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Navigating Weather Shocks: Challenges and Investing to Strengthen Agriculture Resilience in Namibia

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ABSTRACT: Namibia's arid climate makes it highly susceptible to severe weather shocks. The prolonged drought in 2023–24 caused a sharp decline in crop yields and exacerbated food insecurity. This paper documents Namibia's vulnerabilities to future weather shocks, including droughts and changes in rainfall patterns, discusses potential economic and fiscal implications, and explores public investment strategies. Investing in agricultural resilience, including water infrastructure, drought-resistant crops, and farmer insurance schemes, can mitigate climate-induced economic losses and improve food security.

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SELECTED ISSUES PAPERS

Navigating Weather Shocks: Challenges and Investing to Strengthen Agriculture Resilience in Namibia

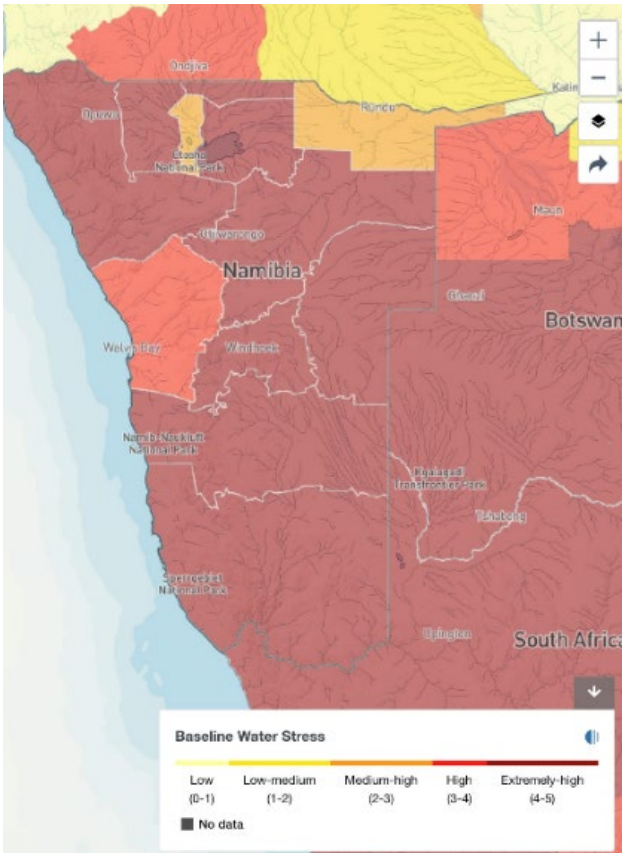
Namibia

Prepared by Chen Chen, Ankita Goel, Koralai Kirabaeva, Nooman Rebei and Hajime Takizawa

A. Introduction

1. Namibia is one of the most arid countries in the world, rendering it vulnerable to severe weather shocks. With 92 percent of Namibia's land classified as arid, much of the country is inhospitable, owing to severe water scarcity causing challenges in sustaining agriculture and human settlements. The country is ranked as the 21st most water stressed countries globally.[1] This arid environment affects food security, as 11 percent of Namibian households depend on subsistence or commercial farming as the main source of livelihood, which makes them highly vulnerable to drought and water shortages.[2] It also has implications for energy security, as the bulk of domestic electricity generation comes from hydropower, which is planned to be expanded further.[3] During 2020–24, imports accounted for an average of 67 percent of total electricity demand in the second half of the year, a predominantly dry season with lower hydropower generation. In contrast, the import share averaged 54 percent in the first half of the year, which is typically wetter (The Villager, 2024) (NSA, 2024).

Figure 1. Water Stress in Namibia



Source: WRI Acqueduct.

2. The vulnerability of the economy, notably agricultural and water-dependent sectors, has been exposed by the drought since 2023. The drought has sharply reduced crop farming output,[4] contributing to slower GDP growth in 2024 and causing serious socio-economic consequences, as agriculture supports 70 percent of the Namibian population directly or indirectly (FAO, Namibia). It led to a sharply higher incidence of food insecurity compared to past years, with approximately 40 percent of the population already facing high levels of acute food insecurity and 84 percent of food reserves

[1] Aqueduct Country Ranking.

[2] 2023 Population and Housing Census.

[3] For example, Ruacana Hydro Power Station accounted for 79 percent of locally generated electricity in August 2024 when import increased to make up for insufficient domestic supply due to the drought condition.

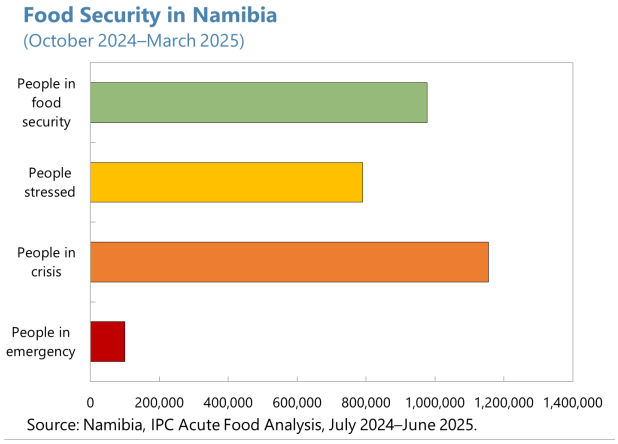
[4] According to the national accounts data (2024), crop farming was down by 31.7 percent and 6.6 percent in 2023 and 2024, respectively. The crop yields in Namibia were already below the regional average. According to the World Bank, crop yields in Namibia were 649kb per hectare compared with the Sub-Saharan Africa (SSA) average of 1,613 kg per hectare in 2022.

exhausted as of September 2024.[5] Furthermore, dam water levels declined by 70 percent, constraining activities in other water-intensive sectors (Reliefweb, 2024).

3. **Namibia's already vulnerable economy could be exposed to even greater weather shocks in the future.** More severe or frequent weather events could increase food and energy insecurity, which could in turn accelerate an internal migration, mostly from rural to urban regions, increase pressures on infrastructure and social services, and exacerbate the already high pressure to address the acute unemployment problem.

4. **This paper reviews Namibia's vulnerabilities to extreme weather events and discusses public investment policy options.** It reviews historical data on the impacts of severe weather events and presents likely future scenarios, followed by a model-based analysis of the need for public investment to mitigate its effects. Since the impact on agriculture will likely be the most prominent channel for such shocks to have macroeconomic and socio-economic consequences in Namibia, it builds on a two-sector model encompassing the agricultural sector. Key recommendations include scaling up public development investment aimed at raising productivity in the agricultural sector, increasing public adaptation investment to build climate resilience of the sector, and improving public investment management.

Figure 2. Impact of Drought in 2024



Source: Namibia, IPC Acute Food Analysis, July 2024–June 2025.

B. Namibia's Vulnerability to Severe Weather Events and Climate Change

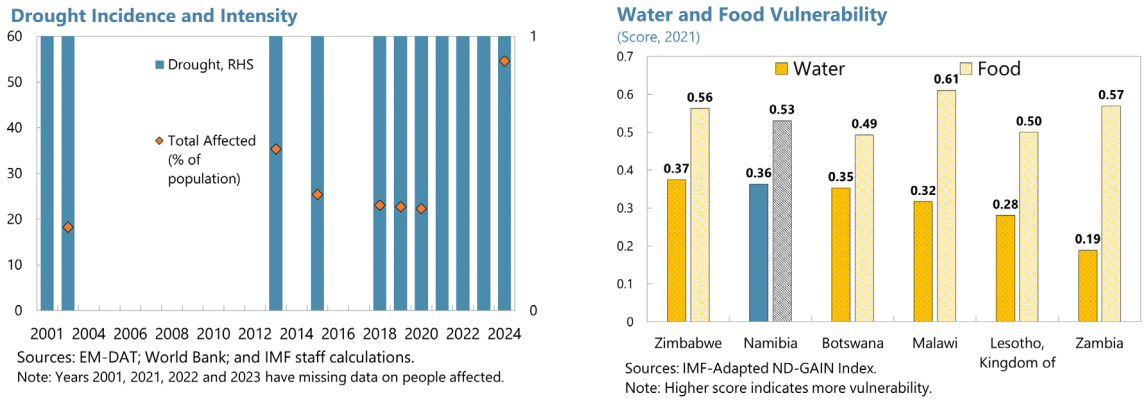
5. **Namibia's climate has undergone significant changes over the past century, marked by rising temperatures.** The average annual temperature in Namibia has increased by 1.2°C, reflecting a broader global warming trend.[6]

6. **Rainfall patterns in Namibia have become more unpredictable and variable.** Namibia is facing more frequent droughts and a steady decline in annual rainfall, with the incidence of natural disasters rising over the past few decades (Figure 3, left panel).

[5] Food insecurity data as of September 2024. According to the Integrated Food Security Phase Classification (IPC) Acute Food Insecurity Analysis, July 2024–June 2025, prepared by the Namibia Vulnerability Assessment Committee (NamVAC). This analysis has been conducted under the patronage of the MVAC (e.g. Ministry of Agriculture).

[6] Namibia - Climatology | Climate Change Knowledge Portal.

Figure 3. Climate Vulnerabilities



7. Namibia is vulnerable to severe weather events. According to the ND-GAIN Index, Namibia ranks 109th out of 187 countries for climate vulnerability, with heightened vulnerabilities in water (in dam capacity) and food security (in agricultural capacity) (Figure 3, right panel). The country also ranks 77th out of 163 nations on the Children's Climate Risk Index, placing it at a medium-high risk level. Furthermore, Namibia's INFORM Climate Change Risk Index score of 3.2 reflects a moderate level of risk, driven by high exposure to droughts, floods, and epidemics.[7]

8. Concurrently, severe weather events have caused socio-economic damages in Namibia. Drought and flood have been their major causes, often affecting a large share of the population (3 million in 2023):

- Droughts between 2013 and 2016 affected approximately 450,000 people and caused wide-spread food insecurity across the country. Another drought in 1991 impacted over 550,000 people, including around 200,000 children, and resulted in damages worth 4 percent of GDP.[8] (UNICEF Namibia, 2019).

- Flooding events have also intensified, affecting roughly 70,000 people each year. In 2011, a major flood impacted nearly 500,000 people, displacing over 60,000, with 19,000 requiring relocation camps and resulting in 65 fatalities (UNESCO, 2021).
- According to the 2023 Housing and Population Census, 6.1 percent of total deaths between October 2022 and September 2023 were caused by natural disasters.

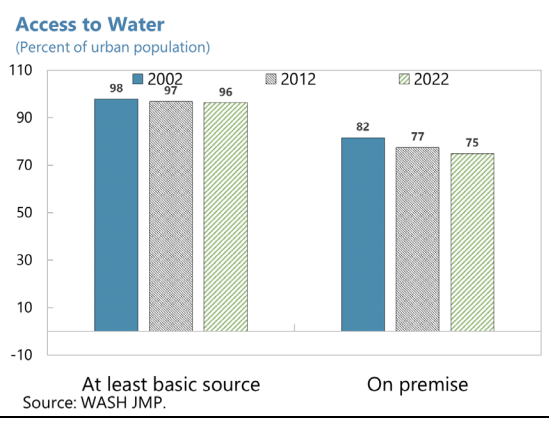
9. Water resources in Namibia are also facing significant strain. Water accessibility has worsened over decades in urban Namibia (Figure 4, left panel). The reduced water levels in the Kunene River have caused water shortages for both domestic use and agriculture including livestock and has also affected the output of the Ruacana hydropower plant, a key source of electricity for Namibia (IFRC, 2022) (Namibia Economist, 2023) (News24 Business, 2022). Worsening water availability could weigh on other water intensive sectors such as food and beverages (Figure 4, right panel). Erratic floods can lead to damages worth 0.4

[7] INFORM Climate Change Risk Index is a tool designed to assess the risk of humanitarian crises and disasters influenced by climate change.

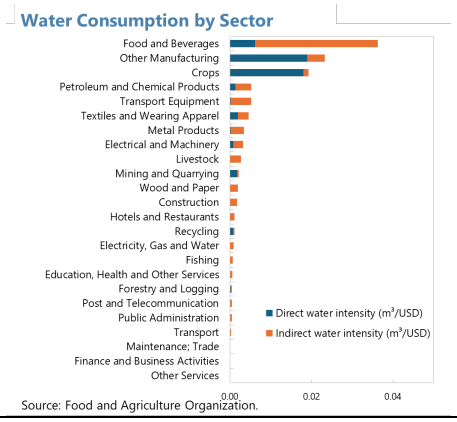
[8] IMF staff calculations using data from EM-DAT and World Economic Outlook.

percent of GDP by 2030.[9] And water stress in Namibia is projected to be extremely high for the next 30 years.[10]

Figure 4. Water Utility by Households and Producers



Source: WASH JMP.



Source: Food and Agriculture Organization.

10. Namibia has a legal framework and regulations for water resource management in place, but effective implementation requires further work. Namibia's traditional water sources include groundwater (45 percent), perennial border rivers (33 percent), and impoundments on ephemeral river (22 percent).[11,12] Persistent future droughts are likely led to falling ground water tables and reduced surface water flows, posing challenges to water supply infrastructure and water quality. Against this backdrop, Water Resources Management Act of 2013 outlines the sustainable management, use, and protection of water resources in Namibia. It also provides for regulation and monitoring of water services providers to ensure proper management of these resources. The 2023 Water Resources Management Regulations operationalize the Act by enforcing water use licensing, infrastructure registration, and groundwater protection. However, effective implementation has been hindered by several factors, including institutional capacity and financial constraints, administrative burdens for rural users, high compliance costs, inadequate data and monitoring infrastructure, and limited public awareness. This prompted the authorities to enhance financing mechanisms, strengthen cross-border water cooperation, build institutional and human capacity in water resource management, and promote more efficient water use.

11. Namibia's vulnerability to climate change is expected to intensify over time, with rising temperatures, shifting rainfall patterns, and more frequent extreme weather events. There is strong confidence in an increase of Namibia's average annual temperatures by at least 2˚C by 2050. Under a high-emissions scenario, this rise could reach 4˚C, while a low-emissions scenario suggests a range of 1.1–3.1˚C. Additionally, both daily minimum and maximum temperatures are projected to rise, with 15 to 40 more days each year expected to exceed 35°C across the country. Such conditions are likely to affect disproportionately vulnerable groups, especially the elderly, and will heighten demand for public health services. While precipitation projections are less certain, the staff has moderate confidence that Namibia will become generally drier and average rainfall may fall by 12 percent by 2050 (Figure 5).

[9] WRI Aqueduct Floods and IMF staff calculations.

[10] In the business-as-usual scenario by WRI Aqueduct Water Risk Atlas.

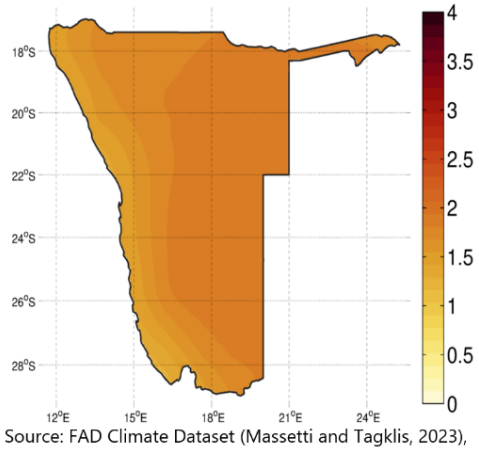
[11] Namibia. (2020). Fourth National Communication to the United Nations Framework Convention on Climate Change.

[12] Additionally, unconventional water sources (e.g., desalinated water) have been adopted to augment the limited traditional sources.

Figure 5. Weather and Precipitation Projections Under SSP2–4.5

Projected Increase in Temperature by 2050

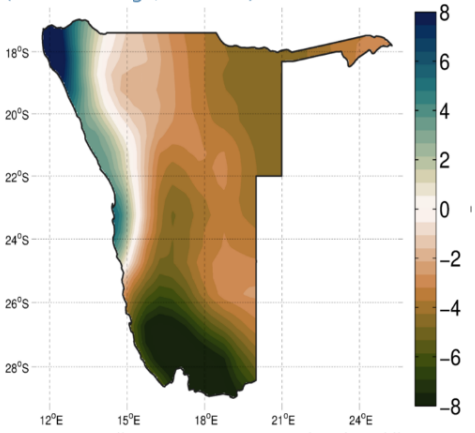
(Units Celsius Degrees, SSP2–4.5)



Source: FAD Climate Dataset (Massetti and Tagklis, 2023), using Climate Research Unit data (Harris et al., 2020).

Projected Increase in Precipitation by 2050

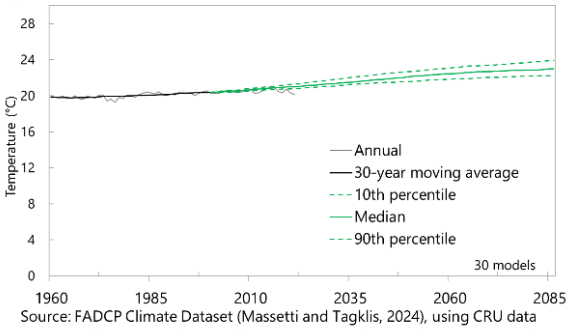
(Percent change, SSP2–4.5)



Source: FAD Climate Dataset (Massetti and Tagklis, 2023), using Climate Research Unit data (Harris et al., 2020).

Historical and Simulated Annual Average Temperature

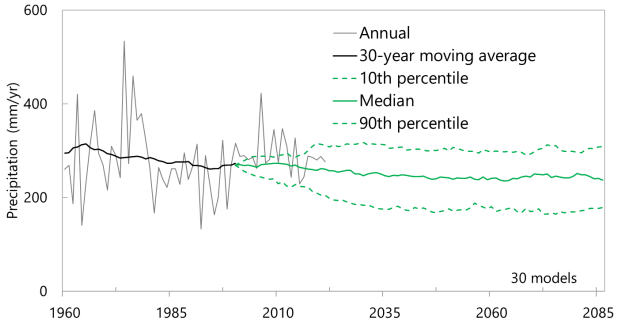
(SSP2-4.5)



Source: FADCP Climate Dataset (Massetti and Tagklis, 2024), using CRU data (Harris et al., 2020), and CMIP6 data (Copernicus Climate Change Service, Climate Data Store, 2021: CMIP6 climate projections).

Historical and Simulated Annual Average Precipitation

(SSP2-4.5)



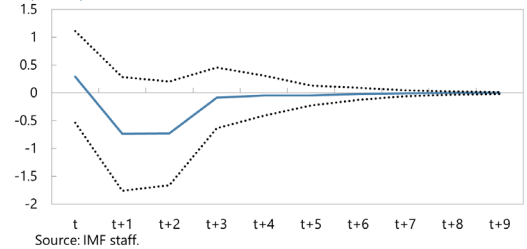
Source: FADCP Climate Dataset (Massetti and Tagklis, 2024), using CRU data (Harris et al., 2020), and CMIP6 data (Copernicus Climate Change Service, Climate Data Store, 2021: CMIP6 climate projections).

12. Overall, climate change impacts will likely have substantial economic and fiscal consequences. Historical data are indicative of the climate shocks increasing vulnerabilities in the agricultural and energy sectors. A simple VAR analysis indicates that a severe drought condition is estimated to have an adverse impact on GDP growth (Figure 6).[13] As climate change progresses, traditional agriculture production may drop by 40 percent in moderate climate scenario to 80 percent in an extreme climate scenario, and livestock carrying capacity could fall by 20–50 percent by 2050 (IIED, 2007). In terms of energy, rising temperatures alongside Namibia's progressive industrialization and urbanization will drive electricity

Figure 6. Impact of Drought on Real GDP

Impulse Response Function for Real GDP Growth Following Severe Drought 1/

(Percent)



Source: IMF staff.

1/ Based on a VAR encompassing agriculture GDP growth, real GDP growth and a dummy variable for precipitation. Dotted lines represent 90 percent confidence interval. t=year.

[13] GDP growth is estimated to have been lowered by 0.7 percentage points in the year following a drought shock.

demand higher. However, increased heat could reduce hydroelectric supply and potentially limit imports, on which Namibia currently depends for half of its electricity needs.

13. Responding to the impacts of the drought has required fiscal resources. The government made a cumulative budgetary allocation of 0.9 percent of GDP in FY23/24 and FY24/25 to respond to the crisis caused by the drought. It rolled out a nationwide drought relief program aimed at supporting over half of the country's population across all 14 regions. The program includes food assistance (through distribution of food and food voucher), provision of seeds and horticultural supplies, support for the sale of livestock, and improvement of water access.[14]

C. Public Investment Strategy to Improve Agriculture Resilience

14. It is important to strike a balance between ex-post intervention to deal with damage in the agricultural sector and ex-ante building of resilience. The significant fiscal outlays related to the drought relief program in the past two years have highlighted the importance of building resilience. Furthermore, balancing investments between adaptation and broader development goals would help minimize climate-related losses while using fiscal resources more efficiently.

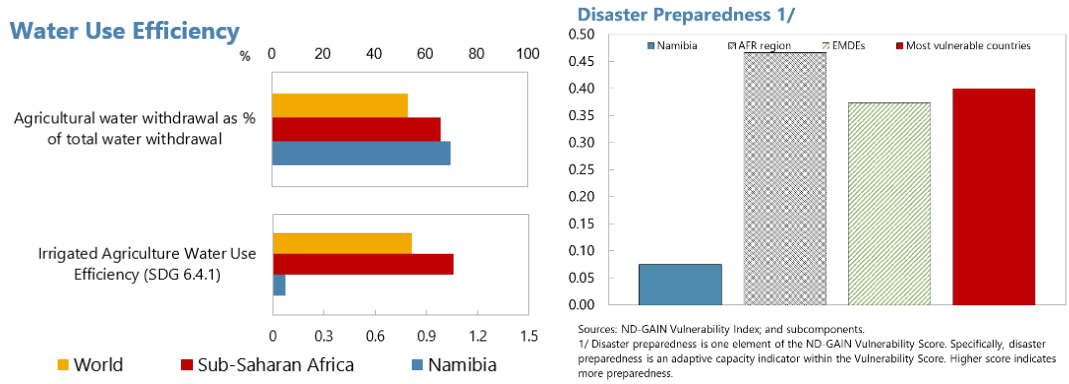
15. Efforts to build resilience are already under way. The government is developing a National Resilience Building Strategy to implement cost-effective adaptation and resilience measures for key hazards identified in a national risk profile. It is also preparing for a Green Climate Fund project aimed at strengthening climate information and early warning systems to enhance adaptation planning. To strengthen resilience to increasing aridity, the government envisages scaling up capital expenditure on water infrastructure as laid out in the FY24/25 budget, at the annual cost of 0.3 percent of GDP on average over the Medium-Term Expenditure Framework for FY24/25–26/27.

16. There remains ample room to improve adaptation capacity. Despite the high share of water used in agriculture, efficiency of irrigated agriculture water use in Namibia is lower than the Sub-Saharan Africa region (Figure 7, left panel). Disaster preparedness of Namibia, which is a measure of adaptation capacity, is well below those of comparator country groups (Figure 7, right panel).

17. This chapter explores public investment strategies to mitigate the climate-related damage to the agricultural sector. Agriculture is highly vulnerable to climate change. Indeed, extreme weather events in Namibia have affected primarily the agricultural sector, with consequences for food security given the prevalence of subsistence farming. Investment in agriculture is important for raising productivity and reducing future damages to output that could be caused by intensified weather-related shocks.

[14] The authorities' efforts are also complemented by international communities. For example, United Nations is allocating $3 million through the Central Emergency Response Fund (CERF) for drought relief efforts. The funding will be used to provide cash assistance, rehabilitate water supply points, treat acute malnutrition, and support survivors of gender-based violence.

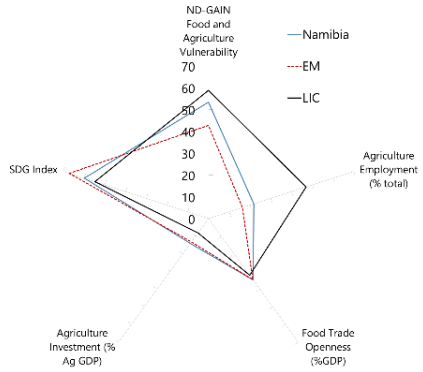
Figure 7. Water Efficiency and Disaster Preparedness



Source: IMF staff estimates using FAO Aquastat.

18. We use a Climate Adaptation and Food Security model to study investment needs for agricultural adaptation, taking into accounts broader development needs (Chen, 2024). The model incorporates both agricultural and non-agriculture sectors, international trade, and two types of public capital stocks used in the agricultural production. Food import is an important component to help ensure food security, although its role as a mitigating factor against local weather shocks might diminish as the climate change could increasingly affect the agricultural output and prices globally. Furthermore, subsistence farming is prevalent in Namibia. Strengthening climate-resilience in the agricultural sector is therefore key to ensuring food security. The model distinguishes broad development capital, which enhances production, and adaptation capital, which also mitigates climate change damages and costs more to build. Examples include promotion of climate-resilient farming technology and enhancement of climate resilience of infrastructure.

Figure 8. Elements of Balanced Adaptation Strategy in Namibia, 2019



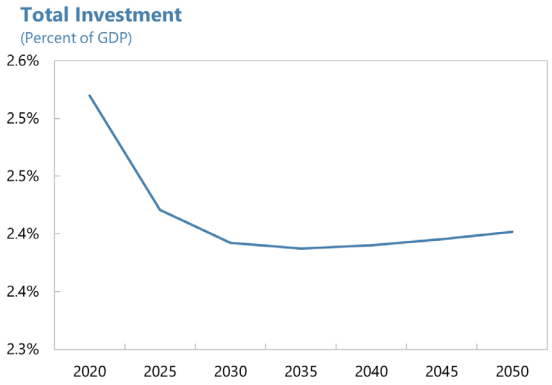
Sources: ND-GAIN Index; IMF, World Economic Outlook; World Bank, Sustainable Development Report; and Food and Agriculture Organization.

19. The model is calibrated to capture salient features of the Namibian economy. The current level of public spending on agriculture is estimated at 0.7 percent of GDP, while the share of agricultural consumption from imports is comparatively high at 39 percent. The model uses the country-specific central projection from Cline (2007) to calibrate a parameter that determines agricultural productivity loss from climate change. In particular, 3.3˚C warming is projected to lead to agricultural productivity loss by 27 percent in Namibia without adaptation. Efficiency of adaptation investment capital, which determines the extent of loss-mitigation effect of the capital, is calibrated based on the SSA average reported in Agrawala (2010). Specifically, adaptation investment rate of 0.01 percent of GDP per year reduces climate change-induced damage by 30 percent. There are, however, great uncertainties regarding the efficiency of adaptation investment. An alternative assumption that 0.1 percent of GDP adaptation investment per year is needed to

achieve the same reduction in damage is also explored to illustrate how lower efficiency of adaptation investment (by ten folds) affects the optimal mix of investments.

20. The analysis shows that offsetting fully climate change-induced damages requires substantial scaling-up of development investment. If no financing constraint is imposed, the model estimates that 2.4–2.5 percent of GDP investment in development capital per year through 2050 will mitigate a substantial part of climate change damages (Figure 9).

Figure 9. Total Investment Under no Financing Constraints



Source: IMF staff.

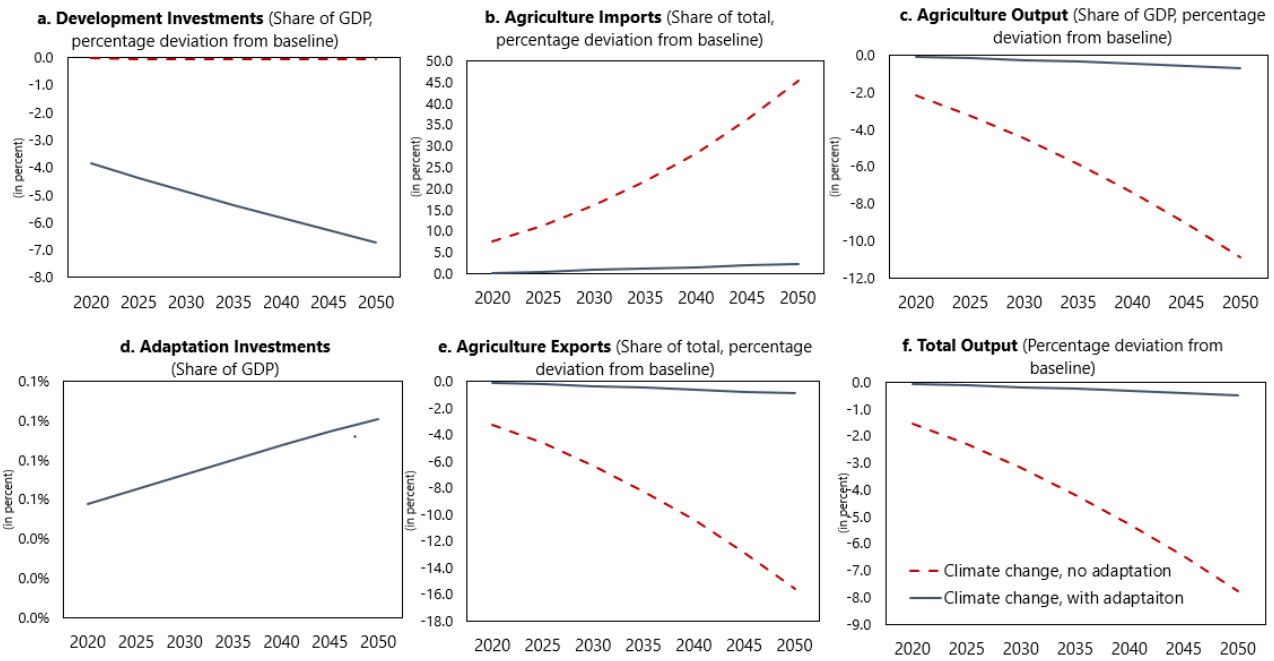
21. In light of limited fiscal space, analysis is conducted on the effect of allocating resources between development and adaptation investment. In particular, two public investment policy options— (1) only standard development capital and (2) a combination of both development and adaptation capital— were simulated under a binding financing constraint of 1.5 percent of GDP, the resulting endogenous variables (output, investment, exports, and imports) are presented as percentage deviations from a counterfactual of "no climate change" baseline (Figure 10).

22. The simulation shows the significant benefit of a modest amount of allocation for adaptation investment under a binding financing constraint. Underinvesting in adaptation would require a higher level of total development investment to contain the impacts of climate-related shocks.

- Under the binding financing constraint, climate change is projected to result in substantial damage over time if investment is made only for development capital. A lack of investment in adaptation is projected to lower agricultural output by ten percent and total outputs by seven percent relative to the no-climate change counterfactual in 2050 (dashed red lines in Figure 10). Similar impacts are also observed for agricultural net imports: imports are projected to increase by 45 percent relative to the baseline, while exports are 16 percent lower.

- However, reallocating a modest amount of public development investment to adaptation investment would reduce damages considerably. Investing in adaptation would entail reallocating part of financing from investing in standard development (blue solid lines in Figure 10), while keeping the total amount of public investment at 1.5 percent of GDP. Under this second policy option, a total output loss would be limited in within 0.5 percent by 2050 compared with the no-climate change counterfactual, reflecting the damage-mitigating effect of adaptation investment. Other key variables also improve substantially under this policy option.

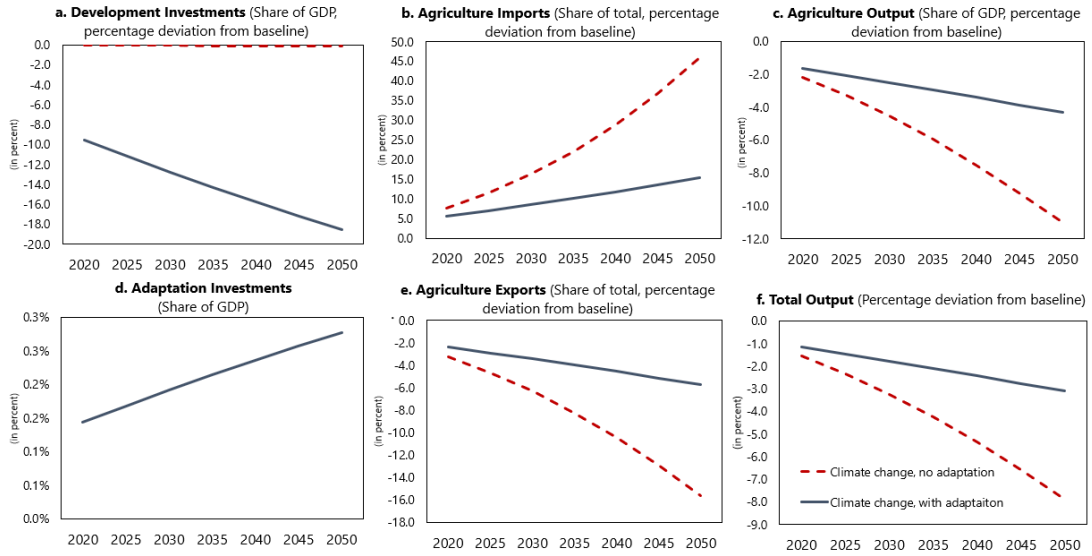
Figure 10. Two Public Investment Policy Options—Default Assumption on Efficiency of Adaptation Investment



Source: IMF staff.

23. The model suggests that a cost-effective mix of development and adaptation investment in Namibia can be achieved with a modest amount of allocation to adaptation investment. The optimal split is a combination of adaptation investment of 0.1 percent of GDP and development investment of 1.4 percent of GDP. The result of an alternative assumption about efficiency of adaptation investment is qualitatively similar but tilts the optimal mix toward a slightly larger allocation to adaptation investment (0.3 percent of GDP) than the default case, with an output loss of 3.1 percent by 2050 (Figure 11). The relatively low optimal level of adaptation investment reflects high food import dependency and significantly larger productivity gap between agricultural and non-agricultural sectors (therefore greater room to close it) compared with those in similar income-level countries. However, continued high reliance on food imports exposes the economy to regional and global shocks, including impacts of climate change and trade fragmentations, which limits trade and the scope for food imports as other countries prioritize meeting their own food consumption needs. In the event, the country would be forced to increase investment to raise agriculture productivity. Likewise, closing of the productivity gap implicit in the model might not materialize given the prevalence of subsistence agriculture.

Figure 11. Two Public Investment Policy Options—Alternative Assumption on Efficiency of Adaptation Investment



Source: IMF staff.

D. Conclusions

24. It is crucial to plan and implement a sound and fiscally feasible adaptation investment strategy to boost the resilience of agriculture. Climate-related shocks will likely cause more frequent or severe economic damage, leading to increased fiscal costs to mitigate the associated damage, as evident from the experience of the ongoing drought. The authorities are appropriately aiming to increase public investment to build climate resilience.[15] The model-based analysis suggests that investment needs for public development capital to offset climate-related production loss in the agricultural sector could be large but cost-effective combination of development and adaptation investment could reduce such loss at relatively modest costs. To realize the benefits of such investment, it is crucial to improve public investment management as there currently is a significant scope for improvement, as highlighted in Public Investment Management Assessment (PIMA) and Climate-PIMA undertaken in 2024. It is also advisable to reduce reliance on food imports by implementing measures to raise agriculture productivity.[16]

25. Continuing complementary efforts to strengthen adaptation are also important. The ongoing development of the National Resilience Building Strategy provides an opportunity to improve practices that help increase agriculture productivity and food security. Potential measures include encouraging greater adoption of drought resilient crops and livestock and mixed farming, improving water management system, and strengthening early warning system. Expanding access to insurance mechanisms could help distribute risks, thereby cushion individuals and economies from financial shocks of climate-induced natural disasters and facilitate recovery efforts. Development and adoption of crop and animal insurance could be encouraged.

[15] FY 2024/25 Mid-Year Budget Review Statement.

[16] As recommended by GIZ Sector Brief: Namibia 2022 and A Growth Diagnostic of Namibia, 2022.

Other insurance products could mitigate shocks against natural disasters.[17] Together, these efforts help alleviate the financial burden of disasters, enabling affected populations to recover more efficiently and sustainably.

[17] One notable initiative is the Global Index Insurance Facility (GIIF), launched by the World Bank, which provides affordable insurance solutions to farmers and micro-entrepreneurs in emerging economies, particularly in Sub-Saharan Africa. The program aims to shield vulnerable communities from climate-related risks such as droughts and floods. Similarly, the InsuResilience Global Partnership focuses on strengthening the financial resilience of poor and vulnerable populations.

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