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Executive Summary

Climate Risk Analysis for Identifying and Weighing Adaptation Strategies in Burkina Faso's Agricultural Sector

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The Executive Summary is complemented by the Scientific Report and a Policy Brief.

Setting the Scene

Climate change is already affecting the agricultural sector in Burkina Faso and its impacts will continue to increase in the future. This puts livelihoods and economic growth at risk and shows the urgent need for effective adaptation strategies. However, decision-makers in Burkina Faso have to cope with limited information on climate risks and on suitable adaptation strategies.

This summary provides decision-makers and implementers in Burkina Faso with **localised information on current and future climate risks for the agricultural sector** including information on future crop yields**.** It presents **four suitable adaptation strategies** which enable farmers to cope with these climate risks and stabilise their crop yields. Additionally, this summary makes **suggestions for strengthening an enabling environment** that supports all farmers in taking up adaptation strategies that are most suitable for them.

Key Recommendations[1]

Climate Information Services (CIS) can help farmers to make informed decisions and thereby raise yields with little additional efforts. CIS represent a highly beneficial adaptation strategy with a rather small-scale investment and a positive return, but require high institutional support for optimal application. Communication needs to be timely, actionable and targeted to end-users needs. It is therefore crucial to promote awareness raising and access to those services.

Irrigation has the potential to mitigate climate risks in Burkina Faso as well as to help diversify diets and ensure food security, but needs the provision of support services to avoid over-exploitation of already scarce water resources in the long-term. Raising awareness about water-saving irrigation management is crucial to ensure a long-term responsible use of natural resources. We therefore recommend low-cost irrigation options with low maintenance requirements across Burkina Faso, where water resources are available.

Integrated Soil Fertility Management (ISFM) includes various indigenous practices that hold great potential for climate change adaptation with various co-benefits. We therefore recommend policies towards sustainable land use intensification, as well as the rehabilitation of degraded soils and the necessary mechanisms to implement and evaluate these, as this can help to promote the uptake of ISFM.

Improved crop varieties present a high-risk mitigation potential and high cost-effectiveness. To efficiently use improved crop varieties and to limit potential negative outcomes, there is a need for more institutional support due to a lack of seeds suitable for the local context as well as the limited knowledge on the use of the available improved varieties. To account for uncertainties in future emissions, one high emissions scenario (SSP3-RCP7.0) and one low emissions scenario (SSP1-RCP2.6) were used. Thereby, the high emissions scenario is built upon the assumption of continuously high future emissions, while the low emissions scenario assumes high mitigation efforts and thus a future that is in line with the Paris Agreement and global warming that is likely well below 2 °C.

[1] Further information on the four adaptation strategies is detailed in sections “Adaptation Strategies” and “Policy Recommendations for an Uptake of Adaptation Strategies”.

The Study Area

The Climate Risk Analysis focuses on Burkina Faso, a **semi-arid landlocked country in Western Africa in the Sahel**, bordering Mali to the west and north, Niger to the northeast, Benin to the southeast and Ghana, Togo and Côte d'Ivoire to the south.

Burkina Faso can be divided into **five agro-ecological zones** (AEZ) (Figure 1), which also define the agricultural production in the country: the arid/Sahel zone to the north, the semi-arid/Sudan savannah and the northern Guinea savannah spanning the central part of the country, and the southern Guinea savannah and derived savannah to the south.[2]

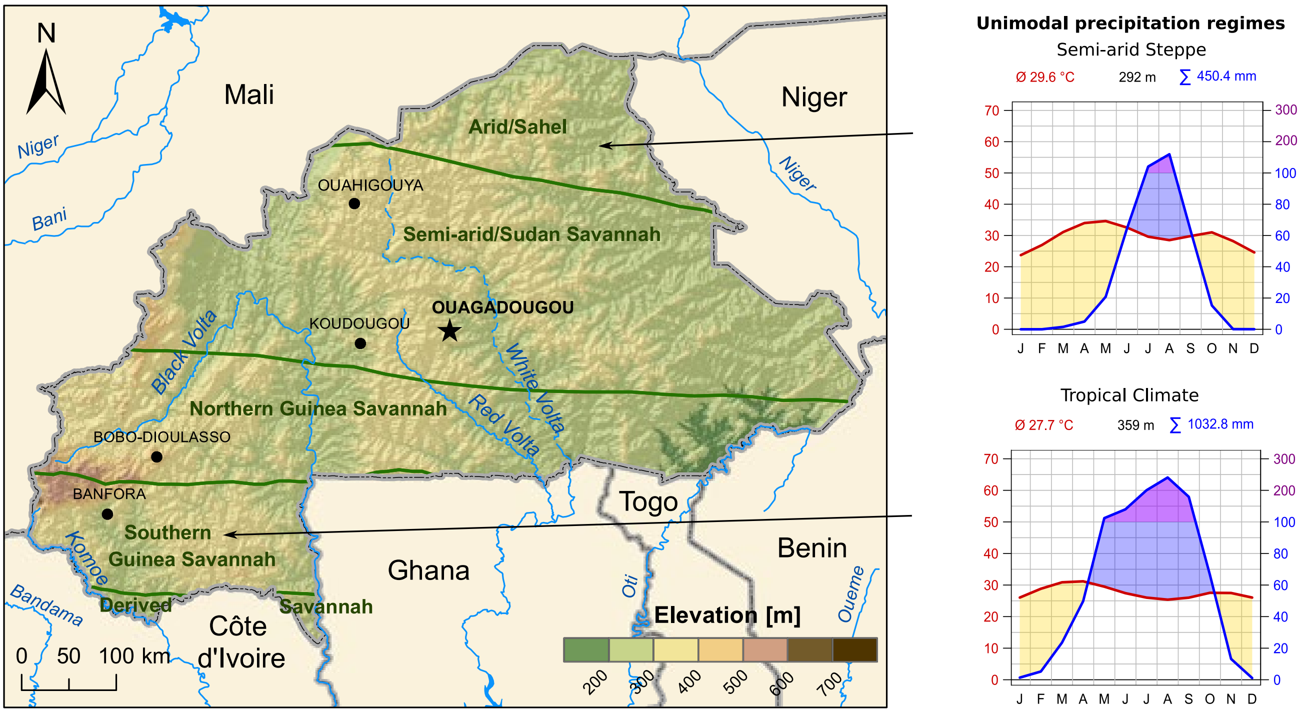


Figure 1: Topographical map of Burkina Faso with agro-ecological zones adapted from International Institute of Tropical Agriculture

The climate of Burkina Faso is characterised by a **mean annual temperature of 27–30** °C, with higher values in the north of the country, and a single rainy season. The total **amount of annual rainfall is between 300 and 1 100 mm**, with decreasing values towards the north, and most rainfall between mid-April and end of September for the south, and between mid-July and mid-August for the northern part of the country (Figure 1). Although the amount of rainfall varies greatly from year to year, a general shift towards a drier climate with decreasing rainfall and increasing drought frequency and intensity has been noticed since the late 1960s.

Climate trends and impacts on crop and livestock production ought to be examined closely, since these two sectors are seminal for the national economy, food and nutrition security. 80–90% of the population is engaged in smallholder farming and heavily relies on rainfed agriculture for food security and livelihoods (FAO, 2014). Furthermore, food demand will increase as the population is expected to double within the next 25 years. In addition, limited economic and institutional capacity may hamper adaptation efforts. The vulnerability of smallholder farmers to climate change being likely to increase further in the coming years, **Robust science-based adaptation planning in Burkina Faso is required in order to improve their resilience.**

[2] It should be noted that there are different classifications of AEZs in Burkina Faso. We focused on a commonly used classification of five zones.

Past and Projected Future Climate Changes

Table 1: Overview of changing climatic conditions for Burkina Faso.

Climate Impact	Past Trend	Future Trend[3]	Certainty[4]
Mean annual temperature	Increasing	Increasing	Very high
Number of very hot days & tropical nights	Increasing	Increasing	Very high
Heavy rainfall intensity & frequency	Increasing	High emissions scenario: Increasing Low emissions scenario: No clear trend	High High
Mean annual rainfall sums	Increasing since the 1980s	Increasing	Medium
Rainy season onset	No clear trend	High emissions scenario: No clear trend Low emissions scenario: Later onset	Low

Past climate changes

- **Temperature** has increased in the last decades in Burkina Faso, with a **rise of 0.27 °C in the annual mean temperature between 1988 and 2006** (Figure 2).
- Burkina Faso is **slowly recovering from decades of drought** (1970s–1980s) with mean annual **rainfall sums, heavy rainfall intensity and frequency having increased since then**. However, rainfall amounts are still below those of the mid-20th century, and are characterised by high year-to-year variability and regional differences. Higher increases were observed in the north than in the rest of the country (Figure 3).

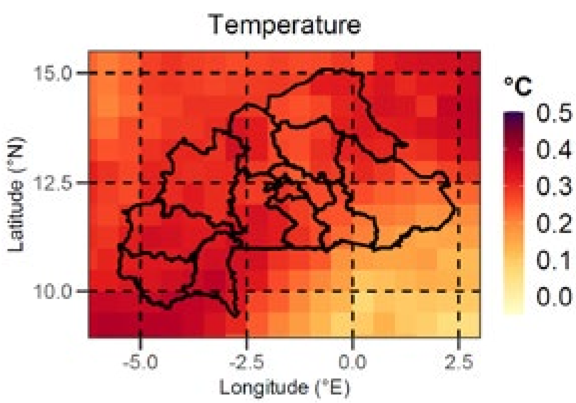


Figure 2: Difference in mean daily temperature in °C over Burkina Faso from 1988 to 2006.

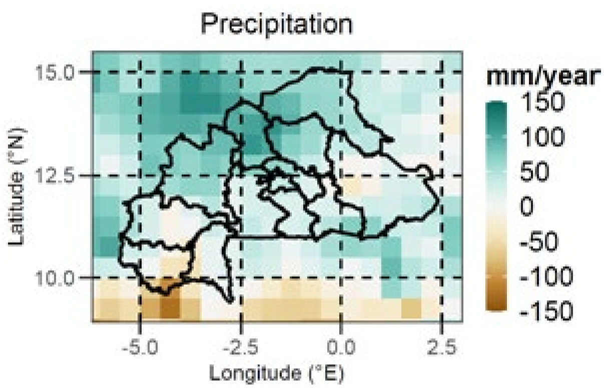


Figure 3: Difference in mean annual precipitation in mm over Burkina Faso from 1988 to 2006.

[3] The trend is determined by a Mann Kendall Test with significance level 0.05 for the years 1979–2016 in the past and the years 2015–2100 under the respective emissions scenario in the future. If at least 40% of the models show a significant trend in the same direction, a trend with a specific uncertainty level (see next footnote) is stated.

[4] The certainty level of future climate projections is determined by the percentage of models agreeing on the trend (with significance level of 0.05) (compare IPCC, 2014). ≥ 90%: very high; ≥ 80%: high; ≥ 50%: medium; ≥ 50%: low.

Future Projections

Future projections of temperature show an overall continuation of the recent increasing trend (Figure 4). **Mean daily temperature is projected to increase between 0.9** °C **(low emissions scenario) and 1.3** °C **(high emissions scenario) by 2050,** compared to 2004. Further rises until the end of this century will occur under high future emissions. Additionally, **extreme temperatures, namely the number of very hot days** (maximum temperature above 35 °C) and **tropical nights** (minimum temperature above 25 °C)**, will increase** in all parts of the country under both emissions scenarios. In particular, the high emissions scenario projects 308 very hot days and 270 tropical nights for the end of the century.

Future rainfall projections are subject to modelling **uncertainty,** especially under the high emissions scenario. In case of low global efforts in climate mitigation (i.e. high emissions scenario), **mean annual rainfall sums** (Figure 5) and **extreme rainfall events might increase until 2050 and beyond**. Should there be strong climate change mitigation (i.e. low emissions scenario), Burkina Faso would see slight increases in the mean annual rainfall sums during the next decades, followed by a slight decline from mid-century, while having no or little changes in heavy rainfall intensity. As for the rainy season, models hint at a later onset under the low emissions scenario and no clear trend under the high emissions scenario, with regional differences and changes over time. More generally, the year-to-year variability will remain high for the rainfall amounts as well as the rainy season onset, offset and length.

To account for uncertainties in future emissions, one high emissions scenario (SSP3-RCP7.0) and one low emissions scenario (SSP1-RCP2.6) were used. Thereby, the high emissions scenario is built upon the assumption of continuously high future emissions, while the low emissions scenario assumes high mitigation efforts and thus a future that is in line with the Paris Agreement and global warming that is likely well below 2 °C.

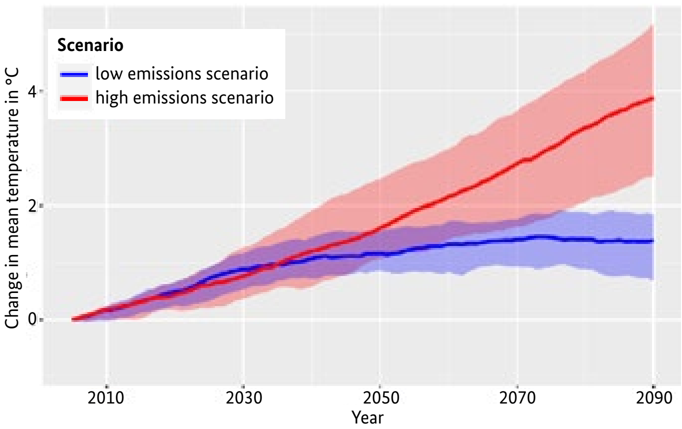


Figure 4: 21-year running mean of change in mean annual temperature in Burkina Faso under the low emissions scenario (blue) and the high emissions scenario (red).

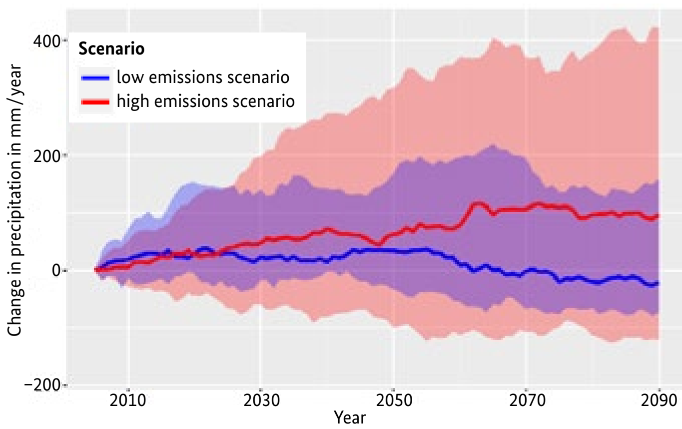


Figure 5: 21-year running mean of change in mean annual rainfall sum in Burkina Faso under the low emissions scenario (blue) and the high emissions scenario (red).

Past and Projected Future Hydrological Changes

Hydrological changes, and therefore water availability changes, are important to evaluate given that Burkina Faso has a primarily rural population reliant on agriculture and living under an arid to semi-arid climate. Past and future hydrological changes have been simulated using a semi-distributed hydrological model that is driven by the greenhouse gas concentration pathway scenarios and global climate models' outputs.

Table 2: Summary of the hydrological changes.

Impact	Trend past	Trend future	Confidence[5]
River discharge	Increasing	Increasing, decreases possible under the low emissions scenario	Medium
Groundwater recharge	Increasing	Increasing	Medium
Evapotranspiration	No major change	Increasing	High
Flood peak discharge	Increasing since the 1990s	Increasing, but shifts in regime possible	Medium

Past hydrological changes

Past hydrological changes in Burkina Faso are dominated by inter-annual and decadal variability: the 1950–60s were predominantly wet periods, followed by severe droughts in the 1970–80s (Conway et al., 2009; Descroix et al., 2012b; Mahe et al., 2013). Since then, **precipitation amounts and river discharge are recovering with a recently increasing trend**. Additionally, water management has improved, and numerous small reservoirs and deep wells have been constructed to deal with the high variability of runoff (Pavelic et al., 2012).

Projected hydrological changes

In line with increasing precipitation, the **annual average of river discharge** is projected to **increase generally, although not under all emissions scenarios and global climate models**. The largest rivers of Burkina Faso, the Black Volta (Mouhoun) and the White Volta (Nakambé), are projected to carry 18–30% more annual discharge within the next two decades (2021–2040) under both emissions scenarios, compared to the reference period (1995–2014). The discharge is then projected to either increase by 20–34% and eventually decline to about −10 to −20% in 2080–2099 (low emissions scenario) or remain 50–60% higher compared to the reference period until the end of the century (high emissions scenario).

The increases in precipitation amounts partially also translate to **greater annual rates of groundwater recharge mainly under the high emissions scenario** in large parts of the country, especially in the agriculturally important south. Under the low emissions scenario, decreases are more likely towards the end of the century, especially in the south-west of the country, yet these changes are not statistically significant.

Evapotranspiration is projected to increase moderately by 2–6%, assuming similar vegetation cover as in the reference period.

Annual peak discharge, an indicator for the seasonal flood, is expected to increase in line with seasonal increases in discharge, **increasing the likelihood of flooding**.

Therefore, future projections of hydrological changes mainly show a continuation of the past trends but slight variations such as shifts in regime of flood peak discharge are possible.

[5] The confidence level of future climate projections is determined by the percentage of models agreeing on the trend (compare IPCC, 2014). ≥ 90%: very high; ≥ 80%: high; ≥ 50%: medium; ≤ 50%: low.

Climate Impacts on Agricultural Production

Table 3: Summary of climate change impacts on agricultural production showing overall trends at national level (for further information about regional differences, see the full Climate Risk Analysis).

Impact	Current situation	Future trend	Certainty
Weather influence in sorghum yields	50%	-	Medium
Sorghum suitability	Medium	Relatively stable (low emissions scenario) Relatively stable (high emissions scenario)	High
Sorghum yields	Medium	Decreasing (low emissions scenario) Decreasing (high emissions scenario)	Medium
Weather influence in millet yields	70%	-	Medium
Millet suitability	Medium	Relatively stable (low emissions scenario) Relatively stable (high emissions scenario)	High
Weather influence in maize yields	70%	-	Medium
Maize suitability	Low to medium	Relatively stable (low emissions scenario) Relatively stable (high emissions scenario)	High
Cowpea suitability	Medium	Decreasing (low emissions scenario) Decreasing (high emissions scenario)	High

Using statistical and process-based crop models, the impacts of climate change on the following four staple crops were analysed: the **annual grain crops sorghum, millet** and **maize** as well as the **annual legume cowpeas**. These four crops were selected based on stakeholder interests, their use in the Burkina Faso, data availability and suitability for the crop models.

Sorghum is an annual grass species cultivated for its grain. The crop takes 90–300 days to mature. Sorghum is adapted to warm days and night temperatures above 22 °C throughout the growing season and requires about 500–1000 mm of rainfall for optimal growth.

- **Current suitability: More than half of the country's territory is considered either optimally or moderately suitable** for sorghum production under current climatic conditions.
- **Projections:** Crop models show that the **suitability to grow sorghum will increase in some areas and decrease in others** by 2030, 2050 and 2090. Decreases might outnumber increases, except in 2050 and 2090 under the high emissions scenario. At worst, 10.3% of the areas that are currently suitable for sorghum will lose their suitability by 2090 under the low emissions scenario. Besides, sorghum suitability will remain stable in most areas where precipitation is projected either to increase or not to change. In addition to the suitability analysis, sorghum was used as a case study to analyse yield changes using a process-based model. At the national level, sorghum yields are projected to remain nearly unchanged until the end of the century. However, changes in sorghum yields will vary between regions**, models suggest increasing yields in a few northern regions** (Sahel, Nord, and Centre-Nord; up to +30% under the low emissions scenario and up to +20% under the high emissions scenario) and a **decreasing trend in the south** (Cascades, Haut-Bassins, and Sud-Ouest; down to −30% under the low emissions scenario and down to −20% under the high emissions scenario).

Millet is one of the main staple crops in Burkina Faso, cultivated as a food grain and a forage crop. It can grow under conditions considered as too harsh for other food crops, i.e. on soils that are low in fertility and receive relatively low amounts of rainfall. Millet takes 55 to 280 days to mature and thrives under 20–32 °C and 500–750 mm of precipitation.

- **Current suitability:** Today, **60.9% of Burkina Faso is moderately to optimally suitable for millet production,** especially in the southern part of the country.
- **Projections:** Areas will **remain largely suitable for millet production** under climate change. The future general climatic conditions will meet the production requirements for millet, except for a few areas where a loss in suitability is projected.

Maize is a vigorous annual grass and grain crop. Its maturing period depends on local conditions and can vary 65 to 365 days in Burkina Faso. Temperature and rainfall during the growth period should be between 18 °C and 33 °C, and 600 to 1200 mm respectively.

- **Current suitability: Only a fifth of Burkina Faso is optimally suitable for maize production**, mainly in the south-western and the central-southern parts of the country.
- **Projections:** Maize **suitability will largely remain unchanged** under both emissions scenarios.

Cowpea is an annual legume that is adapted to semi-arid and hot climate and grows on sandy soils. Like most other legumes, cowpea can fix nitrogen in the soil leading to improved soil fertility. The crop takes 60 to 240 days to mature and needs 20–35 °C as well as 600–1500 mm of precipitation during the growing season.

- **Current suitability:** Currently **suitable areas for cowpea are in the southern parts of the country extending to the western areas.**
- **Projections: Relatively high net losses in cowpea suitability are expected** throughout the century under both emissions scenarios.

Overall, the **areas suitable to grow cowpea are projected to decrease under climate change in Burkina Faso, while those for sorghum, millet and maize will remain stable.** Crop suitability is primarily determined by the amount of rainfall in the growing season for sorghum and cowpea, the annual temperature range for millet, and the growing season temperature for maize. A **multiple crop suitability analysis** shows that 11.5% of the country is suitable for producing at least 3 of the 4 crops under current conditions, but this will decrease to 9.2% (low emissions scenario) and 8% (high emissions scenario) by 2090. The Boucle du Mouhoun, Nord and Centre-Ouest regions are the most likely to experience such decreases, whereas the potential for multiple cropping is thought to increase in the Haut-Bassins (south-west part of the country). More generally, **crop suitability will shift southwards under climate change conditions**, with more severe shifts under the high emissions scenario.

Climate Impacts on Livestock Production

Table 4: Summary of climate change impacts on livestock production.

Impact	Trend past	Trend future	Confidence
Livestock number	Increasing	- no data -	-
Fodder availability, grazing potential	Decreasing	Decreasing (low emissions scenario) Decreasing slightly (high emissions scenario)	High

The impacts of climate change on grassland productivity and therefore grazing-based livestock production (cattle, sheep, goats) in Burkina Faso have been analysed using a process-based dynamic global vegetation model.

Currently, the grazing potentials are the highest in the Cascades Region, exceeding 3.5 tonnes dry matter per hectare per year along the border with Côte d'Ivoire. Grazing potentials decrease towards the north-east following the decreasing precipitation gradient across Burkina Faso. The lowest potentials are found in the Sahel region, going down to less than 1.5 tonnes dry matter per hectare per year along the border with Niger and Mali.

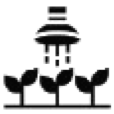
There is high agreement among climate models that **grazing potentials will decrease in Burkina Faso over the course of the century**, under both high and low emissions scenarios, with larger losses under the latter. 4% (high emissions scenario) to 10% (low emissions scenario) of losses are expected by 2090, compared to the period 1995–2014. Besides, some climate model simulations point to a slight increasing trend in grazing potentials in the Sahel region that is contrary to the trend for the rest of the country. While there is high confidence in this positive trend under the high emissions scenario, only a minority of models project it under the low emissions scenario.

Adaptation Strategies

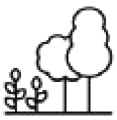
Well-designed and implemented adaptation strategies can not only **reduce present and future yield losses** induced by climate change, but also have various **positive economic, social and environmental co-benefits** and **can contribute to combating land degradation**.

Based on the projected climate change impacts and stakeholder interests, **four adaptation strategies** were analysed regarding their suitability under changing climate conditions in Burkina Faso:

Climate Information Services (CIS) provide a timely decision aid, in order to assist individuals and organisations to improve ex-ante planning, policy and practical decision-making about planting dates, crop varieties, fertiliser application and other production factors. CIS foster information and knowledge exchange, and can help to compensate for uncertainties regarding water availability and agricultural production. The use of information systems, including CIS, is one of the five strategic axes defined in the country's NAP and is considered as a priority area in agricultural development as well as in climate adaptation. However, smallholder farmers currently have limited access to CIS, likely due to a lack of production and provision of climate information from databases and research (Alvar-Beltrán et al., 2020).



Irrigation: Since precipitation is increasingly erratic and the growing season is limited to the five-month rainy season, irrigation can help farmers to secure their income and livelihoods throughout the year. Currently, it is mainly practised as an off-season engagement (December – April) on cereals (rice and maize) and vegetable crops, conducted in addition to common water management practices such as Zaï and half-moon. While most irrigations systems are initiated and managed by farmers themselves, a few large and small-scale dams (e.g. Bagré Dam on the White Volta) and irrigation systems have been set up across the country with the support of the Burkinabé government and international donors.



Integrated Soil Fertility Management (ISFM) is a set of soil fertility management practices adapted to local conditions, and that include the use of fertiliser, organic inputs and improved germplasm (Vanlauwe et al., 2010). Zaï, half-moons, stone bunds, filter bunds, grass strips and mulching are all ISFM practices that help to prevent land degradation and improve soil fertility. They have already been adopted by some Burkinabé farmers for decades, particularly in the central and northern areas of the country.

Improved crop varieties are plant species that have higher tolerance to abiotic stressors (e.g. drought), better resistance to diseases and pests, or improved resource use. Their cultivation would result in enhanced quality and/or quantity of the crops, or help to improve the agronomic management if for example the growing cycle is shorter. In Burkina Faso, improved varieties exist mainly for maize, millet, sorghum, cowpea, rice, cassava, sesame, vegetables and cotton, the latter being the most sown. Nevertheless, the adoption rate of improved seeds is currently low, as most seeds are farmer-saved landraces which come from family inheritance or exchange between producers. The highest uptake rate can be found in the Haut-Bassins region.

Cost-Benefit Analysis

A **farm-level cost-benefit analysis** (CBA) was carried out for four different adaptation strategies in the district most suitable for the strategy. Thus, the economic benefit of using climate information services for rainfed maize cultivation[6], complementing rainfed maize cultivation with irrigation, implementing soil and water management technologies in rainfed sorghum cultivation, as well as using improved varieties of sorghum could be assessed.

Different economic indicators give detailed insights on the economic potential of the adaptation strategies. In the table below, two indicators are displayed: (1) the benefit-cost ratio (BCR) which represents the ratio between discounted benefits and costs of a strategy and is greater than 1 for economically beneficial strategies and (2) the net present value (NPV) which represents the discounted net benefit for a strategy applied on one acre (approximately 4 050 m²). Uncertainties based on future emissions, future economic developments as well as other factors were included in the results whenever possible. Given that the assumptions used are slightly different between the adaptation strategies, the results should only be compared with caution.

Table 5: CBA of four adaptation strategies with values for BCR and NPV.

Adaptation strategy	Benefit-cost ratio in 2050	Net present value per acre
Rainfed maize cultivation using climate information	1.95 (low emissions scenario) 2.00 (high emissions scenario)	244,000 CFA (low emissions scenario) 259,000 CFA (high emissions scenario)
Rainfed maize cultivation under supplementary irrigation	1.14 (low emissions scenario) 1.17 (high emissions scenario)	804,000 CFA (low emissions scenario) 959,000 CFA (high emissions scenario)
Sorghum cultivation with integrated soil fertility management	1.29 (low emissions scenario) 1.65 (high emissions scenario)	77,000 CFA (low emissions scenario) 176,000 CFA (high emissions scenario)
Sorghum cultivation with improved crop varieties	7.87 (low emissions scenario) 6.82 (high emissions scenario)	1,991,000 CFA (low emissions scenario) 1,687,000 CFA (high emissions scenario)

The indicated values for BCR and NPV display positive economic returns (after 2 years for CIS, 10–11 years for irrigation, 6–10 years for ISFM, in the first year of usage for improved crop varieties) for all strategies irrespective of the emissions scenario (high or low) or future economic development pathway (negative or positive). Thus, **all four analysed strategies were found to be economically beneficial under the current as well as the projected future climate**, compared to business-as-usual agricultural practices. More specifically, the results indicate that for our case studies, **the use of improved varieties of sorghum has the highest ratio between benefits and costs followed by IFSM for sorghum, CIS for maize and supplementary irrigation for maize cultivation.**

[6] Due to a lack of data for Burkina Faso, crop model results from selected districts in North-West Ghana (using also a low (SSP1-RCP2.6) and high emissions scenario (SSP3-RCP8.5)), where production and climate conditions are largely comparable to case study districts of Burkina Faso, have been used for the maize projections.

Policy Recommendations for an Uptake of Adaptation Strategies

The four adaptation strategies were also analysed looking specifically at their biophysical risk mitigation potential as well as soft-assessment indicators including **co-benefits, potential negative outcomes, barriers for implementation, the potential to reduce climate risks as well as existing inequalities**. These results lead to policy recommendations that can support the sustainable uptake of individual adaptation strategies by maximizing potential co-benefits and minimizing negative consequences. The policy recommendations are detailed in the following table.

STUDY RESULTS & POLICY RECOMMENDATIONS

Climate information services (CIS) can help farmers to make informed decisions, thereby conduct a more targeted agricultural production and raise yields with little additional efforts. With a rather small-scale investment and its positive return, **CIS represent a highly beneficial strategy**. Nevertheless, CIS require high institutional support, from national meteorological agencies and research institutes among others. It should also be noted that results depend on the local context, the climate, the type of crops as well as the type and accuracy of CIS. Furthermore, equitable access to CIS should be ensured, otherwise existing social inequities may deepen.

Policy recommendations

- **Awareness raising campaigns** can help to inform farmers and rural communities about the advantages of CIS and gain trust in the information received. Furthermore, **trainings** on CIS can help farmers and especially rural women to fully understand the communicated information and to be able to act on it. **Ensuring that women and other minority groups have equal access** to CIS can contribute to promote gender equality in agricultural production.
- Existing **communication channels** (radio, television, word of mouth) currently represent the most effective way for CIS upscaling, yet new information channels (mobile phones, smartphones, internet-based devices) and sources are being developed throughout Burkina Faso and should be considered to reach optimal coverage. Therefore, access to more modern information and communication technology (e.g. smartphones, internet) should be supported.
- CIS should be **targeted to the various end-users needs**. An analysis along the whole value chain can help to identify those needs and develop target-oriented formats and makes communication more effective.
- When disseminating information through CIS it is crucial to ensure timely and actionable **communication in the local language(s)** and effective use of e.g. visualisation and audio formats to **overcome access barriers** for poorly educated or illiterate people.

Irrigation can mitigate climate risks in Burkina Faso and help diversify diets and ensure food security by: (**1**) **supplying the water needed during the rainy season**, thereby mitigating the impact of dry spells on staple crops and by **(2) enabling farmers to cultivate irrigated high-value crops** such as vegetables during the dry season, for both household consumption and (market) sales.

However, this requires high investments, maintenance costs, technical knowledge, as well as institutional support, and is likely to put additional pressure on water resources and land. Provided that irrigation is developed in a planned and equitable manner, **the adaptation strategy** has the potential to **strengthen the livelihoods of farming and non-farming households**. Employment opportunities are created especially in the dry season, as labour is required for the construction, operation and maintenance of irrigation facilities. In return, these opportunities can reduce rural exodus, and help households to pay for education and health-related expenses among others. Besides, irrigation facilities, including small dams and reservoirs, can also act as protective infrastructures to control seasonal floods.

Policy recommendations

- **Low-cost irrigation options with low maintenance requirements** should be promoted across Burkina Faso, where water resources are available.
- **Awareness raising about water-saving irrigation management** is crucial to ensure a long-term responsible use of natural resources and should therefore go hand-in-hand with irrigation promotion.
- Ideally, **water saving equipment such as drip irrigation and smart irrigation systems should be promoted** and supported by extension services to encourage farmers to use sustainable and environment responsible techniques.
- **Provision of support services is needed** to ensure the ability of farmers to further operate the technology and take care of their maintenance.
- For upscaling irrigation, all user interests in water and energy should be carefully considered. **Dispute settlement mechanisms can be implemented to address potential conflicts** between upstream and downstream users.
- Developing **financing mechanisms**, such as access to loans or credits, can support the accessibility for irrigation equipment.

Since it contributes to improve water use efficiency, prevent erosion and restore degraded lands, **integrated soil fertility management (ISFM)** holds great potential for climate change adaptation. In Burkina Faso, such measures have already proven successful in ameliorating soil structure, crop yield, groundwater recharge, rainfall infiltration and tree density (Sawadogo, 2011; Zougmore et al., 2003). For example, the adoption of Zaï can entail significant increases in sorghum yields over all regions of Burkina Faso, especially in the north, up to 600%. The livestock sector will also benefit from ISFM, because of the greater availability of forage entailed, due to the regeneration of vegetation and increased crop residues. Despite these substantial benefits, the uptake of ISFM can be difficult due to its strenuous manual labour requirements and the implications on farmers' income.

Policy recommendations

- **Awareness raising and training** on the advantages and implementation of ISFM to support the effectiveness of this strategy, which is relatively time consuming for farmers.
- **Policies towards sustainable land use intensification, as well as the rehabilitation of degraded soils** and the **necessary mechanisms to implement and evaluate such policies** can help to promote the uptake of ISFM.
- **Research on innovative ISFM practices and dissemination of results** can improve the effectiveness of the technology and further strengthen the adoption rate.
- The public sector can play an important role in creating a platform for bringing together and linking key partners in research, education, extension, service providers, input providers, and farmers to facilitate farmer mobilisation and capacity development.
- Policies that incentivise **credit and loan schemes and subsidy programmes for the production of organic inputs** could also address the issue of a lack of access to equipment and input.

Improved crop varieties are a promising adaptation strategy which presents a high-risk mitigation potential and high cost-effectiveness. Not only does its use bring about higher household incomes and therefore increased opportunity to improve other life areas, but it also helps to fight undernutrition and malnutrition as crop yields and levels of nutrients will increase (up to a 150% yield increase in the north under both emissions scenarios). Furthermore, the cost-benefit analysis shows a **very positive return on a rather small-scale investment**: the **investment into improved sorghum varieties** already pays off in the first year of usage.

Nonetheless, factors such as **expensive agricultural inputs, insufficient logistical and financial support, climatic risks associated with agricultural production and a decline in soil fertility impede the use of improved varieties**. In addition, there is a need for more institutional support, and to address potential negative outcomes due to a lack of seeds suitable for the local context or to limited knowledge on the use of the available improved varieties.

Policy recommendations

- Ideally, improved varieties are promoted that fulfil several conditions, such as farmer's preference, local suitability, agronomic management, and that are available and accessible for smallholder farmers. The **sufficient supply of locally adapted good quality seeds on a local level should therefore be supported**.
- **Knowledge transfer** regarding the varieties' potential and the best way to cultivate them can help farmers to use improved varieties.
- For a profitable adoption it is necessary to **ameliorate the functioning of the agricultural value chain including functioning infrastructure and agriculture markets** to make agricultural inputs available and accessible.
- It is also important to **highlight the value of local landraces as they are a pillar for safeguarding local gene pools, traditions, agronomic practices, and accompanying knowledge**. Such a safeguarding of seeds and practices could be institutionalised by in-situ conservation projects, local seed banks, corporations with national or international gene banks and diversity fairs.
- Improved **communication and interaction of seed sector stakeholders** can help to improve seed and knowledge dissemination on a local, regional and national level.

All four adaptation strategies have a **high potential to improve the livelihoods of smallholder farmers under current and projected future climate conditions** in Burkina Faso, and entail various co-benefits. Particularly, ISFM can be highly recommended for smallholder farmers, resulting in very positive effects for societies and environment. Irrigation and improved varieties have a high potential to improve livelihoods especially in northern Burkina Faso, but are also complex, costly and support-intensive adaptation strategies that needs to always ensure a sustainable use of already scarce water resources. Lastly, CIS can support farmers to make informed decisions and thereby reduce the impact of climate risks.

The Study Approach

To provide localised information on current and future climate risks as well as recommendations on suitable adaptation strategies for the agricultural sector, an impact-action-uncertainty chain was followed (Figure 6). As a first step, the current and future changing climate conditions as well as hydrological changes were analysed. Secondly, the resulting future impacts of climate change on crop production and livestock fodder management were modelled. Then, the results were fed into an action dimension to assess different adaptation strategies with regard to their risk reduction potential, their cost-effectiveness, and other socio-economic evaluation criteria, such as potential maladaptive outcomes and development co-benefits. Finally, the uncertainty attached to the results was critically discussed and recommendations targeting decision-makers were given.

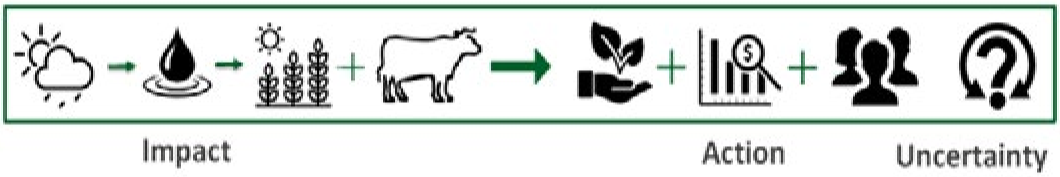


Figure 6: The impact-action-uncertainty chain of the climate risk analysis.

The analysis utilised data from global climate models, different process-based models[7] and a farm level cost-benefit analysis in collaboration with the Humboldt Forum for Food and Agriculture (HFFA) Research GmbH. Information from expert interviews and literature complemented the findings.

Figure 7: Stakeholder engagement followed throughout the study process.

Relevant stakeholders from Burkina Faso's local and national governmental institutions, civil society, academia, the private sector, practitioners and development partners were engaged throughout the study process to ensure that the study results are suitable for the country and can best support local decision-makers in adaptation planning and implementation.

In two workshops (a kick-off workshop and a validation workshop) and a household survey conducted by the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), key stakeholders at the regional and national level contributed with conceptual inputs, technical expertise as well as local insights which shaped and validated the study design and results (Figure 7). At the beginning of the study process, the local stakeholders actively steered the foci of the climate risk analysis, by specifying, contextualising and prioritising the adaptation strategies to be analysed in the study.

[7] The global climate models have been downscaled to 55 km × 55 km for a higher spatial resolution and bias-corrected on observed climate data in Burkina Faso.

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The climate risk analysis for Burkina Faso's agricultural sector at national level aims at contributing to Burkina Faso's NDC implementation and the objectives of the NDC Partnership.

For more information and further study results, please visit www.agrica.de. Any questions can be addressed to Christoph Gornott (gornott@pik-potsdam.de) or Nele Gloy (nele.gloy@pik-potsdam.de).

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