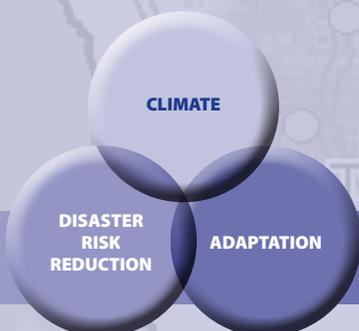


# Vulnerability, Risk Reduction, and Adaptation to Climate Change

## YEMEN



**GFDRR**  
Global Facility for Disaster Reduction and Recovery



## COUNTRY OVERVIEW

Yemen has a land area of 527,970 km<sup>2</sup> of which only 2.6% is arable.<sup>1</sup> Yemen's economy has been dominated by the oil sector, but declining oil revenues and resource depletion render it necessary to diversify economic activity. The Government has consequently scaled up its efforts to spur non-oil growth and create jobs in sectors such as agriculture, fisheries, natural gas, urban manufacturing, services, and the financial sector. The country has a predominantly rural and rapidly growing population of over 23 million, with a 38 % poverty rate and per capita GDP of \$1,118, one of the lowest in the Middle East Region. Despite modest gains against urban poverty in recent years, 40 % of the country's population continues to be classified as poor.<sup>2</sup> As a food-insecure nation that is highly dependent on staple food imports and with 32 % of its population considered undernourished, Yemen is severely affected by the recent food crisis. Water resources are scarce and rapid groundwater depletion, along with inadequate infrastructure, pose challenges to sustainable development in the country.

Yemen has five major land systems: (1) the hot and humid coastal plain, (2) the temperate Yemen highlands, (3) the Yemen High Plateaus and Hadramawt-Mahra Uplands, (4) the desert interior, and (5) the islands.<sup>3</sup> This topography of rugged mountains, highlands, deserts, and coastal plains, coupled with arid weather conditions, render several regions susceptible to desertification and floods. Several ecological zones are fragile and confined to small areas, with communities, flora, and fauna highly adapted to subsist within them. Yemen faces multiple natural hazard risks and has experienced at least one natural disaster every year for the last twenty years.<sup>4</sup> Climate variability is likely to increase and to have negative impacts on agriculture, while intense rainfall events could increase the risk of floods.

Climate change poses a significant threat to Yemen's development. Already early signs of water shortages are apparent. Furthermore, a range of other socioeconomic and institutional factors hamper Yemen's ability to respond to current and projected changes in climate, including: weak institutional structures, lack of long-term reliable data or technical capacity to analyze the data, uncertainties in regional and local climate scenarios as well as socioeconomic scenarios, generally low awareness levels regarding climate change, low institutional or technical capacity to interpret, modify, or develop existing models or methodologies, and a dearth of research on applicable policy measures to address climate change. Many of these challenges will need to be addressed in order to support the Yemenese government in its response to climate change.

## PRIORITY ADAPTATION MEASURES

Key Sectors<sup>1</sup>

Water Resources
Agriculture and Livestock
Energy
Coastal Zones

Source: Yemen's National Adaptation Program of Action, 2009.

Yemen submitted its National Adaptation Program of Action (NAPA) in 2009, thus laying the groundwork for a national plan of action on climate change. It specifies several poverty and economic growth criteria to be used in the evaluation and prioritization of proposed new projects. The key vulnerable sectors identified include water resources, agriculture and livestock, energy, and coastal zones. Adaptation options were subsequently selected via a consultative process with relevant stakeholders across the country. In order of priority, these include:

- ➔ Developing and implementing integrated coastal zone management programs;
- ➔ Water conservation through the reuse of treated waste water and grey water from mosques, as well as irrigation-saving techniques;

<sup>1</sup> World Bank Data Catalogue: <http://data.worldbank.org/country/yemen-republic>.

<sup>2</sup> World Bank Yemen Country Brief: <http://go.worldbank.org/8NOZE6X500>.

- ➔ Developing and implementing an awareness-raising program on adaptation to the potential impacts of climate change;
- ➔ Establishing and maintaining a database for climate change and adaptation;
- ➔ Planting and re-planting mangroves and palms for adaptation to projected sea level rise;
- ➔ Developing and implementing programs to improve Yemen's preparedness to cope with extreme weather events;
- ➔ Rainwater harvesting through various techniques, including traditional methods;
- ➔ Rehabilitation and maintenance of mountainous terraces;
- ➔ Promoting research on drought-resistant and heat- and salinity-tolerant crops;
- ➔ Designing and implementing sustainable land management strategies to combat desertification and land degradation;
- ➔ Sustainable management of fisheries resources;
- ➔ Incorporating climate change and adaptation in school curricula;
- ➔ Investing in a 'knowledge response' to climate variability and change, particularly forecasting and early warning, together with improved data collection and sharing and public awareness and stakeholder involvement.

## CLIMATE BASELINE AND CLIMATE FUTURE

### CLIMATE BASELINE

Yemen is a largely arid sub-tropical country where temperature depends primarily on elevation, and, in the coastal areas, is determined by distance from the sea. Mean temperatures in the highlands range from below 15°C in winter to 25°C in summer, and in the coastal lowlands from 22.5°C in winter to up to 35°C in summer.<sup>5</sup>

Rainfall regimes differ in the highlands and in coastal areas, with relatively little rainfall received in the center of the country. The annual frequency of rain days increases with elevation, with the mean number of wet days showing a strong decline from west to east. Coastal areas receive 80% of the annual rainfall during the winter months, while rainfall in the highlands follows two distinct rainy seasons: the *saif* (April-May) and the *kharif* (July-September).<sup>6</sup> The *saif* rains are governed by the north-west trade winds (entering the Red Sea Convergence Zone), while *kharif* rainfall is governed by mechanisms of the Inter-Tropical Convergence Zone. *Kharif* rains typically fall in short events.

### RECENT CLIMATE TRENDS

- ➔ Annual mean temperatures have risen across Yemen since the 1960s, particularly at higher elevations such as Sana'a. Station records for Aden show a warming of about 1.4°C per century since the 1900s. On average across this country, this warming has been 0.5°C over the 20<sup>th</sup> century.<sup>7</sup>
- ➔ High year-to-year variability makes it difficult to detect a trend in precipitation. Since the 1950s, summer precipitation totals appear to have declined across the Yemen Highlands, although local data for Yemen are lacking, and there are differences between data sets.

<sup>5</sup> UNDP Climate Change Country Profile: Yemen.

<sup>6</sup> World Bank Yemen study: Assessing the Impact of Climate Change and Variability on the Water and Agriculture Sectors, and the Policy Implications, 2010.

<sup>7</sup> Mitchell, T.D., Hulme, M. and New, M. 2002. Climate Data for Political Areas. Area, 34, 109-112.

## Mean Annual Temperature



## Mean Annual Precipitation

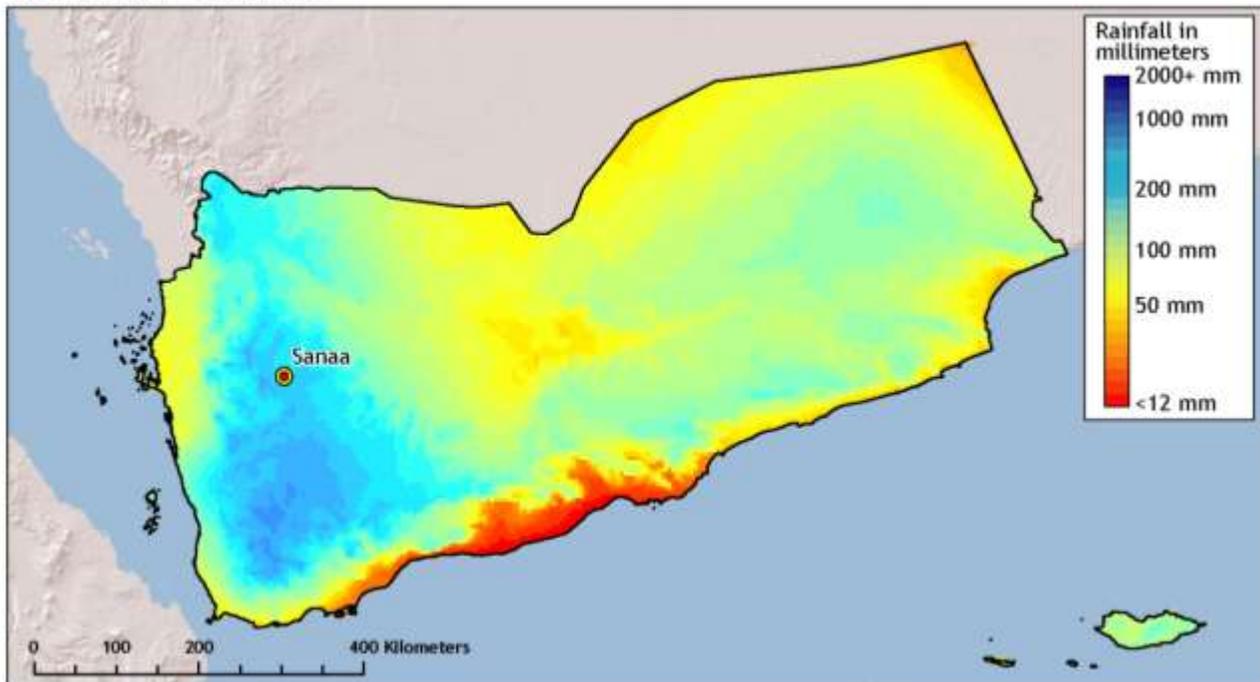


Figure 1: Annual Climate Baseline for Yemen<sup>8</sup>

<sup>8</sup> 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](http://www.worldclim.org/current)

## Major Climate Processes

Red Sea Convergence Zone  
 Inter-Tropical Convergence Zone  
 Cyclonic regimes driven by frontal rainfall in the north

## Impacts on Climate

- Drives saif rains of April-May in highlands
- Drives kharif rains of July-September in highlands
- Bring winter rainfall on the coast

## CLIMATE FUTURE

The climate science community sources a suite of models to inform decision makers on future climate. Among the most widely used are GCMs (Global Climate Models), RCMs (Regional Climate Models), downscaling techniques (both empirical and statistical), and several comprehensive reviews are available on the subject. Global Climate Models (GCMs) are our primary source of information about future climate. GCMs 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 from a suite of GCMs used by the Intergovernmental Panel on Climate Change.

Climate change summary for Yemen:<sup>9,10,11</sup>

- ➔ Mean annual temperature is expected to increase by 1.2°C to 3.3°C by 2060, and the projected rate of warming is more rapid in the interior regions than in areas close to the coast. This is consistent with the higher rates of warming that are projected for the Arabian Peninsula and East Africa, according to the Intergovernmental Panel of Climate Change (IPCC) Fourth Assessment Report.
- ➔ Projections of future rainfall disagree, with some models projecting increases in rainfall while other models project decreases. These large uncertainties in future rainfall patterns are in part a function of differences in model behavior of the Inter-Tropical Convergence Zone over this region. The proportion of rainfall that falls in 'heavy' events shows an increase for autumn (September, October, and November) in most model projections.
- ➔ Runoff is expected to increase by 13%.
- ➔ The number of days and nights that are considered 'hot'<sup>12</sup> under current climate is projected to increase while the frequency of days and nights considered 'cold'<sup>13</sup> under current climate is projected to decrease.

## CLIMATE CHANGE IMPACTS ON NATURAL HAZARD VULNERABILITY

## AT A GLANCE

Climate-related hazards in Yemen include extreme temperatures, floods, landslides, sea level rise, and droughts. While these hazards are a natural occurrence in Yemen, they nevertheless pose serious constraints on development and food security, and their intensity and frequency are likely to increase under a changing climate. The causes and impacts of these natural hazards across Yemen are discussed below:

<sup>9</sup> World Bank Climate Change Knowledge Portal: <http://sdwebx.worldbank.org/climateportal>.

<sup>10</sup> UNDP Climate Change Country Profile: Yemen.

<sup>11</sup> Wilby, R. 2009. An evaluation of climate data and downscaling options for Yemen.

<sup>12</sup> Hot days and nights are defined as the temperature above which 10% of days or nights are recorded in current climate of that region and season.

<sup>13</sup> Cold days and nights are defined as the temperature below which 10% of days or nights are recorded in current climate of that region or season.

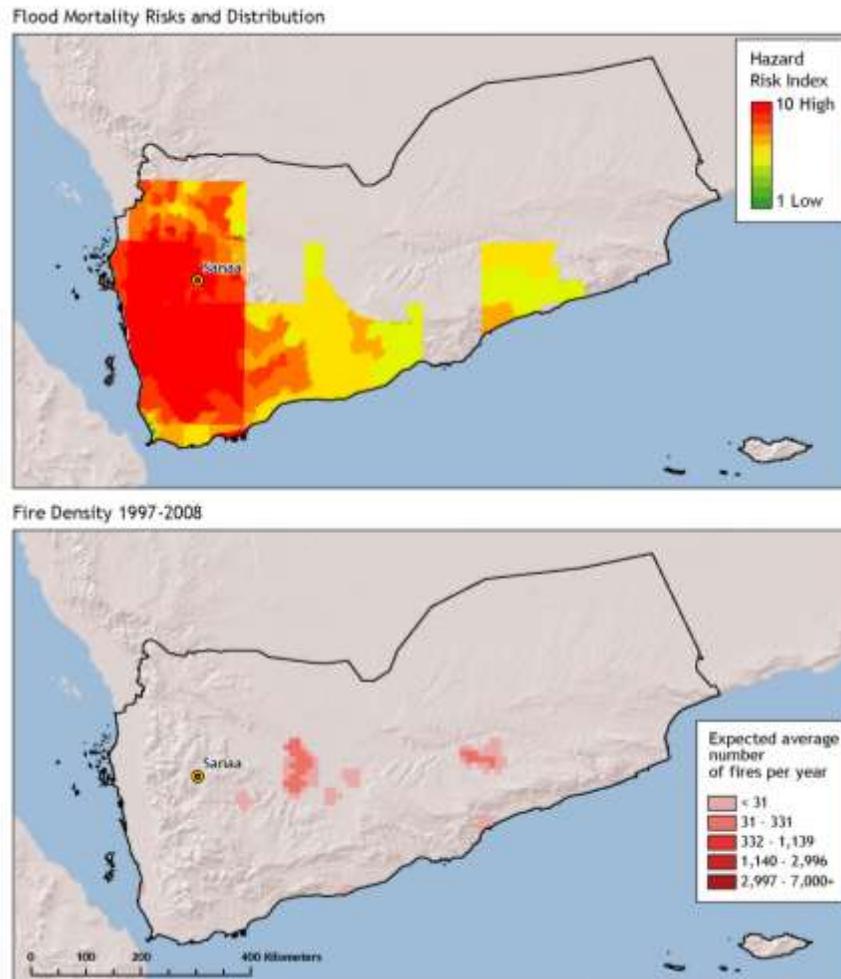


Figure 2: Exposure to climate-related hazards across Yemen<sup>14</sup>

➔ **Floods:** Rainfall in Yemen is characterized by seasonally intense and short-lived heavy storms that often lead to flash floods with implications for soil erosion and degradation of agricultural terraces. Occasionally, these floods have caused significant economic damage and loss of crops. The heavy rains associated with a tropical storm in October 2008, for example, brought 90 mm of rainfall over the course of 30 hours, as opposed to the usual 5-6 mm over the same period.<sup>15</sup> This led to severe flooding in the Hadramout and al-Mahara governorates in eastern Yemen, resulting in over 70 deaths, the displacement of 25,000 people, and the destruction of over 2,800 houses.<sup>16</sup> The overall damage from the flood was estimated at \$1,638 million. Due to their concentrated physical assets and population, floods in urban areas can result in very high losses; the average annual loss due to recurrent floods in Sana'a is estimated at US\$ 3.0 million.<sup>17</sup>

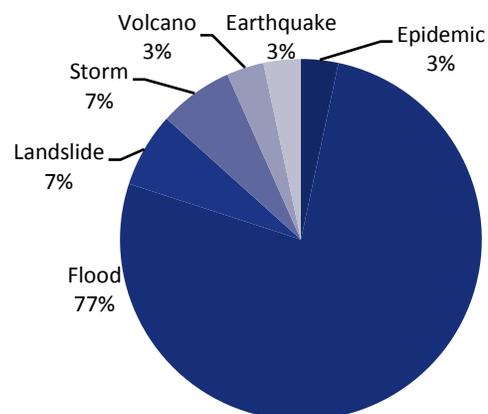
<sup>14</sup> Preliminary risk maps from WHO e-atlas of disaster risk for Eastern Mediterranean Region, 2008; population density map from LandScanTM Global Population Database (2006). Oak Ridge National Laboratory: <http://www.ornl.gov/landscan/> in: Disaster Risk Management Programs for Priority Countries: Republic of Yemen.

<sup>15</sup> Disaster Risk Management Programs for Priority Countries: Republic of Yemen. <http://gfdrr.org/ctrydrmrnotes/Yemen.pdf>.

<sup>16</sup> Damage, Losses and Needs Assessment: October 2008 Tropical Storm and Floods, Hadramout and Al-Mahara, Republic of Yemen. A Joint Assessment of the Government of Yemen, the World Bank, the United Nations, International Strategy for Disaster Reduction, the International Federation for the Red Crescent and Cross, supported by the Global Facility for Disaster Reduction and Recovery. January 2009.

<sup>17</sup> Republic of Yemen Urban Risk Management Brief: Sector Note for Spring Meetings 2011.

- ➔ **Drought and desertification:** Heavy rainfall is frequently followed by long dry periods that result in widespread drought, desertification and land degradation. Climate change may increase the length of these dry periods. Water stress is observed to be increasing, with groundwater reserves likely to be mostly depleted in two to three decades regardless of climate change, reducing agricultural output by up to 40 %.<sup>18</sup> Yemen's water crisis ranks among the worst in the world<sup>19</sup>. High aridity, fast-depleting groundwater reserves, and projected increases in temperature indicate that stress on agricultural production will increase. Greater rainfall variability could result in prolonged drought periods.
- ➔ **Landslides:** Western and southern portions of Yemen are located in the seismically active zone between the Arabian and African tectonic plates, at risk from earthquakes. In addition, Yemen's mountainous terrain renders the entire country at risk of landslides. A vast majority of the urban poor is vulnerable to rockslide and landslide risk as they live in informal settlements that are typically on marginal and environmentally sensitive land.
- ➔ **Sea level rise:** A rise in sea levels would result in increased coastal flooding and possible damage to infrastructure and ecosystems, leading to salt-water intrusion that affects the country's already fragile water balance. Coastal areas are already suffering degradation. Sea level rise could exacerbate deterioration of wetlands, infrastructure damage, coastal flooding, erosion, saltwater intrusion into groundwater, and mangrove migration.



**Figure 3: Natural disaster incidence in Yemen by type (%), 1900-2011**

Source: EM-DAT: The OFDA/CRED International Disaster Database, Université Catholique de Louvain, Brussels, Belgium Data version: v11.08

## SECTORAL CLIMATE RISK REDUCTION RECOMMENDATIONS

The impacts of climate change for the Yemenese 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. Effects of climate variability and change across Yemen are described for several key sectors below:

### WATER RESOURCES

Yemen's water resources are rainfall-dependent. In general, about 6 % of rainfall runs off as surface water and flows into stream beds, often as violent spate torrents.<sup>20</sup> However, very large rainfall events occasionally occur outside of normal patterns and cause destructive floods. Alluvial and rock aquifers are partly recharged annually, but rapid increases in water abstraction and use have affected the water balance, so that the rate of groundwater overdraft is currently twice that of the recharge rate. The overdraft rate is increasing, resulting in water shortages and inequity. According to some modelling studies, groundwater reserves will be exhausted by about 2025-2030<sup>20</sup>. Adaptation options in the water sector include:

- ➔ Investment in an improved knowledge base related to hydro-meteorological data collection and analyses, forecasting, and early warning system with robust dissemination strategy, and development of tools to guide decision making;

<sup>18</sup> World Bank Yemen study: Assessing the Impact of Climate Change and Variability on the Water and Agriculture Sectors, and the Policy Implications, 2010.

<sup>19</sup> Republic of Yemen Water Resources Assistance Strategy, May 2005, World Bank.

<sup>20</sup> World Bank Yemen study: Assessing the Impact of Climate Change and Variability on the Water and Agriculture Sectors, and the Policy Implications, 2010.

- ➔ Investment in efficient irrigation systems (e.g., piped conveyance and distribution, pressurized irrigation, wastewater reuse); this needs to be accompanied by appropriate incentive policies for efficient water resources management and use, such as removing the incentives that encourage over-exploitation of the groundwater and replacing them with those that ensure water saving, and enforcing regulations and policies that are already in place;
- ➔ Monitoring of groundwater use for supplementary irrigation;
- ➔ Adoption of integrated management of water resources at all levels (e.g., water resource evaluation and monitoring, incentive structure to encourage efficient and sustainable use, promotion of basin-level planning and management, watershed management in key catchments).

## AGRICULTURE

Agriculture remains the country's most important productive sector, contributing 25% of the country's GDP and employing over 45 % of the country's work force.<sup>21,22</sup> However, as a result of low productivity and emerging water shortages, rural incomes are stagnating and poverty is increasing. The fact that this sector and the rural economy have fared well compared to other countries in the region can be attributed in large part to the intense mining of groundwater and to *qat* production.<sup>23</sup> As agriculture is estimated to use 93 % of available surface and groundwater, Yemen's groundwater reserves are expected to be exhausted in another two to three decades. Not considering climate change, this would result in reductions in output of over 40% by 2030. Table 1 shows the marginal impact of climate change on crop production in Yemen, for three different climate scenarios ('mid', 'hot and dry', and 'warm and wet'), based on downscaled model results.

Most robust adaptation measures are already a part of Yemen's National Water Sector Strategy and Investment Program (NWSSIP) and of the National Adaptation Program of Action (NAPA). However, investment and implementation of these programs need to be strengthened and accelerated. Adaptation options in the agriculture sector are heavily linked to those in the water sector. Recommendations include:

- ➔ Macroeconomic solutions to remove incentives for water mining and inefficient water use, and introducing incentives that improve water use efficiency;
- ➔ Technical solutions to develop and disseminate the technology needed for improving value added (strengthening the traditional agricultural and water-harvesting techniques);
- ➔ Management solutions to give more responsibility and ownership for both resource management and service provision to farmers and farmer institutions, and to improve the quality and cost effectiveness of public services to agriculture;
- ➔ Research into drought-resistant and heat- and salinity-tolerant crops;
- ➔ Adaption of farming practices, including changing cropping patterns, using crops with shorter growing cycle or later maturing varieties, changing the cropping calendar, etc.

Table 1: Marginal impact of climate change scenarios on crop production

	Mid			Hot and Dry			Warm and Wet		
	2030	2050	2080	2030	2050	2080	2030	2050	2080
Temperature (°C)	+1.6	+2.0	+3.1	+2.0	+2.6	+4.5	+1.0	+1.2	+1.6
Rainfall change	+3%	+3%	-3%	-13%	-13%	-24%	25%	20%	13%
Crop Production	1.0%	1.1%	-6.3%	-10.7%	-11.2%	-27.2%	14.1%	11.7%	6.5%

Source: World Bank Yemen study: *Assessing the Impact of Climate Change and Variability on the Water and Agriculture Sectors, and the Policy Implications*, 2010.

<sup>21</sup> Summarized from the World Bank Yemen study: *Assessing the Impact of Climate Change and Variability on the Water and Agriculture Sectors, and the Policy Implications*, 2010.

<sup>22</sup> According to the Yemen Country Assistance Strategy, *qat* production employs 14% of the population and contributes one-third of the country's GDP. However, it is reported to have adverse impacts on population health and productivity.

<sup>23</sup> *Qat* production consumes one-third of the abstracted groundwater, according to the World Bank Yemen Country Brief.

### COASTAL RESOURCES

Yemen's coastal communities and their livelihoods are currently threatened by coastal erosion and flooding of low-lying areas.<sup>24</sup> Under conditions of sea level rise, these communities could face damage to assets and property, constraints on water supply and quality, as well as loss in agricultural yields. Tourism is likely to be affected, and infrastructural and cultural heritage assets are at risk of damage. Shore coral reefs, already prone to damage by the intense wave activity of storms in the Red Sea and Gulf of Aden, may see an increase in intense wave activity and possibly more frequent storms. In terms of adaptation responses, Yemen's NAPA prioritizes the following adaptation options for the coastal areas of Yemen:

- ➔ Implementation of integrated coastal zone management programs; and
- ➔ Conservation and sustainable use of marine and fishery resources through the development and strict implementation of policy, legislative, and management tools.

### URBAN AREAS

Yemen is expected to cross the 50 % urbanization mark by 2035.<sup>25</sup> Its urban coastal areas are growing at a rate of about 3 % per annum due to immigration from agricultural hinterlands, and the risks of exceeding the carrying capacity of the coastal areas to support livelihoods is high. A significant proportion of the urban-poor live in informal settlements, typically on marginal or hazardous lands, where vulnerability to risks from rock and landslides is high. Considered 'illegal' by the Government, such settlements have generally lacked access to basic municipal infrastructure and services, thereby increasing socio-economic exclusion and inequality in the city and compounding vulnerability to natural hazards. The Government has recently begun to prioritize infrastructure development in urban areas, however, partly in order to attract foreign investors.

### ENERGY<sup>26</sup>

Yemen's economy has been dominated by the oil sector (27 % of GDP and 90 % of merchandise exports), but it has suffered severe fiscal difficulties following recent sharp declines in oil revenues associated with the gradual depletion of reserves and the decline of oil prices after the peak in 2008. Solutions to the economic challenge require diversification of economic activity away from oil. Consequently, the Government has boosted efforts to spur non-oil growth and create jobs in sectors such as agriculture, fisheries, urban manufacturing, and services and the financial sector. Since 2004, the Government has also been taking measures to enhance the business environment and facilitate private sector-led economic diversification. Natural gas is now being hailed as a promising new source of economic growth and energy; foreign companies will be encouraged to expand gas exploration and extraction activities, and the expanded use of natural gas for domestic power production is also expected to contribute to non-oil growth.

## ADAPTATION

As a country with over 40 % of a rapidly growing population classified as poor, prone to climatic (e.g., heavy rainfall, high aridity) and other risks, and with the looming threat of increasing water scarcity, Yemen is highly vulnerable to the adverse impacts of climate change. A wide range of adaptation and vulnerability-reducing activities and studies are thus being explored by the country and international partners. The Yemen Government is taking steps to diversify its economy and to invest in infrastructure development. International organizations are engaged in action on a number of climate-sensitive fronts in Yemen, spanning natural resource programs such as rainfed agriculture, livestock management, water management, and fisheries conservation. A range of urban poverty reduction and infrastructure development activities are also

<sup>24</sup> Yemen National Adaptation Programme of Action (NAPA), 2009.

<sup>25</sup> Republic of Yemen Urban Risk Management Brief: Sector Note for Spring Meeting, 2011.

<sup>26</sup> World Bank Yemen Country Brief. <http://go.worldbank.org/8NOZE6X500> and Yemen Country Assistance Strategy, 2009.

underway, as are efforts to reduce disaster risk in the country and building capacity to address climate and disaster risk issues.

### Ongoing Efforts — At a Glance

#### Adaptation

- National Adaptation Programme of Action
- Adaptation to climate change using agrobiodiversity resources in the rainfed highlands<sup>27</sup>
- Adaptation of Water Management to Climate Change<sup>28</sup>
- Rainfed Agriculture and Livestock Project<sup>29</sup>

#### Vulnerability Reduction

- Second Port Cities Development
- Integrated Urban Development Project
- Study on Informal Settlements in Yemen
- Sana'a Basin Water Management
- Fisheries Resource Management and Conservation

#### GFDRR Interventions

- Risk Assessment Studies and Risk and Vulnerability Mapping (including hydraulic modeling for Sana'a)
- Feasibility Study for Water Harvesting in two Governorates
- Preliminary Assessment of Seismic Risks in Dhamar
- Training Activities for Post-disaster Assessment of Damages and Losses

## EXISTING ADAPTATION FRAMEWORK/STRATEGY/POLICY AND INSTITUTIONAL SETUP

A number of institutional actions are being carried out in Yemen, many of which are set to offer significant insights and experiences on current and potential adaptation strategies for addressing climate change. These include<sup>30</sup>:

- ➔ In support of irrigated agriculture, the Government has been implementing a series of water sector projects to improve participatory irrigation management through Water User Associations and Water User Groups. These activities have focused on rehabilitating irrigation infrastructure and increasing agricultural productivity (more crop per drop).
- ➔ Pilot work is underway to test the concept of integrated water management. The creation of a National Irrigation Program at the Ministry of Agriculture and Irrigation has centralized the government's management of irrigation activities.
- ➔ A program involving General Seed Multiplication Corporation and contracted farmers produced 75 tons of rainfed cereal seeds that were sold back to 1,646 farmers operating in rainfed areas (covering an area of 4,721 hectares). This outcome has benefited from a fruitful collaboration among various agricultural research organizations.
- ➔ New government funding allocations have supported livestock health and production as well as the creation of formal and informal cooperatives among farmers and beneficiaries to strengthen their capacity to identify problems, prioritize needs, and seek financing to help them prepare and implement income-generating projects.
- ➔ The Ministry of Fisheries is restructuring and creating (i) Fishermen's Authorities in coastal governorates, (ii) a Fish Research Authority, and (iii) a Fish Port Authority.

<sup>27</sup> Link to detailed information on this GEF-World Bank project available at: <http://go.worldbank.org/NBG96YSSCO>.

<sup>28</sup> Information on this WRI Netherlands Climate Change Studies Assistance Project (NCCSAP) available at: <http://projects.wri.org/adaptation-database/yemen-adaptation-water-management-climate-change>.

<sup>29</sup> Information on this WB-IFAD project is available at: <http://www.ifad.org/media/press/2008/03.htm>.

<sup>30</sup> World Bank Yemen Country Assistance Strategy, 2009 (for the period FY2010-2013).

- ➔ Local water and wastewater corporations have been established in 14 cities. Coverage of urban water supply services has thus increased.
- ➔ A new Rural Water Supply and Sanitation Strategy is in use, leading to improved efficiency of rural water supply management on the part of Water User Associations.
- ➔ During the NAPA process, a National Project Coordination Unit and a Multidisciplinary Assessment Team were established.
- ➔ A long-term City Development Strategy (CDS) for several municipalities has been developed. Key components of the CDS include urban upgrading strategy (addressing the growing amount of urban squatters and informal settlements), an update of land-use plans, Capital investment plan, and a time-bound prioritized action plan.<sup>31</sup>

## RESEARCH, DATA, AND INFORMATION GAPS

A range of factors pose challenges to addressing climate and disaster risk reduction in Yemen. These include weak institutional structures, lack of long-term reliable data or technical capacity to analyze the data, uncertainties in regional and local climate scenarios as well as socio-economic scenarios, generally low awareness levels regarding climate change, low institutional or technical capacity to interpret, modify, or develop existing models or methodologies, and a dearth of research on applicable policy measures to address climate change.

### ➔ *Monitoring, data collection, and early warning*

- Meteorological information for Yemen is sparse, and a country-wide network of hydrometeorological stations needs to be established in order to quantify long-term changes in climate, including benchmarking future climate variability and change.
- Given the high vulnerability to flood and drought in Yemen, forecasting and early warning programs are needed.
- Information is needed on safe yield for the country's various groundwater and surface-water sources.
- Decision makers presently lack the information necessary to evaluate risk and to support risk reduction for longer-term threats by climate changes. Additional support is needed for the design of comprehensive risk management strategies at the national, provincial, and local levels, enabling long-term disaster risk reduction planning and mitigation measures.

### ➔ *Data sharing and coordination*

- Improved data analysis, sharing, and coordination are necessary. Information on water resources, risks, and vulnerability in different parts of Yemen needs to be disseminated at the local level as soon as possible, as improved public awareness and involvement will be an essential part of future adaptation programs.

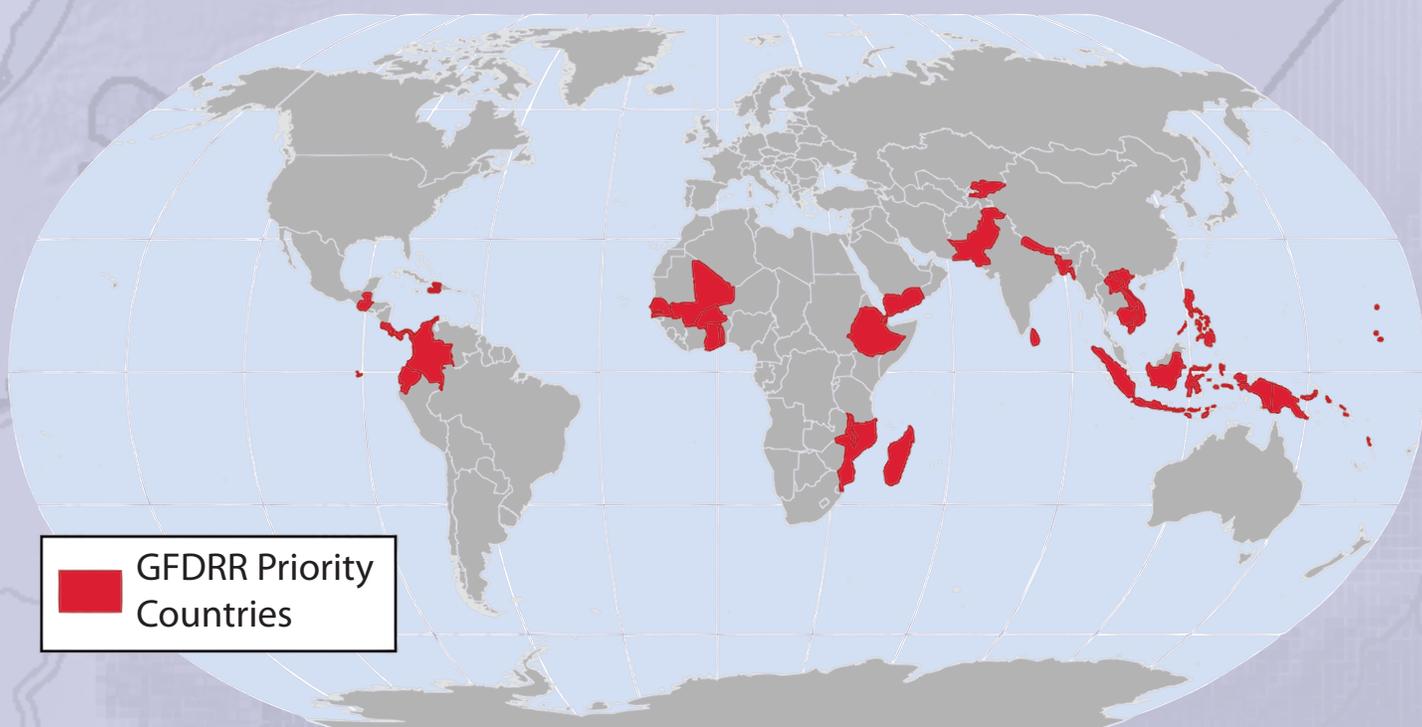
### ➔ *Research and capacity*

- Research is needed on technology options for adaptation in the water resources and agriculture sectors, including crop research.
- Capacity needs to be built to use, modify, and develop appropriate modelling, forecasting, and decision-support tools and software.
- Existing coping mechanisms of communities to climate variability need to be inventoried and experiences that can be replicated or scaled up identified.

<sup>31</sup> Probabilistic Risk Assessment Studies in Yemen. Global Facility for Risk Reduction and the World Bank, 2009.

# Climate Risk and Adaptation Country Profile

This Country Profile (<http://countryadaptationprofiles.gfdr.org>) is part of a series of 31 priority country briefs developed by the Global Facility for Disaster Reduction and Recovery (GFDRR) as part of its Disaster Risk Management Plans. 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.



**Acknowledgments:** The *Country Profiles* were produced through a partnership between the Global Facility for Disaster Reduction and Recovery and the Climate Change Team of the Environment Department of the World Bank, by a joint task team led by Milen Dyoulgerov (TTL), Ana Bucher (co-TTL), and Fernanda Zermoglio. Additional support was provided by Sarah Antos, Michael Swain, Carina Bachofen, Fareeha Iqbal, Iretomiwa Olatunji, Francesca Fusaro, Marilia Magalhaes, Habiba Gitay, and Laura-Susan Shuford. IT, GIS, and map production support was provided by Varuna Somaweera, Katie McWilliams, and Alex Stoicof from the Sustainable Development Network Information Systems Unit (SDNIS). Jim Cantrell provided design. The team is grateful for all comments and suggestions received from the regional and country specialists on disaster risk management and climate change.

© 2011 THE WORLD BANK GROUP  
1818 H Street, NW  
Washington, DC 20433  
Internet: [www.worldbank.org](http://www.worldbank.org)  
Contact: Milen Dyoulgerov,  
[mdyoulgerov@worldbank.org](mailto:mdyoulgerov@worldbank.org)

This volume is a product of the World Bank Group. The World Bank Group does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgement on the part of the World Bank Group concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

All rights reserved.



**GFDRR**  
Global Facility for Disaster Reduction and Recovery

