On behalf of

POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

PIK

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Federal Ministry for Economic Cooperation and Development

Policy Brief: Climate risk analysis for adaptation planning in Zambia's agricultural sector

Overview

The climate crisis increasingly affects the resilience of **Zambia's agricultural sector**, with droughts and high precipitation variability challenging livelihoods as well as the economic prospects of agricultural production. Understanding climate risks and impacts is therefore crucial for effective adaptation planning. New research conducted by the Potsdam Institute for Climate Impact Research (PIK) in cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the Federal Ministry for Economic Cooperation and Development (BMZ) provides a comprehensive climate risk analysis for the agricultural sector in Zambia.

Based on global climate models, the study projects how temperature and precipitation in Zambia are expected to change under different climate change scenarios and how these impacts might affect three selected crops (**sorghum, maize, groundnut)**. Together with stakeholders, two adaptation options were selected to analyse whether they can buffer the impacts of climate change: **Conservation agriculture and early warning systems.** The analyses include aspects related to the risk mitigation potential, cost-effectiveness and financing. Additionally, gender dimensions of the two adaptation options are considered.

Projected climatic changes

Climate models project a robust trend towards **increasing temperatures** all over Zambia during the 21st century (Fig. 1). The low emissions scenario indicates a stabilization of mean annual temperatures over Zambia at around 2 °C in the mid-century compared to pre-industrial levels. Under the high emissions scenario, temperatures continually increase throughout the 21st century. The **number of very hot days** is projected to increase in all parts of the country with 88 very hot days more per year by 2080 for the country average. The southern parts of the country show the strongest temperature increases.

Projections of **mean precipitation** indicate high spatial variations within the country (Fig. 2). The southern and central parts of the country, which are already today drought prone, show a decrease in precipitation of around 12 % (10 %) by 2050 (2080). Under the high emissions scenario, most of the country shows a drying trend throughout the 21st century.

Overall, these trends in extreme indicators show a shift towards **more intense climate conditions** both in terms of dry as well as wet conditions.

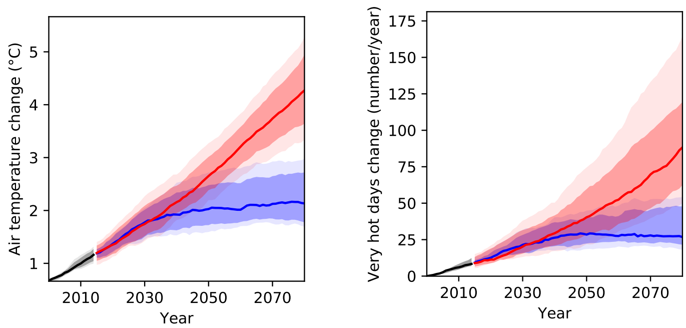

Figure 1: Projected temperature change (left) and projected change in the number of very hot days per year (right) in Zambia for SSP1-RCP2.6 (blue) and SSP3-RCP7.0 (red)

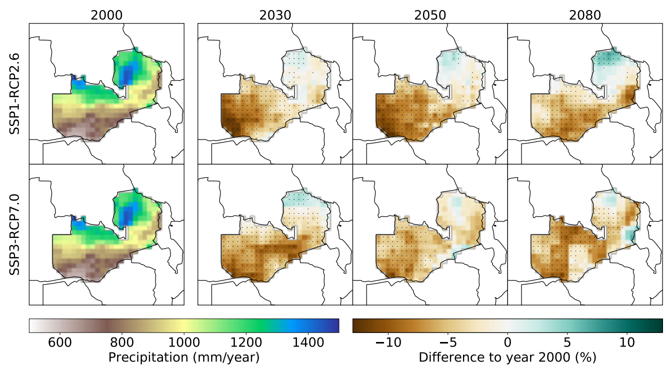

Figure 2: Projected change in annual precipitation in Zambia for SSP1-RCP2.6 and SSP3-RCP7.0

Climate impacts on agriculture

Smallholder farming systems are most prevalent in Zambia. Approximately 90 % of farmers are small-scale farmers and are disproportionally vulnerable to climate change. The livelihoods of smallholder farmers mostly depend on rainfed agriculture so that changes in rainfall, temperature and the occurrence of extreme events directly affect their income, food security situation and well-being.

Climate change will have various impacts on agriculture through changes in modal conditions, seasonal changes and extreme events. Extreme events increasingly cause crop yield losses related to droughts, heat, excessive water or a combination of multiple hazards. For example, climate change and related extreme events negatively affect sorghum yields in Zambia. **Sorghum** is a **major starchy food crop** in Zambia, which plays a vital role in providing nutrient-dense food, particularly for poorer parts of the population. Mean **sorghum yields** for the whole country are projected to **decrease by 5.8 to 12.2 % by mid-century** with spatial and temporal disparities. The strongest negative impact is projected in the south of Zambia, which has currently the highest production intensity areas for sorghum. The decreases are, however, only about half of the projected decrease in maize yields. This confirms that sorghum is indeed a more resilient crop compared to other cereals.

Climate change also affects the **extent and distribution of suitable areas for crop production in Zambia**. On the national level, the crop suitability analysis of small-scale production systems shows a net reduction in suitable areas for maize and sorghum production and no significant change in groundnut suitability with climate change. For example, for sorghum a net reduction in suitable areas is projected between 28 and 35 % by 2050 on the national level (Fig. 3). However, the northern parts of the country are projected to remain highly suitable for sorghum production throughout the century. For maize production, a decrease in suitable areas between 35 and 37 % until mid-century in projected, with the strongest decreases in Central Province (>70 %). Projections for groundnut production show no significant changes on the national level, however, some northern parts gain in suitability, whereas southern and western parts are projected to face reductions in suitability. Generally, there is a **northward shift in crop suitability** in Zambia. Already today, northern parts of Zambia are more suitable for sorghum, maize and groundnut production than the southern parts of Zambia and climate change is going to intensify this pattern. This partly contradicts with currently high production areas for sorghum and maize, which can be found in central and southern Zambia.

The projection results solely focus on **climatic impacts on crop suitability** and show the projected changes in crop suitability if left unaddressed, meaning if no adjustments were made in agricultural management practices or agricultural policies. Thus, the results highlight the importance of taking timely and effective adaptation measures to mitigate the negative impacts of climate change on crop suitability. How to translate these findings into policy recommendations depends on the specific policy objective. Whereas crop production on suitable land can maximize yields, production on marginal land of certain crops can be recommended from a food security and social protection perspective. For example, sorghum production on marginal land can enable or sustain agricultural production on land that will no longer be suitable for more demanding crops with ongoing climate change.

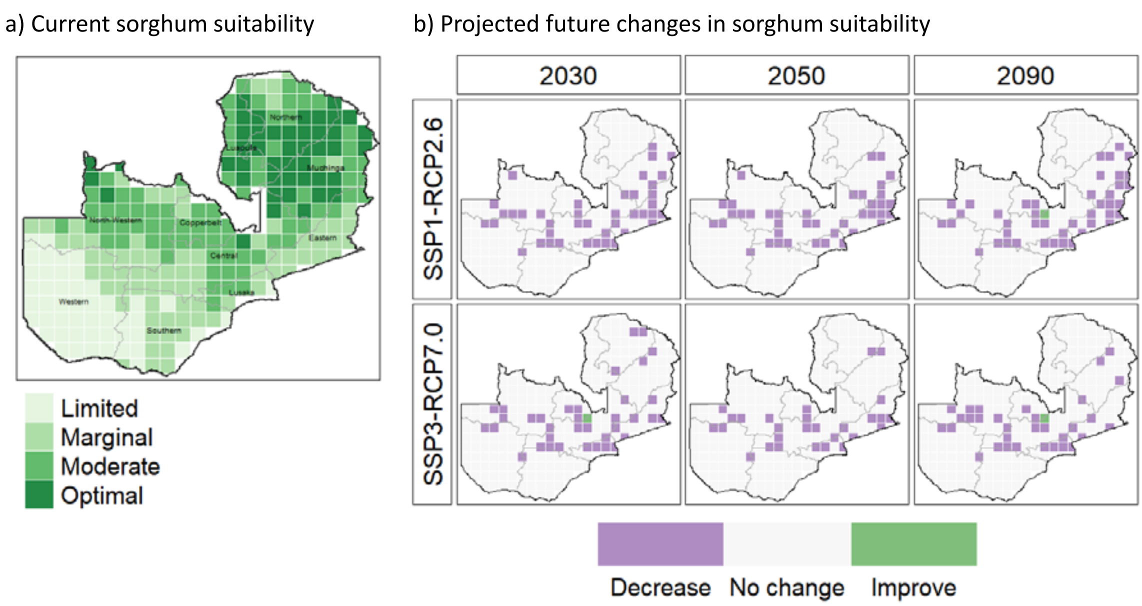

Figure 3: a) Current suitability of sorghum production; b) projected future change in sorghum suitability in Zambia under the low emissions scenario SSP1-RCP2.6 (top row) and the high emissions scenario SSP3-RCP7.0 (bottom row) for periods of 20 years centered around 2030, 2050 and 2090

Methods

The study provides a detailed assessment of projected climate parameters and related impacts on agriculture under different climate change scenarios – called Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs). In a **low emissions scenario** (SSP1-RCP2.6) global warming will likely be kept below 2 °C above pre-industrial temperatures. The **high emissions scenario** (SSP3-RCP7.0) builds upon the assumption of continuously high future greenhouse gas (GHG) emissions. The impacts of climate change on agricultural production and the potential of selected adaptation options to buffer these impacts are assessed based on **process-based crop simulations** and **suitability modelling**. Results have been complemented by a **cost-benefit analysis** and cross-checked by expert and literature-based assessments and two stakeholder workshops.

Climate impacts on water availability

Sufficient and timely water availability is not only key for agricultural production, but also for the energy security of Zambia as well as for maintaining and promoting resilient ecosystems. Moreover, Zambia is estimated to hold about half of the surface and underground water resources of Southern Africa, so that water availability in Zambia is also relevant from a regional perspective. This study analyses climate impacts on the water availability in the Kafue Catchment and in parts of the Zambezi Catchment (Fig. 4) and assesses the implications for the irrigation potential.

- **Average crop water demand:** Crop water demand is projected to increase for all considered global warming levels. The increase is projected to be highest in the south, with up to 10 % under the high-emissions scenario.
- **Average irrigation water need:** Already today, rainfall cannot meet the water demand of crops in the study area making further irrigation necessary. Projected changes in the irrigation water need show an increase throughout the whole case study area with no clear spatial pattern.
- **Average water availability:** Projections show a decrease in water availability of about 15 to 25 % in the high emissions scenario. A smaller part in the south shows an increase in water availability. However, this area is also where projections show a higher demand for water as shown by the crop water demand and the irrigation water need in this area.

The water balance analysis shows an **increase in water demand** due to rising temperatures with ongoing climate change. At the same time, most simulations show a **decrease in water availability** in the case study area. Consequently, the potential for irrigation will be further reduced in future. In addition to climate change impacts, there are socio-economic developments related to population growth, water allocation or potential conflicts over water which strongly influence water availability in Zambia. For example, per capita water availability is projected to decrease by 75 % per year until the end of the century. Moreover, there are barriers for implementation of irrigation schemes in Zambia. Large-scale irrigation schemes might thus not be easily accessible for the majority of smallholder farmers who currently practice rainfed agriculture. Hence, water resources and land management need to take account of multiple user groups and the local context – promoting more water-efficient irrigation technologies, region-specific drought and heat tolerant crops and sustainable agricultural practices amongst others. Furthermore, nature-based adaptation solutions can ensure that water resources are used sustainably while at the same time protecting nature conservation and forest areas in Zambia.

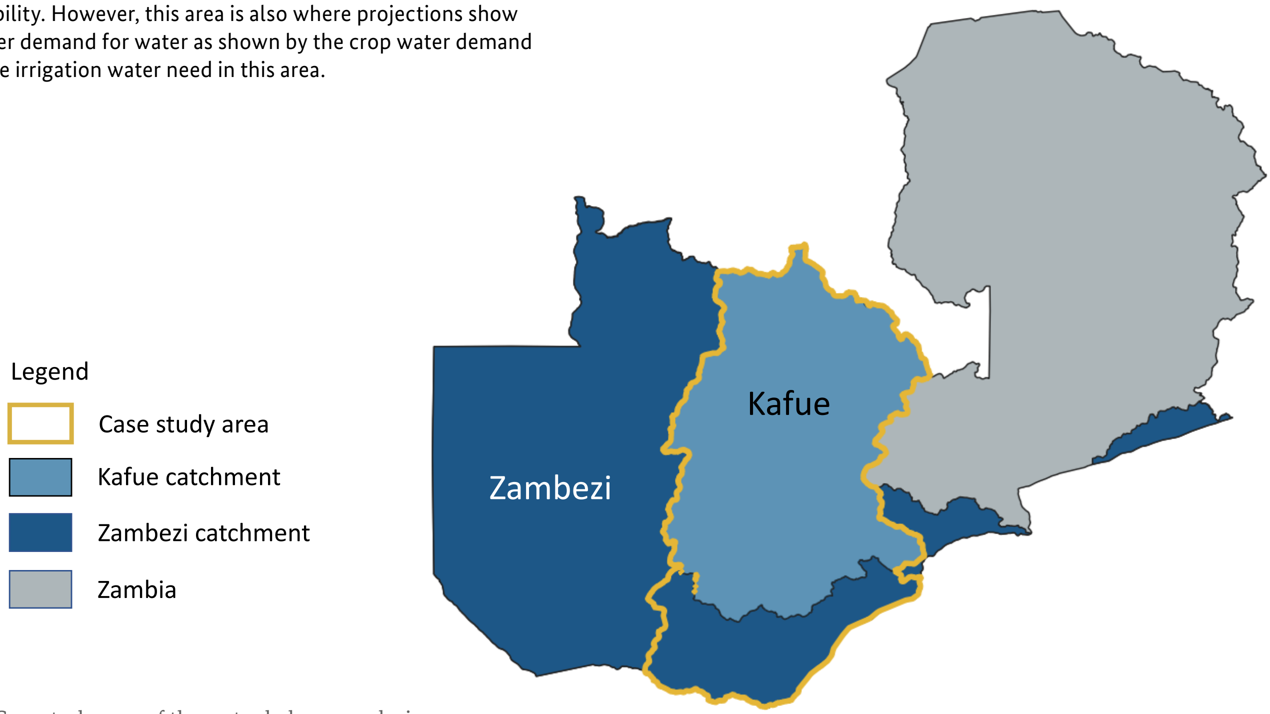

Figure 4: Case study area of the water balance analysis

Adapting to climate change impacts

With on-going climate change, there is a need for **sustainable intensification and adaptation measures** that can increase production and buffer climate shocks while minimizing environmental degradation. Possibilities to adapt to climate change in agriculture are manifold. They range from sustainable intensification measures and nature-based solutions to infrastructural, technological or institutional measures. Examples are sustainable use of fertilizer and improved cultivars, adjustment of planting dates, agricultural diversification to spread risks in case of harvest losses, water and soil management practices, water harvesting, agro-ecological approaches, agroforestry, climate services, livelihood diversification or integrated approaches which address climate adaptation and mitigating simultaneously. In light of the complexity of climate impacts, a meaningful **combination and integration of different adaptation options** considering the local context, intersectoral and gender aspects, the diversity of involved actors and co-benefits with climate mitigation is therefore crucial for effective adaptation responses.

This study analyses two adaptation options, namely **conservation agriculture** and **early warning systems,** which were selected jointly together with the Zambian Ministry of Agriculture and stakeholder priorities. Given the different nature of the two adaptation options (field-level adaptation measure vs. institutional adaptation measure), we used different methods for the evaluation. Whereas the risk-mitigation potential of conservation agriculture is assessed based on biophysical crop modelling, we provide an economic assessment of costs and benefits of early warning systems, focusing on the Participatory Integrated Climate Services for Agriculture (PICSA) approach. Additionally, both adaptation options are evaluated in terms of gender aspects and possible financing options.

Conservation agriculture

Conservation agriculture (CA) is a promising adaptation and sustainable intensification measure, defined as the bundle of practices involving minimum soil tillage, optimum organic ground cover with crop residue or cover crops and proper crop rotations.

- Under current climatic conditions, adopting CA practices would result in an increase in sorghum yields of 11 % compared to conventional tillage at the national level (Fig. 5).
- The greatest increases in sorghum yields would be expected in the currently drought prone areas in southern Zambia. Here an increase of 30.7 % could be achieved in the agro-ecological zones I and an increase of 26.5 % in agro-ecological zone IIa. In contrast, yields in agro-ecological zone III would not show significant changes in yields (i.e. <5 %) by mid-century.
- The climate change buffering potential of conservation agriculture is highest in the near future and decreases with time, particularly under the high emissions scenario.
- Whereas conservation agriculture has a high potential to improve soil quality and thus water availability, the model projections suggest that this adaptation measure alone will not be sufficient in terms of counteracting the strong temperature increases towards the end of this century.

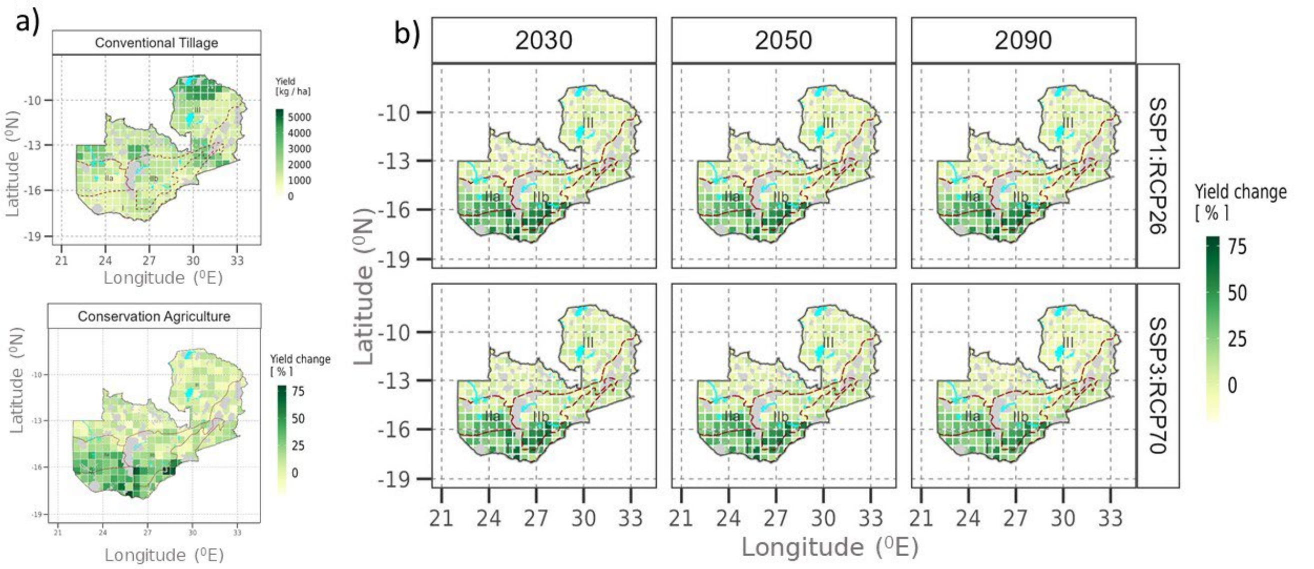

Figure 5: The grid-level spatial distribution map of a) projected sorghum yields in kg/ha under current climatic conditions with conventional tillage (top) and with conservation agriculture (bottom). b) shows changes in sorghum yield in % with conservation agriculture under the low emissions scenario SSP1-RCP2.6 (top) and the high emissions scenario SSP3-RCP7.0 (bottom) for periods of 20 years centered around 2030, 2050, and 2090

Conservation agriculture can play a vital role in adapting to increasingly extreme and dry climatic conditions in the near future in Zambia. Additionally, conservation agriculture has a positive impact on biodiversity and can contribute to climate change mitigation. However, towards the end of the century with increasing climate change impacts, the model projections indicate that conservation agriculture might not be sufficient anymore to mitigate the strong temperature increases. Moreover, evidence suggests that the projected productivity increases due to conservation agriculture are not sufficient to avoid further expansion of arable land into forest land in Zambia, which underlines the need for **complementary sustainable intensification measures** and land management. To address barriers to the implementation of conservation agriculture in Zambia, guidance and experiences with conservation agriculture, leveraging existing financing options as well as a careful gender-sensitive design of conservation agricultural practices are needed.

Financing options for conservation agriculture

The following **financing options** were identified that are particularly suitable to support the implementation of conservation agriculture in Zambia:

- **National Climate Fund or National Financing Vehicle (NFV):** A national financial facility providing finance, from both international and domestic sources, in the form of grants, concessional loans or equity investment, to initiatives that aim to strive towards mitigation and/or adaptation activities. Zambia is currently setting up a NFV to institute a climate resilient economy and has three financial institutions who have accreditation (or are getting ready for accreditation) to access financing from multilateral climate funds. Furthermore, Zambia's Ministry of Finance and National Planning is seeking accreditation as a national implementing entity to the **Adaptation Fund** and already is an accredited entity to the **Green Climate Fund**.

- **TerraFund:** An innovative climate finance instrument developed under the Global Innovation Lab for Climate Finance to provide loans to small and medium-sized enterprises (SMEs) working in land restoration. In Zambia, four locally led community organisations and entrepreneurs were part of the 100 project cohorts selected under the TerraFund for AFR100 initiative – Mooto Cashew Suppliers, Schools and Colleges Permaculture (SCOPE) Zambia, Solidaridad (Zambia), and WeForest Zambia.

- Sale of Carbon Credits: Carbon markets aim to turn emission reductions and removals into tradable assets and can be a powerful tool to tackle land and ecosystem degradation. In Zambia sale of carbon credits is already ongoing under the Community Markets for Conservation (COMACO). COMACO, with support from Shell and the GRZ, have successfully completed verification of 0.9 million tons of carbon credits for the nine chiefdoms that have protected customary land from destructive activities.

Early warning systems

Early warning systems have a high potential for **anticipating climate risks**, such as droughts, and can therefore contribute to improving food security and provide timely and effective information to avoid or reduce risks related to a hazard or to prepare for an effective response. Moreover, they contribute to both short-term and long-term risk reduction behaviour. For this study, we focus on the **PICSA approach** (box below), which uses early warnings to support farmers in making decisions about their own agricultural practices.

> The **Participatory Integrated Climate Services for Agriculture** (PICSA) is a participatory approach for climate services and agricultural extension. PICSA combines historical climate data and forecasts with farmers' knowledge of what works in their own context, and then uses participatory planning methods to help them make informed decisions about their agricultural practices. PICSA has already been applied successfully in at least 20 different countries, thereby training hundreds of thousands of farmers.

Based on **a cost-benefit analysis**, we evaluated the economic viability of introducing the PICSA approach in Zambia. The results show that PICSA is a **highly cost-effective adaptation measure** for farmers:

- The **net cash flow** of the PICSA implementation for smallholder farmers in Zambia increases sharply with time and is already positive after merely one year (Fig. 6).

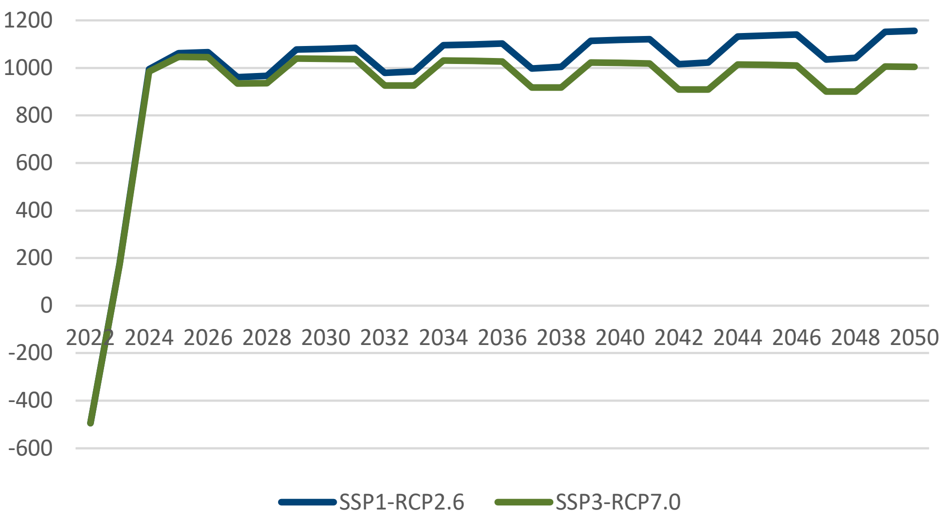

Figure 6: Net cash flow of the PICSA implementation for smallholder farmers in Zambia in Kwacha per farm beginning in the year 2022 until the year 2050 under the low emissions scenario SSP1-RCP2.6 and the high emissions scenario SSP3-RCP7.0

- The initial investment needed to employ PICSA already becomes economically beneficial after one year with **increasing returns** in the future under both climate change scenarios. Each USD invested in PICSA generates between 3.64 and 3.83 USD in benefits depending upon the climate scenario considered.
- Farmers, who participated in a PICSA training, can **improve their productivity and income**, which increases their resilience towards changing climate conditions and thus constitutes an important variable in the safeguarding of their long-term livelihood.

The analysis underlines the relevance of strengthening farmers in developing their individual livelihood strategies targeted to their specific and contextual needs.

Financing options for early warning systems

Two **financing options** are suggested for the implementation of early warning systems in Zambia:

- **Climate Risk and Early Warning Systems Initiative (CREWS):** CREWS is a pooled financing mechanism that aims to "significantly increase access to early warnings and risk information in Least Developed Countries and Small Island Developing States". CREWS has not yet been initiated in Zambia. However, CREWS pipeline of work includes a proposal to strengthen Hydromet and early warning systems as well as preparedness, early action and response by disaster management offices to hazardous Hydromet events across the Southern African Development Community (SADC) region, which Zambia is a part of. The US$ 5.5 million proposal, pending review by CREWS Trust Fund in January 2024, will leverage strategic collaboration and partnerships between UNDRR, World Bank, and WMO.
- **National Climate Fund or National Financing Vehicle (NFV):** See above under "Financing Options for Conservation Agriculture" for more details.

Gender

Climate impacts and adaptation processes are intrinsically linked with **gender** and other social factors, such as age, ethnicity, marital status or disability. Different social groups experience climate impacts differently and have **varying opportunities to adapt** to climate change:

- In **conservation agriculture**, labour requirements for different management steps (e.g. pre-tillage, basin digging, hand how weeding) vary between woman and men and need to be considered in the design and implementation of conservation agricultural practices.
- To counter power imbalances, the **PICSA approach** allows for the combination of farmers' traditional ecological knowledge with scientific information and can also identify and reduce gendered differences in rural households.

In summary, all community groups and income strata, including women and marginalized groups, should be engaged at all adaptation planning and implementation stages and levels. To **transform agricultural systems** towards greater gender equality, gender-disaggregated data and gender-sensitive approaches can help design gender-responsive adaptation strategies.

Risk	Risk retention	Risk transfer
Drought	Develop and implement risk retention instruments including: ■ National Disaster Relief Trust Fund ■ Contingent credit ■ Climate resilient debt clauses	■ Continue to expand coverage of agricultural microinsurance. ■ Work with development partners to explore opportunities for greater protection through ARC (i.e., increase the ceding percentage). ■ Encourage the uptake of ARC Replica and/or expand coverage of ARC. ■ Explore need/opportunity to optimise balance of risk transfer and risk retention mechanisms (once these are established).
Flood		■ Explore the development of private insurance market products for flood risk in buildings. ■ Continue to expand coverage of agricultural microinsurance. ■ Explore sovereign solutions, with a potential focus on property assets.

Table 1: Opportunities to close Zambia's protection gap

Climate and Disaster Risk Finance

In addition to climate adaptation, Climate and Disaster Risk Financing (CDRF) will increasingly become important to **close the protection gap** with on-going and increasing climate change in Zambia. According to the Disaster Risk Profile published by UNDRR & CIMA Research Foundation in 2019, Zambia currently faces an annual average economic loss of US$ 100 million due to drought and flood risks, a figure projected to escalate significantly in the forthcoming decades. CDRF is an **integral part of comprehensive risk management** and is concerned with arranging financing and funding for climate and disaster risks before a specific shock occurs. CDRF covers a wide range of instruments that reduce, retain or transfer residual risks. Yet Zambia still lacks a CDRF strategy, which could increase resilience by determining the **optimal mix of pre-arranged financing mechanisms** that enable swift and effective responses to disasters. Here we will focus on risk retention and risk transfer mechanisms that countries and specifically Zambia can use to reduce the protection gap, i.e., the difference between the expected financial impacts associated with disasters and the extent to which there are pre-arranged finance mechanisms in place:

- **Risk retention mechanisms:** The country remains responsible for meeting the necessary costs (i.e., the risk is retained) but has developed **pre-arranged financial instruments**, such as reserve funds, budget lines or contingent credit, to ensure that it can access funding quickly.

- **Risk transfer mechanism:** The responsibility for providing financial resources in the event of a disaster is transferred to a third party, in exchange for a premium**. Risk transfer instruments** include a range of different insurance products as well as alternative risk transfer instruments such as catastrophe or disaster relief bonds.

Similar concepts can also be applied when considering how households and businesses respond to the impacts of disasters. In general, most analyses show that **risk retention instruments** are more cost effective for covering the costs associated with relatively low impact disaster events that happen more frequently. By contrast**, risk transfer instruments** are generally considered to be more effective in providing finance for less frequent but more severe disasters. This is known as **risk-layering**.

Zambia has already taken some important steps to plan for and finance the impact of disasters. Yet the current protection gap for drought and flood risks in Zambia amounts to 43 % in the agricultural sector and 82 % in the entire economy. This quantification of the protection gap considers the budget of the Zambia's Disaster Management and Mitigation Unit (DMMU), the annual value of grain provided for free by the Food Reserve Agency the country's contingency fund, its African Risk Capacity (ARC) cover and various insurance schemes. Table 1 summarises the key insights from the protection gap analysis that could inform the design of Zambia's future CDRF strategy.

Moreover, engaging with the Global Risk Modelling Alliance (GRMA) hosted by the InsuResilience Solutions Fund is highly recommendable as a successful application would **unlock grant-funded risk modelling** and **data support** according to the needs of the Government of the Republic of Zambia. This support could be complemented by the G7/V20-Initiative "**Global Shield against Climate Risks**" if Zambia will become a Global Shield Partner Country in the future.

Policy recommendations

- **Crop diversification and locally adapted crops to take account of region-specific climate impacts:** Locally-adapted crops should be promoted that can better cope with the specific climatic conditions in the different agro-ecological zones within Zambia. **Crop diversification** can help to spread production and economic risks over a broader range of crops. Promoting crop diversification and regionally adapted crops within the Comprehensive Agricultural Transformational Support Programme (CASTP) and the **Farm Block Development Programme** would therefore contribute to better prepare for climatic risks in the agricultural sector in Zambia.

- **Region-specific and holistic adaptation planning:** Adaptation planning should be regionally specific. Conservation agriculture is particularly beneficial in drought-prone areas in Zambia. In a holistic system approach, single adaptation options need to be combined and integrated to **foster synergies between different options** and to consider intersectoral aspects.

- **Coupling location-specific climate information with local knowledge for actionable early warning systems:** A nation-wide implementation of the **Participatory Integrated Climate Services for Agriculture** (PICSA) would be a highly cost-effective investment towards making farmers more resilient to climate change in Zambia.

- **Integrated water and land management to adapt to decreasing water availability with climate change:** Climate change coupled with socio-economic factors, such as population growth and economic development, will further add pressure on Zambia's water resources. To address water shortages in Zambia, **integrated land and water resources management** should be a priority for agricultural development planning, integrated in the Farm Block Development Programme and Irrigation Master Plan and involve mandated institutions.

- **Designing gender-responsive adaptation strategies:** All community groups and income strata, including women and marginalized groups, should be engaged at all adaptation planning and implementation stages and levels. Gender-disaggregated data and **gender-sensitive approaches** can help design gender-responsive adaptation strategies.

- **Financing adaptation measures:** To finance climate adaptation in Zambia, a **National Climate Fund** would help to bundle climate finance from various domestic, international, public and private sources and disburse it to a broad range of initiatives.

- **Developing a climate and disaster risk finance strategy:** The development of a **climate and disaster risk finance and insurance strategy** to identify disaster risk finance needs should be prioritised.

A report prepared by the Potsdam Institute for Climate Impact Research (PIK) together with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), in cooperation with the HFFA Research GmbH and stakeholders from local and national governmental institutions, civil society, academia, the private sector, practitioners and development partners. The analyses have been conducted as part of the project AGRICA - Climate risk analyses for adaptation planning in sub-Saharan Africa.

For more information and further study results, please visit www.agrica.de

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