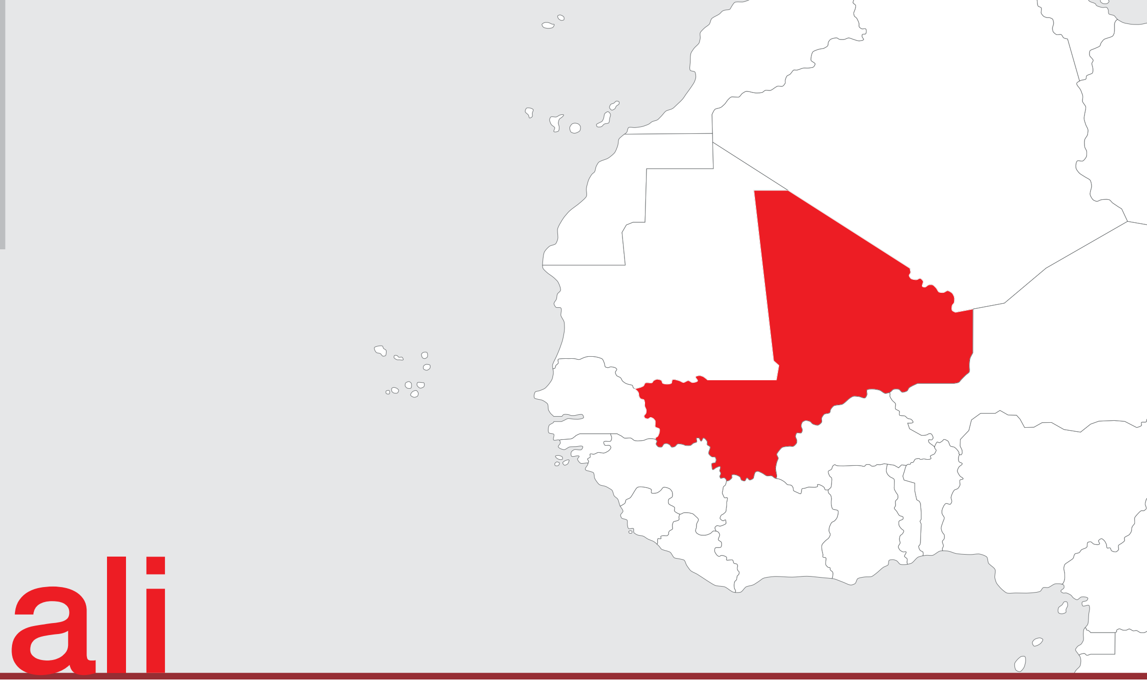
Climate Centre

Country-level | Climate fact sheet



Mali

1. Country overview

The Republic of Mali is a low-income country located in the Sahel region of West Africa, with a population of 19.7 million people (World Bank 2019a). It is populated by a diverse population of sub-Saharan ethic groups with a rich culture and history. It is also characterized by extreme poverty, with over 40 per cent of the population falling into this wealth category. Gross domestic product (GDP) per capita is 879 US$ making it one of the poorest countries in the world (World Bank 2019b). In the last decade, it has also suffered from political instability and conflict. The population is concentrated in the southern region of the country, where rainfall is relatively higher (Global Facility for Disaster Reduction and Recovery (GFDRR 2019). The climate is dry, with average annual rainfall totalling 333 millimetres (mm) (World Bank n.d.). The capital city of Bamako is growing rapidly, with nearly 2 million inhabitants according to the most recent census (United Nations Statistical Division (UNSD) 2010).

Mali's economy is based on a combination of agriculture and agropastoralism, with heavier reliance on pastoralism in the drier northern region. The northern region is also the area most affected by desertification and migration (Food and Agriculture Organization of the United Nations (FAO) 2017a). Agriculture is a key industry, accounting for over 35 per cent of GDP and employing 80 per cent of the population in some capacity (GFDRR 2019). Cotton is its largest agricultural export. Other major crops include millet, maize, and rice (FAO 2017a). Political and institutional instability, as well as a challenging dry and variable climate, all threaten key economic industries (FAO 2017a).

Mali ranks 169 out of 181 countries in the Notre Dame Global Adaptation Initiative (ND-GAIN) index. The ND-GAIN index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve

Figure 1: Map of Mali. Source: Maps of World, 2020

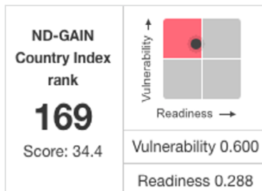


Figure 2: Mali's ND-GAIN Ranking (ND-GAIN 2021).

2021

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resilience. This ranking indicates that Mali has high vulnerability levels, and low levels of readiness to adapt to climate change (ND-GAIN 2020).

1.1 Climate

Mali has three distinct climate zones: the tropical Savannah in the south, which receives the most rainfall; the warm semi-arid region and the warm desert region in the north, each of which receives successively less rainfall (World Bank n.d.). The hottest time of the year in the capital Bamako is typically April before the onset of the monsoon rains, while nationally May and June historically have the highest temperatures (World Bank n.d.). There is a large day to night temperature difference, especially in the cooler, dry season. The rainy season typically spans from June-October, followed by a dry season in November-March. The major climate feature is the West African Monsoon, which is controlled by the tropical rain belt – also called the Inter-Tropical Conversion Zone (ITCZ). As this rain belt moves, it produces large variations in seasonal rainfall (McSweeney *et al.* 2010).

Since the beginning of the 20th century there has been a decline in the long-term trend in Mali's rainfall (Funk *et al.* 2012). However, Mali is also part of the Sahel – a region where there are large multi-decadal shifts in the climate due to natural changes in the earth's atmosphere–ocean system (Folland *et al.* 1986; Mohino *et al.* 2011). This means that in the past there have been periods of about 10–30 years when it was significantly drier than average, and other periods when it has been significantly wetter than average. For example, in the 1950–60s, the Sahel was in a wet period, whereas in the 1970–80s it entered a dry period, marked by severe periods of drought with cascading negative effects throughout the food system (World Bank and GFDRR 2011). In recent decades (1995 and onwards) Mali has experienced a relatively wetter period (on average), although variability exists throughout the three climatic zones which is not captured in these averages (Funk *et al.* 2012).

Mali is prone to multiple hydro-meteorological hazards including droughts and dry spells, riverine floods, pluvial floods (flash floods), heatwaves and sand-storms. It is also susceptible to hazards affected by climatic conditions, including wildfires, locust invasions, epidemics and epizooty (epidemics among animals). Conflict and instability in the region are inextricably linked to the stresses imposed by the hydro-meteorological conditions and climate change (Institute of Development Studies (IDS) 2012).

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1.2 Climate change

Historical Climate	Projected climate
Rainfall	
Rainfall variability has increased, with a dry period in the 1980s and 1990s followed by a relatively wetter period to the present, as outlined in the section on 'climate' (above). Multiple studies have demonstrated a return to wetter conditions and increasing intensity of rainfall events with longer dry periods in between (Aich et al 2016; Panthou *et al.* 2014).	According to the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) from the Intergovernmental Panel on Climate Change (IPCC 2012) there is medium confidence in observed changes including: ▪ a decrease in cumulative rainfall (over the rainy season) ▪ an increase in rainfall intensity ▪ an increase in dry spell duration ▪ an increase in extreme rainfall events during May and July (IPCC 2014; Cook and Vizy 2012).
Temperature	
Mali is one of the hottest countries in the world, crossed by the thermal equator (Birkel and Mayewski 2015). Surface temperatures in the Sahel increased by 0.5–0.8°C in 1970–2010 (Collins 2011), as have the number of warmer days and nights (New *et al.* 2006). The number of warm days and nights have also significantly increased since 1961, while the number of cold days and nights have decreased (IPCC 2014; New *et al.* 2006). These changes in temperature are particularly significant in April–May, the hottest time of the year. Increases in temperature can affect human health and wellbeing (Singh *et al.* 2019).	Recent IPCC projections suggest that these warming trends will continue in the West African region (IPCC 2018). This means: ▪ an increase in warm days and a decrease in cold days (high confidence) ▪ an increase in warm nights and a decrease in cold nights (high confidence) ▪ more frequent and/or longer heatwaves and warm spells (high confidence) ▪ a significant increase in temperature of the warmest day and coolest day (medium confidence) ▪ an increased frequency of warm nights, and a decrease in cold nights (medium confidence).

1.3 Climate variability

The region experiences high levels of rainfall variability. Notably, the period of the 1970s to near the turn of the century marked a substantial decrease in annual rainfall which, at the time, was the most substantial decline in rainfall recorded anywhere in the world since the advent of instrumental measurements of rainfall (Hulme and Kelly 1997). After this period, average rainfall levels began to slowly recover. The cause of the shift is still debated but may be due to natural variability, a system response to an increased concentration of greenhouse gas (GHG), or a reduction in aerosols (IPCC 2014; Mohino *et al.* 2011; Haarsma *et al.* 2005; Biasutti 2013; Ackerley *et al.* 2011).

Observations of rainfall in recent years indicate an increase in year-to-year variability as compared to the long-term historical trends (IPCC 2018; IPCC 2014). Rainfall variability in the region has been linked to anomalies of sea surface temperatures (SST) often related to the El Niño Southern Oscillation (ENSO) or North Atlantic Oscillation (NAO) cycles (note: while ENSO does seem to influence annual variations, Ward (1998) demonstrates that it is not the dominant factor in rainfall) (Birkel and Mayewski 2015). Variability makes predicting the future more complex. IPCC reports have emphasized the difficulty of accurate climate projections in the Sahel in particular (IPCC 2018). For the future, there is high uncertainty regarding how climate change will interact with the natural year-to-year and multi-decadal shifts observed in the Sahel, and whether the observed pattern of increasing variability will persist.

There is also multi-decadal variability in temperature in Mali, meaning there are hotter and colder trends observed over time. However, these shifts are not as significant as they are for rainfall, and temperature in Mali generally tends to be higher during dry periods and lower during wet periods (Birkel and Mayewski 2015). The role of global climate change in terms of temperature change is clearer and the dominant trend is of rapidly increasing temperature (IPCC 2014; IPCC2018).

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2. Humanitarian sectors and climate change

2.1 Water and habitat

While Mali has abundant water resources, these are primarily concentrated around the Niger and Senegal Rivers and the inland delta in the central region, while the north is water stressed due to low rainfall and high drought risk (United States Agency for International Development (USAID) 2013). Flows from the Niger river have been highly variable over the past 50 years, and are highly sensitive to variable rainfall patterns and droughts, and river flow affects groundwater quantities directly (USAID 2013).

Mali's hydrogeology is severely understudied, which makes it difficult to draw firm conclusions to inform water management – especially for decisions on groundwater extraction (both where to extract, and sustainable quantities). In Mali, MacDonald *et al.* (2012) estimated that there was 27,100 cubic kilometres (km^3) of groundwater storage, within a range of 10,600–87,000 km^3. Data from 2003 suggest only 66 km^3 was exploited – largely via boreholes (an estimated 15,100 in 2003 and 19,000 in 2008) and large diameter wells (an estimated 9,400 in 2003 and 10,000 in 2008) (Traore *et al.* 2018). While these figures are dated, it is clear there is untapped groundwater potential in Mali, and ample need to better understand the characteristics of Mali's aquifers and their potential.

There are several challenges in groundwater management in Mali. A key challenge remains the uneven distribution of groundwater reserves, with less access in the populous south (USAID 2013). Mineral and saline content is also estimated to vary widely, which is an important consideration for sourcing drinking water. More recently, Díaz-Alcaide *et al.* (2017) conducted a review of 26,040 boreholes – both successful and unsuccessful (insufficient water) – throughout the country, and concluded that groundwater is widely available across nearly 80 per cent of the country, but highly productive boreholes are rare. In this study, the Inner Niger Delta was exceptional in that it had a higher success and yield rate.

The Sahel may experience a decline in groundwater recharge with climate change because of drought and rainfall anomalies which are expected to become more frequent with climate change. Shallow aquifers respond more quickly to seasonal and yearly variations in rainfall and river flows as compared to deep aquifers (USAID 2013; Traore *et al.* 2018), and thus reliance on shallow aquifers holds more uncertainty and risk. The Bani River Basin in Mali was highlighted in one of the plausible climate scenarios reviewed in the IPCC 5th Assessment Report (A2 scenario), in which the basin is estimated to experience substantial reductions in runoff, which could have cascading effects on livelihoods across the catchment (Ruelland *et al.* 2012).

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2.2 Economic security

Hazards – especially floods and droughts – produce devastating impacts on livelihoods (including those linked to the economically important exports of cotton and livestock), as well as public and private infrastructure, and contribute to economic instability (e.g. food price volatility) (FAO 2017b). These climate stressors dampen economic growth and security both directly and indirectly.

The cultivation of irrigated crops has been identified as a key strategy to adapt to rainfall variability and increase productivity and incomes in Mali's national climate change policy (FAO 2017a; Giannini *et al.* 2016). Accessing groundwater to expand off-season cultivation holds considerable potential for improving food security and livelihoods, especially as seasonal rainfall is increasingly variable for rainfed agriculture. Especially for rice cultivation, surface water from the Niger River and its tributaries is insufficient for the water demand of rice cultivation, in particular. As such, rice offices in Mali have prioritized groundwater extraction to meet water demands in a large-scale irrigation scheme. However, there have been recent incidences of aquifer levels dropping below average as compared to previous years in localities where rice farming is heavily reliant on groundwater extraction, and experts suggest the demands of irrigated agriculture cannot be met in years of low flows in the Niger river (USAID 2013). This can be traced back to the inter-linkage to the shallow groundwater resources with the Niger river and vulnerability to rainfall anomalies.

2.3 Health

Health impacts of climate change in Mali are far-reaching – from negative impacts on nutrition and sanitation to epidemics and contributing to a wide range of chronic health conditions. Variability of water distribution has its own impacts: low rainfall limits both water quality and quantity, while flooding exacerbates water- and vector-borne disease by contaminating water sources and creating breeding grounds for mosquitoes (World Health Organisation (WHO) 2018). Higher air and water temperatures increase the presence of certain pathogens in water and therefore increase the risk of contracting certain water borne diseases (Karvonen *et al.* 2010). Warmer temperatures have been associated with outbreaks of cholera, for example (Wu *et al.* 2018). Positive associations have also been found by many researchers between higher air temperatures and diarrheal illnesses (Levy *et al.* 2016). Bacterial meningitis is another waterborne disease that has been linked to higher temperatures and desert storms in the Sahel (Justo *et al.* 2017; USAID 2018). However, climate change could lead to a decrease in malaria transmission in Mali as suitable mosquito habitats disappear (Bomblies and Eltahir 2009). Malaria is presently the leading cause of death in Mali (USAID 2018).

Furthermore, climate change has a multiplier effect on pre-existing health challenges. Increased temperatures will also lead to increased heat stress which can increase morbidity and mortality of the most vulnerable such as older people, especially those above 65 years of age; people with pre-existing health conditions, such as heart disease, respiratory illness and diabetes; young children; people who are homeless or have inadequate housing, such as those living in camp settings (Singh *et al.* 2019; Bakshi *et al.* 2019). Further, displaced populations (by floods, droughts or otherwise) tend to use less hygienic sources of water for drinking and household use (International Institute for Sustainable Development (IISD) 2018). In addition to physical health effects, the impacts of climate on mental health is understudied but thought to be significant, especially when it pertains to trauma associated with loss (IISD 2018).

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2.4 Protection

Conflict and the presence of non-state armed groups pose a major threat to population safety in Mali. There is insufficient research to discern relative risks of climate-induced stressors to protection, as compared to the conflict itself. The exacerbating role of environmental stress in conflict in Mali remains disputed (IDS 2012; Djoudi *et al.* 2011). For example, the influence of droughts on herder-farmer conflict is a commonly cited example of how climate can exacerbate existing tensions. However, these tensions are highly complex and can flare up even in ideal growing conditions for crops and pasture. A report from IDS stresses that interventions to reduce conflict by helping the population adapt to a changing climate '… will only begin to address the main issues in conflict situations by considering the wider political economy' (IDS 2012).

Although more attention has been paid to the impacts of droughts in Mali, floods are increasingly posing a protection risk. An analysis completed by the government's civil protection on the impacts of floods of the past 30 years (1989–2018) shows a steep increase in flood impacts in all measured areas: destroyed dwellings, affected people, loss of assets, as well as deaths, disappearances and injuries (International Federation of the Red Cross/Red Crescent Societies (IFRC) 2020). Most recently, flooding in 2018 affected 8,968 households, spread across all regions of Mali. The capital city of Bamako is particularly flood-prone, with houses and road infrastructure becoming submerged or structurally unsound during flood events. Those in informal settlements in Bamako and substandard housing are particularly at risk of urban flooding (Directorate General of Civil Protection (DGPC) 2018). Academic literature suggests that there is a 'levee-effect' on flood vulnerability, whereby levees and other flood protection infrastructure increase flood vulnerability as a result of an increase in adjacent population density and development/settlement in floodplains. Importantly, when infrastructure fails in extreme events, damages are higher than they would have been, due to this shift (Aich *et al.* 2016).

Mali hosts more than 26,000 refugees and has nearly 208,000 Internally Displaced People (IDPs) (United Nations High Commissioner for Refugees (UNHCR) 2021). Displaced people, including IDPs and refugees, are often particularly vulnerable to climate extremes. This includes flood events that can quickly destroy the limited infrastructure in camps, as well as heat waves that leave people with few options for cooling and shelter. In June 2019, a major flooding event damaged the infrastructure of a camp in the Mopti region of Mali. The International Organization for Migration reported that heavy rains associated with the flooding event destroyed the tents sheltering 304 IDPs, leaving them exposed to the elements (FloodList 2019).

Around the world, people in detention frequently have heightened vulnerability to natural disasters due to: spatial marginalization resulting from prison locations on hazard-prone land and/or isolation from emergency evacuation services; limited to no connections to social networks, which are crucial aspects to hazard resilience; and political marginalization, including lack of policies and services to prevent disaster impacts on imprisoned populations (Gaillard and Navizet 2012). These vulnerabilities, coupled with more frequent and intense disasters due to climate change may leave prison populations in especially precarious positions to hazards such as extreme heat, dust storms and floods.

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2.5 Policy

Mali has signed (and ratified) the 2015 Paris Agreement as of September 2016 and submitted its first Nationally Determined Contribution (NDC) in March of the same year. The NDC set mitigation commitments as both conditional, depending on support by other partners, and unconditional. Due to its current dependence on resource extraction, and its position as a non-Annex 1 country, Mali reserves its right to being a GHG sink up until 2030 when it commits to carbon sequestration of over 84,000 kilotons under a mitigation scenario. All in all, its NDC represents a commitment of a reduction of GHG emissions by sector that represents 29 for agriculture, 31 per cent for energy, and 21 per cent for land use. In terms of adaptation, the NDC text highlights priorities for a green economy and climate change resilience (United Nations Framework Convention on Climate Change (UNFCCC) 2016).

At the national level, policy on climate change is developed through Mali's Agence de l'Environnement et du Développement Durable (AEDD). Currently, the country has both a national climate change policy and a climate action plan – both developed in 2011. In 2016, the country was accredited by the UNFCCC's Green Climate Fund and Adaptation Fund, which will give it access to resources to mitigate the effects of, and adapt to, a changing climate. So far the major projects and programmes proposed by the government centre on the development of irrigation capacity and the production of irrigated crops (FAO 2017a).

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