

Vulnerability, Risk Reduction, and Adaptation to Climate Change

MALI



COUNTRY OVERVIEW

AT A GLANCE

Mali is a landlocked country in West Africa that is one of the poorest in the world, with over 60 percent of the population living in poverty.¹ Mali is a highly diverse country, both in terms of culture and the diversity of its environments. The country can be divided along a north-south axis, with the northern areas extending into the Sahara and Sahel, and the southern region, where most of the country's economic activity is concentrated. Agriculture is the mainstay of the Malian economy, accounting for 50 percent of the country's GDP and employing a substantial portion of the country's workforce. Cereals dominate the Malian diet, and the main subsistence crops grown are rainfed millet and sorghum millet, with commercial agriculture devoted to cotton and rice, the latter of which is irrigated. In spite of this heavy reliance on agriculture, only 14 percent of the country's land area is considered suitable for agriculture, making sustainable land management a major concern. Furthermore, most of the major investments and advancements in Malian agriculture to date, including extension services, market development, and increased use of inputs, have been focused on cotton and rice production, with relatively little emphasis placed on increasing production of crops critical to the country's food security like sorghum and millet, whose yields have remained constant over nearly half a century.²

In spite of significant advances in recent years³, Mali's low economic development, limited land suitable for agriculture, and poverty make the country particularly vulnerable to climate change. Climatic changes are already a significant threat to the country's development and the nutrition and health of its inhabitants⁴, due in part to erratic rainfall, increased crop pests, rainfall shortages, and breaks during critical growing periods, as well as desertification over the last 50 years. The most highly stressed regions of the country are in the south where agriculture is concentrated, including *Sikasso*, *Mopti*, and *Segou*. Not only are these regions critical to the country's continued food security, they are also "endowed with many ecosystem services which are deteriorating, have high population densities and high levels of poverty".⁵

PRIORITY ADAPTATION MEASURES

Mali signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, and the Kyoto Protocol in 1999. The country is also a signatory to the United Nations Convention to Combat Desertification and the Convention on Biological Diversity. In 2007, Mali's National Adaptation Programme of Action (NAPA) laid the groundwork for a national plan of action on change and identified several poverty and economic growth criteria to be used in the evaluation and prioritization of proposed new projects. The plan focuses on the key vulnerable sectors identified in the NAPA and includes three focal areas:

Key Sectors

Agriculture and Food Security
Water Resources
Public Health
Fisheries
Land resources
Biodiversity

Source: Mali's Initial National Communications on Climate Change and the Adaptation Learning Mechanism.

➔ *Expanding agricultural extension services*—including the introduction of new cropping systems, strengthening early warning systems and helping farmers make use of agro-meteorological information, increasing the use of improved varieties that are adapted to local conditions, using new agricultural technologies (soil and water conservation), diversifying agricultural production, and improving access to credit for agricultural activities.

¹ People living on less than one dollar a day.

² FAO Stat 2005.

³ Economic growth for the period 2003-06 was 5.3% per year according to the World Bank, 2008. Major growth sectors are notably major growth gold mining, transport, and telecommunications services.

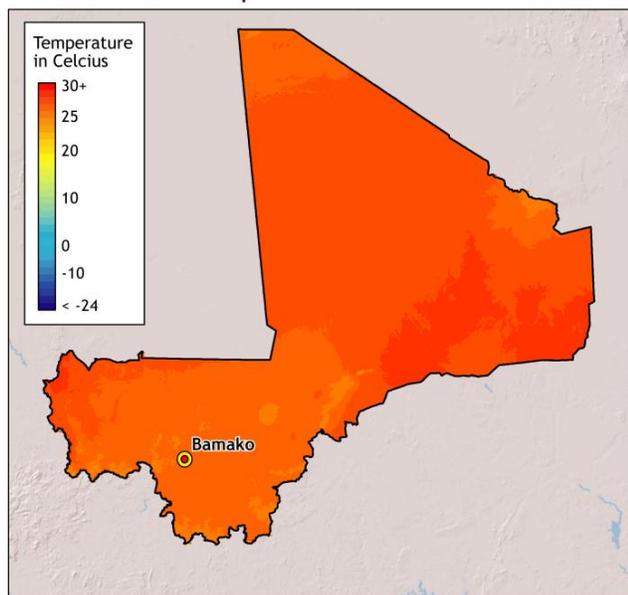
⁴ According to the FAO (2008), over 29% of Mali's population is malnourished.

⁵ Butt, T.A., B. A. McCarl, J. Angerer, P. T. Dyke and J. W. Stuth. 2005. Food Security Implication of Climate Change In Developing Countries: Findings from a case study in Mali.

- ➔ *Securing water for agriculture* through the building and maintenance of wells, digging of canals to irrigate more land and cleaning of canals that have been filled with sand, and constructing new irrigation schemes based on water from the Niger and Boni Rivers.
- ➔ *Domestic energy development* through the use of improved stoves, replacing charcoal with gas for cooking, improving coal production efficiency, and regulating charcoal markets.

CLIMATE BASELINE AND CLIMATE FUTURE

Annual Mean Temperature



Total Annual Precipitation

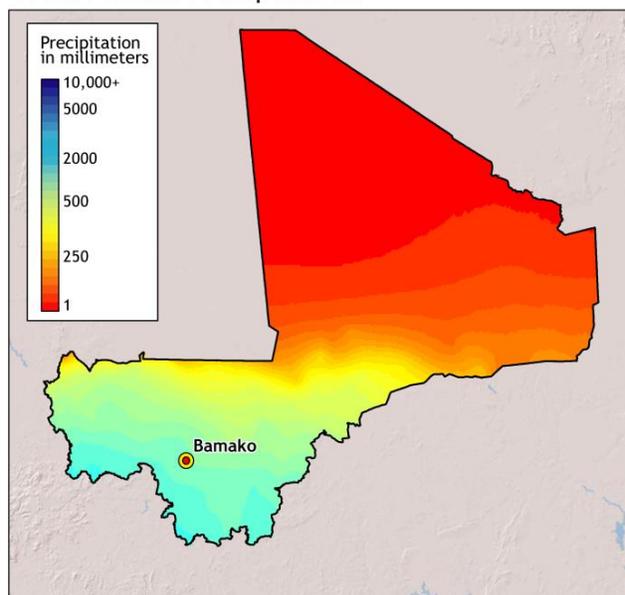


Figure 1: Baseline annual climate (left: rainfall, right: temperature) for Mali⁶

CLIMATE BASELINE

Due to its geographical position, Mali spans four different eco-climatic zones: **Sahara**, **Sahelian**, **Sudanian** and **Sudanian-Guinean** with an average annual precipitation ranging between 100 and 1700 mm. It presents only one rainy season entirely limited to the summer, which lasts up to six months in the South and decreases to two months in the North. Only the Sudanian, Sudanian-Guinean and the areas with irrigation possibilities offer agricultural or agro-pastoral potential. These zones have sufficient rainfall, fertile soils, and offer possibilities for agriculture and livestock integration. Rainfall is controlled in large part by oscillation of the Intertropical Convergence Zone (ITCZ) across the northern and southern African continent, which brings rainfall to southern Mali between June and October. Three seasons are distinguished across Mali, and their time of occurrence and length vary along a latitudinal gradient. Roughly, these include a cool and dry season occurring between October and January, a hot and dry season occurring between February to May, and a rainy season where humidity increases and lower temperatures are experienced between June and September. Mali spans four different eco-climatic zones with an average annual precipitation ranging between 100 and 1700 mm. It presents only one rainy season entirely limited to the summer, which lasts up to six months in the South and decreases to two

⁶ WorldClim 1960-1990 averages. Robert J. Hijmans, Susan Cameron, and Juan Parra, at the Museum of Vertebrate Zoology, University of California, Berkeley, in collaboration with Peter Jones and Andrew Jarvis (CIAT), and with Karen Richardson (Rainforest CRC). www.worldclim.org/current

months in the North. Only the Sudanian, Sudanian-Guinean, and the areas with irrigation possibilities offer agricultural or agro-pastoral potential. These include:

- ➔ The arid **northern** zone, encompassing over 30 percent of the country across the southern Saharan desert. This arid region receives hot temperatures and less than 50 mm per year of rainfall, mostly in the form of isolated showers, with significant year to year variability. In Gao, in Mali's northeast Sahel, rainfall is about 23 cm (9 in) a year. Economic activity focuses on salt curing, as well as caravan trade to Algeria.
- ➔ The **sub-desert Sahelian** zone, which receives 100-300 mm of rainfall annually and where considerable variations of temperature are experienced, especially in April, May, and June, the period of maximum heat, and in December, when the hot, dry *harmattans* blow. Major food resources in this region include rice, sorghum, and millet, while tomatoes, onions, and dried fish contribute to local incomes. Low river levels, erratic rainfall, and pest infestations pose a significant risk to food security in these areas.
- ➔ **Southern Sahelian** zone—which receives 800-1100 mm of rainfall over 125-150 days of the year, and where livestock production is the principal income-generating activity. Rain shortages and breaks in rainfall during critical times in the growing cycle stress subsistence production of millet and sorghum in this region. A subset of this zone is the Niger River delta, a flood plain of the Niger River that is flooded for over five months every year, where a diversity of agricultural and subsistence opportunities exist, including the majority of the country's irrigated rice production.
- ➔ **Southern and western Mali** exhibit a Sudanese-style climate with a short rainy season from June to September. Rainfall ranges from 700 to 1400 mm, and the length of the rainy season increases to the south. Income-generating activities focus on the production of groundnuts, cowpeas, banana, mango, citrus, cotton, maize, and other vegetables. Major climatic hazards in these regions include poor rainfall distribution over the rainy season, and in the southern most area, high input costs for cotton production.

RECENT CLIMATE TRENDS

Climate variability and change already strongly influence activities across Mali. The following is a summary of recent climate trends for Mali (since 1960 unless otherwise noted):⁷

- ➔ Mean annual temperature has increased by 0.7°C since 1960, an average rate of 0.15°C per decade. The rate of increase is most rapid in the hot, dry season, April through June. Droughts have become more frequent, especially in the northern areas, which have seen increased migration.
- ➔ The frequency of days considered hot⁸ has not changed significantly in Mali, but the frequency of nights considered hot have increased significantly except during December to February.
- ➔ Rainfall in the Sahel is characterized by high variability on both annual and inter-decadal time scales, which make trends since 1960 difficult to categorize. The early 1960s, 1990s, and 2000s were particularly wet years while the 1980s were markedly dry. The unpredictability of the rainy season across Mali has been a subject of much debate and reporting, nevertheless, statistical analyses will need to be conducted in order to substantiate these claims.

CLIMATE FUTURE

The climate science community sources a suite of models to inform decision makers on future climate, including GCMs (Global Climate Models), RCMs (Regional Climate Models), and downscaling techniques (both empirical and statistical). GCMs are our primary source of information about future climate. They comprise simplified but systematically rigorous interacting mathematical descriptions of important physical and chemical processes governing climate, including the role of the atmosphere, land, oceans, and biological processes. The following insights into a changing climate are derived for the Sahelian region as a whole, based on a suite of GCMs used by

⁷ IPCC 4th Assessment Report and UNDP Climate Profile for Mali and the World Bank Climate Change Knowledge Portal.

⁸ Hot nights or days are defined by the temperature exceeded on 10% of days or nights in current climate of that region and season.

the IPCC, as well as a collection of 15 downscaled stations across Mali available from the Climate Systems Analysis Group at the University of Cape Town.

- ➔ Mean annual temperatures across Mali are projected to increase by 1.2 to 3.6°C by the 2060s, and by 1.8 to 5.9°C by the 2090s, and this rate of warming is projected to be similar across all seasons.
- ➔ More frequent El Niño events could also increase the frequency and intensity of droughts across Mali, with important implications for disaster management and response.
- ➔ Although significant changes in the duration of the dry spells are projected, particularly between November and March, there is still uncertainty as to the direction of change, with some models indicating increases in the duration of the dry spells while others suggest decreases.
- ➔ The number of hot days and hot nights⁹ are projected to increase across Mali by 18-38 percent and 23-40 percent by 2060, and this rate of increase is projected to be more rapid in the south.
- ➔ As yet, it is not possible to get a clear picture for precipitation change for Mali under a future climate. This is due to large model uncertainties, with multi-model analyses of the Sahel suggesting a drying trend, and some individual models suggesting a more humid future. What is clear, however, is that the future will increase climate variability and extreme events.

Secondary impacts from the above changes in climate are discussed throughout this document, and include, among others:

- ➔ Increased incidence and intensity of crop pest infestations;
- ➔ Increased intensity of heat stress on crops;
- ➔ Loss of biodiversity and forests;
- ➔ Loss of water quality and quantity;
- ➔ Increase in the incidence of climate-related human health impacts.

CLIMATE CHANGE IMPACTS ON NATURAL HAZARD VULNERABILITY

AT A GLANCE

Climate-related hazards in the Mali include droughts, floods, and crop pests. These hazards are a natural occurrence in Mali, which nevertheless pose serious constraints on development and food security, and their intensity and frequency are likely to increase under a changing climate. An indication of the relationship between extreme events and the severity of floods and droughts is available in Figure 3, which demonstrates the outputs of a Weighted Anomaly Standardized Precipitation (WASP) for the Niger River basin. These data were calculated based on the meteorological information available from the Climatic Research Unit at the University of East Anglia by the World Bank's Africa Region. The causes and impacts of these natural hazards across Mali are discussed below.

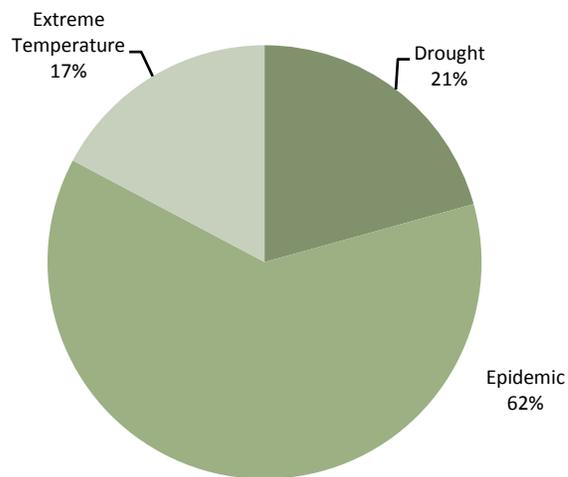


Figure 2: Average annual distribution of reported disasters¹⁰

⁹ Hot nights/days are defined by the temperature exceeded on 10% of days/ nights in current climate of that region and season.

¹⁰ EM-DAT: The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels, Bel." Version: v11.08.

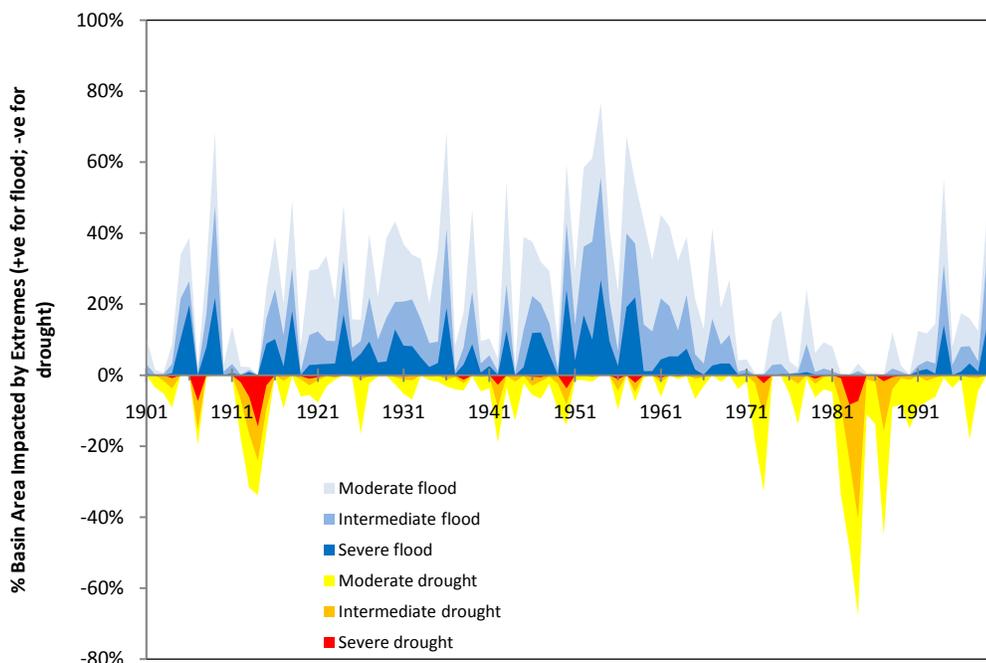
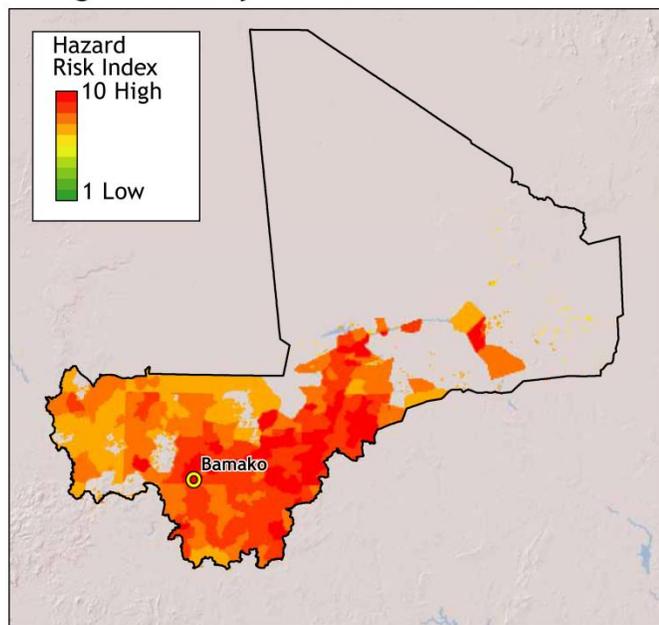


Figure 3: Niger Basin Weighted Anomaly of Statistical Precipitation (WASP) Index¹¹

Drought Mortality Risks and Distribution



Flood Mortality Risks and Distribution

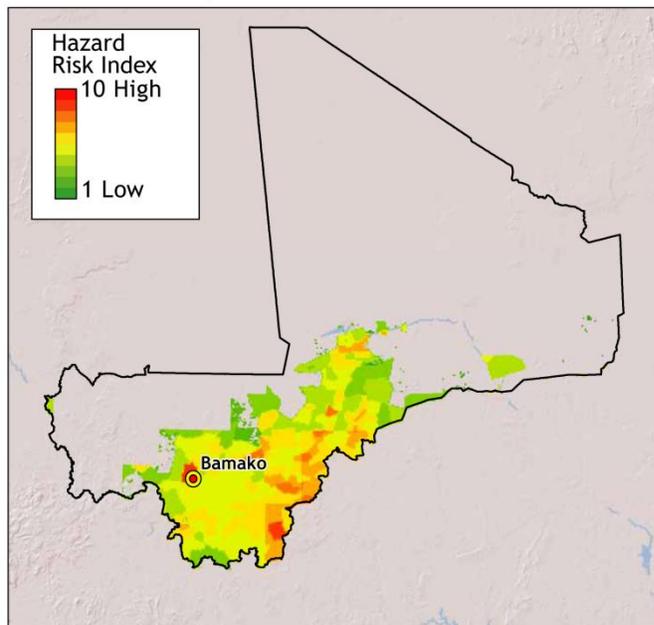


Figure 4: Exposure to climate-related hazards across Mali¹²

¹¹ IRI (2009) for World Bank Africa Region Water Resources & Climate AAA.

¹² Columbia University Center for Hazards and Risk Research (CHRR) and Columbia University Center for International Earth Science Information Network (CIESIN).

- ➔ **Droughts**—droughts due to erratic rainfall are part and parcel of the natural variability in climate across Mali, and several traditional mechanisms are employed across the country to adapt to drought conditions. Nevertheless, more frequent and longer droughts have plagued Mali in recent decades, exacerbating natural adaptive capacities. The 2004 drought across the north, brought about by rainfall deficits, seriously affected transhumant populations, forcing pastoralists to remain near permanent water sources and leading to considerable overgrazing. Crop losses in and around Mopti, Segou, and Tombouctou are often the result of extended dry spells, poor rainfall and dry conditions.
- ➔ **Floods**—Expanding agriculture, coupled with poor land management practices, particularly on the Niger River flood plain, has significantly increased erosion and sedimentation, and the propensity of some areas to experience severe flooding and subsequent crop loss. One clear example of this is the 2000 events in Mopti and Gao, where dry spells led to late planting of the area's rice crops, which were lost to subsequent flooding of the river prior to emergence.

Implications for Disaster Risk Management

- ➔ Although it remains difficult to pin particular disasters such as floods and droughts to climate change, it is clear that a destabilized climate system, together with other forms of environmental damage, will cause havoc more frequently, especially in already stressed and marginal environments such as those in Mali. Climate change is not just about average values, but rather a matter of extremes.
- ➔ The predicted increases in maximum and minimum temperatures for Mali, coupled with reduced or erratic rainfall, are likely to make natural hazards more frequent and severe. Without improved planning and management, the incidence and impacts of these disasters could increase.
- ➔ Vulnerability is a key factor that could be influenced by expected changes in climates. The poor have limited access to resources and few income-generating opportunities, and their living conditions are often affected by laws, policies, and economic forces over which they have little or no control. Although it is by no means clear whether vulnerable groups, with their pressures to survive, or affluent groups, with their pressures to consume, ultimately lead to the impacts that continue to drive vulnerability, it does seem clear that poor people will not, indeed, cannot, adapt if this requires looking beyond their immediate needs. The potential impacts of climate change on the most vulnerable should, thus, be prioritized.

SECTORAL CLIMATE RISK REDUCTION RECOMMENDATIONS

The impacts of climate change for the Malian society will vary by geographical location. Poor communities are likely to feel greater impacts as they lack a capacity to cope with natural hazards and are often heavily dependent on the natural-resource base for their livelihoods. Climate variability and change effects across Mali are described under several key sectors below.

AGRICULTURE

Mali's agricultural sector is currently concentrated in the country's limited arable lands, found along the Niger River in the Kayes, Koulikoro, Segou, Mopti and Sikasso regions. Subsistence cereals¹³ dominate the Malian diet, and the main subsistence crops grown are rainfed millet and sorghum millet, with commercial agriculture devoted to cotton and rice, the latter of which is irrigated. Crop failure is common and current food crop production is unable to adequately provide for local needs due to persistent threats from droughts, floods, and pest invasions, and in recent years grain imports have been required to fill the widening gap between necessity

¹³ Subsistence crops comprise about 90 percent of the 1.4 million ha under cultivation in the Sahelian zone, with the principal food crops being cereals, primarily sorghum, millet, and maize (US Department of State 2005; Global Environment Facility 2003).

and production. The droughts in the 1970s and 1980s were particularly notable in reducing food production. Livestock and fishing are also an important source of food, particularly in the sub-Saharan zone around Mopti and in Segou where transhumant systems are still common, and on the Niger River floodplain. Additional factors that limit food security in the country include the limited productivity of available land, as well as the fact that most of the major investments and advancements in Malian agriculture to date, including extension services, market development, and increased use of inputs, have been focused on cotton and rice production, with relatively little emphasis placed on increasing production of crops critical to the country's food security like sorghum and millet, whose yields have remained constant over nearly half a century.¹⁴ The food insecurity situation is likely to worsen under a changing climate unless a concerted effort is placed on improving subsistence food production across the country.

Adaptation in the agricultural sector should focus on at least some of the following activities:

- ➔ The introduction of improved technologies including the provision of inputs to improve soil conditions, and water harvesting to secure productivity under variable rainfall patterns.
- ➔ Seed priming, or soaking of millet and sorghum seeds in water prior to sowing has been shown to increase yields by 50 percent and should be implemented.
- ➔ Increased intercropping with shade tree species to prevent loss of soil moisture, prevent wind-shed, and provide fodder for livestock.
- ➔ Increased density of cowpea plantations to secure livestock fodder.
- ➔ Increased irrigation capacity.
- ➔ Increased educational and outreach activities to change management practices best suited to climate change.
- ➔ Improved pest and disease forecast and control.

WATER RESOURCES

The Niger and Senegal Rivers that cross southern Mali are its principal source of surface water, providing a total annual flow of 56 billion m³ and a majority of the country's irrigation and potable water supply. These basins together account for nearly 48 percent of the country's surface area and are heavily reliant on precipitation. Groundwater from aquifers near the capital of Bamako provides much of the city's needs. Access to potable water is already a significant problem across Mali, which is provided to only half of the country's population. Uneven supply and quality (including increased salinity and contamination) render water access a significant challenge both today and under a changing climate. Proper management of water resources are required to mitigate drought conditions and ensure water availability, especially since a substantial decline in available supplies is projected by 2020, primarily from reduced flood waters, and evaporation. Water resource management under a changing climate should focus on the following:

- ➔ Increasing supply, e.g. by using groundwater, building reservoirs;
- ➔ Improving or stabilizing watershed management, particularly in flood plain areas where runoff sources are being degraded;
- ➔ Increasing water use efficiency, reducing water, introducing water recycling, and improving irrigation practices;
- ➔ Developing and introducing flood and drought monitoring and control systems to respond to changing conditions.

¹⁴ FAO Stat 2005.

PUBLIC HEALTH

Mali's public health sector is vulnerable to climate variability and change, particularly with regard to the increased incidences of nutritional deficiencies due to crop yield losses and damages, and diarrheal and vector-borne diseases. Limited information is available on the extent and frequency of health issues with a significant link to climate variability and change, but what is clear is that water-related diseases such as cholera and diarrhea represent a large majority of the diseases in the country, and together with malaria these diseases are rather common in the Malian population. Malnutrition is also common across Mali, and in some regions children with acute malnutrition are common. Increased temperatures, projected flooding, and anecdotal evidence on reduced water quality point to a potentially deteriorating condition in the health sector under a changing climate. Addressing the impacts of climate variability and change on the health sector requires addressing issues of poverty, sanitation, nutrition, and environmental degradation, all of which significantly hamper a community's capacity to adapt to vulnerability. Adaptation recommendations in the health sector that were identified in the National Adaptation Programme of Action, 2007, include:

- ➔ Awareness-raising activities on the potential impacts of climate change on health, including projected changes in the outbreaks of water- and insect-borne diseases, as well as appropriate response mechanisms for dealing with these.
- ➔ Improved provision of sanitation and reliable access to potable water.

EXISTING ADAPTATION FRAMEWORK/STRATEGY/POLICY AND INSTITUTIONAL SETUP**AT A GLANCE**

A number of climate change projects and activities have been carried out in Mali, many of which are set to offer significant insights and experiences on current and potential adaptation strategies for addressing climate change risks in the country. Some exemplary efforts in this regard are listed below. It is nevertheless important to note that these are only a stepping stone on a broader set of activities, starting with the country's identified priorities from their NAPA, which will need to be implemented and fully funded in order to address the detrimental impacts of climate change.

Ongoing Efforts—At a Glance

<i>Description of Project</i>	<i>Donor/Agency</i>
Integrating Climate Resilience into Agricultural Production	FAO/ LDCF
Enhancing Adaptive Capacity and Resilience to Climate Change in the Agriculture Sector in Mali	UNDP/GEF
CASE STUDY Agriculture and Food Security: A case study on adaptation to climate change and the process of prioritizing adaptation options	USAID
Mali - Climate Adaptation From the Bottom-Up: Established help to the members of three pilot communities in southern Mali to identify and implement promising water management innovations that could improve household conditions by increasing resilience to climate change.	NCAP
Tombouctou Region Irrigation Scheme: GTZ's program on support to irrigation schemes along the Niger River in the Tombouctou region	GTZ
Developing the Agro-pastoral Potential and Improving Access to Basic Services in the Kidal region: supporting pastoral groups in the Kidal region and funding a program on capacity building of local organizations and institutions to express their collective needs and to realize and manage investments.	IFAD
Improving Access to Potable Water in Sikasso and Mopti.	Danida

INSTITUTIONAL AND POLICY GAPS

- ➔ As previously noted, there has been a relative lack of support to agricultural initiatives in subsistence farming, and this gap must be addressed in order to guarantee Mali's future food security. From an institutional and policy perspective, this requires a concerted effort to support agricultural activities and favorable price policies.
- ➔ Strengthening the institutions of farmers is key to guaranteeing access to inputs and necessary credits for increased productivity.
- ➔ The limited integration of climate change considerations into current development activities needs to be addressed by strengthening coordination among the country's relevant institutions.
- ➔ Responding to climate change requires that a significant effort is made to raise education activities and awareness regarding current and projected climate variability and change. Integrating climate change into formal education curricula as well as community awareness programs could help in meeting these goals.

RESEARCH, DATA, AND INFORMATION GAPS

Mali, like all Least Developed Countries (LDCs), has been identified as one of the most vulnerable to the adverse impacts of climate change. This vulnerability is also amplified by the fact that development activities have outpaced traditional conservation and coping practices. While it is clear that climate impacts are already being felt across the country, a specific climate change focus has been missing from many of the current development activities. A number of institutions across the country are actively engaged in activities that should address climate change considerations, but additional work needs to be done. Some key gaps in the areas of research, data, and information that need to be addressed in order to keep pace with projected changes in climate are listed below.

RESEARCH GAPS

- ➔ Climate change, particularly the projected changes in rainfall across West Africa, remains uncertain in part because of a lack of understanding of the processes that generate tropical rainfall. There is a need to increase our understanding and ability to reproduce realistic inter-annual and inter-decadal rainfall variability in the climate science community, and this is an area which requires more research.
- ➔ Although downscaled climate information is available for several stations across Mali, there is a need to improve the derivative statistics calculated from these data and link them to critical sectoral thresholds in order to better understand how climate change is likely to impact these sectors, particularly with regards to extreme events.
- ➔ Specific research is required on new methods necessary to improve water use in agriculture, in particular in those regions that are currently facing water deficits during the dry seasons.
- ➔ An often ignored research gap is understanding what is needed (particularly at the community scale) to build and enhance the socio-economic capacity to adapt and to manage disaster risks. Indeed, a better understanding of the differential nature of vulnerability within the country's high-risk geographic regions is needed. Analyses of sector impacts must be complemented by social, economic and political assessments of vulnerability and resilience.
- ➔ Water supply and demand studies need to be conducted across the country. Responding to climate change in the water sector is hampered by a limited understanding of how water supplies will be impacted by rising temperatures.

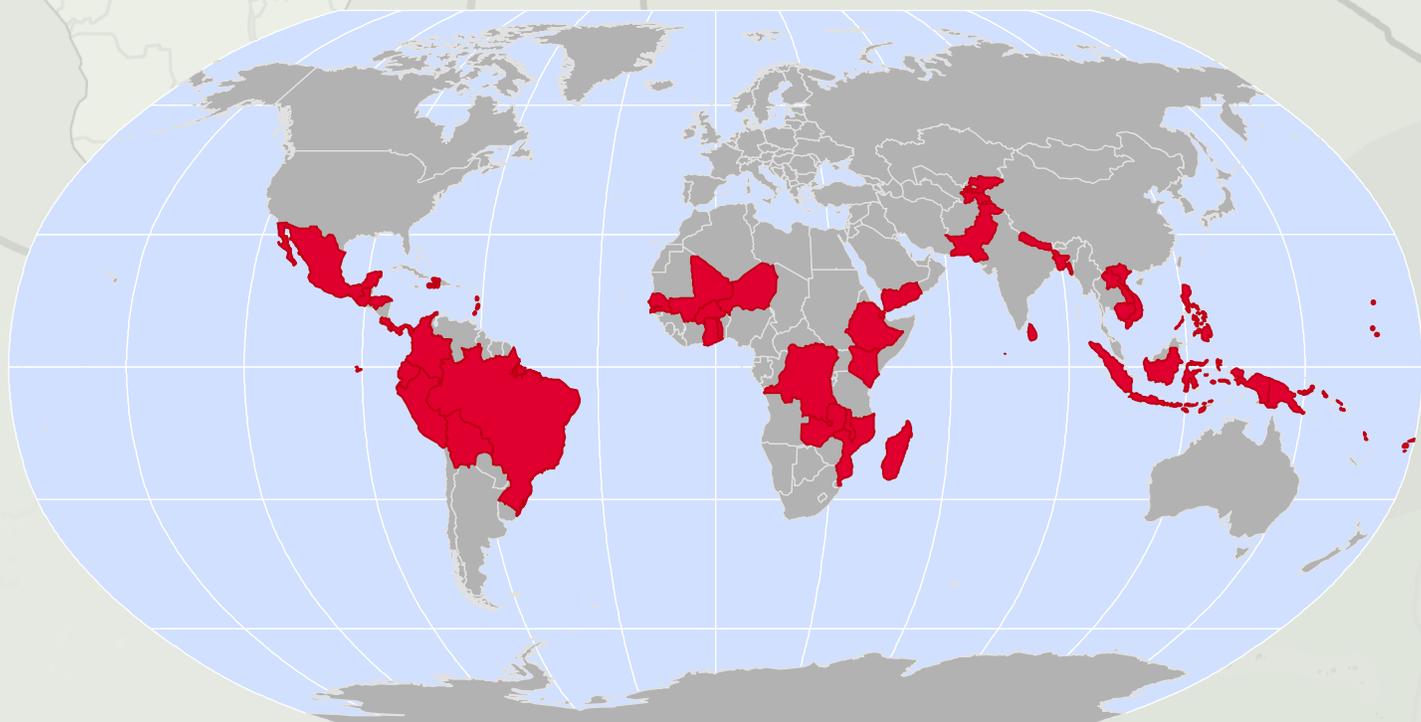
- ➔ Detailed assessments of climate change impacts and risks across a variety of sectors are required in order to develop sound response strategies, in particular focusing on food security, water resources and coastal resources.
- ➔ Community risk assessment and participatory risk assessment methodologies should be promoted with a direct link to action and planning at the sub-national and local levels.

DATA AND INFORMATION GAPS

- ➔ There is a general lack of sector-specific data, including data on fisheries and agriculture, which needs to be addressed in order to develop appropriate response measures.
- ➔ Comprehensive vulnerability maps could support disaster planners in preparing communities for worse case impacts as well as helping local communities take an active role in identifying appropriate response mechanisms.
- ➔ Anecdotal evidence of changes in climate needs to be formally catalogued across the country. For example, there is evidence that water quality and quantity is being reduced, but these dynamics are not well understood due to a limited understanding of the country's hydrometeorological systems. In many cases, there are no weather monitoring sites that could provide key information on flash floods and water flows to managers downstream.
- ➔ The use of existing meteorological information is limited to specific agencies, and this information needs to be tailored to decision makers across a wider series of sectors, including water resources management.

Climate Risk and Adaptation Country Profile

This Country Profile (<http://countryadaptationprofiles.gfdr.org>) is part of a series of 49 priority country briefs developed by the Global Facility for Disaster Reduction and Recovery (GFDRR) and the Global Support Program of the Climate Investment Funds (CIF). The profile synthesizes most relevant data and information for Disaster Risk Reduction and Adaptation to Climate Change and is designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and operations. Sources on climate and climate-related information are linked through the country profile's online dashboard, which is periodically updated to reflect the most recent publicly available climate analysis.



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MALI