

EUROPE AND CENTRAL ASIA REGION ■ SUSTAINABLE DEVELOPMENT DEPARTMENT

# Disaster Risk Management and Climate Change Adaptation in Europe and Central Asia

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THE WORLD BANK

GFDRR
Global Facility for Disaster Reduction and Recovery

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# ABSTRACT

Climate change has been observed in Europe and Central Asia (ECA) through higher temperature, changing precipitation and runoff patterns, and extreme weather, leading to reported increasing incidences of weather-induced disasters in many countries of the region, such as floods, droughts, wild fires, strong winds, and heat and cold waves.

With climate change contributing to an increase in disaster risk, disaster risk management becomes a vital and urgent component of any climate change adaptation program. As part of climate change adaptation policies and investments, ECA countries need to focus on reducing their vulnerability and planning for measures to mitigate natural disaster risks.

The paper reviews the current knowledge on the implications of climate change for extreme weather and analyzes the ability of ECA countries to mitigate and manage the impact of extreme events. It recommends a variety of measures in the areas of financial and fiscal policy, disaster risk mitigation, and emergency preparedness and management to reduce current and future vulnerabilities.

Taking into account the projected impact of climate change, the reduction of current and future vulnerabilities to climate change risk should build on and expand existing disaster risk management efforts. This paper highlights the importance of investing in "win-win" options. Regardless of the accuracy in climate change predictions, reduction of current weather-related disaster risk will reduce losses and initiate necessary actions for climate change adaptation. Planning for extreme weather events also supports preparedness for a variety of other emergencies and, therefore, brings additional benefits.

This paper—a product of the Sustainable Development Department, Europe and Central Asia Region—is an effort to develop an analytical framework for sector and country dialog on climate change adaptation. The authors can be contacted at jpollner@worldbank.org and jkryspin@worldbank.org.

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CAT DDO | Catastrophic Deferred Drawdown Option |
| CDP | Carbon Disclosure Project |
| CMEPC | Civil-Military Emergency Preparedness Council |
| ECA | Europe and Central Asia |
| ECMWF | European Centre for Medium-range Weather Forecasting |
| EOC | Emergency Operations Center |
| ER | Emission Reductions |
| EU | European Union |
| GCM | General Circulation Models |
| GIS | Geographic Information Systems |
| IFRS | International Financial Reporting Standard |
| IPCC | Intergovernmental Panel for Climate Change |
| MCR | Minimum Capital Requirement |
| MIC | Monitoring and Information Center |
| NAO | North Atlantic Oscillation |
| NIBS | U.S. National Institute of Building Sciences |
| SCR | Solvency Capital Requirement |
| SEE | South East Europe |
| SEEDRMAP | South Eastern Europe Disaster Risk Mitigation and Adaptation Program |
| UN/ISDR | United Nations International Strategy for Disaster Reduction |
| WB | World Bank |
| WMO | World Meteorological Organization |

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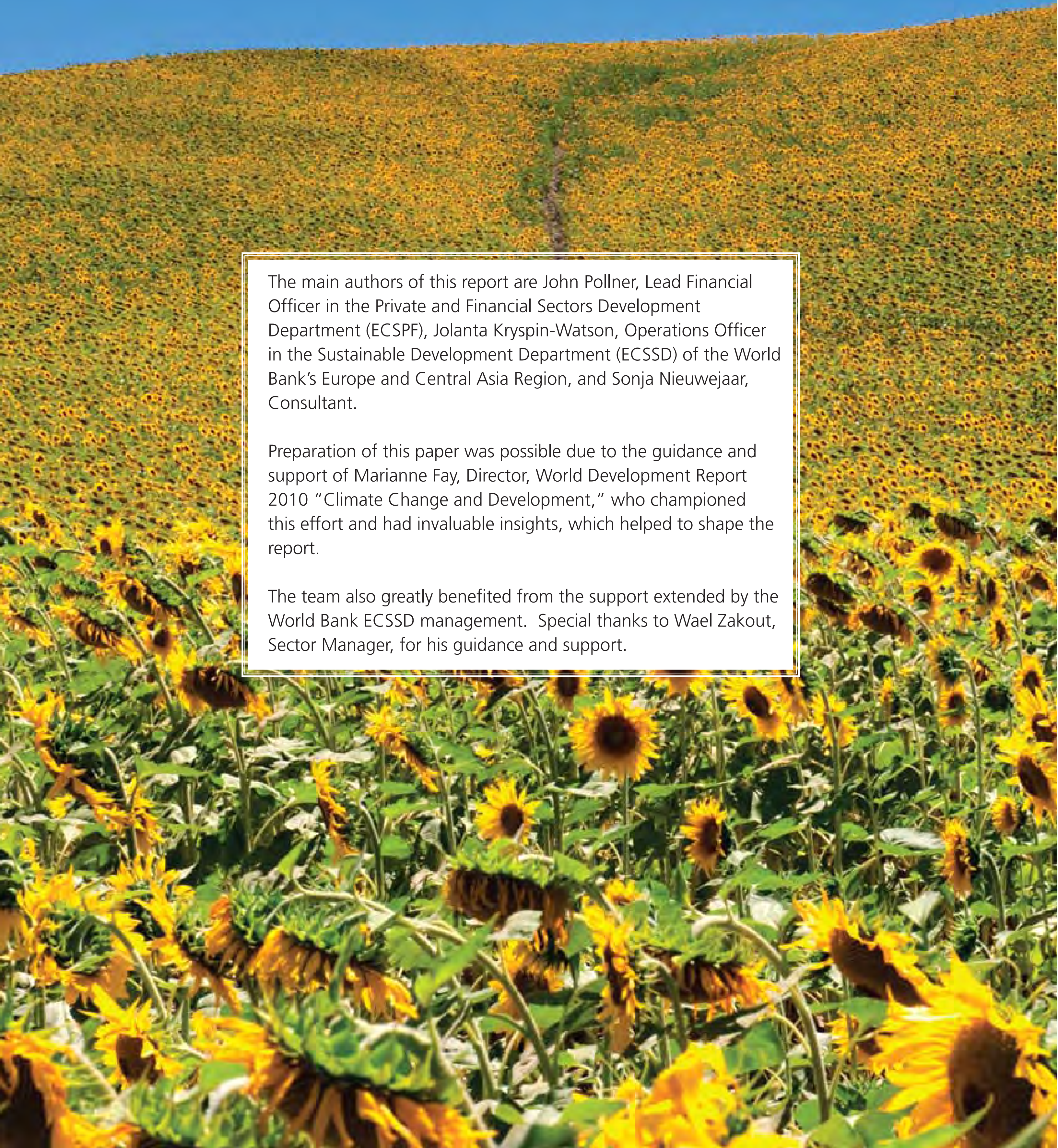
# ACKNOWLEDGEMENTS



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# EXECUTIVE SUMMARY

This paper serves as a sectoral background note for the regional report *Adapting to Climate Change in Europe and Central Asia.* It focuses on what is known about the implications of climate change for extreme weather and the ability of Europe and Central Asia (ECA) to mitigate and manage the impact of extreme events. It also explains how climate change will increase weather-induced disasters in ECA, highlighting the sensitivity of ECA's population to these hazards and recommending various measures in the areas of financial and fiscal policy, disaster risk mitigation, and emergency preparedness and management to reduce current and future vulnerabilities.

The goals of this paper are to (i) present forecasts on how climate change will affect weather-related hazards, their secondary effects and the impacts the extreme hydrometeorological phenomena will have on the countries of Europe and Central Asia and (ii) provide an overview of measures to mitigate and manage these risks.

Globally climate change resulting from growing greenhouse gas emissions is expected to lead to rising temperatures and changing rainfall patterns. The effects may vary by sub-regions and localities, but in general the following may be expected to take place:

- Increase in temperature and decrease in mean precipitation leads to an increase in the frequency and severity of drought and heat waves.
- Increasingly warm ocean surface temperature generates more and stronger hurricanes, as well as commensurate flooding in the aftermath.
- Severe drought leads to an increase in forest fires.
- Greater intensity of wind and rain causes severe floods and landslides.

In Europe and Central Asia, the climate is already changing. Increasing temperatures are recorded in many sub-regions, particularly the Baltics, Central Asia, and the Caucasus, as well as in northern and eastern parts of Russia. Comparing the mean value for annual temperature between 1901 and 2002, warming has varied from 0.5°C (South East Europe) to 1.6°C (South Siberia). There has been an increase in drought conditions over much of ECA in the last two decades, even in regions experiencing growing mean annual precipitation. The General Circulation Models (GCM) project continued warming everywhere with fewer frost days and more heat waves. The anticipated increase in mean annual temperature in ECA ranges from 1.6°C to 2.6°C by the middle of this century. The more northerly parts of the region are expected to have greater temperature changes in the winter months, while the more southerly parts are expected to have greater warming in the summer months. Runoff, a measure of water availability, is projected to decrease everywhere but in Russia with the most dramatic decreases likely to occur in South East Europe (-25%). Throughout ECA, the models consistently show that precipitation intensity will increase.[1]

SIGMA, the catastrophe analysis arm of Swiss Re, one of the major global reinsurance companies (which insures the insurance industry), has also reported increasing incidences of weather-induced disasters in the following countries:

| Country | Hazard |
|---|---|
| Hungary | Wind storms, Floods |
| Poland | Cold wave, Floods |
| Russia | Cold wave |
| Romania | Cold wave, Floods |
| Bulgaria | Cold wave, Floods |
| Czech Republic | Cold wave, Floods |
| Turkey | Cold wave, Floods |
| Estonia | Cold wave |
| Latvia | Snow fall, extreme cold, power shortage |
| Lithuania | Snow fall, extreme cold, power shortage |
| Moldova | Snow fall, extreme cold, power shortage |
| Slovakia | Floods |
| Serbia | Floods |
| Montenegro | Floods |
| Croatia | Floods |

With climate change contributing to an increase in disaster risk, disaster risk management becomes a vital and urgent component of any climate change adaptation program. As part of climate change adaptation policies and investments, ECA countries need to focus on reducing their vulnerability and planning for measures to mitigate natural hazard risks.

Taking into account the projected impact of climate change, the reduction of current and future vulnerabilities to climate change risk should build on and expand existing disaster risk management efforts. This paper highlights the importance of investing in "win-win" options. Regardless of the accuracy in climate change predictions, reduction of current weather-related disaster risk will reduce losses and initiate necessary actions for climate change adaptation. Planning for extreme weather events also supports preparedness for a variety of other emergencies and, therefore, brings additional benefits.

The paper describes how climate change emphasizes the need to identify and support generic adaptive capacity along with hazard-specific mitigation capacity. It is important to recognize, however, that response and disaster mitigation based on past vulnerabilities may not suffice in light of scientific forecasts, because in many countries of Europe and Central Asia, these existing mechanisms are already insufficient for the current level of vulnerabilities.

With growing scientific evidence of climate change, policymakers need to realize the importance of taking actions that can address disaster risk, while decreasing the effects of climate change through vulnerability reduction. For disaster risk management to be effective, institutional structures and management tools to respond to weather-induced catastrophic events should be key elements of local and national adaptation strategies. Better management of disaster risk also maximizes use of available resources for adapting to climate change.

[1] M. Westphal, "Summary of the Climate Science in the Europe and Central Asia Region: Historical Trends and Future Projections," World Bank, 2008.

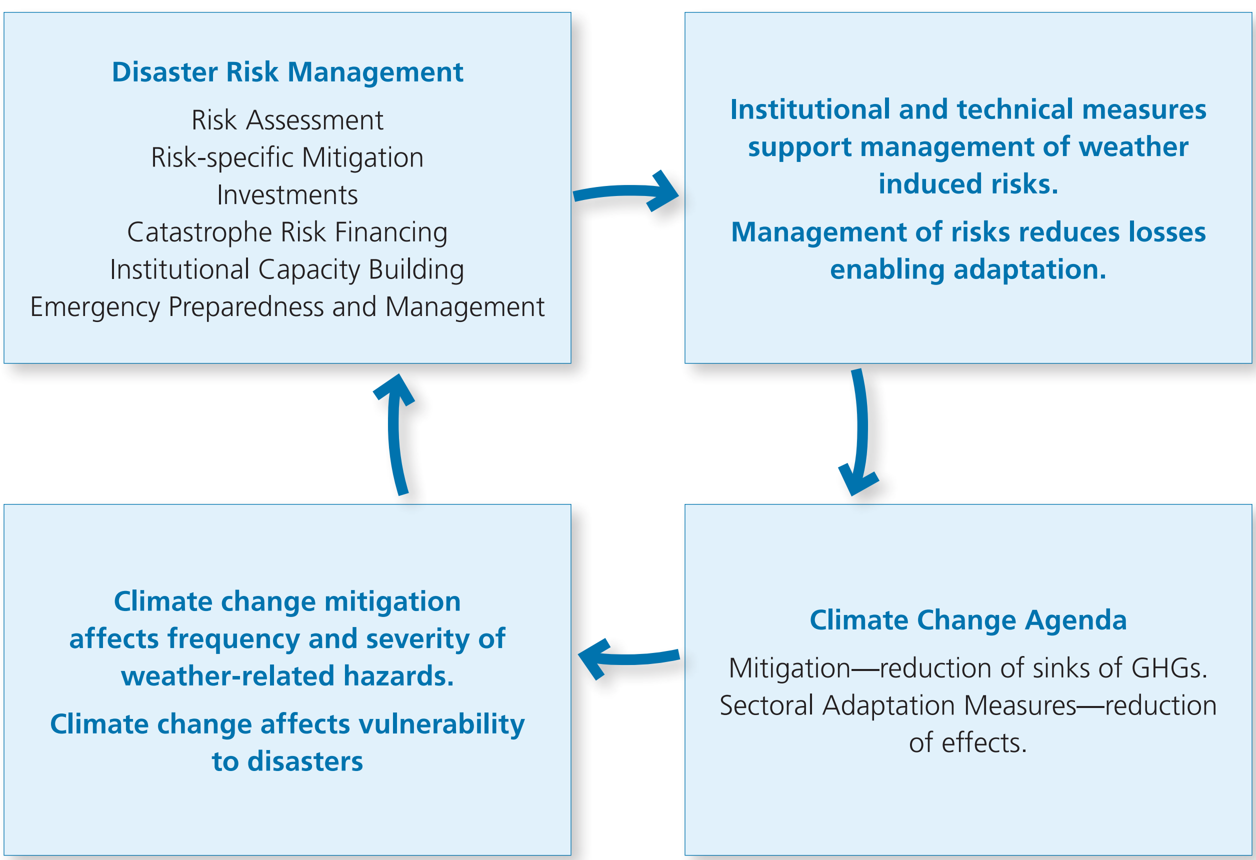
Figure 1 summarizes the linkages between disaster risk management and climate change.

Across the ECA region, developing and strengthening an ***institutional and legislative disaster risk management framework*** would assist in budget appropriations, planning, and finally the implementation of disaster risk management plans. Ensuring legal statutes are clear and hazard risk management is properly funded are the first steps. A strong system should have a robust preparedness program with plans, training, and exercises for all levels of its emergency management system. ***Clarifying the roles and responsibilities*** of local and national governmental bodies in risk reduction, as well as emergency preparedness and response, would improve disaster risk management capacity.

There are many "hard" and "soft" measures countries can take to reduce the risk of natural hazards and to adapt to climatic changes. Before undertaking any concrete steps, however, completing ***hazard risk assessments*** and corresponding hazard maps is recommended. Risk assessments are also crucial for policymakers to evaluate the costs and benefits of risk mitigation investments and to prioritize these investments.

Historically hydrometeorological hazards have affected Europe and Central Asia significantly. The effect these disasters have on the population and infrastructure are exacerbated by several factors: settlements in disaster-prone areas, debilitating land and water use, lack of regulations and standards for hazard risks, and failure to comply with

**Figure 1.** Climate Change and Disaster Risk Management



building codes and land use plans. ***Hazard-specific investments*** can reduce the risk of hydrometeorological hazards and increase adaptive capacity. Early warning systems for various hazards can be developed to monitor heat waves, forest fires, and floods. Flood risk reduction measures can range from soft measures, such as developing flood management plans, to hard measures, such as investments in flood protection schemes. The introduction of drought resistant crops reduces some effects of drought, and retrofitting buildings to withstand heavy winds reduces some storm risks. The government and public can take a combination of regulatory, structural, and protective measures to reduce risk, decrease a country's vulnerability to natural hazards, and adapt to climatic changes.

Another important adaptation measure is to ***strengthen technical capacity*** of emergency responders. This includes purchasing personal protective equipment, tools, and vehicles. To ensure that all levels of government and emergency units can communicate, it is critical to invest in an interoperable emergency communications and information system. Moreover, ensuring public awareness of natural hazard risks and of preparedness and response actions is an effective and relatively low-cost action, which can be pursued by governments of the region.

***Development institutions and credit markets*** are ready to finance losses, providing that adequate adaptation measures are taken in advance to minimize what needs to be "insured." Governments, individually and collectively, need to quantify their climate-induced disaster exposures and calculate the budget allocations required to cover reasonably projected losses. If these are not sustainable, they should consider the range of ***financial instruments*** to optimize (i.e., lower) the cost of premium-equivalent outlays and maximize any loss payout needed if a climate change-induced disaster affects their territory.

The use and price of ***pooled risk approaches, capital market mechanisms, insurance and credit instruments*** can be calculated in combination to reduce the cost of financial protection for emergency reconstruction and to avoid the economic and budgetary disruptions this would otherwise entail. ▼

# INTRODUCTION

Based on the available data and studies, the paper shows that countries can expect extreme weather events to be recurrent and that these events can lead to disasters that may overwhelm a country's emergency management capability. It highlights ECA's vulnerability to disasters and points to measures for risk mitigation and management. The study also presents technical options and policy recommendations to guide activities that governments can undertake in planning and preparing for climatic changes.

The paper concentrates on hazards that have very clear and obvious links to climatic change (i.e., those of hydrometeorological origins, such as floods, wild fires, droughts, and strong winds) but also covers other occurrences like landslides, which can be triggered by floods. Many measures and recommended actions discussed are multi-hazard and cross cutting, while the technical disaster mitigation tools and techniques are more hazard-specific. For the latter, the paper covers weather-induced hazards, and with the exception of land and mudslides that are triggered by floods and heavy rains, it leaves out the issues related to seismic risk. While there are ongoing studies in other regions that investigate a possible link between climate change and seismic and volcano eruption risks, this link is not yet sufficiently explored for the ECA region and, therefore, is not covered by the paper.

*Definitions of mitigation measures are different in the context of disaster risk reduction and climate change.* The Intergovernmental Panel for Climate Change (IPCC) defines mitigation as "a human measure to reduce the sources or enhance the sinks of greenhouse gases." Climate change mitigation measures include energy conservation, land use plan enforcement, strengthening institutional and legislative mechanisms, energy efficiency measures, waste management, fossil fuels substitution with renewable energy sources, other measures in the transport and agricultural sectors, and sequestering carbon biologically through reforestation or geophysically.[2]

For disaster risk management experts, the term mitigation, as defined by the UN International Strategy for Disaster Reduction (ISDR), means "structural and non-structural measures undertaken to limit the adverse impact of natural disasters, environmental degradation and technological hazards." These may include seis-

[2] "On Better Terms – A Glance at Key Climate Change and Disaster Risk Reduction Concepts," United Nations, 2006.

mic retrofitting, construction of flood protection schemes, and reforestation aimed at landslide risk reduction, to name a few examples. In the climate change context, these would be called "adaptation" activities. These activities represent one aspect of adaptation, as adaptation to climate change encompasses broader and more comprehensive measures. For climate change experts, adaptation means adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm.[3] The paper applies disaster risk reduction terminology, while presenting them in the broader framework of the adaptation to climate change.

Because ECA spans differing topography and climate, for the purpose of the report, the region is divided into 6 sub-regions:

1. Baltic States: *Estonia, Latvia, Lithuania, Belarus, and Poland*
2. Caucasus States: *Armenia, Azerbaijan, and Georgia*
3. Central Asian States: *Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan*
4. Central European States: *Czech Republic, Hungary, Moldova, Romania, Slovakia, and Ukraine*
5. Russia
6. South East European States: *Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, FY Macedonia, Serbia, Slovenia, and Turkey*

[3] *Ibid.*

# BACKGROUND AND RISK CONTEXT OF CLIMATE CHANGE IN ECA

The countries of Europe and Central Asia are prone to a variety of natural hazards, including floods, droughts, wild fires, earthquakes, strong winds, and landslides. As seen in Table 1 (ECA Disaster Matrix), multiple disasters occur in each ECA country. For the purposes of this paper, the table does not present the seismic risk to which many countries of the region are exposed. Because this background paper focuses on the impact of climate change on natural hazards, the focus is on hazards exacerbated by hydrometeorological phenomena.

## REVIEW OF HYDROMETEOROLOGICAL HAZARDS BY ECA SUBREGION

### Baltic: *Estonia, Latvia, Lithuania, Belarus, and Poland*

The Baltic states are extremely vulnerable to high wind, storm surge along the coast, and flooding along the Oder and Vistula Rivers. In 1993, floods in Belarus caused US$100 million in damage and affected 40,000 people. In 1997, flooding in Poland killed 55 people, impacted 224,500 others, and caused US$3.5 million in damage.

Storms also cause major damage in the Baltics. In 2005, windstorms hit Estonia causing US$1.3 million in damage. Both in 1999 and 2005, Latvia experienced major windstorms, causing over US$325 million in damage. And in 1993, windstorms struck Lithuania, affecting over 780,000 people.[4]

### Caucasus: *Armenia, Azerbaijan, and Georgia*

The Caucasus states are at risk for floods, drought, and landslides. Although Armenia's major risk is from earthquake (100% of the country is prone to earthquakes), 98% of the country is at risk of drought and 31% of the country is at risk of flooding.[5] In June of 1997, flooding killed 4 people and affected 7,000.[6]

4 Emergency Events Data Base (EM-DAT) www.emdat.be

5 Natural Hazards Assessment Network (NATHAN) http://mrnathan.munichre.com/

6 Emergency Events Data Base (EM-DAT) www.emdat.be

**Table 1.** Disaster Matrix by ECA Country

| Country | Flood | Land slides | Drought | Extreme temperature | Wind storm | Wild fire | Wave / surge |
|---|---|---|---|---|---|---|---|
| Albania | X | X | X | X | X | X | |
| Armenia | X | X | X | | X | | |
| Azerbaijan | X | X | X | | | | |
| Belarus | X | | | X | X | | |
| Bosnia and Herzegovina | X | X | X | | X | X | |
| Bulgaria | X | X | X | X | X | X | |
| Croatia | X | | X | X | X | X | |
| Czech Republic | X | X | | X | X | | |
| Estonia | X | X | | X | X | | |
| FY Republic of Macedonia | X | X | X | X | X | X | |
| Georgia | X | X | X | | X | | |
| Hungary | X | | X | X | X | | |
| Kazakhstan | X | X | | X | X | X | |
| Kyrgyz Republic | X | X | | X | X | | |
| Latvia | X | | | X | X | | |
| Lithuania | X | | X | X | X | | |
| Moldova | X | X | X | X | X | | |
| Poland | X | | | X | X | X | |
| Romania | X | X | X | X | X | | |
| Russian Federation | X | X | X | X | X | X | X |
| Serbia | X | | | X | X | X | |
| Slovak Republic | X | | | X | X | X | |
| Montenegro | X | | | X | X | X | |
| Slovenia | X | X | | X | | | |
| Tajikistan | X | X | X | | X | | |
| Turkey | X | X | | X | X | X | |
| Turkmenistan | X | | | | | | |
| Ukraine | X | X | | X | X | | |
| Uzbekistan | X | X | X | | | | |

*Sources: EM-DAT 2008 and Pusch "Preventable Losses: Saving Lives and Property through Hazard Risk Management"; 2004.*

**Note: Although not included in table 1, ECA countries are also affected by non-hydrometeorological hazards such as earthquakes, technological disasters and epidemics.*

**Table 2.** Exposure to Landslides in ECA

| | Extent of hazard area (classes 4–6) | | Population located in hazard area (classes 4–6) | |
|---|---|---|---|---|
| **Country** | **Square kilomenters** | **Percentage of country area** | **Number of people** | **Percentage of total population** |
| Turkey | 194,000 | 25 | 8,100,000 | 11 |
| Kyrgyz Republic | 93,000 | 47 | 1,016,000 | 20 |
| Russian Federation | 168,000 | 1 | 1,016,000 | <1 |
| Georgia | 40,000 | 58 | 987,000 | 19 |
| Romania | 16,000 | 7 | 952,000 | 4 |
| Tajikistan | 52,000 | 36 | 728,000 | 11 |
| Bosnia and Hezegovina | 12,000 | 25 | 520,000 | 12 |
| Azerbaijan | 15,000 | 9 | 500,000 | 6 |
| Uzbekistan | 11,000 | 3 | 415,000 | 2 |
| Slovenia | 500 | 29 | 230,000 | 12 |
| Moldavia | 28 | 0.1 | 1,640 | <1 |
| Czech Republic | 104 | 0.1 | 9,200 | <1 |

*Source: Norwegian Technological Institute*

Three years later, drought affected 297,000 people and caused US$100 million in damage.

Landslides, flood, and drought also affect Azerbaijan. Over 80% of the country is at risk for floods and drought.[7] In June of 1997, eleven people died and 700,000 were affected by flooding. In 2000, more than ten people lost their lives from landslides, and in that same year, drought caused US$100 million in damage.[8]

Georgia, like its neighbors, has had destructive floods and drought. In 2000, drought struck, impacting 696,000 people and causing US$200 million in damage.[9] Over the past thirty years, major floods have hit Georgia. In 1987, floodwaters completely destroyed 2,600 buildings, resulting in US$300 million in damages.

Mudflows are not noted in Table 1 but are important nonetheless. Mudflows occur in the mountainous regions of the Caucasus, damaging settlements and causing major economic loss. In Azerbaijan, on average, annual economic losses due to mudflows are US$15 million. In Armenia, mudflows have damaged around 200 settlements.[10] And in Georgia, 58% of the country is prone to landslides with 3.5 million hectares of land at risk of mudflow and landslides (see Table 2).[11]

## Central Europe: *Czech Republic, Hungary, Moldova, Romania, Slovakia, and Ukraine*

Central Europe is exposed to landslides, high wind, and heat waves, but one of its greatest hazards is flood. In fact, Romania is known as one of the most flood-prone countries in ECA. Over the past decade, floods killed over 1,400 people: 1,000

7 Natural Hazards Assessment Network (NATHAN) http://mrnathan.munichre.com/

8 Emergency Events Data Base (EM-DAT) www.emdat.be

9 *Ibid.*

10 United Nations Environment Programme. Caucasus Environment Outlook (CEO). Tbilisi, Georgia, 2002.

11 *Ibid.*

people in 1926; 215 people in 1970; 60 people in 1975; 108 people in 1991; and 33 people in 1995. Floods in Romania are responsible for over US$2 billion in damages.[12]

The Czech Republic and Hungary also experienced major flooding. In 2002, the Czech Republic incurred €3 billion in damages due to floods. In Hungary from 1900 to present, the top eight disasters are all due to flooding, impacting over 179,000 people.[13]

Although flooding affects Moldova and Ukraine, wind and heat cause even more damage. In November 2000, a windstorm affected the livelihood of 2,600,000 people. And in Ukraine, the deadliest hazard was the recent heat wave in 2006, which claimed the lives of 801 people.[14] Drought is a recurrent problem for the Moldovan agriculture sector, causing estimated annualized losses of between US$1.6 million and US$20 million.[15]

**Russia:** In Russia, floods and storms result in 1,000 deaths per year; the hardest hit regions are where the population is the poorest: eastern Siberia, far east, and southern regions.[16] Russia also experiences landslides with about 700 towns at risk. On average, both floods and landslides cause annual economic losses of US$300 million.[17] In the past twenty years, extreme temperatures also killed over 1,500 people.[18] In 2003 drought impacted 1 million people.

### South East Europe: *Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, FY Macedonia, Serbia, Slovenia, and Turkey*

The countries of South East Europe are exposed to a variety of natural hazards, including floods, droughts, forest fires, earthquakes, and landslides. Albania, Croatia, FY Macedonia, and Serbia and Montenegro are the most susceptible to floods. On average, Serbia and Montenegro experiences one flood event every two years.[19] In Croatia, floods jeopardize more than 15% of its territory.[20]

While the key natural hazard to Turkey is earthquake, the coastal plains are also vulnerable to flooding. On average, one flood strikes Turkey each year. In May of 1998, Turkey experienced one of the worst floods in the past 100 years. Floods damaged northwestern Anatolia, affecting 4 cities, 10 towns, and 110 villages with 30 people dead and over one million people impacted. The floods destroyed or badly damaged 2,200 houses and estimated losses went as high as US$2 billion.[21]

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12 Emergency Events Data Base (EM-DAT) www.emdat.be

13 *Ibid.*

14 *Ibid.*

15 "Rural Productivity in Moldova – Managing Natural Vulnerability," World Bank, May 2007.

16 A. Kokorin, "Report No. 2. Expected Impact of the Changing Climate on Russia and Central Asia Countries and Report No 3. Ongoing or Planned Adaptation Efforts and Strategies in Russia and Central Asia Countries," WWF Russia, 2008.

17 C. Pusch, "Preventable Losses: Saving Lives and Property through Hazard Risk Management - A Comprehensive Risk Management Framework for Europe and Central Asia," Disaster Risk Management Working Paper Series, No. 9, World Bank, 2004.

18 Emergency Events Data Base (EM-DAT) www.emdat.be

19 UN/ISDR - WB. "South Eastern Europe Disaster Risk Mitigation and Adaptation Initiative: Risk Assessment in South Eastern Europe - A Desk Study Review." Geneva, Switzerland: United Nations, 2008.

20 C. Pusch, "Preventable Losses: Saving Lives and Property through Hazard Risk Management - A Comprehensive Risk Management Framework for Europe and Central Asia," Disaster Risk Management Working Paper Series, No. 9, World Bank, 2004.

21 Gurer and H. Ozguler, "Integrated Flood Management – Case Study 1 - Turkey: Recent Flood Disasters in Northwestern Black Sea Region," WMO/GWP Associated Programme on Flood Management, 2004.

### Central Asia: *Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan*

The countries of Central Asia are prone to earthquakes, floods, drought, avalanches, and landslides. Over the past decade, 2,500 people died and 5.5 million (10% of the total population) were affected by natural disasters in Central Asia.[22]

One of the most sensitive countries to natural hazards is Tajikistan. Extreme poverty (64% of the population lives below the poverty line) and lack of emergency management capacity increases Tajikistan's sensitivity to natural hazards.[23] In 2000, drought affected 3 million people. In 2006, flooding and mudslides affected 13,000 people. Additionally 36% of Tajikistan is at risk of landslides (see Table 2).

Landslides and floods regularly affect Turkmenistan and Kazakhstan. In 2004, landslides killed 48 people in Kazakhstan. Flooding is a major risk for the Kyrgyz Republic. In 2005, floods impacted 2,700 people, washing away wheat crops, devastating the local economy, and causing food shortages. Kyrgyz Republic is also at significant risk for landslides with 20% of the country's population living in susceptible areas (see Table 2).

The Kyrgyz Republic shares the Ferghana Valley with Tajikistan and Uzbekistan. The valley is at risk for flooding; the majority of its population is poor and lives close to the riverbanks for their agricultural and domestic water needs.

Uzbekistan is at great risk of drought, which regularly affects the north and northwest of the country, particularly around the Aral Sea where irrigation has aggravated salinization and desertification. In 2000, drought affected 600,000 people, causing over US$50 million in damage.

## IMPACT OF CLIMATE CHANGE ON EUROPE AND CENTRAL ASIA

Recent studies show that not only are global temperatures on the rise but also global precipitation patterns are changing. Although more scientific research needs to be done, the general conclusion is that the increase in temperature is accelerating the hydrological cycle and altering marine systems, which in turn is changing precipitation patterns.[24] The key implication of changing precipitation patterns is an exacerbation of hydrometeorological hazards, such as floods, landslides, drought, heat waves, and soil erosion.[25]

**Overview of Climate Change on ECA.** Historically hydrometeorological hazards impact Europe and Central Asia, including wave surge events. With climate change, these hazards are expected to intensify and increase in number.

**Rise in Temperature.** By 2050, all of Europe and Central Asia will see an increase in both summer and winter temperatures and will experience a decline in frost days and an increase in heat waves (see Table 3). Russia's Western Arctic will undergo the greatest temperature change with a mean annual temperature increase of 2.6°C (see Figure 2) and a significant increase in the winter temperature of 3.4°C.

22 European Commission - Humanitarian Aid Office (ECHO), "Commission Funds Disaster Preparedness Actions in Central Asia Worth EUR 2.5 million," May 28, 2004.

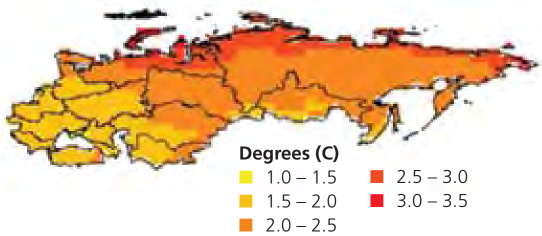
23 World Bank, "Report No: 30853-TJ- Republic of Tajikistan Poverty Assessment Update," 2005.

24 For more information on the relationship between climate change and increasing flood risks, please refer to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC).

25 M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., "Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change," Cambridge, UK: Cambridge University Press, IPCC, 2007.

**Figure 2.** Change in Mean Annual Temperature

(2030-2049; 1980-1999; A1B; 8 GCMs)




*Source: Westphal (2008)*

***Change in Precipitation Patterns.*** In the northern ECA region, mean annual rainfall is predicted to increase by 10-15%, and in the southern ECA countries, rainfall will significantly decrease by as much as -15% (see Figure 3).

All ECA regions will experience an increase in precipitation intensity, however, they will differ drastically in annual runoff (a measure of water availability). Russian Siberia and Far East will experience a 22% increase in annual runoff while South East Europe will have an average decrease of 25% (see Table 3).

**Table 3.** Climate Change Data by ECA Sub-Region

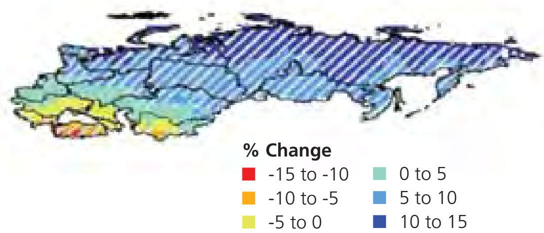
| Region | Mean Annual Temperature Change | Mean Seasonal Temperature Change | Change in Mean Annual Precipitation | Change in Seasonal Precipitation | Change in Annual Runoff (a measure of water availability | Precipitation Intensity | Precipitation per Extreme Events | Consecutive Dry Days | Frost Days | Heat Wave duration |
|---|---|---|---|---|---|---|---|---|---|---|
| **Baltics** | 1.6°C | 1.7°C (Summer)<br>2.0°C (Winter) | ~ | ~ | -6% (South)<br>11% (North) | 5% | 8% | ~ | -30 | 25 |
| **Central Asia** | 1.9°C | 2.4°C (Summer)<br>1.6°C (Winter) | ~ | ~ | -12% | 4% | 2% | ~ | -21 | 22 |
| **Kazakhstan** | 2.0°C | 2.4°C (Summer)<br>1.8°C (Winter) | 4% | ~ (Summer)<br>9% (Winter) | 3% | 5% | 7% | ~ | -22 | 29 |
| **Caucasus** | 1.7°C | 2.1°C (Summer)<br>1.6°C (Winter) | ~ | ~ | -16% | 4% | 4% | 4 | -22 | 23 |
| **Central Europe** | 1.7°C | 1.8°C (Summer)<br>1.9°C (Winter) | ~ | ~ | -13% | 4% | 5% | 2 | -26 | 28 |
| **Southeastern Europe** | 1.8°C | 2.1°C (Summer)<br>1.8°C (Winter) | -6% | ~ (Summer)<br>-6% (Winter) | -25% | 2% | ~ | 5 | -17 | 25 |
| **Russia** | | | | | | | | | | |
| Baltic | 1.9°C | 1.9°C (Summer)<br>2.5°C (Winter) | 6% | ~ (Summer)<br>10% (Winter) | 13% | 6% | 6% | ~ | -23 | 31 |
| Volga | 1.9°C | 2.0°C (Summer)<br>2.1°C (Winter) | 5% | ~ (Summer)<br>9% (Winter) | 7% | 6% | 7% | ~ | -23 | 34 |
| North Caucasus | 1.6°C | 2.0°C (Summer)<br>1.6°C (Winter) | ~ | ~ | -12% | 4% | 4% | 2 | -20 | 37 |
| Siberia and Far East | 2.4°C | 2.3°C (Summer)<br>2.6°C (Winter) | 11% | ~ (Summer)<br>17% (Winter) | 22% | 5% | 9% | -3 | -14 | 29 |
| South Siberia | 2.1°C | 2.2°C (Summer)<br>1.9°C (Winter) | 8% | 8% (Summer)<br>18% (Winter) | 14% | 4% | 6% | -4 | -14 | 23 |
| Urals and WesternSiberia | 2.2°C | 2.3°C (Summer)<br>2.2°C (Winter) | 7% | 6% (Summer)<br>15% (Winter) | 10% | 6% | 6% | ~ | -18 | 31 |
| Western Arctic | 2.6°C | 2.2°C (Summer)<br>3.4°C (Winter) | 10% | ~ (Summer)<br>16% (Winter) | 17% | 6% | 7% | -1 | -20 | 35 |

'~' climate models were not in agreement.

*Source: Westphal (2008)*

**Figure 3.** Change in Mean Annual Rainfall

(2030-2049; 1980-1999; A1B; 20 GCMs)




*Source: Westphal (2008)*

The following describes the variations in predicted impact of climate change on hazard risk across Europe and Central Asia:

### Baltic: *Estonia, Latvia, Lithuania, Belarus, and Poland*

*Prediction of Climate Change.* For the Baltic states, mean annual temperature is expected to increase by 1.6°C, resulting in a decrease in frost days and an increase in heat waves by 2050. Although the climate models do not agree on changes in mean annual precipitation, it is expected that the southern Baltic region will experience a decrease in annual runoff, and the northern Baltic region will experience an increase in runoff.[26] Moreover, the Baltic region will see an increase in precipitation intensity and precipitation per extreme events.

*Impact on Natural Hazards.* Over the past 50 years, the Baltic Sea has seen an increase in wind speeds. Although this rise has been attributed to the North Atlantic Oscillation (NAO), it has also been noted that the NAO may be enhanced with global warming, increasing wind speeds.[27] If wind speeds rise, it will increase not only the risk of windstorms but also the size of waves and storm surge, causing greater flooding along the Baltic coast and worsening coastal erosion. Across the Baltic countries, it is also expected that climate change will result in an increase in river flooding and waterlogged soil.

### Caucasus: *Armenia, Azerbaijan, and Georgia*

*Prediction of Climate Change.* For the Caucasus states mean annual temperature is expected to increase by 1.7°C. Much like the Baltics, the Caucasus states and Turkey will see a decrease in frost days and an increase in heat waves by 2050. Climate models disagree on mean annual precipitation, however, models concur that annual runoff will decrease. Meanwhile, precipitation intensity and precipitation per extreme event will increase.

*Impact on Natural Hazards.* The probable result of a decrease in annual runoff will be a decrease in reservoir water levels, which is a major factor in intensifying landslides.[28] Rising temperatures and a decrease in runoff will also increase drought and desertification for the Caucasus, especially in the eastern part of the region. Desertification has intensified in recent years, even affecting nontypical areas, such as riparian forests.[29]

Another impact of climate change on the Caucasus is the continued rise in level of the Black Sea. Since 1923-1925, the Black Sea has risen at a rate of 2.5mm per year. This rise will increase the vulnerability of the coastline; multiply the risk of flooding along rivers; and foster salinization. Damage from sea level rise can already be observed in Georgia's Poti and Rioni delta, which over the past century has receded from the sea by 0.52m.[30]

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26 Annual runoff is a measure of water availability.

27 S.C. Pryor and R.J. Barthelmie, "Long Term Trends in Near-Surface Flow over the Baltic," International Journal of Climatology, 23: 271–289, 2003.

28 United Nations Environment Programme, "Caucasus Environment Outlook (CEO)" Tbilisi, Georgia, 2002.

29 *Ibid.*

30 *Ibid.*

### Central Europe: *Czech Republic, Hungary, Moldova, Romania, Slovakia, and Ukraine*

*Prediction of Climate Change.* The countries of Central Europe will see an increase of 1.7°C in mean annual temperature. Although the models do not concur on the change of annual precipitation for the years 2030-2049, they all agree that the annual runoff will decrease by 13%. Furthermore, Central Europe will see an increase in heat waves and the greatest decrease in frost days in all of Europe and Central Asia.

*Impact on Natural Hazards.* The countries of Central Europe will see an increase in heat waves. Moreover, what is considered 100-year droughts will return every 50 years for Hungary, Romania, Moldova, and Ukraine.[31]

### Russia. *Russia's Baltic region, Volga, North Caucasus, Siberia and Far East, South Siberia, Urals and Western Siberia, and Western Arctic*

*Prediction of Climate Change.* By 2050, the entire country of Russia, from the Arctic to the Urals to the Volga to the Caucasus states, will undergo a decrease in frost days and an increase in heat waves.[32] Overall, mean annual temperature in Russia is expected to increase 1.6-2.6°C with Russia's North Caucasus experiencing the low-end temperature increase of 1.6°C and Russia's Western Arctic experiencing the high end with 2.6°C increase in temperature.

[31] M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., "Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change," Cambridge, UK: Cambridge University Press, IPCC, 2007.

[32] M. Westphal, "Summary of the Climate Science in the Europe and Central Asia Region: Historical Trends and Future Projections," World Bank, 2008.

With the exception of Russia's North Caucus region,[33] Russia will encounter a significant increase in mean annual precipitation from 6-11%.[34] Russia will also experience an increase in precipitation intensity and precipitation per extreme events.

*Impact on Natural Hazards.* The effect of climate change on Russia will significantly increase its exposure to natural hazards. In the northern part of the country, increasing temperatures will lead to the thawing of permafrost. Permafrost, or perennially frozen ground, covers 60% of Russian territory. By 2050, models predict that total permafrost area could be reduced by 15-20% with the Arctic Coast and West Siberia experiencing as much as 50% during the summer.[35]

Thawing not only will increase water volume but also will cause ground surface displacement. When permafrost thaws, the ground does not settle uniformly, which results in an uneven surface called "thermokarst." As already seen in the Arctic, the resettling of ground surface causes buildings to sag, pipelines to crack, and roads to buckle. In fact, scientists predict that thermokarst will not only cause major damage to the built environment, but if ground subsides near the coast, the land will be overtaken by seawater.[36]

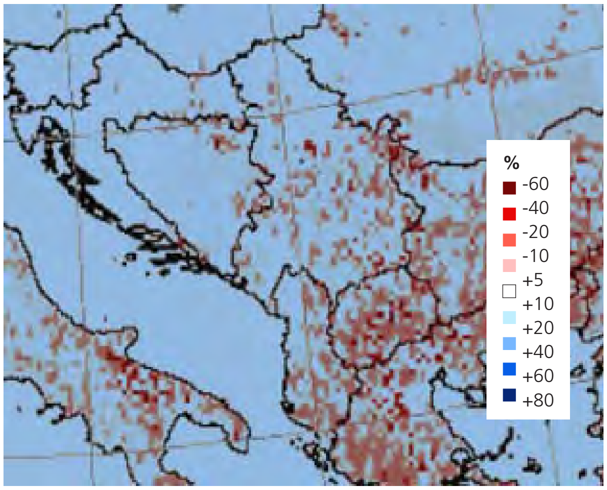
[33] Climate models for North Caucus do not agree on the sign of change for annual or seasonal precipitation for 2030-2049 compared to 1980-1999.

[34] M. Westphal, "Summary of the Climate Science in the Europe and Central Asia Region: Historical Trends and Future Projections," World Bank, 2008.

[35] A. Kokorin, "Report No 2. Expected Impact of the Changing Climate on Russia and Central Asia Countries and Report No 3. Ongoing or Planned Adaptation Efforts and Strategies in Russia and Central Asia Countries," WWF Russia, 2008.

[36] U.S. Arctic Research Commission Permafrost Task Force, "Climate Change, Permafrost, and Impacts on Civil Infrastructure," Special Report 01-03, U.S. Arctic Research Commission, Arlington, Virginia, 2003.

**Figure 4.** Change in Mean Annual Precipitation in 2071-2100 Relative to 1961-1990 (%)




*Source: European Commission (2007)*

Increasing temperatures will cause northern Russia's permafrost to thaw and will melt glaciers and sea ice. Snow is also expected to melt faster, causing underground water levels to rise. Windstorms are predicted to increase. These factors, plus a predicted increase in precipitation by 10-15%, are expected to cause major flooding for most of Russia.

For the southern regions of Russia, temperatures are expected to rise but precipitation to decrease, which will increase the risk of drought. By 2020, it is predicted that for the southern regions drought will have a significant negative impact on agriculture—as much as a 22% decrease in cereal production and 14% loss of forage crops for the North Caucasus.[37] Climate models also predict an increase in wind and an increase in precipitation when it does rain.

The rise in temperature will increase the frequency of forest fires. The area and frequency of forest fires will grow, as well as the length of the fire risk. Ultimately even the south Siberian regions will be affected, increasing their summer fire-risk period by 30-50%.[38]

### South East Europe. *Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, FY Macedonia, Serbia, Slovenia, and Turkey*

*Prediction of Climate Change.* South East Europe will be one of the ECA regions hardest hit by global warming. Annual temperatures are expected to increase by 1.8°C. The highest increases will be in Albania, FY Macedonia, and the southern parts of Bosnia and Herzegovina, Serbia, and Montenegro.[39]

The northwestern tip of South East Europe will see an increase of rainfall by 5% (see Figure 4). For the rest of the Adriatic coastline and Western Balkans region (to include Albania and FY Macedonia), however, annual mean precipitation is expected to decrease by 10-20%. Annual precipitation is expected to decrease and annual runoff will fall sharply by 25%. Despite the lack of precipitation, when it does rain it will be more intense.

*Impact on Natural Hazards.* For South East Europe, the decrease in precipitation and increase in temperature will lead to greater frequency and severity of drought. Moreover, heat waves combined with drought will aggravate conditions that will lead to an increase in forest fires.

[37] A. Kokorin, "Report No 2. Expected Impact of the Changing Climate on Russia and Central Asia Countries and Report No 3. Ongoing or Planned Adaptation Efforts and Strategies in Russia and Central Asia Countries," WWF Russia, 2008.

[38] *Ibid.*

[39] European Commission, "Green Paper from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions: Adapting to Climate Change in Europe - Options for EU Action," June 29, 2007.

Despite the decrease in rainfall in South East Europe (SEE), it is expected that flooding will increase in SEE countries. First, scientists predict that the northern Adriatic coast will be prone to more severe and longer lasting floods due to higher wind speeds, which will intensify storm surge.[40] Second, when South East Europe does receive rain, scientists predict an increase in precipitation intensity.[41] Drought conditions combined with intense bursts of precipitation may lead to flash floods.[42]

An increase in the intensity of rainfall combined with drought conditions can also lead to greater soil erosion rates and an increase in risk of landslides in South East Europe. Droughts lead to a loss of soil nutrients and vegetative structure; slopes that have lost soil structure are more prone to landslides when weakened by heavy rains.

### Central Asia: *Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan*

*Prediction of Climate Change.* Overall, Central Asia will see an increase of 2ºC. Although climate models do not concur on average precipitation, they all agree that annual precipitation intensity will increase. They also predict that annual runoff will decrease by 12%. This decrease will have a major impact on water resources, such as the Aral Sea.

*Impact on Natural Hazards.* The increase in temperature and decrease in annual runoff will cause an increase in heat waves. Heat waves and higher evaporation will lead to drought, the loss of crops and pastures, and the expansion of desert areas.[43] Glaciers will melt, which could lead to flooding in some areas and, in other areas, shortages of fresh water.[44] An increase in intensity of precipitation will aggravate mudflow, landslides, and avalanches.[45] In particular, climate change will hasten the shrinking of the Aral Sea.[46]

Due to climatic changes, the following is a summary of expectations for Europe and Central Asia:

- An increase in temperature and decrease in mean precipitation will lead to an increase in the frequency and severity of drought and heat waves.
- Severe drought will lead to an increase in forest fires.
- Greater intensity of wind and rain will cause severe floods and landslides.

Consequently based on current knowledge, disaster risk management becomes a vital and urgent component of strategy to adapt and cope with climatic changes.

40 M. Pasari, M. Orli and A. Mohorovi, "Meteorological Forcing of the Adriatic: Present vs. Projected Climate Conditions," Geofizika Vol. 21 2004. December 28, 2004.

41 United Nations Environment Program, "Climate Change 2007: Impacts, Adaptation, and Vulnerability," 2007, p. 547.

42 DESA, ISDR, and USA NOAA, Guidelines for Reducing Flood Losses, United Nations, 2004.

43 UNEP/GRID-Arendal, "Climate Change and Natural Disaster Impacts in the Ferghana Valley," UNEP/GRID-Arendal Maps and Graphics Library. 2005.

44 A. Kokorin, "Report No 2. Expected Impact of the Changing Climate on Russia and Central Asia Countries and Report No 3. Ongoing or Planned Adaptation Efforts and Strategies in Russia and Central Asia Countries," WWF Russia, 2008.

45 *Ibid.*

46 *Ibid.*

# ADAPTATION THROUGH DISASTER RISK MANAGEMENT

A broad concept of hazard risk management comprises a systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies, and coping capacities of society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This concept includes all forms of activities, such as structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.[47]

The countries of the ECA region have gone through major political, social, economic, and administrative changes, affecting the institutional aspects of disaster risk management. The primary challenge and focus in restructuring disaster risk management in the region has been (i) demilitarization of the civil protection services and (ii) restructuring of many disaster management functions. The advancement of these processes varies across the ECA region, but the direction taken is highly commendable.

A recent analysis on hazard risk management in the countries of South East Europe reviewed the status of decentralization of disaster risk management, community participation, legislative frameworks, training and education, international cooperation, emergency response planning, exercises, public awareness, communication and information management systems, and technical capacity for emergency response (see Table 4). The analysis showed that many aspects require improvement for effective hazard risk management.

These findings were consistent with a 2004 study on the capacity of all ECA countries to manage risk posed by disasters,[48] which is summarized as follows:

- *The concept of hazard risk management is not fully institutionalized.* With some elements of a regulatory framework in place, there is a lack of sufficient statutory authority to allow for the formulation and execution of comprehensive disaster risk programs.

[47] After *ISDR Terminology: Basic Terms of Disaster Risk Reduction.*

[48] C. Pusch, "Preventable Losses: Saving Lives and Property through Hazard Risk Management - A Comprehensive Risk Management Framework for Europe and Central Asia," Disaster risk management working paper series, no. 9, World Bank, 2004.

- *Coordination mechanisms among authorities are not well developed.* This issue concerns both the horizontal coordination among various sectors and the linkages between the central and local levels.
- *Hazard warning and monitoring systems require improvement.* The region's hydrometeorological systems, in particular, should be enhanced, and technological advancements in this area should be integrated. Hydromet data can be a very efficient tool if it rests on regional and sub-regional collaboration and information sharing among riparian countries.
- *Economic considerations are not fully integrated in investments decisions.* It is important that cost-benefit or cost-efficiency analysis is part of the investment prioritization process necessary for the development of sectoral, national, and local disaster risk mitigation plans and climate change adaptation strategies.
- *Catastrophe risk financing tools are not fully utilized.* The transfer of disaster risk to the capital markets is feasible for most of the region's countries, whether it is on the individual country level, as with most advanced economies for selected hazards or with smaller countries through a regional and sub-regional risk pooling mechanism.
- *Insufficient funding of disaster risk mitigation investments.* Reduction of economic and social losses due to disasters is possible if priority, cost-effective investments are made ex-ante. Recovery and reconstruction is much more costly in the aftermath of a disaster.
- *Information and communication systems require upgrading.* Upgraded systems are needed for managing emergency information and tracking resources. Some countries in the region—Turkey, Romania, and Croatia—have initiated improvements in their emergency communication and information systems, but many others are lagging behind.

Accounting for the projected impact of climate change, the reduction of current and future vulnerabilities to hydrometeorological risk should build on and expand existing disaster risk management efforts. It is important to recognize that response and disaster mitigation based on past vulnerabilities may not suffice in light of recent scientific forecasts: in many countries of Europe and Central Asia, these existing mechanisms are already insufficient for the current level of vulnerabilities.

Given the uncertain impact of climate change on extreme weather phenomena, the planning process for these weather events also addresses high-frequency though low-impact emergencies. Many of the possible investments in adaptation within the area of disaster risk management will have multiple benefits.

While ECA countries recognize the importance of mitigating the risk of natural hazards, most do not have a comprehensive disaster risk reduction strategy and a multi-year, cross-sectoral investment plan. The following chapters describe some measures through which a country can undertake reduction of disaster risks.

**Table 4.** Disaster Risk Management in the South Eastern Europe Countries

| Country | Decentralized Emergency Management System | Community Participation | Legislative Framework | Training and Education | International Cooperation | Emergency Response Planning | Exercises | Public Awareness | Communication & Information Management System | Technical Capacity for Emergency Response |
|---|---|---|---|---|---|---|---|---|---|---|
| Albania | N | N | N | S | G | S | N | S | N | N |
| Bosnia and Herzegovina | N | N | U | N | S | N | N | N | N | S |
| Bulgaria | N | N | S | N | S | N | N | N | N | S |
| Croatia | N | N | S | N | S | S | S | N | N | S |
| FY Macedonia | N | N | S | S | S | N | N | N | N | N |
| Moldova | N | N | N | N | S | N | N | N | N | S |
| Romania | N | N | S | S | G | S | N | N | S | S |
| Serbia | N | N | U | N | S | N | N | N | N | U |
| Montenegro | S | S | U | S | S | N | N | N | N | U |
| Slovenia | S | S | S | S | S | N | S | S | S | S |
| Turkey | N | S | S | S | G | S | S | S | S | S |

G – Good
S – Satisfactory
N – Needs Improvement/Not Available
U – Under Development

*Source: Synthesis Report on SEE Countries Disaster Risks; UN/ISDR-WB; July 2007.*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# FINANCIAL AND INSURANCE INSTRUMENTS

**Impact of Climate Change on "Natural" Disasters.** While many disasters follow secular trends, those linked to weather appear to be subject to increasing intensity—a phenomenon attributed to climate change. For financial/loss planning purposes, climate change effects, while not fully quantified or causally connected to all subregions, are estimated to affect weather-induced disasters in distinct ways:

(a) Increased earth temperatures are likely generating longer and more intense droughts in countries in South East Europe;

(b) Increased ocean surface temperatures result in a higher incidence of larger strength hurricanes, cyclones, and typhoons in subtropical areas. This leads not only to increased wind- and rain-induced damage in directly affected areas but also to weather change impacts on neighboring systems adjoining the Atlantic basin;

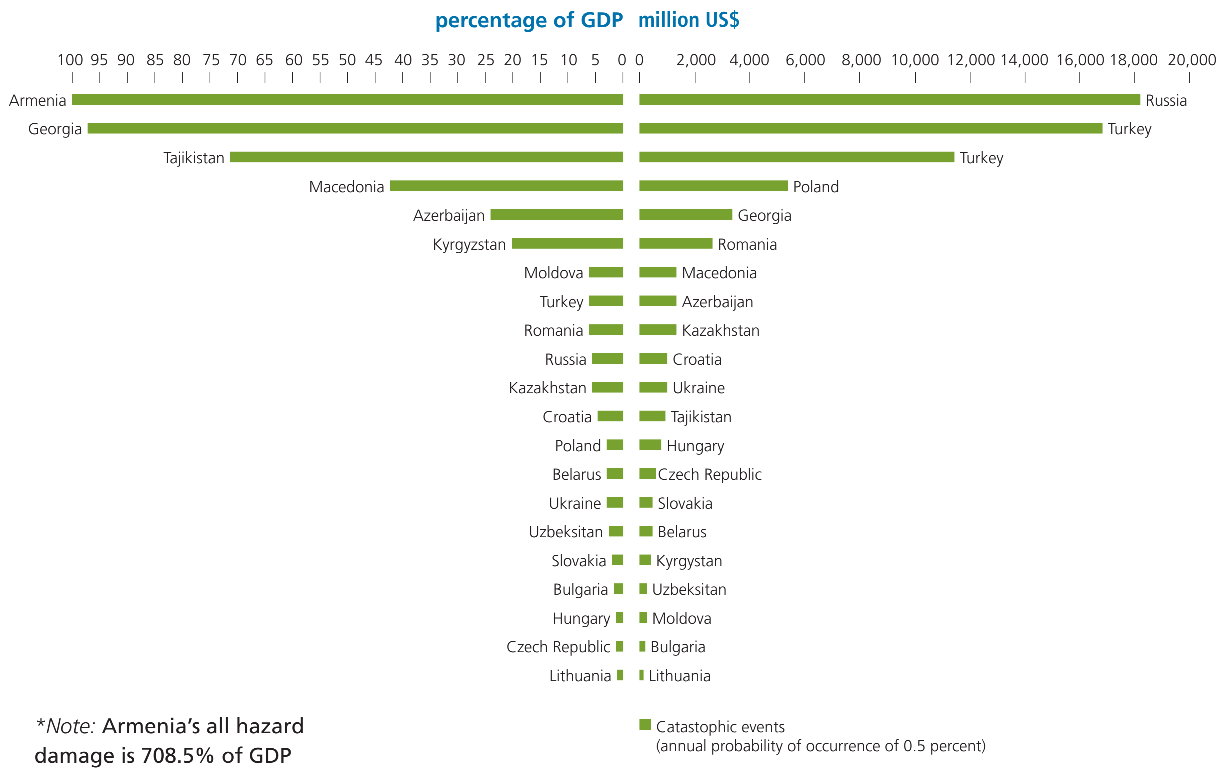
(c) Increased precipitation resulting from rising temperature coupled with some of the above factors, as well as seasonal high and low pressure displacements, can result in increased rain and flooding in many regions.

Increasing trends in the intensity and frequency of catastrophic events are estimated from these effects. The historical and recent information, however, is insufficient to determine the precise direction of such trends, and thus the statistical uncertainty prevents policy makers (as well as private insurers) from planning adequately given the opportunity cost of setting funds aside for a "rainy day."

**Impact on ECA Economy.** For Europe and Central Asia over the past 30 years, disasters have caused US$70 billion in economic losses. On average, expected annual losses are US$2 billion, with most of the losses concentrated in Armenia, Romania, Poland, the Russian Federation, and Turkey.

Due to catastrophic events that have an annual probability occurrence of 0.5%, expected economic loss for the Kyrgyz Republic and Moldova is 10% of GDP. For Armenia, Azerbaijan, Georgia, FY Macedonia, and Tajikistan, expected losses double to 20% of GDP. To better illustrate the economic loss potential of disasters, Figure 5 shows the impact of catastrophic events on GDPs of ECA countries.

**Figure 5.** Economic Loss Potential from Catastrophic Events




**Note:* Armenia's all hazard damage is 708.5% of GDP

*Source: Pusch (2004)*

**Types of Financial Protection Mechanisms.** From a country perspective, financial mechanisms to address losses generated from climate change-induced disasters can be "macro/sovereign" or "individual/industry" linked. Sovereign "insurance," for example, aims to address major economic disruptions from disasters that have strong adverse impacts on budget finances. Governments can use these special insurance instruments correlated to large magnitude events to hedge and compensate for potential fiscal losses (such as for reconstructing essential infrastructure). In this instance, the "insurer" would normally have a broad capital base to redistribute losses without creating systemic financial problems (the insurer thus could be large capital market investors/hedgers, major global reinsurers, or other countries).

On the other hand, individual insurance (whether for businesses or households) is linked to specific damages to their assets. This type of insurance is typically provided by the traditional insurance industry and requires verification of the damaged assets before paying out loss claims. It is well suited to protect private sector assets and requires the government to primarily ensure the financial sustainability and solvency of the insurance providers.

Both types of insurance are essential although "sovereign" mechanisms are a newer phenomenon increasingly considered as a supplement to fiscal budgets, using novel financial mechanisms that avoid the volatility of market prices (premiums) for traditional insurance. Governments primarily require stable expenditure trends, such as for budgeted premiums (under typically limited fiscal envelopes); otherwise a fiscal insurance policy would not be sustainable for long.

**Magnitudes of Country Losses.** To further illustrate the negative impact natural disasters can have on the economy, Table 5 shows some specific examples of economic loss in various ECA countries. With a potential increase in windstorms and hurricanes due to ocean temperature warming, this issue becomes more acute.

**Table 5.** Economic Losses from Natural Disasters in SEE Countries, 1974-2006

| Number of years taken for average | Country | GDP PPP per capita [$/inh.] 2005 | Annual average economic loss due to all perils (in million US$) | % GDP | Economic loss (in million US$) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Drought | EQ | Flood | Tropical cyclone |
| 1974-2006 | Albania | 2755.3 | 68.67 | 2.49 | 2238 | 2 to 5 | 24.673 | 0 |
| 1989-2006 | Bosnia and Herzegovina | 2384.0 | 22.94 | 0.96 | 408 | > 5* | 0 | 0 |
| 1974-2006 | Bulgaria | 4733.9 | 14.76 | 0.31 | 0 | 5* | 260.23 | 0 |
| 1989-2006 | Croatia | 6376.2 | 33.76 | 0.53 | 330 | > 5* | 0 | 0 |
| 1989-2006 | FY Macedonia | 4467.7 | 24.59 | 0.55 | 0 | 5* | 353.6 | 0 |
| 1984-2006 | Moldova | 2876.1 | 61.40 | 2.13 | 0 | 0 | 152.584 | 31.6 |
| 1974-2006 | Romania | 5954.9 | 292.76 | 4.92 | 500 | 2756* | 3269.3 | 0 |
| 1989-2006 | Serbia and Montenegro | 4936.0 | 82.0 | 1.66 | | 2705 | 0 | 0 |
| 1984-2006 | Slovenia | 13611.4 | 7.31 | 0.05 | 0 | 10 | 5 | 0 |
| 1974-2006 | Turkey | 4680.8 | 560.56 | 11.98 | 0 | 15988 | 2511 | 0 |

*Source: EM-DAT, * from National Geophysical Data Centre website, GDP- World Bank statistics*
*Note: Economic loss of other perils is also included for calculating annual average economic loss.*

Although multiple small disasters can slowly erode a nation's budget, all it takes is one major catastrophe to severely affect the economy. In 1999, for example, a major earthquake in Turkey caused economic damage estimated at 3–6% of GDP.[49] In 2002 in the Czech Republic, flooding caused €3 billion in damages. Fortunately for the Czech Republic, 40% of losses were insured—a lesson the country learned from the floods of 1997.[50]

The Czech Republic, however, is unique for the ECA region. In general, ECA countries have budget but not insurance funds for such eventualities (see Table 6) and have yet to develop more sophisticated financial instruments to cope with such losses on a systematic basis, especially since climate change effects may be increasing the frequency and intensity of hazards.

[49] C. Pusch, "Preventable Losses: Saving Lives and Property through Hazard Risk Management - A Comprehensive Risk Management Framework for Europe and Central Asia," Disaster risk management working paper series, no. 9, World Bank, 2004.

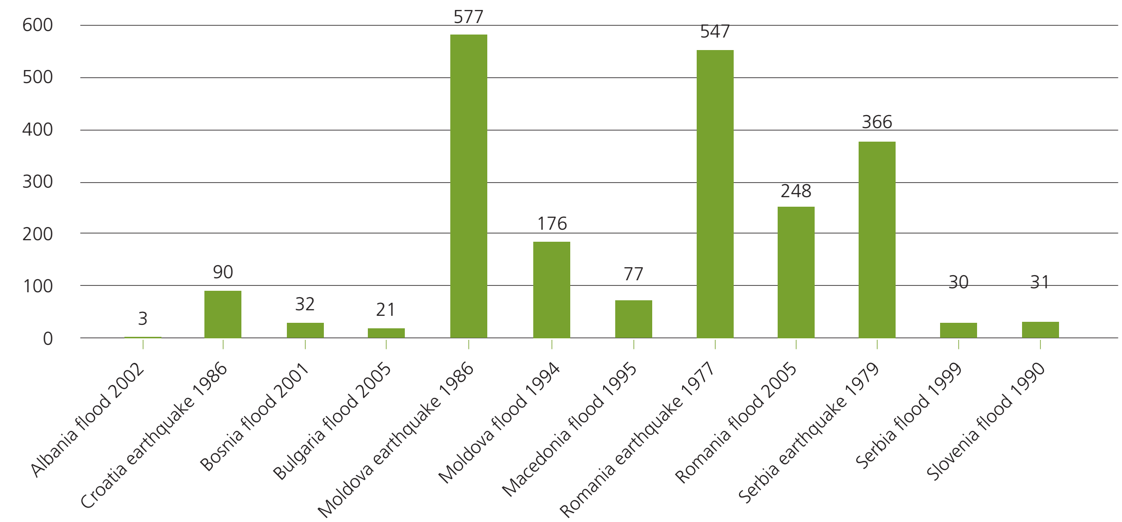
[50] CEA Insurers of Europe, "Reducing the Social and Economic Impact of Climate Change and Natural Catastrophes Insurance Solutions and Public-Private Partnerships," Brussels, June 2007.

**Table 6.** Natural Disaster Funds in ECA Countries

| Country | National Disaster Fund | Size (US$ mil) | Annual Appropriations (US$ mil) | Local Disaster Funding |
|---|---|---|---|---|
| Albania | (i) Civil emergency fund<br>(ii) Council of Ministers reserve fund (can be used for emergencies)<br>(iii) Ministries' reserve funds | 0.4<br><br>17 | 0.4 annually if needed<br>Plus additional budgetary appropriations in case of emergency | Local government reserve funds |
| Croatia | Budget reserve | 5.5 | Annual allocations | Municipal budget funds |
| Bosnia and Herzegovina | Budget reserves<br>Fund for special reimbursement for protection and rescue | 0.5 | 0.5 payroll tax | |
| Republika Srpska | Budgetary reserve | | Annual appropriations | |
| Bulgaria | Republican fund* | 31.25 | Depends on annual budgetary appropriations | Municipal budgets |
| FY Macedonia | State budget reserve<br>The Solidarity Fund | 6.0 | Annual appropriations<br>Donations | |
| Moldova | Reserve fund<br>Agencies' reserve funds | 2.3 | Annual budgetary replenishments | 2% of local budgets |
| Montenegro | Disaster assistance fund | 0.52 | 0.52 | |
| Romania | Intervention fund<br><br>Reserve budgetary fund | 5.0 | Annual appropriations<br>Annual local budget appropriations | 5% of local budgets |
| Serbia | Disaster Emergency Fund<br>Reserve Fund | 1<br>21 | 1<br>1 | |
| Slovenia | Budget reserve fund | 40 | Annual budget appropriations | |

*Source: World Bank and UN ISDR, Mitigating Adverse Financial Effects of Natural Hazards on the Economies of South Eastern Europe, 2008*

**Figure 6.** Economic Loss from Catastrophic Events and Emergency Funds




*Source: Ibid.*

Furthermore, as seen in Figure 6, ECA government budget funds are grossly insufficient to finance large losses from extreme events. This potential problem calls for a more rational fiscal policy that could budget annual premiums for risk transfer (insurance), but avoid massive layouts and fiscal/economic disruption when disaster-related emergency expenditures are needed.

While risk mitigation and adaptation actions are imperative to reduce losses from events arising with short warning, certain residual risks and losses will materialize nonetheless. Potentially financial and insurance markets can cover these costs along with the creation of special financing and risk transfer facilities in collaboration with the private and public sectors and international institutions.

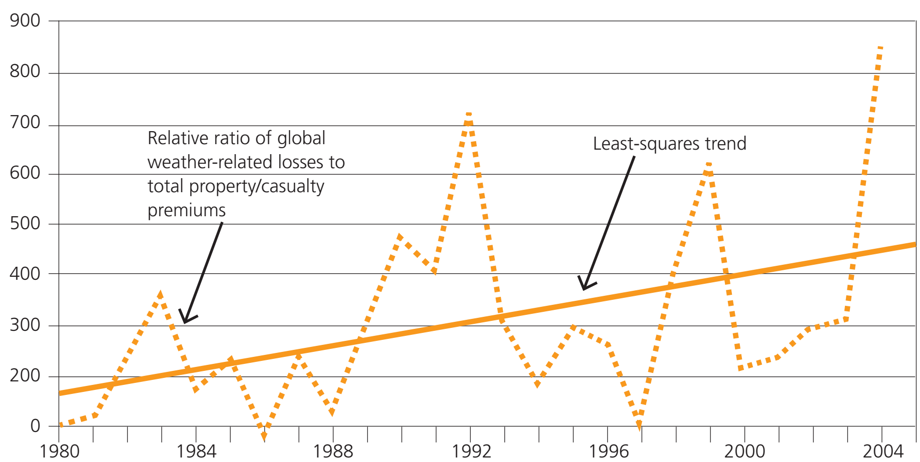
**Insurance Industry Concerns on Climate Change.**[51] For insurance purposes, catastrophe risks are broken up into layers. The lower or more frequently hit layers where implicit premiums are not much greater than the expected loss (commonly called working layers), are usually retained by the direct insurer, depending on size, capital resources, and portfolio diversity. The higher layers are laid off to reinsurers or the capital markets (the latter most often through catastrophe bonds). As the higher layers represent the least frequent but most severe events, about which there is little data (and where climate change is likely to have the most effect), there is a much greater amount of capital required per unit of sum insured, and the premium is a greater multiple of expected loss. Ken Froot, Harvard professor, brought this to light in his 1999 book on catastrophe bonds where the price to expected loss multiple ranges between 1 and 2 at the lower layers and up to 8 for the top layer.

[51] R. Lester, "Climate Change, Development and the Insurance Sector," presented at Williams College, April 2008.

At the time the Froot book was written, the main concern was that direct insurers were not buying sufficient coverage at the upper layers, presumably because of a combination of short price and career horizons compared to the return periods of the catastrophes concerned. There is some evidence that this is changing, however, possibly driven by the increased frequency of climate change-induced natural disasters in the last decade and a half. From an insurer's point of view, this increased frequency and cost of catastrophic losses is due to hydrometeorological events and may reflect the lagged impact of human-induced $CO_2$ contamination finally emerging.

**Figure 7.** Hydrometeorological Insurance Losses Versus Total Non-life Insurance Premium

(1980 base ratio normalized to 100)




*Source: Mills, Science 309, 2005*

Aside from balance sheet realities of insurance companies, there are other imperatives for direct insurers to offload climate-induced catastrophe exposures. In particular, it is very uncommon for insurers to be allowed to build reserves for losses that may occur after the current operating cycle. The insurance elements of the new international financial reporting standard (IFRS) do not allow for such reserves, and any catastrophe buffers need to be held as equity capital. In addition most tax regimes do not allow catastrophe reserves to be set aside from pre-tax income. Executives or boards are not likely to allow large amounts of unutilized capital to build up in the normal course of events.

The incentive to hold minimal capital will be offset to some extent if current thinking about insurer regulatory capital becomes the norm. This thinking is best captured by the proposed Solvency II regime in Europe, which follows the Basel II formulation for banks. Under Solvency II, insurers will be required to establish two capital levels, a solvency capital requirement (SCR), which represents the economic capital required given the risk characteristics of the insurer, and a minimum capital requirement (MCR), below which the insurer will lose its right to trade.

If an insurer falls below its solvency capital level, the financial supervisor will be required to intervene in its affairs. The solvency capital will reflect a range of risks, including market, capital, reserving, and underwriting risk. All four of these will be affected by climate change, and the capital allocation for reserving and underwriting risk will include an explicit allowance for retained catastrophe risk. In addition there is a trend for insurance supervisors to look at quality of reinsurance when determining insurer solvency.

The financial sector and the European Insurers' Association have been actively monitoring developments related to climate change-induced effects on their business. The megaglobal insurer, AIG, has been one of the few US-based institutions to actively acknowledge this issue. Insurers are also active participants in the Carbon Disclosure Project (CDP) and the UNEP Financial Institutions partnership, which hosts the Climate Change Working Group.

**The Insurance Market for Extreme Events.** The global catastrophe insurance market exhibits inherent cyclical risks with rising and falling price cycles. If insurance premiums for extreme events fluctuate periodically, this generates a problem with countries "hedging" against climate change-induced disaster losses. This makes it difficult for countries to budget for fiscal allocations in a reliable and sustainable manner once they decide to deploy such financial tools.

Disaster-prone countries can obtain alternative protection against catastrophic risk and premium volatility by using capital markets. Generally capital markets can help insure low probability/high impact events, since the risk taken by them is akin to a default risk on a bond. The climate change-induced events fall into this category, as to date the probabilities of extreme losses have been in the 1% range (annualized), which is the probability expectation acceptable to the markets. This allows the capacity of the broader financial private sector to absorb and spread the risks, both domestically and internationally. Two mechanisms are proposed for more efficient management of catastrophic risk: (a) pooled insurance coverage supported by liquidity and credit enhancement facilities and (b) weather-indexed bonds to securitize risk.

Multilateral development institutions can play a catalytic role in supporting the development of these mechanisms, while still ensuring actuarially fair premiums. In fact, an example of each mechanism has already been developed and implemented in client countries with support of the World Bank. The Caribbean Catastrophe Risk Insurance Facility implemented a risk pool, which reduced the cost of premiums paid by the island governments to protect against extreme hurricane and earthquake events. In the second case, the Bank assisted Mexico in launching an indexed catastrophe bond (in this case the hazard was extreme earthquake). Currently, the Bank is assisting ECA countries in establishing the Catastrophe Risk Insurance Facility, which will pool individual disaster risks and provide coverage to homeowners and SMEs in the South East and Central Europe.

Smaller countries may require multilateral support (a credit enhancement) to gain access to capital markets. Governments and local industry may simply need to recognize that new mechanisms can both increase coverage and stabilize the cost of premiums. Such assessments require skills in financial modeling, something multilaterals can help organize and finance.

Climate change-induced catastrophic events are unique among insurance risks. While traditionally noncatastrophic insurable risks occur with predictable frequency and relatively low losses, catastrophes occur infrequently but with high losses. Three mechanisms have been developed in recent years to tap capital markets to better manage these risks.

In the United States, public authorities in earthquake-prone California and in hurricane-prone states, such as Florida and Hawaii, collaborated with the private sector to address insurers' fears of large losses (and thus potential market flight). These public-private efforts combined catastrophe coverage under special-purpose pooled funds with outside capital (such as long-term loans and bonds that securitize insurance risks), increasing the availability of insurance by tapping capital markets. The pooling arrangement achieved efficiencies of scale while giving all parties the confidence that contractual obligations would be met. This approach is also used in Europe where national governments provide last recourse funding and coverage for extreme events (e.g., France, Spain).

In Japan, Europe, and the United States, markets for "catastrophe bonds" have offered an alternative for transferring risks, especially when global insurance and reinsurance markets become pressed for capital due to payment of claims for above average catastrophic events (these periods coincide with "hardening" markets, i.e., higher premiums charged until the industry can recover its capital).

In the alternative catastrophe bond markets, (where the global markets have a capital multiple of approximately 70 times that of the global insurance markets) investors buy high-yield bonds from the party that seeks to be insured. These bonds can either be backed by premiums collected on an underlying insured pool of assets and property or can be structured as a financial option where a physical measurable disaster triggers the loss of interest and principal if a major catastrophe occurs during the life of the bond, and thus the bond proceeds are used by the "insured party" but lost by the investors. Investors are attracted to these bonds because of their low probabilities of "disaster default" while paying attractive yields and by their lack of risk correlations with overall financial markets, which provides them with a diversified asset. Many of these risk management methods could be adapted for use in developing countries.

**Volatile Premiums for Traditional Insurers.** In countries prone to extreme weather phenomena generated from climate change and catastrophe-prone developing countries, the domestic insurance industry generally reinsures its local portfolio with international reinsurance companies that can better bear the risk of catastrophic losses through global diversification. Insurance for extreme events is generally available for developing countries. Following an unusual series of major losses domestically or globally, however, insurance could become scarcer and more expensive.

Thus, relying on reinsurance from foreign companies affects the price of disaster insurance. If prices rise sharply again after a major catastrophe occurs, extreme event reinsurance markets will tighten. In 1990, for example, the rate for home insurance in parts of the hurricane-prone Caribbean was 0.4%. After Hurricane Andrew hit Florida in 1992, prices more than tripled reaching 1.3% in 1994 then declining to 0.8% near the end of the decade. While the Caribbean itself was not the major area affected by Hurricane Andrew, prices in that region rose dramatically because global insurance/reinsurance capital was exhausted, and the industry needed to recover it through higher premiums to remain solvent in the longer term. By contrast, Hurricane Mitch, which devastated parts of the Caribbean and Central America in 1998, had little effect on insurance prices because much of the damaged property was uninsured and thus the insurance industry did not have to pay out.

Transferring risks abroad also means that domestic insurers retain very little of the underwriting risk. They, therefore, face low incentives to monitor compliance with structural codes or to promote measures to prevent losses through adaptation actions or improvements in industry efficiency, which in the long run might lower the cost of insurance. When all but very low levels of risk are reinsured abroad, the reinsurance coverage is generally expensive because of the high likelihood that it will be triggered. Contracting reinsurance at much higher levels of loss would lower the premiums because of the lower probability that losses would reach those levels. Thus, a key issue is finding the right balance over time between retaining risk locally and transferring it abroad, the latter being mainly for the most extreme events.

**Fiscal Considerations.** Governments may be involved directly in insuring against extreme events associated with climate change (e.g., increasing strength hurricanes, floods, or droughts). Ironically, the countries with the highest exposure to climate-induced catastrophe risk are those least able to afford the cost of protection by reallocating scarce budget resources away from already thin social programs. Therefore, in considering sovereign clients for the deployment of catastrophe bonds, an initial reality check can be the current budget and policy environment.

Even in countries with healthy fiscal accounts, the idea of risk transfer via cat bonds and/or other instruments makes sense. For such countries, a megacatastrophe would not mean a loss representing a small 1%-2% of GDP as in the U.S. but rather anywhere from 10% to 120% of GDP and hence the relevance of such risk transfers for many developing countries.

Sovereigns manage various types of country structures from federalist states to highly centralized states. In the former, catastrophe risk programs can be welcome from the perspective of the central government's need to manage unusual budgetary flows, but any countrywide risk exposure analysis needs to recognize that fiscal responsibilities exist at the decentralized levels and the central government may not participate in coverage at those levels. In countries with more centralized management, nationwide exposure may be more relevant to the authorities, but the budgetary cost of cat bond risk transfer may make such propositions unrealistic. In these cases, the design of cat bond products should be coupled with a decision model for prioritizing the hierarchy of assets or infrastructure at risk, which can be included given budgetary limitations.

**Insurance or Fiscal Hedge.** The diagnosis of sovereign needs for risk transfer using the cat bond market also has to determine whether client governments seek targeted disaster protection (e.g., protection of infrastructure in key cities) or merely a source of funding to prevent excessive fiscal volatility in the event of a major disaster. While from a product outcome perspective the difference is not all that great, from a design perspective the difference is relevant to whether a government may want a cat bond program or not.

For example, in assessing client needs, the requisite risk modeling work may take the form of either (a) quantifying asset and infrastructure losses and their probabilities across key urban centers and designing an instrument to cover a significant portion of those losses, appropriately priced, or (b) determining probabilities of events of certain magnitudes that are historically associated with PML type damages and pricing a cat bond based on such probabilities.

While these scenarios require similar methodologies to develop and price a cat bond, the approach differs. The first case focuses on selective losses by geographic location, and the second approach deals mostly with funding usage and replenishment needs to avoid disruptions or delays. In general, experience shows that countries with high exposure but few budgetary means are more likely to be interested in the first "location targeted" approach, while countries with modest exposure and a sound budgetary situation are more likely to gravitate towards the second approach, the fiscal hedge. In the first approach, however, asset selectivity is key since under a limited budgetary (or deficit) situation, governments will seek to minimize the cost of premium/spread given the political difficulty of reserving scarce budgets for "contingent" events.

**Cat Bonds vs. Reinsurance.** One question that is likely to emerge in any discussion with sovereign clients on implementing a cat bond program will be the alternative of using the reinsurance market. Nevertheless, the emerging and more common practice of cat bond structuring using parametric triggers clearly gives this instrument a competitive advantage. Even if the risk modeling phase perfects the vulnerability and loss estimations on an individual asset basis within sovereign territories allowing for an indemnity-based approach, most institutional investors would likely shy away from indemnity-based triggers given the difficulty in providing assurances against moral hazard, adverse selection, and the loss adjusting/verification process.

While an outright reinsurance/insurance contract channeled via that industry is certainly an option and the premium costs may certainly be lower than cat bond spreads, the bulk of the costs will come precisely during the loss adjustment process, which will need to involve local insurance intermediaries. Under an indemnity approach, therefore, all these costs will need to be quantified and compared with the purely financial costs of a cat bond transaction. The trigger verification (e.g., for climate change-induced hurricane/typhoon/cyclone risks) under a parametric cat bond contract, which counts not only on national and local reporting but also on internationally renowned weather agencies, facilitates the marketability of such instruments in the investor market with the added benefit of diversifying that investor group's portfolio risks.

**Multiple Products.** In the end, sovereign clients, while interested in the idea of parametrically based cat bonds, act like all rational economic agents to maximize their coverage and minimize their costs. In this context, while the cat bond is certainly an interesting and attractive instrument (and for some sovereigns may be an attractive opportunity to establish a market presence), it is not a panacea. Many client governments have highly sophisticated analysts and policy makers and are not impressed merely by an innovative product. Rather, after solid risk modeling analysis, they would like to see the options and combinations of capital market, insurance, and credit instruments, which can expand their coverage against climate-induced catastrophic exposure without a prohibitive cost to their fiscal purse.

A more optimal approach is to work in partnerships across financial industries and international agencies to offer a mix of products yielding an optimal result. In this context, the loss layers reflective of any portfolio of climate change-induced disaster exposure provides good reference points for the applicability of each kind of product whether it be cat bonds, reinsurance, credit, or other. For example, windstorm or flood risk in high exposure countries can generate a range of loss scenarios where just one type of instrument for coverage may be inadequate or insufficient.

In the case of "upper mezzanine level" losses at probabilities of 2%-3%, the cat bond market may be inappropriate given the traditional less frequent attachment points for such instruments. Rather, a contingent-long amortizing credit with a low or zero commitment fee may be more cost effective, since the probability of loss is such that calculating the actuarial average of using the credit and repaying it with interest (versus not using it and only paying a front end fee) may result in a much lower equivalent premium cost than other instruments.

In the case of "lower mezzanine level" losses not in the cat bond range, a credit may be invoked a little too frequently, making it a costly and debt-rising proposition. Rather, the reinsurance/insurance market would be better suited at such a level with modest but not overly high losses. At the lower layers, the most optimal approach given the cost of premiums for highly frequent events would be retention, in this case through an allocation of government budgetary resources. Under a serious government risk transfer program, this would be a natural structure, but the expected monetary losses and their associated probabilities are crucial in designing the attachment and exhausting points of each loss layer.

**Other Fiscal Considerations.** Sovereign clients have different risk and utility profiles than corporate clients who have very specific concentrated exposures well suited for risk transfer via catastrophe bonds. In assessing country client needs, the World Bank encourages complementing the loss estimation and financing gap approaches with a deliberate analysis of the policy context, macroeconomic/fiscal practices, and even political considerations in the design of government risk transfer programs. Nonetheless, partnerships with the Bank and with financial institutions, capital markets, and reinsurance industries are encouraged, since sovereign management and, in particular, national climate-induced catastrophic risk management are complex business and require complex solutions.

If not emphasized sufficiently a large stock of analytical ammunition is necessary for country economic policymakers and politicians to demonstrate that any cat bond or other form of contingent risk transfer program can actually increase a country's long-term welfare—even if it means holding back highly sought fiscal resources from competing sources in the short term.

**Practical Issues in Transferring Extreme Climate Induced Risks to the Capital Markets.** A numerical example shows how capital markets can replace or supplement insurance and reduce costs, while absorbing higher magnitude extreme risks. Assume that a primary insurance company calculates the probability of a loss of more than US$150 million but less than US$250 million at 1%. If the primary insurer purchases reinsurance at this level, it would cost more since the variance uncertainty, business costs, and required profit would be higher than the pure probability rate. Otherwise at 1% it would hardly break even over time. Adding administrative and operating costs, an uncertainty factor, and the required return on equity, the reinsurer might charge a premium of 5% (1%+4%). Such a margin is typical at these infrequent high catastrophe levels where climate change-induced phenomena comes into play, particularly when markets "harden."

Alternatively, the primary insurer could issue a US$100 million bond to investors then put the US$100 million in treasury notes paying 4%. The investors' principal of US$100 million would be put at risk as part of the contract discussed previously. If a catastrophe with losses exceeding US$250 million occurred, the investors would lose all of their principal since the upper insured limit would have been breached (known as the "exhaustion point"). For putting their principal at risk, the investors would demand at least an 8% return—4% as risk-free interest and 4% for the "pure" risk of losing their principal (akin to a default risk or the equivalent reinsurance pricing). However, no other costs or profits would be demanded beyond those. Net of the investment in treasury notes, the insurer's total financing cost would approach 4% compared with the 5% of traditional reinsurance.

In yet another option, the insurer could arrange a standby credit of US$100 million with a modest commitment or front-end charge amounting to 0.5% and an interest rate of 7% that kicks in if the loan is needed. If a catastrophe occurs, assuming a ten-year repayment period for principal, this would yield a combined principal plus interest (insurance premium equivalent) annual cost of 10%. Thus, the expected financing cost would be the probability-weighted average of that versus the chance of not disbursing and only paying the commitment fee. This would amount to 0.01 (10%) + 0.99 (0.5%), which equals 0.6%, much lower than with direct reinsurance. It should be noted that even with a higher uncertainty factor added to the probability (such as a 20% chance of the disaster occurring), the cost effectiveness result would not change. These capital market or credit schemes to replace or supplement insurance have many possible variations. These range from full risk transfer with no financing (where the full principal is at risk, just as in reinsurance) to zero risk transfer with full financing (full repayment of principal).

**New Insurance Technologies to Adapt to Climate Change Losses.** Two compatible financial structures could be used to address the challenges of catastrophe insurance in climate-induced, disaster-prone countries, separately or as a joint mechanism.

**Pooled Coverage Supported by Liquidity and Credit Enhancement Facilities.** A mechanism could be established in which liquidity and credit enhancement facilities support insurance coverage against catastrophic risks. The domestic insurance industry would transfer catastrophic coverage (through premium cessions) to a central fund regulated by the government and operated by the insurance industry. The risks covered would not be reflected on the balance sheets of local insurers but would instead be liabilities of the pooled fund. The international insurance industry could then reinsure climate-induced catastrophic coverage under the fund up to a specified loss limit.

Multilateral institutions might provide contingent credit at the next highest loss level, supporting the liquidity of the fund in the event of immediate large losses in the initial years of operation. The credit would eventually be repaid and secured through future premium collections by the fund. The extended repayment period would provide optimal risk spreading over time. This layer of cover would also serve as a partial buffer against fluctuations in international reinsurance pricing (if capital markets were not used), since the loan terms would, in contrast, remain unchanged. Once such arrangements prove financially viable, local financial markets or international commercial lenders could offer liquidity support facilities. Development of these instruments would be catalyzed by the initial credit provided by multilateral development institutions. While this mechanism would finance rather than transfer risk, if structured with proper terms and appropriate levels of excess-of-loss coverage, it could provide more cost-effective coverage and longer-term price stability than traditional insurance markets, particularly for the potentially volatile climate-induced disasters.

**Weather-Indexed Bonds.** Weather-indexed catastrophe bonds, based on payouts linked to measurable weather events (as reflected in weather indexes or parametric measures), have the advantage of being relatively easy to implement once a reliable weather measurement mechanism is identified. They bypass the traditional insurance loss adjustment process, which requires site-by-site evaluation of losses before indemnity is provided. The payout is simply based on the weather index reaching a certain range. For example, payouts for the Tokyo Marine Insurance cat bond, while not weather related, are based on specified Richter measures of earthquake intensity and damages in Tokyo within a specified radius around the city. This is known as a "parametric" trigger.

The main risk with weather-indexed instruments or parametric triggers is basis risk—the risk that the basis of data for triggering the loss payment (such as a high wind speed, excessive rainfall, or earthquake intensity) is not directly linked to actual losses on the ground (such as specific damage to a house, building, or major piece of infrastructure). A loss payment could be made (with the bondholder losing interest and principal) even though the insured experiences no loss. Or the insured party may experience a loss but receive no indemnity because the parametric index was not triggered (e.g., as a result of a lower-than-threshold wind speed).

Most catastrophe bonds, such as those issued in Europe and the United States, are triggered by reported losses and indemnification claims in the industry rather than weather indexes.[52] Investor appetite for such bonds issued in developing countries, however, is low due to lack of direct knowledge of the local insurance industry. Bonds based on easily verifiable weather indexes or parametric triggers would be more attractive. Adding to their attractiveness are the opportunities they would offer international investors for portfolio diversification, since natural disasters have little or no correlation with global financial market trends, as discussed previously.

What would the financial structure of a scheme based on weather-indexed bonds look like? Catastrophe bonds could cover public infrastructure or provide financing to a private-pooled fund, as described in the previous section. The bonds would pay higher-than-average yields but would also carry a risk of a significant drop in the coupon rate or a loss of principal in the event of a climate-induced catastrophe that leads to loss payments. A multilateral institution or affiliate could guarantee the contractual payments of bond coupons and any principal due investors if no disaster occurred. In a fully private arrangement, the bond payments would need to be fully secured by the premiums collected in the common fund. The basis for triggering loss payments could be information from weather station tracking equipment with satellite links to global recording centers or from weather monitoring systems of major industrialized countries, which typically track high-altitude hurricane activity, for example, in the Pacific and Atlantic regions.

Before weather-indexed bonds are introduced, historical data on weather events and associated losses would need to be compiled and analyzed to ensure a sufficiently strong correlation between index-triggered payments and actual losses. Climate change effects on previous trends in natural disaster would need to be incorporated to adjust the expected probabilities of such events. These data are essential for structuring and pricing such "insurance" contracts.

**Protection for Agricultural Losses.** While weather-indexed bonds are generally structured for high impact events, such as hurricanes, typhoons, or other forms of windstorm, one of the effects of climate change is increasing temperatures (e.g., South East Europe), leading to drought periods. While the catastrophe bond market is less apt for such "slow onset" events, which have less of a random-type distribution, there are other weather contracts (structured like financial options) that could be used to compensate farmers financially for periods of severe drought (and potentially severe rainfall as well).

Such weather "options" are generally structured as an insurance contract where the farmer or temperature-linked business pays a premium in case crop output is not as expected in a year of severe heat (conversely, these contracts are also used for years of severe cold where crops can freeze). The trigger of the contract is generally the temperature index—an established parametric measure. The contract (which would pay a pre-defined fixed amount in the event it is triggered), however, can only be called if the higher (or lower) than threshold temperatures persist for a pre-defined number of days (such temperatures for such elapsed times) estimated by agricultural experts to result in crop losses. Thus, the contracts would predefine all these parameters and the payment (on which the premium would be based) is set according to the compensation needs of farming and agricultural businesses affected by climate change.

If the affected farming community is of modest to low income, governments can also assist by subsidizing part of the premium of such weather

[52] An index is a form of a parametric trigger. Usually the term index is used when an existing scale for a measurement index (e.g., a temperature index, a reported industry index) is used instead of a custom-made physical measurement.

contracts or alternatively have the government be the protection provider. In this latter case, however, the country would not be transferring the risk, since the event occurrence would result in the government paying farmers' insurance claims out of the fiscal purse, albeit compensated via some of the premiums collected. Thus, if the government wishes to subsidize the premium, it would be better to do so with a third party providing the actual insurance protection. The third party would have to be vetted at the outset regarding its own creditworthiness.

**Mechanisms Combining Instruments and Role of Development Institutions.** While a weather-indexed bond could be developed on its own to protect government resources, it could also be combined with a climate catastrophe insurance pool where the bond could serve as one of the upper layers of coverage. Such risk transfer mechanisms involving capital market instrument under multi-period contracts can further reduce the potential volatility of insurance and reinsurance prices. They would also enable governments to insure public property against climate-induced catastrophes at more reasonable prices than going to the traditional market alone. And they would enable the local insurance industry to extend coverage to such hard-to-insure sectors as small farmers, public infrastructure, and low-income communities.

Financial support from multilateral institutions to create an insurance pool for climate change-affected countries and weather-indexed bonds (both of which have been done before for traditional natural disasters) can be combined separately or together. These would meet several objectives. The support would help reduce potential market failures due to historical premium volatilities, which would result in lapses in coverage for ever-increasing risks. It would also help overcome suboptimal coverage, resulting from scale diseconomies in countries' insurance markets if they go it alone and from the lack of incentives for measures to adapt to catastrophic losses. In addition, capital market-based arrangements could increase the insured-asset base in developing economies while promoting reliability in economic compensation following natural disasters. Such support could encourage participation by the national and international insurance industries once they realized that all the risk was not being transferred to them.

Such initiatives go hand in hand with the needed restructuring of local insurance industries. Thus the involvement of multilateral institutions could help strengthen the domestic insurance industries and improve hazard adaptation measures. Where regional rather than national arrangements are more optimal, multilateral institutions could facilitate the needed intercountry policy dialogue.

**Insurance Associated with Carbon Mitigation Mechanisms.** While mitigation of climate change effects through reduction of carbon emissions is the primary course of action to attack climate change, the emission reductions (ER) market may also benefit from insurance instruments. While the current Kyoto protocol agreements and the EU's emissions trading system has succeeded in creating a market in ERs, the next phase contains uncertainties about the parameters of the ER market, such as equilibrium ER trading prices, initial rights, auctioned rights, emission credits, etc. One mechanism that might be considered while policymakers continue deliberations on the parameters of the market and the new protocols to be established would be an insurance mechanism to protect sellers and purchasers of ER credits from price swings, which may be caused by regulatory or framework uncertainties.

One such mechanism could be an insurance provider protecting or compensating ER sellers against unanticipated ER price swings. The EU, for example, could be the seller of such insurance and charge a premium to those needing price protection. ER sellers would be the primary clients, since they are most likely to buy such insurance to avoid overinvesting in mitigation without a guarantee of a floor ER price.

The insurance for ER credits would be limited, however, in the price variation covered (for example a 25% variance against "initial market conditions"), so as to limit the claims liability of those countries (e.g., EU) providing such insurance. Multilateral institutions could offer such countries a contingent-style facility for use in paying these claims immediately if they arose. The premiums charged for the limited price variance protection would be used to pay for any contingent loan fees and possibly principal, if a claims event occurred. By limiting the price variance that was protected, it would be easy to quantify what the maximum liability of such a scheme might be.

**Conclusions.** Climate change-induced disasters are likely to rise given recent evidence of weather trends. The insurance industry is recognizing this and adapting its analytical models for this purpose. The capital markets have also entered to offer more capital, provided that overall pricing demanded from such exotic bonds reflects the risks. Development institutions and credit market are ready to finance losses provided that adequate adaptation measures are taken in advance to minimize what needs to be "insured." Therefore, governments—individually and collectively—need to quantify their climate-induced disaster exposures and calculate the budget allocations required to cover reasonably projected losses. If these are not sustainable, they should consider the range of financial instruments to optimize (i.e., lower) the cost of premium-equivalent outlays and maximize any loss payout needed if a climate change-induced disaster affects their territory.

The use and price of pooled risk approaches, capital market mechanisms, insurance, and credit instruments can be calculated in combination to reduce the cost of such financial protection for emergency reconstruction, while avoiding the economic and budgetary disruptions this would otherwise entail. ■

# OVERVIEW OF RISK MITIGATION MEASURES

**Disaster Risk Mitigation.** The term mitigation, as defined by the UN International Strategy for Disaster Reduction (ISDR), means "structural and non-structural measures undertaken to limit the adverse impact of natural disasters, environmental degradation, and technological hazards." According to a study done by the U.S. National Institute of Building Sciences (NIBS), on average, one dollar spent on hazard mitigation saves four dollars in future disasters.[53]

Mitigation reduces the impact of disasters, saves lives, and reduces economic loss. Mitigation measures can be taken for every hazard and can be classified into four subject areas:[54]

- *Retrofitting.* Property protection involves the modification of existing structures to withstand natural hazards. Examples include installing back-up valves in sewage and water pipes, elevating structures, installing storm shutters, seismic strengthening, etc.

- *Regulations.* Regulations involve controlling the use of land and construction of buildings to reduce potential loss. Examples include enforcing building codes and establishing land use zones.

- *Protective Structures.* Structures can be built to protect and mitigate the impact of disasters. Examples include erecting seawalls, building safe rooms, and constructing levees.

- *Natural Resource Management.* Managing natural resources minimizes risk of hazards. Examples include controlling erosion, managing forests, and restoring wetlands.

Mitigation measures can also be grouped into two types of actions: "soft" measures are typically non-structural, process-oriented actions completed through

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[53] Multihazard Mitigation Council (MMC) - U.S. National Institute of Building Sciences (NIBS), "Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities," Washington, DC, 2005.

[54] U.S. Federal Emergency Management Agency (FEMA), "FEMA 386-3: Developing the Mitigation Plan: Identifying Mitigation Actions and Implementation Strategies," April 2003.

regulations and planning, such as mapping hazards and enforcing building codes, and "hard" measures usually encompassing structural investments, such as building dykes and reservoirs. Discussions of both soft and hard measures follow.

## ALL-HAZARD RISK MITIGATION MEASURES

The following are recommended actions to reduce the general risk of natural hazards:

**Development of Regulatory and Institutional Framework.** A regulatory and institutional framework establishes national responsibilities for risk mitigation by providing authority to respective government agencies to discharge responsibilities related to agreed upon government measures. Included in this framework are specific legislations that allow jurisdictions to adopt and enforce land use ordinances and building codes.

The framework should also include the development of a national mitigation action plan. After assessing risks and potential mitigation measures, an action plan can be developed describing how actions and investments will be prioritized, implemented, and administered.

As part of the South East Europe Disaster Risk Mitigation and Adaptation framework program, the World Bank will support the development of comprehensive disaster risk management and adaptation strategies in the SEE countries, which will include sectoral reviews and multi-sector analyses involving all key stakeholders. The reviews will provide recommendations for organizational and legislative improvements and priority investments in adaptation and disaster risk reduction.

**Hazard Monitoring and Data Collection.** To determine the vulnerability of a country's population, the institutions responsible for monitoring hydrology and meteorology and collecting geological data must be properly equipped. The monitoring and data collection for natural hazards may be spread across institutions. For example, monitoring the risk of landslides may require geological surveys, as well as hydrometeorological forecasting. Collection and analysis of data should be shared across institutions to ensure the proper evaluation of risks.

**Development of Risk Assessments.** The development of natural hazard risk assessments for selected areas and hazards, based on the analysis of historical events at these locations, can feed into probability distributions and predictions of likely future occurrences. To undertake a risk assessment, data should be collected and analyzed on the assets and populations exposed in a given location. Probable damage scenarios, vulnerability models, and loss scenarios analyses are useful tools, which constitute key foundations for the development of preparedness actions and investments, as well as for risk financing options.

Among the ECA countries, Albania, with support from international donors, completed a multi-hazard risk assessment for floods, landslides, forest fires, heavy snow, earthquakes, epidemics, and technological hazards. For each hazard type, the study assessed areas at risk, impact on the population and infrastructure, estimation of potential casualties, and evacuation needs. The study also focused on some broader groups of elements at risks, such as particularly vulnerable populations, housing, public facilities (schools and hospitals), vital transport infrastructure, and critical industrial complexes.

**Hazard Risk Mapping.** Hazard risk mapping can provide data on the likelihood and consequences of specific hazards in selected areas—information that gives a basis for risk mitigation prioritization and investments. A critical element in reducing vulnerability is analysis of human settlements and infrastructure in high-risk areas. Geographic Information Systems (GIS), with layers of digital data, create risk maps and data sources that enable further use of subsequent mitigation measures, such as land-use planning, improved building codes, incorporation in the relevant legislation, securing funds for investments, etc.

**Implementation of All-Hazard Land-Use Plans and Development/Enforcement of Building Codes.** Land use planning, resistant designs and construction, building regulations and permitting systems, and enforcement of urban plans and building codes address the safety of future structures. These measures are particularly important in fast-growing and often unregulated development areas. Spatial development plans and regulations for natural hazards, as well as enforcement of the existing or newly formulated building codes and regulations, are of key importance for mitigation against all hazards.

Several municipalities in Turkey, particularly those most vulnerable to hazard risk, carried out multi-hazard risk analyses, hazard mapping, loss estimations, and development of mitigation plans. The purpose of this work is to improve land use plans based on the particular risk of a given municipality, allowing the locality to make informed decisions about their urban development. Based on the results of this pilot work supported by the Bank through the Marmara Earthquake Emergency Reconstruction project, further amendments were made to the respective regulations, including formulation of the Development Law.

**Construction of Hazard-Resistant Buildings.** The purpose of constructing hazard-resistant buildings is to prevent loss of lives and injuries sustained as a result of damaged buildings. In addition for certain types of public facilities, such as hospitals, emergency response services, etc., it is important that they continue their operations in the aftermath of a disaster. Typically designs account for seismic events; however, buildings can also be constructed to resist wind and lessen the flood damage.

**Provision of Risk Mitigation Education to the Public.** It is important to develop and implement a public awareness campaign to educate individuals on how they can personally reduce the risk of hazards that occur in their area. Television and radio, schools, and community outreach programs can disseminate this kind of information. Public awareness of these risks also helps monitor developments on the ground and keeps authorities accountable for their actions in adaptation and hazard risk mitigation. For example, Romania has developed the Hazard Risk Mitigation and Emergency Preparedness project, a multi-hazard public awareness campaign tailored to various target audience, such as children, using multiple media, including internet web site with links to educational tools for students.

## HAZARD-SPECIFIC ADAPTATION INVESTMENTS

**Flood Risk Reduction.** Accounting for the projected impact of climate change and growing risk and losses due to floods in the ECA region, flood protection measures to reduce country vulnerability need to be improved and expanded. The following are examples of soft and hard measures that can be taken:

*Implementation of Flood Management Program.* Flood management should be addressed in river basin and catchment water management plans. Watershed basin planning and feasibility studies for the rehabilitation and upgrading of existing flood protection schemes should be developed or reviewed in light of climate change projections. Flood management also includes floodplain zoning, development of land use plans, and implementation of regulations. Specifically for coastal regions prone to rising water levels in the long term, a flood management program should include coastal planning and development of coastal zone regulations, such as shoreline setback requirements.

*Natural Resources Management.* Restoring resources to their natural state may reduce the impact of flooding. For example, restoring dunes and beaches can impede coastal erosion. Removing debris in river channels allows for the natural movement of water and prevents sediment build up. To assist in the design of specific measures, multi-country studies for specific watershed areas can be carried out and agreements reached to determine how the management of natural resources within each country can reduce the likelihood of flooding.

*Flood Protection Infrastructure.* Flood protection investments that safeguard particular localities may include riverbank protection; improvement of reservoirs and dykes; retrofitting of dams for safety with larger spillways and gates; enlarging floodways; building levees, floodwalls, seawalls/bulkheads; dam monitoring; reviews and revisions of operating rules for dams, etc. Feasibility studies that incorporate economic, environmental, and social assessments should precede decisions on flood protection investments, accounting not only for historical frequency and loss data but also climate change data and projections, as the probability and return periods may change and require a modified technical approach.

In Poland, the World Bank has supported improvements in the flood management system through the policy framework and institutional capacity for flood management, investments to upgrade hydrotechnical infrastructure, modernizing flood management systems and meteorological systems, updating mapping and modeling of river basin areas using GIS, improving forecasting and planning, and building flood protection infrastructure. The recent major flood protection project will protect an estimated 2.5 million people in the Odra River Basin against loss of live and property damage through establishment of storage in a dry polder on the river upstream, enabling reduction of flood peak downstream of the reservoir.

*Flood Resistant Construction.* A variety of measures can be undertaken to build flood-resistant structures. First, buildings can be constructed with flood-resistant materials.[55] Buildings walls can be strengthened to withstand the pressure of floodwaters and floating debris, and structures can be properly anchored to foundations or footings. Buildings can be elevated above the average waterline for a 100-year flood event, so that building floors are above floodwater level.

*Hydrometeorological Monitoring and Forecasting System.* Due to the current and projected impact of weather-induced natural hazards, the effective functioning of hydrometeorological systems is very important for disaster preparedness and response. Floods occur not only through the inundation of large water plains but also in small, shallow river areas. Spillages and failures of dams can also cause flooding. In many cases, these disasters are predictable in a given time horizon and allow for early warning and response actions, particularly in downstream countries. For the warning and response to be effective, a reliable weather and water monitoring system must be in place. The sharing of meteorological and hydrological data and forecasts is essential both within a country and among upstream and downstream countries.

Russia's National Hydromet Modernization Project aims to increase the accuracy of forecasts provided

[55] The U.S. Federal Emergency Management Agency defines flood resistant as materials that can withstand direct contact with flood waters for 72 hours without being significantly damaged. U.S. Federal Emergency Management Agency (FEMA), "Build with Flood-Resistant Materials," http://www.fema.gov/plan/prevent/howto/how2025.shtm#other (accessed April 2008).

to the Russian people and economy by modernizing key elements of RosHydromet's technical base and strengthening its institutional arrangements. This will enable enterprise and household adjustments to protect lives and support economic growth. The project supports (i) modernization of computing, archiving, and telecommunications facilities; (ii) upgrading of the observation networks; and (iii) institutional strengthening, improvement in output dissemination, and emergency preparedness.

ECA has just completed a Review of Weather and Climate Services in the region. The study strengthens ECA's client countries' understanding of gains to be made by enhancing weather and climate services. The study also highlighted cost-effective solutions to regional capacity gaps.

*Retrofitting of Buildings and Infrastructure.* Measures to retrofit existing buildings to withstand flooding may include anchoring of storage tanks to prevent flotation and installing flood vents to equalize pressure of floodwaters and save buildings from extreme damage. Other important measures include protecting wells—prone to contamination by such toxic materials as raw sewage, oil, and chemicals—from flood waters through technical measures, such as extending well casings to at least two feet above the highest-known flood elevation and installing backflow valves in the water line.[56]

**Extreme Temperature and Wildfire Risk Reduction.** Wildfire is a key risk associated with increasingly frequent heat waves and dry conditions. Forests in Europe that are already moisture-limited or temperature-limited will have greater difficulty in adapting to climate change. Fire protection will be an important component in protecting forest and grassland, particularly in South East Europe. Summer 2007 wild fires highlighted the losses and long-term environmental consequences of forest fires in the region and the comprehensive fire safety measures that need to be adopted.

*Monitoring of Forest Fires.* In areas of wild fires risk, development of an early warning system for monitoring forests is particularly advisable. To help predict when forest fires are more likely to occur, an early warning system should include a forest fire index that incorporates data, such as soil moisture, air humidity, precipitation, etc. GIS and satellite imagery can also enhance the monitoring of forest fires by digitizing maps and referencing them to forest inventory data. As in the case of floods, internal cooperation within a country among various sectors and agencies (e.g., hydromet, forestry sector, fire fighting command) and externally with the neighboring states is very important for the wild fires monitoring system to be effective.

The increase in wild fires observed in South East Europe has been associated with climate change. Most of these forest fires are transboundary in nature, therefore, coordination among neighboring countries on early warning systems and response is critically important. In 2008 Croatia initiated efforts to better coordinate response to forest fires and other hazards through the establishment of a Regional Coordination Center (RCC) for Wild Fires

*Development of Forest Management Program.* In view of climatic changes, managing forests through wild fire mitigation may incorporate the following: (i) replacing highly flammable species, (ii) regulating age-class distributions, (iii) widespread managing of accumulated fuel, eventually through prescribed burning, (iv) changing species composition of forest stands and planting forests with genetically improved seedlings adapted to a new climate, (v) thinning of plants and trees, (vi) extending the rotation period of commercially important tree species to increase "sequestration"

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56 U.S. Federal Emergency Management Agency (FEMA), "Protect Wells from Contamination by Flooding," http://www.fema.gov/plan/prevent/howto/how2026.shtm (accessed April 2008).

(the storage of carbon), and (vii) planting based on a forest's micro-climate. The introduction of multi-species planting into currently monospecies coniferous plantations can also be beneficial.

Much can be done for better forest resources management at the community level. In Armenia, the Natural Resources Management and Poverty Reduction project is assisting communities in the northern part of the country through community-based forest management and small-scale local initiatives to reverse degradation of natural resources. The locally implemented measures include reforestation, reseeding of indigenous species, and rehabilitation of forest pastures, meadows, and steppes, etc.

*Regulation of Land Use.* Regarding settlement in proximity to forest areas, regulations and their enforcement are of key importance to wild fire mitigation. Regulations on population settlements near forests should be developed and locally enforced. These can include requiring land use permits and fees, establishing safety zones around dwellings by requiring the removal of vegetation around houses, and banning settlements in proximity to high risks areas. These measures can limit the negative impact of human activities on areas vulnerable to wild fires.

*Public Awareness Campaigns.* Countries that climate data shows are increasingly prone to heat waves should develop an aggressive public awareness program. Information on how extreme heat affects the body and what steps to take to reduce heat's impact is important to communicate to save lives. Also, education and public awareness efforts should target specific groups, such as farmers, tourists, and house owners in the vulnerable areas, on behavior in the high-risk seasons to reduce wild fire risks.

**Landslide and Mudflow Risk Reduction.** Many countries in the ECA region are prone to landslides. While landslides fit into the geohazards category, they often occur as secondary consequences to other events. For hazards derived from climatic conditions, floods can be key triggers for landslides in particularly prone areas. Due to the projected increase in precipitation intensity and precipitation per extreme event, the vulnerability to mudslides and landslides is expected to grow. Similar to earthquakes, the occurrence of landslides and their precise location are difficult to predict, though there are already some technologies, notably coming from satellite imaging, which can analyze ground movements and project their likelihood. The following are some key landslide and mudslide risk reduction measures:

*Development of Landslide and Mudflow Maps and Monitoring System.* A cornerstone for landslide mitigation is knowledge of the location of areas particularly prone to landslides. Studies and GIS maps should be produced for selected areas, including data on morphology, hydrogeology, land use, soil type, etc. Current satellite technology allows for better monitoring of slope movement. This information can serve as a foundation for regulations, land use plans, and if feasible, stabilization works.

To reduce risk related to Lake Sarez in Tajikistan, a modern monitoring system coupled with an early warning system was recently installed as part of the Lake Sarez Risk Mitigation project. The satellite-based remote sensing technology detects and measures ground deformation, arising from natural or induced causes to millimeter accuracy. The system couples with a hydromet monitoring system and aims to alert people living in the Lake Sarez area, which is vulnerable to landslides, floods, and earthquakes. The system also helps map hazard risk scenarios.

*Regulation of Land Use and Population Settlements.* Often landslides occur as disasters associated with other hazard events, such as floods and earthquakes. Key to landslide risk reduction is spatial planning and environmental management (e.g., aforestation), highlighting the importance of land use regulations and their enforcement. Foremost, buildings and other infrastructure should not be constructed on land vulnerable to landslides, such as drainage ways or steep slopes.

*Slope Stabilization Works.* In cases where it is economically and technically feasible, slope stabilization and erosion control measures can be employed. Planting ground cover on slopes and building retaining walls on hillsides may reduce landslide risk.

**Drought Risk Reduction.** Drought risk is expected to increase due to climatic changes in many ECA countries, particularly those in South East Europe, Caucasus, parts of Russia, and Central Asia. The increasing shortages of water will affect both rural and urban areas. Governments can consider the following summarized mitigation measures for implementation:

*Regulation of Water Use.* Governments can take a number of regulatory and technical measures to reduce water demand. Water metering and leak detection programs can be implemented to better regulate and enforce water usage. Emergency water conservation regulations can also be enacted when a community determines it is entering a drought situation.

*Drought Resistant Crops.* To reduce the impact of drought on agriculture, farmers can opt to substitute crops (e.g., replacing winter with spring wheat) or to introduce new species of drought resistant crops and cultivars (higher drought resistance and longer grain-filling).

*Soil Management Practices.* Practicing good soil management maintains soil structure and composition, which reduces soil degradation and erosion. Reducing erosion decreases surface runoff and increases soil moisture. Soil management practices include crop rotation, terracing, off-season tillage or reducing tillage, diversifying crops, mulching, and reclamation of salinized soil.

*Building Water Retention Structures.* Building structures that retain water can increase soil moisture and replenish groundwater. Water retention structures include trenches and contour bunds, check dams, and percolation ponds, all of which direct and retain the flow of runoff.

*New Irrigation Methods.* Adopting efficient irrigation methods will reduce the demand for water. Incorporating or substituting current irrigation methods with schemes like harvesting rainwater and drip irrigation can improve water usage and reduce demand. Landscape contouring to form saucer basins under trees and planting crops using ridges and furrows can also help collect and direct runoff to planted areas.[57]

In the Kyrgyz Republic, the Bank through the Water Management Improvement project supports enhancements in irrigation service delivery and water management. The works include headworks construction and repair; settling basins and sediment ejectors; concrete lining, overpasses, and underpasses to direct cross-drainage and sediment flows across canal sections; repair, replacement, or construction of channel control structures; mechanical desilting of canal sections; and gauging stations construction and repair.

*Enhancement of Hydrometeorological Monitoring System.* Establishing a reliable weather and water monitoring system mitigates risks both for flood (as explained previously) and drought, enabling prediction and early response, as well as developing long-term adaptation strategies. Modernizing the hydromet system will increase the ac-

[57] The Ojos Negros Research Group, "Drought Facts." http://threeissues.sdsu.edu/three_issues_droughtfacts04.html, Accessed April 2008).

curacy of weather forecasts and will allow farmers to better plan the sowing and harvesting of crops.

*Collection and Monitoring of Drought Data.* Predicting and monitoring drought requires a wide range of collection of data. Soil moisture, levels of stored water, snow pack quantity, melt rate, and rainfall are examples of hydro data that can be collected to determine drought risk. Assessing drought impact also requires extensive data collection. Relevant factors on how drought will affect a community include type of land use, demographics, and existing infrastructure. Determining when localities are in drought and the extent of impact allows governments to trigger drought-related actions, like regulating public water usage and launching targeted water supplies.

**Strong Winds and Storms Risk Reduction**. Climate change projections indicate that the Baltic and South East Europe countries will experience increased wind speeds, posing additional risk to infrastructure and population to be addressed by governments and individuals through technical measures. For the latter, public education on the nature of the threats and the tools required for mitigation is particularly important.

*Designing, Building, and Retrofitting of Wind Resistant Structures.* Designing and constructing buildings and other infrastructure to resist wind in risk-prone areas is a key adaptation measure. In particular, proper roof design and construction is the number one factor for mitigating wind damage to a building. For example, buildings with hip or flat roofs are more wind resistant than others, such as gable end roofs. Constructing with strong roof materials, such as 26-gauge alusteel sheeting, can also improve a building's envelope. Construction techniques like spacing timber purlings no more than 900mm apart are other ways to build wind-resistant roofs.[58] Buildings can be retrofitted to withstand strong winds. Retrofitting may involve installing straps to secure roofs and clipping metal siding to a building's frame.

*Assigning Shelters.* In particularly vulnerable communities, assigning or building shelters to protect people from high-speed winds and other hazards should be considered. This requires development and execution of public alerts and evacuation procedures.

*Enforcement of Building Codes.* Structures should be designed to withstand heavy winds. In areas that are at risk of strong winds, relevant building codes should be developed and enforced. Areas that have adopted and enforced high-wind building codes have clearly benefitted from these regulations. For example in 1995, the coastal areas in the state of Florida began to use and enforce wind-resistant building codes. A 2004 study on insurance claims from Hurricane Charley determined that houses built after enforcement of the building codes had frequency of claims reduced by 60%, and when a loss did happen, the claim was 42% lower.[59]

*Protection of Building Envelope.* Relatively simple measures can improve resistance of buildings to high winds. Because a broken window or other opening in a building's envelope can increase the difference in pressure and cause roof failure, the need to protect windows and doors should be communicated to the population. Covering doors with sturdy fabric screens can protect them. Installation

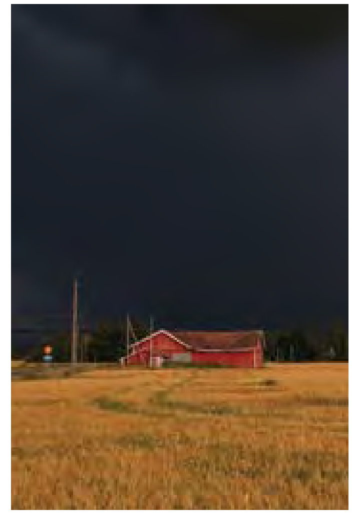
58 Organization of American States - Caribbean Disaster Mitigation Project. 2001. "Costs and Benefits of Disaster Mitigation in the Construction Industry," Note originally prepared by J. Pereira for presentation at the Caribbean Disaster Mitigation Planning Workshop, Trinidad, March 14-16, 1995.

59 Institute for Business and Home Safety, "The Benefits of Modern Wind Resistant Building Codes on Hurricane Claim Frequency and Severity," 2005.

of storm shutters can reduce damage to windows from wind-borne objects. Securing outside objects and trimming trees around structures also reduces damage from flying debris.

***Meteorological Monitoring.*** As in the case of heavy rains and floods, the monitoring of weather and country forecasting capacity are key prerequisites for early warning and timely preparedness measures. Also, the availability of historical meteorological data and projected medium- and long-term changes can inform government's policy and regulatory decisions. ■

# EMERGENCY MANAGEMENT



Emergency management is defined as the organization and management of resources and responsibilities for dealing with all aspects of emergencies. Emergency or disaster management involves plans, structures, and arrangements established for a comprehensive and coordinated response to the whole spectrum of emergency needs.[60] This section discusses main actions governments of the region can take to strengthen their emergency management capacity, focusing on preparedness and response aspects.

**Development of Institutional and Legal Arrangements.** Emergency management occurs at all levels: national, regional and local. The legislative framework should define the authority to carry out emergency management duties, how a disaster is declared, and the mechanisms for accessing emergency resources. Other legal considerations include outlining emergency powers; identifying lines of succession in case an emergency affects a government's leader; and defining authorities and actions a successor may take during a disaster.

To properly coordinate emergency services, the roles and responsibilities of key stakeholders should be specified not only for government agencies but also for non-governmental organizations. Moreover, if local entities own emergency management resources, neighboring towns need to develop mutual aid agreements to share resources. Nations can also enter into these mutual agreements.

**Emergency Response Planning.** A response plan should clearly delineate roles and responsibilities of disaster response organizations, explaining coordination both horizontally with each other and vertically with local and national authorities. Often national response plans include how to request international resources, while local plans include evacuation and shelter plans. Typically response plans consist of operational and logistical components, including procedures for damage and needs assessment in the aftermath of a disaster.

**Emergency Training and Exercises.** After plans are developed, relevant groups need training and exercising to determine gaps and shortfalls. National, regional, and local levels should conduct training and exercise programs to test coordination, response, and readiness, and to modify the emergency response plans, if needed.

[60] UN International Strategy for Disaster Reduction, "Basic Terms of Disaster Risk Reduction," March 2004.

**Monitoring, Alert, and Early Warning Systems.** Monitoring, alert, and early warning systems involve the communication of all-hazard forecasts to the public and government officials. An early warning system comprises a regularly tested process to receive data and disseminate warnings 24 hours a day, 7 days a week. It includes a back-up system to ensure communications in case the primary system fails. Communications to the public are hazard specific and contain clear emergency directions. Alert and warning systems are designed for specific hazards, such as floods and strong winds.

Flood, heavy rain, and strong wind warning systems combine meteorological data (rainfall, snowmelt, and storms) with water-level measurements on rivers and reservoirs to provide data for warnings of approaching floods and storms. The early warning system should establish data sharing and functional linkages between the hydromet service organizations and emergency response units (e.g., civil protection) and the authorities to allow sufficient time to inform the public of response measures, such as evacuations and launch rescue operations. In the area of flood early warning, transboundary cooperation among countries sharing river basins is particularly important.

**Public Awareness and Education.** Public knowledge about natural and technological hazards and about measures for risk reduction and disaster response is a vital element of emergency management. Public awareness strategies and campaigns that produce public awareness materials (e.g., printed materials, infomercials, public displays, etc.) through various delivery measures (e.g., radio, TV, press, public information centers) should be developed.

Another measure to enhance public awareness and preparedness is through age-differentiated student education in schools on natural hazards, prevention, preparedness, and response. Educational programs can have national coverage or be tailored regionally to certain types of disasters to which localities are prone. School curricula, educational materials, and teacher training can be developed to provide scientific understanding of natural hazards.

**Establishment of Emergency Operations Centers.** A key element of emergency response is the establishment of an emergency operations center (EOC). An EOC is where emergency services are coordinated. It is responsible for activating staff to respond to emergencies; requesting resources, such as equipment and teams; coordinating response and recovery activities; tracking resources; and collecting information from the field like damage and needs assessments. An emergency operations center is an important element in developing a robust emergency management system.

In Turkey, the Bank projects have helped establish the national emergency operations center in Ankara, as well as the center for the Istanbul province with full technical information and communication capacities to manage emergencies and disasters.

**First Response Services.** First response services include fire fighting, medical, public safety, and search and rescue services. Typically fire-fighting services not only manage fires but also respond to vehicle accidents and hazardous material emergencies, such as explosions. Search and rescue, swift water rescue, and other specialized teams usually fall under civil protection or fire fighting services.

Provision of equipment and tools like personal protection equipment or emergency medical units can strengthen first response. Planning for the location of the emergency response equipment should consider accessibility and safety of storage. Continuous training and exercises strengthens first responders.

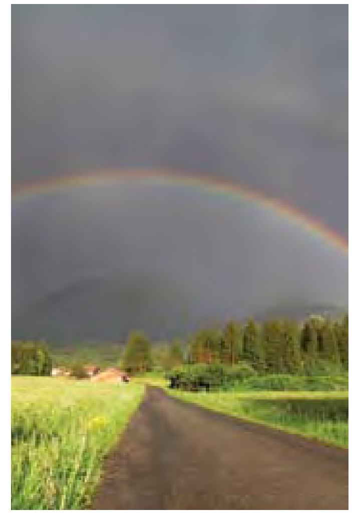
**Mass Care Services.** Mass care is an essential element of emergency response, which includes temporary shelters and comfort stations to provide medical assistance, food, and water to the public. Effective mass care considers provision of shelter services, proper sanitation, emergency power, safety of food and water supplies, and prevention of infectious outbreaks.

**Development of Robust Logistics System.** Logistics is the backbone of an emergency response. It includes facility management, resource management, and transportation. Facility management encompasses the identification, acquisition, and set-up of response facilities, such as staging areas. Resource management is the identification, acquisition, storage, maintenance, distribution, accounting, and disposal of emergency resources. Transportation involves the movement of resources into the affected area. Logistics requires strong coordination across all emergency functions.

**Emergency Communication and Information Systems.** Provision of accurate and timely information to decision makers and response units is crucial for saving lives and property. Interoperability and coverage of both voice and data communications capabilities across emergency management agencies, such as fire brigades and medical units, is of key importance. Emergency management information systems collect, analyze, and share real-time data between emergency management institutions and other public authorities at the national, regional, and local levels. The system should allow for two-way processing of information and support the daily operations of relevant agencies.

In recognition of the importance of such a system, the Government of Romania is in an advanced stage of establishing a modern national emergency management system, which will link all key government institutions and incorporate already existing sectoral systems into an integrated information management system. This system will support not only the management of major catastrophic events but also the decision-making process in other emergencies and operations. The system being developed is part of the Hazard Risk Mitigation and Emergency Preparedness project.

# CONCLUSIONS AND RECOMMENDATIONS FOR PUBLIC POLICY



Climate change is expected to increase global temperature, thereby changing precipitation patterns worldwide. For all subregions of Europe and Central Asia, these climatic changes are likely to increase the risk of extreme weather-related hazards. To reduce financial and environmental vulnerability and *improve adaptive capacities*, decision makers should consider specific measures described in the preceding chapters.

These measures will not only strengthen climate change adaptation but also benefit management of present-day disasters that the region already endures. Furthermore, these actions and investments will decrease the risk of large-scale catastrophes brought on by climate change, as well as small and medium-sized disasters.

Across the ECA region, developing and strengthening an *institutional and legislative disaster risk management framework* would assist in budget appropriations, planning, and finally the implementation of a disaster risk management plan. Ensuring clear legal statutes and proper funding for hazard risk management are the first steps. A strong system should have a robust preparedness program with plans, training, and exercises for all levels of its emergency management system.

*Clarifying the roles and responsibilities* of local and national governmental bodies in risk reduction, as well as emergency preparedness and response, would also improve disaster risk management capacity. Emergency risk management is a multisectoral process with multiple governmental entities responsible for overlapping functions. Emergency risk management responsibilities not only fall horizontally among multiple governmental bodies but with decentralization emergency management responsibilities also fall vertically. This matrix can be confusing and ineffective if roles and functions are not clearly defined at every level.

There are many "hard" and "soft" measures a country can take to reduce the risk of natural hazards and adapt to climatic changes. Before undertaking any concrete steps, however, first completion of *hazard risk assessments* and corresponding hazard maps is recommended. Data from the risk assessment can also assist policymakers in developing all-hazard land use plans, which in turn will help develop all-hazard building codes. Risk assessments are also crucial for policymakers to evaluate the cost/benefit of risk mitigation investments, leading to prioritization of investments.

Historically hydrometeorological hazards affect Europe and Central Asia significantly. Several factors exacerbate the effect these disasters have on population and infrastructure: settlements in disaster-prone areas, debilitating land and water use, lack of regulations and standards to account for hazard risks, and failure to comply with building codes and land use plans. *Hazard-specific investments* can reduce the risk of hydrometeorological hazards and increase adaptive capacity. Early warning systems for various hazards can be developed to monitor heat waves, forest fires, and hydrometeorological events, such as floods. Flood risk reduction measures can range from soft measures like developing flood management plans to hard measures like investments in flood protection schemes. The introduction of drought resistant crops can reduce drought damage, and retrofitting buildings to withstand heavy winds can reduce the risk of storm damage. Both the government and the public can take a combination of regulatory, structural, and protective measures to reduce risk, to decrease their country's vulnerability to natural hazards and to adapt to climatic changes.

Another measure a government can take is to *strengthen the technical capacity* of emergency responders, including the purchase of personal protective equipment, tools, and vehicles. To ensure that all levels of government and emergency units can communicate, investing in an interoperable emergency communications and information system is of critical importance. Moreover, *ensuring public awareness* of natural hazards risks and educating in preparedness and response actions are effective and relatively low-cost measures, which governments of the region can pursue.

Development institutions and credit markets are ready to finance losses provided that adequate adaptation measures have been taken to minimize "insured" needs. Governments, individually and collectively, need to quantify their climate-induced disaster exposures and calculate the budget allocations required to cover reasonably projected losses. If these are not sustainable, they should consider the range of *financial instruments* to optimize (i.e., lower) the cost of premium-equivalent outlays and maximize any loss payout needed if a climate change-induced disaster affects their territory.

The use and price of *pooled risk approaches, capital market mechanisms, insurance, and credit instruments* can be calculated in combination, reducing the cost of such financial protection for emergency reconstruction, while avoiding the economic and budgetary disruptions these outlays would otherwise entail. ■

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