu/publications/doing-growth-diagnostics-practice-mindbook

Hausmann, R., Hidalgo, C., Bustos, S., Coscia, M., Simoes, A., & Yildirim, M. (2014). *The atlas of economic complexity: Mapping paths to prosperity* (Updated edition). The MIT Press.

Hausmann, R., Santos, M., Barrios, D., Taniparti, N., Tudela Pye, J., Muci, J., Lu, J. (2022). *A Growth Diagnostic of Namibia*. CID Faculty Working Paper No. 405 February 2022. Copy at http://www.tinyurl.com/2cjxqahm

Hausmann, R., Santos, M., Barrios, D., Taniparti, N., Tudela Pye, J., Muci, J., Lu, J. (2022b). *The Economic Complexity of Namibia: A Roadmap for Productive Diversification*. CID Faculty Working Paper No. 410 March 2022. Copy at http://www.tinyurl.com/27er6wc8

International Service for the Acquisition of Agri-biotech Applications (2016), Global Status of Commercialized Biotech/GM Crops & United States Department for Agriculture (USDA) Economic Research Service

International Service for the Acquisition of Agri-biotech Applications (2019), Global Status of Commercialized Biotech/GM Crops https://www.isaaa.org/resources/publications/briefs/55/executivesummary/default.asp

Johnson, M., Hazell, P., & Gulati, A. (2003). The Role of Intermediate Factor Markets in Asia's Green Revolution: Lessons for Africa? American Journal of Agricultural Economics, 85(5), 1211–1216.

Kaapanda, V., (2023) “Grapes to sprout 1000 Etunda jobs”. *New Era*. 24 July 2023. https://neweralive.na/posts/grapes-to-sprout-1-000-etunda-jobs

Karlan, D., R. Osei, I. Osei-Akoto, and C. Udry. 2014. “Agricultural Decisions after Relaxing Credit and Risk Constraints.” Quarterly Journal of Economics 129 (2): 597–652.

Khandker, Shahidur R. 2021. Credit for agricultural development. In Agricultural development: New perspectives in a changing world, eds. Keijiro Otsuka and Shenggen Fan. Part Three: Context for Agricultural Development, Chapter 16, Pp. 529-562. Washington, DC: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/9780896293830_16

Klinger, B., Ordonez, I. & Sturzenegger, F., 2023. *Scaling Partnerships to Activate Idle Community Land in South Africa*. CID Working Papers. Harvard Kennedy School. Copy at http://www.tinyurl.com/234b73ew

Kooper, L., (2023). "Villagers sell cattle to fix Govt boreholes". *The Namibian*. 10 July 2023. https://www.namibian.com.na/villagers-sell-cattle-to-fix-govt-boreholes/

Lenaerts, B., Collard, B. C. Y., & Demont, M. (2019). Review: Improving global food security through accelerated plant breeding. Plant science: an international journal of experimental plant biology, 287, 110207. https://doi.org/10.1016/j.plantsci.2019.110207

Le, K. (2020). Land use restrictions, misallocation in agriculture, and aggregate productivity in Vietnam. Journal of Development Economics, 145, 102465. https://doi.org/10.1016/j.jdeveco.2020.102465

Lowder, S. K., Skoet, J., & Raney, T. (2016). The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide. *World Development*, 87, 16–29. https://doi.org/10.1016/j.worlddev.2015.10.041

Lunduka, R., Fisher, M., & Snapp, S. (2012). Could farmer interest in a diversity of seed attributes explain adoption plateaus for modern maize varieties in Malawi? Food Policy, 37(5), 504–510.

Malpass, D. (2022, December 22). "A transformed fertilizer market is needed in response to the food crisis in Africa" https://blogs.worldbank.org/voices/transformed-fertilizer-market-needed-response-food-crisis-africa

Manysheva, K. (2022). "Land Property Rights, Financial Frictions, and Resource Allocation in Developing Countries". Job Market Paper. https://nbviewer.org/github/manysheva/MyWebsite/blob/master/Land_finance_allocation.pdf?flush_cache=true

Matthys, D. (2023) "6732 tonnes of maize expected from green schemes". Namibian. 12 July 2023. https://namibian.com.na/6-732-tonnes-of-maize-expected-from-green-schemes/

McMullen, N. (1987). Seeds and world agricultural progress. Report 227, National Planning Association.

Neema, M., & Kalitanyi, V. (2023). ”Factors affecting farmers’ entrepreneurial action at Etunda Green scheme project, Namibia”. *International Journal of Research in Business and Social Science* (2147- 4478), 12(1), 350–361. https://doi.org/10.20525/ijrbs.v12i1.2252

NPC (2020) “Report on the Evaluation of Namibia’s Green Scheme Programme” Windhoek: National Planning Commission

Noleppa, S. (2017). The socio-economic benefits of UPOV membership in Viet Nam: An ex-post assessment on plant breeding and agricultural productivity after ten years. HFFA Research Paper 03/2017
https://www.upov.int/export/sites/upov/about/en/pdf/HFFA_Final_Report_Vietnam.pdf

Pienaar, L., Lingani, M., Swart, P., (2019). *The Economic Contribution of the South African Blueberry Industry*. Western Cape Department of Agriculture, Division for Macro & Resource Economics & South African Berry Producers’ Association (SABPA)
https://www.berriesza.co.za/wp-content/uploads/2021/01/BlueberryIndustryReport_2019FINAL.pdf

Pingali, P. (2023). Are the Lessons from the Green Revolution Relevant for Agricultural Growth and Food Security in the Twenty-First Century? In: Estudillo, J.P., Kijima, Y., Sonobe, T. (eds) Agricultural Development in Asia and Africa. Emerging-Economy State and International Policy Studies. Springer, Singapore. https://doi.org/10.1007/978-981-19-5542-6_2

Ruess, P. J., Konar, M., Wanders, N., & Bierkens, M. (2023). Irrigation by Crop in the Continental United States From 2008 to 2020. Water Resources Research, 59(2), e2022WR032804. https://doi.org/10.1029/2022WR032804

Salom, N. & Khumalo, P. (2022) “Challenges Facing Community Management of Rural Water Supply: The Case of Ohangwena Region, Namibia”. *African Studies Quarterly*. Vol. 21, Issue 1, May 2022. https://asq.africa.ufl.edu/wp-content/uploads/sites/168/V21i1a2.pdf

Santos, M., & Hani, F. (2021). Diagnosing Human Capital as a Binding Constraint to Growth: Tests, Symptoms and Prescriptions (Elements in the Economics of Emerging Markets). Cambridge: Cambridge University Press. doi:10.1017/9781108975223

Sheahan, M., Barrett, C. B., & Sheahan, M. B. (2014). Understanding the agricultural input landscape in sub-Saharan Africa: Recent plot, household, and community-level evidence. World Bank Policy Research Working Paper, (7014).

Shiimi, I. (2011). "Enhancing access to finance in Namibia through an improved land tenure system". Annual address by Mr Ipumbu Shiimi, Governor of the Bank of Namibia, 27 October 2011. https://www.bis.org/review/r111229g.pdf

Sims, B., & Zienzle, J. (2006). "Farm power and mechanization for small farms in sub-Saharan Africa." Agricultural and Food Engineering Technical Report No. 3. Rome, Italy: Food and Agriculture Organization of the United Nations.

Singh, S., & Benbi, D. K. (2016). Punjab-Soil Health and Green Revolution: A Quantitative Analysis of Major Soil Parameters. Journal of Crop Improvement, 30(3), 323–340. https://doi.org/10.1080/15427528.2016.1157540

Srivastava, P., Balhara, M., & Giri, B. (2020). Soil Health in India: History and Future Perspective. In B. Giri & A. Varma (Eds.), Soil Health (Vol. 59, pp. 1–19). Springer International Publishing. https://doi.org/10.1007/978-3-030-44364-1_1

Suri, T., & Udry, C. (2022). Agricultural technology in Africa. Journal of Economic Perspectives, 36(1), 33-56.

The Namibian (2022). "Govt to buy more land for Neckartal irrigation scheme" *The Namibian*. 24 July 2022. https://www.namibian.com.na/govt-to-buy-more-land-for-neckartal-irrigation-scheme/

The Brief (2023). "Govt budgets N$10m for Neckartal irrigation project" *The Brief.* February 27, 2023. https://thebrief.com.na/index.php/component/k2/item/2476-govt-budgets-n-10m-for-neckartal-irrigation-project

Tuukondjele, H. (2022). "Asparagus investor ditches Etunda Irrigation". *Eagle FM*. August 2, 2022. https://www.eaglefm.com.na/news/asparagus-investor-ditches-etunda-irrigation/

Varshney, A. (1989). Ideas, Interest, and Institutions in Policy Change: Transformation of India's Agricultural Strategy in the Mid-1960s. Policy Sciences, 22(3/4), 289–323. http://www.jstor.org/stable/4532173

Von Der Goltz, J., Dar, A., Fishman, R., Mueller, N. D., Barnwal, P., & McCord, G. C. (2020). Health Impacts of the Green Revolution: Evidence from 600,000 births across the Developing World. Journal of Health Economics, 74, 102373. https://doi.org/10.1016/j.jhealeco.2020.102373

UPOV (2005). Report on the Impact of Plant Variety Protection. Geneva: International Union for the Protection of New Varieties of Plants.

World Bank (2021). World development indicators 2021. The World Bank.

Appendix 1: Methodology for benchmarking Namibia's Agriculture

The assessment of agriculture production performance in Namibia can be based on a comparative analysis that can shed light on any unusual evolution pattern in the country over time. To achieve this, the general method followed by the Growth Diagnostics Framework is to select *similar* countries that can serve as a collective counterfactual. As described below, a total list of 25 countries was pre-selected to study Namibia. The final list of countries was adjusted to keep a reasonable number to guarantee a more thoughtful assessment of each in the posterior steps of the Growth Diagnostics Framework. The final list included Bolivia, Egypt, Ghana, Mongolia, Peru, South Africa, and Zambia.

Variables and data limitations

This study aimed at finding similar countries to Namibia (peers), according to a set of economy- and agriculture-related prioritized variables that altogether determine the production of all primary crops, cereals, vegetables, fruits, and livestock at the country level.

The selection started with a set of two economic variables to capture the development levels and demography of the countries. The first variable is proxied by the GDP per capita in constant dollars of 2015 and the second corresponds to the population density. This is a critical aspect in Namibia, as the second least dense country in the world, which conditions the functioning of its markets and the overall economy. The selection of these two variables was followed by other three agriculture-related variables to represent the incidence of the sector and the efficiency with which it operates. First, to consider the prevalence of agriculture, the study first took the share of crop and livestock subsectors as a percentage of GDP. Second, the study took the share of crop and livestock subsectors as a percentage of total employment. Finally, this study also considered the productivity of the crop and livestock subsectors by taking the value added per worker, in constant dollars of 2015.

These five baseline variables were complemented by another two variables that capture endowments on agroecological conditions, which determine the sector's production performance, namely the availability of water and land. Specifically, the first one was the rainfall index (mm/year), constructed according to the national average of the total annual precipitation weighted by its long-term average. And the second one was the percentage of land used for cultivation of crops and animal husbandry. In all cases, variable values were sourced from FAOstat and the World Bank Development Indicators. Additionally, the time corresponded to the 2015-2019 yearly average as it would allow smoothing year-specific shocks that affected agriculture production.[35]

Methodology and results

Approach 1: Cluster Analysis

Cluster analysis is a statistical method for processing data.[36] It works by organizing items into groups or clusters based on how strongly associated they are. Its goal is to find similar groups of subjects and countries in the context of this study, where "similarity is based on a set of characteristics. To this end, the measure of inter-subject similarity is the set of variables described above. Among the different options, this study employed the hierarchical cluster method, which generates a series of cluster solutions from 1 (all countries in one cluster) to *n* (each country is an individual cluster) and finds an optimal number of clusters.

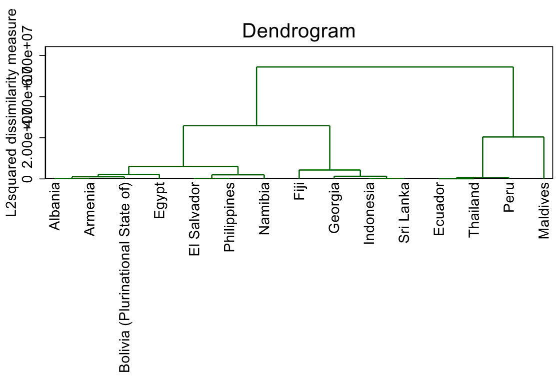
Under this approach, this study ran two different analyses. The first one considered all the countries in the world, while the second one restricted the sample to Sub-Saharan countries. The following Dendrograms show how the clusters are merged and permit identifying the most similar countries to Namibia. In the worldwide sample, the most similar countries are Albania, Armenia, Bolivia, Egypt, El Salvador, Mongolia, Niger, and the Philippines. Meanwhile, in the SSA countries

[35] Common cross-country agriculture datasets include sub-sectors beyond crops and livestock, which are the ones studied in this Growth Diagnostics. This became the most important limitation for choosing peers as a significant number of indicators showcased by FAO do not filter out fishery and forestry and thus were unable to be included in the analysis.
[36] See more in Landau, S., & Ster, I. C. (2010). Cluster analysis: overview. NO LO ENCONTRÉ

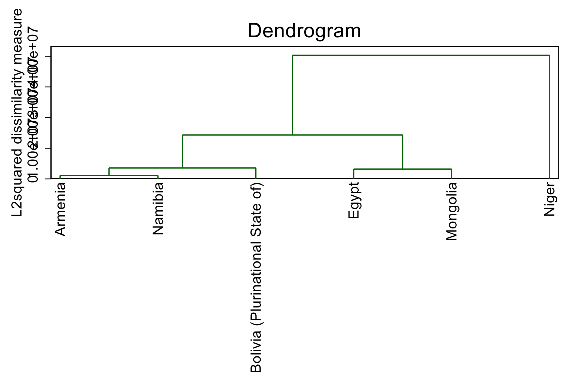
sample, the set of most similar countries are Burkina Faso, Chad, Ghana, Guinea-Bissau, Kenya, Madagascar, Mali, Mozambique, Nigeria, Rwanda, Senegal, Sierra Leone, Togo, Zambia, and Zimbabwe.

Figure A.1. Results of Clusters approach: Potential peers across the world

a) Only considers five baseline variables



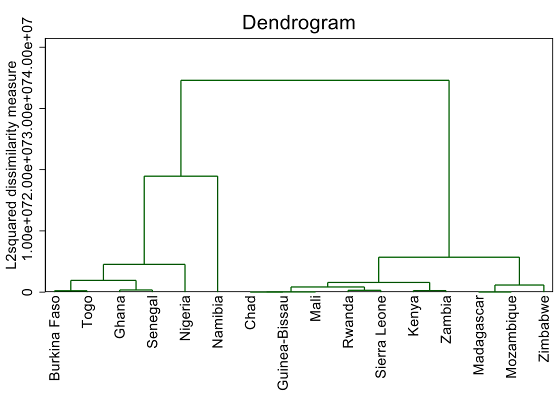
b) Considers five baseline variables plus water and land availability



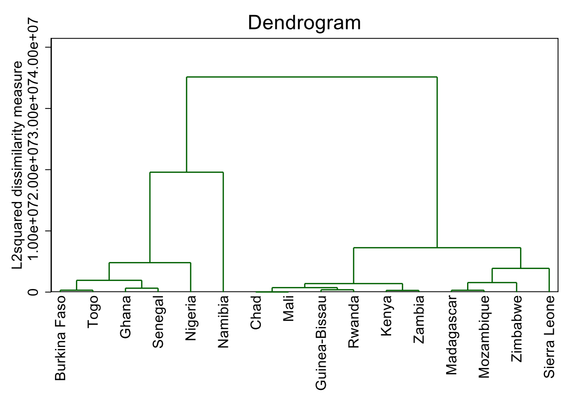
Source: Own elaboration

Figure A.2. Results of Clusters approach: Potential peers across Sub-Saharan Africa

a) Only considers five baseline variables



b) Considers five baseline variables plus water and land availability



Source: Own elaboration

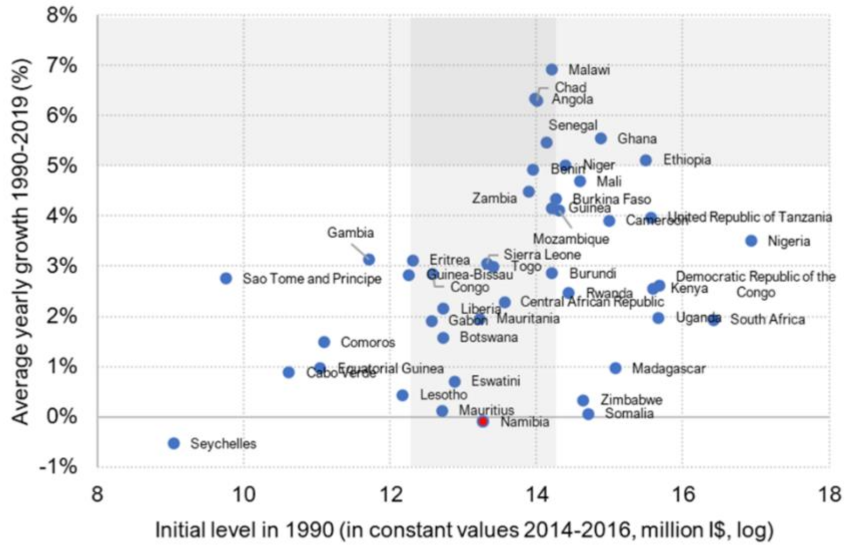
Approach 2: Aspirational analysis

With the aim of refining the growth diagnosis, the cluster analysis was complemented with additional selection filters. The narrative around the growth question required a sound set of peer countries to establish a sound diagnosis. One way to achieve so is by including countries whose agriculture performance over time could have been achieved by Namibia had effective policies been put in place. These "aspirational" peers when studying Namibia's agriculture performance are important because they provide a benchmark or a target for improvement and progress. These countries serve as role models or examples of success in agriculture policies in a way that it brings to the study references on ambitious goals and standards that Namibia can aspire to achieve while bringing a clear direction for policymakers and leaders to work towards. This process can also prompt a more critical assessment of implemented policies and practices that Namibia may have to rethink and include in its long-term sectorial vision.

This approach thus started by considering countries in Sub-Saharan Africa that experienced substantial production growth in agriculture and countries that had similar production levels to Namibia by 1990. To this end, the study estimated the average yearly growth of agriculture gross production value, in constant 2014-2016 thousand I$, over 1990-2019.[37] This led to a potential new set of peers that helped adjust the cluster analysis results (see figure below), reinforcing the previous selection of Ghana and Zambia.

[37] In this case, this study considered the evolution of agriculture production in total -not in per capita terms- given Namibia's limited information on employment by this sector for the studied period.

Figure A.3. Results of Aspirational approach: Potential peers across Sub-Saharan Africa



Source: Own elaboration

Moreover, this “aspirational” approach considered the ad-hoc inclusion of countries of other regions that have been commonly regarded as notable agricultural success stories. First, this study included South Africa (Klinger et al., 2023; Haggblade et al., 2010) and Peru (Ghezzi et al., 2022), as commercial farmers in these countries have adopted modern agricultural practices, advanced technologies, and efficient management systems, leading to high productivity and competitiveness. These countries also managed to produce a wide variety of agricultural commodities, including a well-developed agribusiness sector, including food processing, storage, transportation, and marketing, demonstrating their adaptability to different agroecological zones. Importantly, these countries faced similar challenges in land ownership and access.

The study included Egypt (Abdel-Dayem et al., 2007), one of the world’s driest countries, which has dealt with water scarcity, land degradation, and climate change impacts by implementing extensive irrigation systems and developing drought-resistant crop varieties to expand agricultural land and increase crop yields. Finally, the study included Mongolia as the countries least densely populated. It, therefore, sees its agriculture production restricted by reduced market sizes and limited economies of scale, costly construction, and maintenance of productive infrastructure and logistics, which altogether reduces the incentives for profitable investments in and development of the agriculture sector.

Appendix 2: Peru's experience as a UPOV member

The Peruvian National Institute for Agrarian Innovation (INIA) is the body responsible for performing the technical functions for granting Plant Breeding Protection (PBP) rights, namely testing to prove the discovery of a new plant variety. In an interview with officials from INIA, the Growth Lab learned about the country's motives and processes behind joining UPOV, the key features of its current PBP system, and the observed effects on the productivity of agricultural exports and access to markets[38].

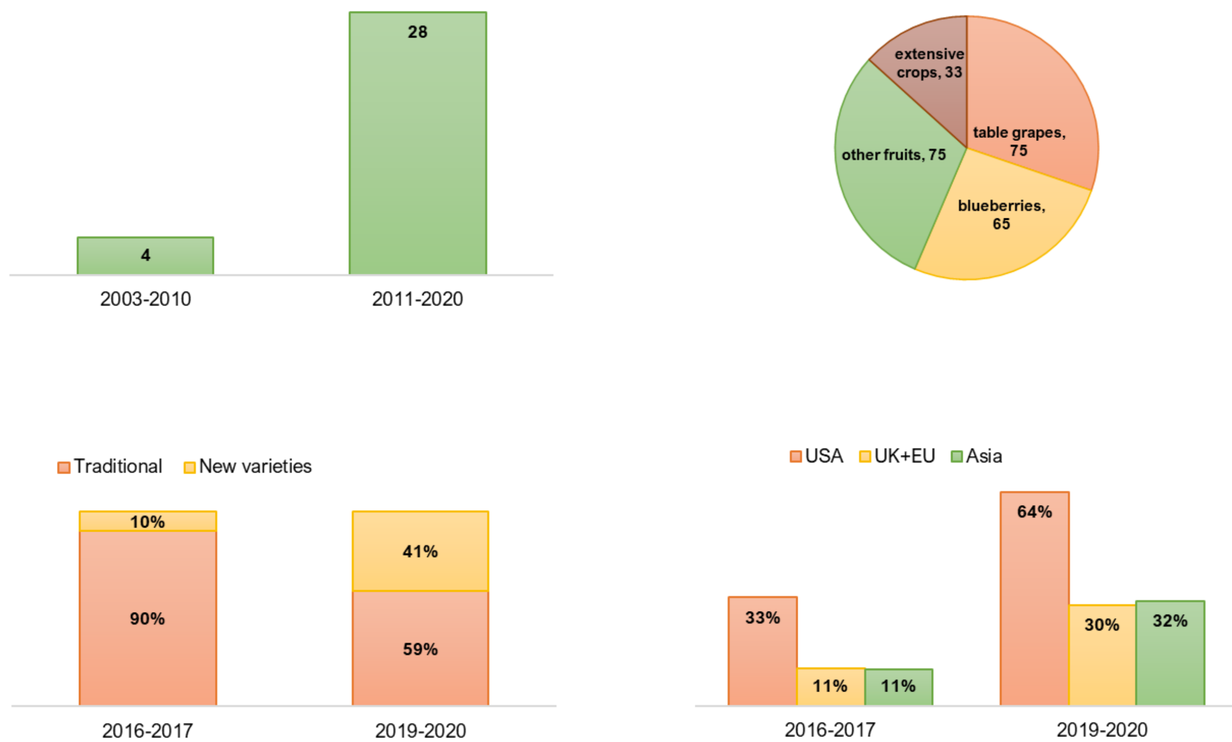
Peru formalized its UPOV membership in 2011. The country already had a legal *sui generis* PBP system since 1996, which permitted breeders from any origin to protect the discovery of a new plant variety. In 2008, the Act was reformed to align with UPOV protocols as part of the Trade Agreement negotiations with the USA.[39] The new Act was enacted in 2011 and included changes regarding the definition of rights, the scope of protection, and the institutional architecture behind the system.

After joining UPOV, PBP-granted rights increased substantially.[40] The number of rights granted increased on average from 4 rights per year between 2003-2010 to 28 per year between 2011-2020. Half of all the rights have been granted for two crops that make Peru one of the main exporters worldwide, namely table grapes (75 rights) and blueberries (65 rights). The rest of the grants are concentrated on other fruits (75 rights) and on extensive crops such as rice, maize, and wheat (33 rights).

The increased access to improved seeds with higher yields helped grow the exports of high-value crops. Nowadays, over 40% of all table grapes exports (volume) correspond to new accredited varieties, with figures increasing to 64% for exports to the USA, the main market for this crop from Peru[41]. The better adaptation of these new varieties to soil and weather conditions has driven significant increases in crop yields. According to FAO data for 2019, yields of Peruvian table grapes (19.2 TM/ha) were higher than other main exporters such as China (19.1), South Africa (17.2), USA (16.6), and Chile (13.8).

[38] Interview on 22 September 2022 with Juan Guerrero (Head of the Directorate of Genetics Resources and Biotech), and Manuel Sigueñas and Alicia Garcia (Managers from the Directorate of Agricultural Innovation).
[39] 1996 Act was *Decreto Supremo Nº 008-96-ITINCI.* 2011 Act was *Decreto Supremo 035-2011-PCM.*
[40] INDECOPI (2021). Strategies to promote the protection of plant variety protection in Peru. Access here.
[41] Carrasco et al (2020). Agricultural exports post-COVID. The case of table grapes. Access here.

Figure A.1. The Peruvian experience under UPOV



The main reflections on the effects of UPOV on Peruvian agricultural exports according to the officials interviewed are the following:

1. **Most new varieties of improved seeds were generated by private foreign breeders; however, local firms have started to innovate as well.** The private sector has been able to conduct research and development and grow new seeds. While 78% of all PBP rights granted between 2016 and 2020 have been for foreign breeders, INIA officials pointed out successful cases of local agro-export firms that, in collaboration with national and international centers, have started to develop new seeds for their own produce.

2. **New improved seeds have been beneficial for intensive, highly specialized agriculture, without significant or obvious negative effects on small farmers.** High-value fruits with high returns or extensive crops with considerable demand support the large investments that are necessary to innovate in breeding. According to the INIA officials, this explains why other domestically produced crops that do not have high

commercial value, in the hands of small farmers with limited access to international markets, have not been directly benefited by the development of new seeds.

3. **The PBP system's effectiveness depends partly on the regulatory environment in which it is enacted and on institutional arrangements.** INIA officials emphasized that the PBP regulation should be flexible enough to facilitate the application process and should reduce costs for breeders. The Peruvian PBP system includes the recognition of testing of new varieties carried out abroad, in-field testing for local breeders, and clear, and open-access guidelines. INIA officials also highlighted the strong and permanent coordination with Peruvian National Institute for the Defense of Competition and the Protection of Intellectual Property (INDECOPI), the body responsible for granting and administering the rights. Finally, the country implements checks and balances to ensure that indigenous peoples' traditional biodiversity knowledge is protected throughout the PBP application processes.[42]

[42] 2002 Law 27811 regulates the protection of indigenous peoples' traditional knowledge related to biodiversity.