MOUNTAIN ADAPTATION OUTLOOK SERIES

Synthesis Report

UN environment

DISCLAIMER

The development of this publication has been supported by the United Nations Environment Programme (UN Environment) in the context of its inter-regional project "Climate change action in developing countries with fragile mountainous ecosystems from a sub-regional perspective" that is financially co-supported by the Government of Austria (Austrian Federal Ministry for Sustainability and Tourism).

Federal Ministry
Republic of Austria
Sustainability and Tourism

This synthesis publication builds on main findings and results available through the Mountain Adaptation Outlook Series. It is based on review of existing literature and not based on new scientific results generated through the project.

The contents of this publication do not necessarily reflect the views or policies of UN Environment, contributory organizations or any governmental authority or institution with which authors or contributors are affiliated and neither do they imply any endorsement. While reasonable efforts have been made to ensure that the contents of this publication are factually correct and properly referenced, UN Environment does not accept responsibility for the accuracy or completeness of the contents, and shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance on, the contents of this publication.

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of UN Environment concerning the legal status of any country, territory or city or its authorities, or concerning the delimitation of its frontiers or boundaries. Mention of a commercial company or product in this publication does not imply endorsement by UN Environment.

We regret any errors or omissions that may unwittingly have been made.

G·R·I·D ARENDAL

Production team
Björn Alfthan, GRID-Arendal
Magnus Andresen, UN Environment
Hanna Lønning Gjerdi, GRID-Arendal
Matthias Jurek, UN Environment
Laura Puikkonen, GRID-Arendal
Larisa Semernya, UN Environment
Tina Schoolmeester, GRID-Arendal

Reviewers
Harald Egerer, UN Environment
Musonda Mumba, UN Environment
Nina Shatberashvili, Caucasus Network for Sustainable Development

Layout
GRID-Arendal

Cartography
Hisham Ashkar

ISBN: 978-82-7701-180-6

Recommended Citation
Alfthan, B., Gjerdi, H.L., Puikkonen, L., Andresen, M., Semernya, L., Schoolmeester, T., Jurek, M. (2018). *Mountain Adaptation Outlook Series – Synthesis Report.* United Nations Environment Programme, and GRID-Arendal, Nairobi, Vienna, and Arendal. www.unenvironment.org, www.grida.no

Acknowledgements
We would like to thank all who contributed to the respective Mountain Adaptation Outlook Series.

CONDESAN
Consorcio para el Desarrollo Sostenible de la Ecorregión Andina

ICIMOD

eia

RMCCA

SUSTAINABLE CAUCASUS

ARCOS NETWORK

Nature-RIDD
RESEARCH & INFO DISSEMINATION

SZENT ISTVÁN UNIVERSITY

eurac research

CARPATHIAN CONVENTION

UN Environment promotes environmentally sound practices globally and in its own activities. This publication is printed on fully recycled paper, FSC certified, post-consumer waste and chlorine-free. Inks are vegetable-based and coatings are water-based. UNEP's distribution policy aims to reduce its carbon footprint.

MOUNTAIN ADAPTATION OUTLOOK SERIES

Synthesis Report

Southern Bogota, Colombia

Foreword

Mountain ecosystems are critical to the lives of over half of the world's population. They are a source of water, energy, agriculture and other essential goods and services. But they are vanishing in front of our eyes. For example, Venezuela's last glacier, the Humboldt glacier in the Andes is about to disappear. On the other side of the world, the world's highest glaciers in the Himalayas are also shrinking, threatening the livelihoods and water security of almost one billion people.

As climate change threatens to wipe out this vital ecosystem, many communities often living in remote locations in poverty, remain on the fringes of climate action. It is for these reasons that the United Nations Environment Programme and partners have developed a series of outlook reports about the need for urgent action to protect mountain ecosystems and to mitigate human risk from extreme events.

The series examines the effectiveness of existing adaptation policies in a number of areas including the Carpathian Mountains, Central Asia, Eastern Africa, Western Balkans, Hindu Kush Himalaya Southern Caucasus and the Tropical Andes. The reports identify critical gaps that must be addressed to meet current and future risks from climate change. The assessment process included widespread consultations with national governments and regional and international experts, with the aim of offering comprehensive recommendations to help people and ecosystems adapt to climate change.

Importantly, the Report synthesizes and highlights common challenges to increase global cooperation around mountain adaptation. Across all regions rising temperatures and changing precipitation patterns affect a range of mountain ecosystems, including forests, grasslands and lakes. Furthermore, other anthropogenic threats such as pollution from mining and unsustainable agriculture, erode people's ability to cope with climate change. The combined impact has increased the vulnerability of local populations that depend on mountain ecosystems. Their vulnerability is compounded by isolation from markets, services and governance institutions that impact their ability to deal with climate risk

Adaptation to climate change is presenting policymakers with a range of complex challenges and sharing evidence of practical solutions and polices is important for all mountainous countries and communities, which are facing similar climate hazards.

We hope that this report will serve as a practical companion for local, regional and national policymakers and will foster cooperation globally between mountain regions to protect fragile mountain ecosystems and the people who depend on them.

Joyce Msuya
Acting Executive Director
UN Environment

Introduction

Mountain regions occupy about one-quarter of the Earth's land surface, and are home to 15% of the world's population. The influence of mountains extends far beyond their ranges: they provide goods and services, most notably water, to millions of people downstream.

Many mountain ranges provide natural borders between countries, meaning that they are found on the edge of countries, often away from the centres of power where important decisions are made. Mountain peoples and regions can often – but not always – be marginalized in decision-making, and face lower levels of development.

They are also on the frontline of climate change. Just like the poles, high-altitude areas are warming faster than the global average (a phenomenon known as altitude amplification), and almost all glaciers across mountain regions are retreating. The topography of mountains means they are often steep, with human populations earning a living on precarious land which is prone to flooding, landslides and a host of other climatic and non-climatic hazards. Adaptation to climate change in mountain regions is crucial, not only for the people living in mountains, but also for those living downstream.

This *Mountain Adaptation Outlook Series – Synthesis Report* provides a concise summary of the findings of a series of reports focusing on adaptation to climate change in some of the world's major mountain regions, with a particular focus on developing regions and economies in transition. Those reports, published under the common title of *Mountain Adaptation Outlooks*, were prepared for the Carpathians (2017), Central Asia (2017), East Africa (2016), Hindu Kush Himalaya (2018), South Caucasus (2015), Tropical Andes (2016) and the Western Balkan mountains (2015). This Synthesis Report does not include an analysis of policies released after the publication date of each Outlook. The full reference to all the Outlooks can be found in the back of this report.

Specifically, the report is intended to:

- Identify common climate change trends, key risks and impacts, and sectoral vulnerabilities both within and across different mountain regions;
- Identify common policy gaps for adaptation to climate change both within and across different mountain regions;
- Identify important regional/country differences to the above;
- Identify potential solutions at the regional/transboundary and international levels to promote adaptation to climate change in mountain regions;
- Highlight some of the initial key outcomes of Stages 2 and 3 of the UN Environment project "Climate change action in developing countries with fragile mountainous ecosystems from a sub-regional perspective" financed by the Government of Austria (see below).

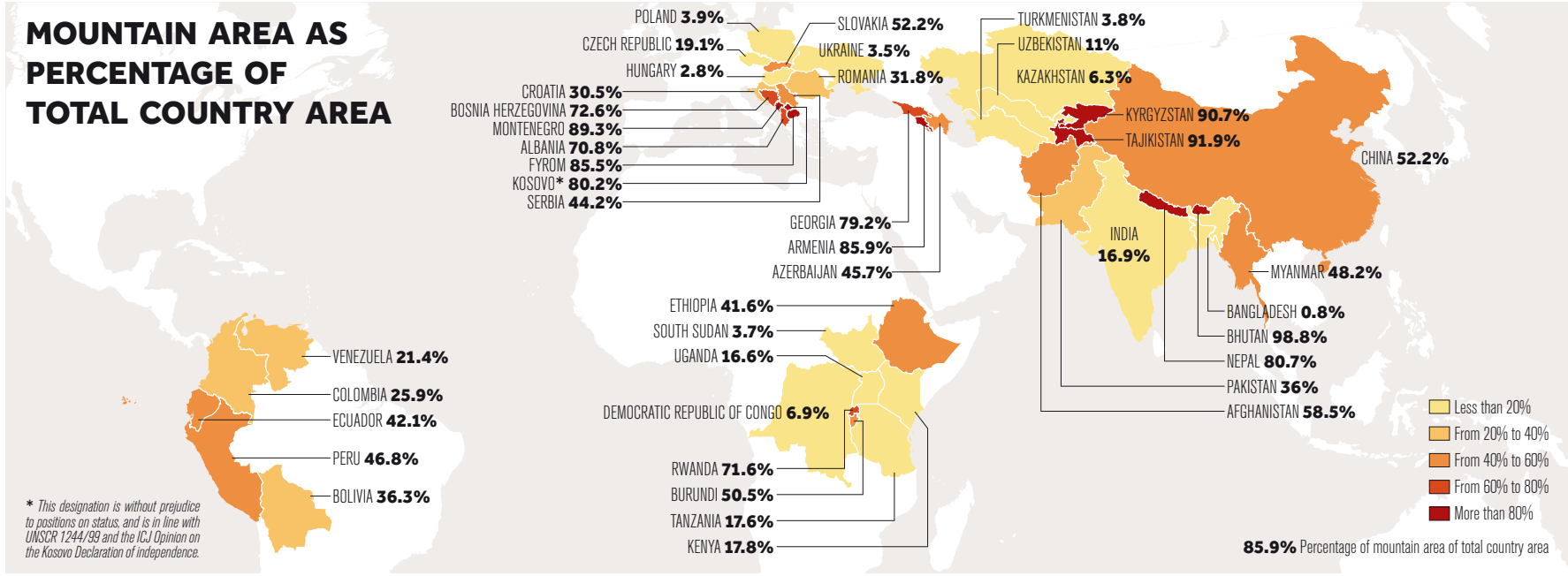
This Synthesis draws on the findings of the seven mountain regions targeted through the Outlook series. Here we apply the definition of mountain regions initially developed by Kapos et al. (2000) to determine the percentage of mountain area per country. The 2015 UN adjusted Gridded Population of the World dataset was used to determine the share of the population living within each country's mountain area.

A short glossary

Some important definitions used in this report and throughout the Mountain Adaptation Outlooks series (IPCC, 2014):

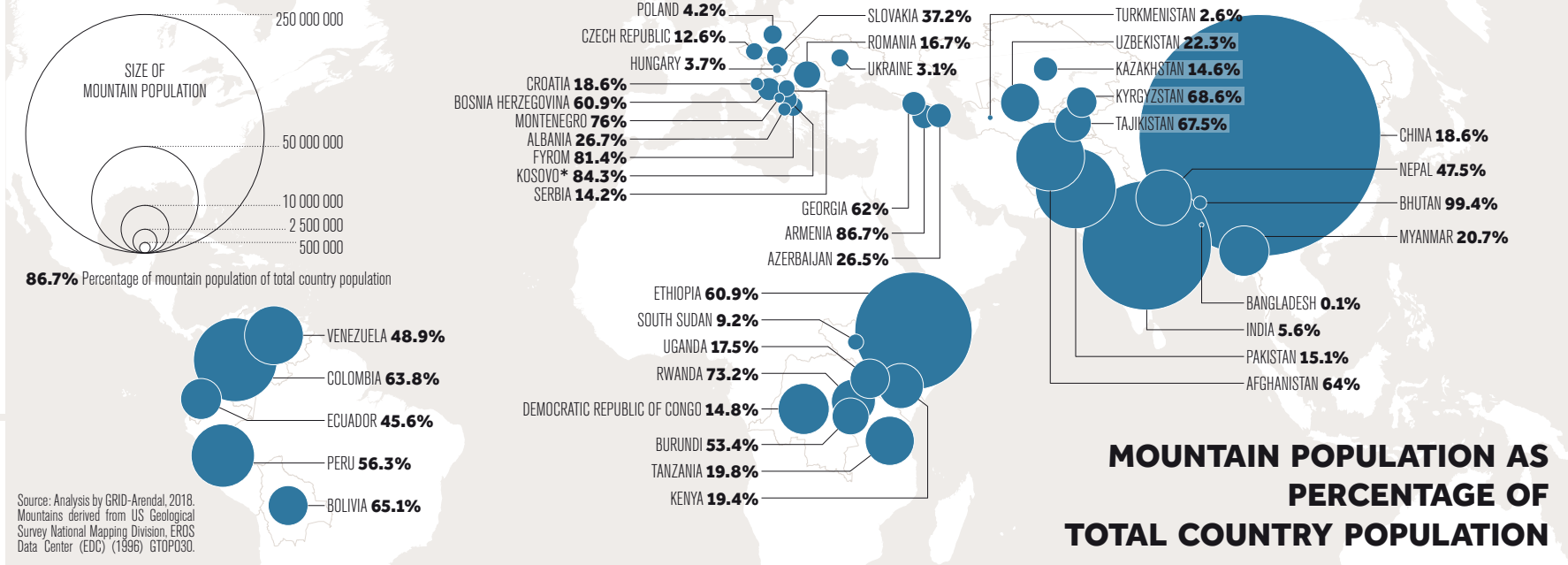
Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.
Adaptive Capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
Exposure: the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Hazard: climate-related physical events or trends or their physical impacts
Impacts: Effects on natural and human systems, also referred to as consequences or outcomes.
Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values.
Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

MOUNTAIN AREA AS PERCENTAGE OF TOTAL COUNTRY AREA



* *This designation is without prejudice to positions on status, and is in line with UNSCR 1244/99 and the ICJ Opinion on the Kosovo Declaration of independence.*

85.9% Percentage of mountain area of total country area



86.7% Percentage of mountain population of total country population

Source: Analysis by GRID-Arendal, 2018. Mountains derived from US Geological Survey National Mapping Division, EROS Data Center (EDC) (1996) GTOP030.

MOUNTAIN POPULATION AS PERCENTAGE OF TOTAL COUNTRY POPULATION

Background to this report

Since 2015, UN Environment, in collaboration with GRID-Arendal and a series of partners (mountain centres of excellence) in selected mountain regions, have been working on the project "Climate change action in developing countries with fragile mountainous ecosystems from a sub-regional perspective" to promote climate change adaptation in mountain regions.

The goal, in a nutshell, has been to assist targeted countries and regions to identify existing gaps – and opportunities – to integrate mountain-specific adaptation measures into key sectoral, national and regional development strategies and policies. In other words, the aim is to promote adaptation to climate change in mountains at the national and regional scale, as well as across regions.

The project has three stages:

Stage 1: ***The Mountain Adaptation Outlooks:*** The Mountain Adaptation Outlooks are a series of assessment reports which provide a baseline on climate change impacts, vulnerabilities and existing policies in each of the regions. These assessments were undertaken between 2015 and 2018 for the Carpathians, Central Asia, East Africa, Hindu Kush Himalaya, South Caucasus, Tropical Andes and the Western Balkan mountains. All were developed through a participatory assessment process involving key experts, including scientists, governmental representatives and civil society in each region.

Each of these Outlooks follows a similar format and methodology. First, existing and projected climate change trends (such as for temperature, precipitation and related extreme events) are identified for the mountain region in question. Second, key risks and impacts of climate change, both current and projected, on key sectors are analysed. Third, regional, national and sectoral policies are examined to identify the extent to which they take into account mountain-specific climate change impacts, hazards and vulnerabilities. Finally, a gap analysis identifies key gaps in policies and provide prioritised actions for climate change adaptation in mountain ecosystems. Each Outlook provides a set of recommendations tailored to the region.

Stage 2. ***Sub-regional policy dialogues:*** A series of policy dialogues, in the form of meetings and workshops and within given respective institutional frameworks, was undertaken in the above-mentioned regions. These sub-regional policy dialogues involved key designated governmental and non-governmental stakeholders and experts on climate change and sustainable mountain development from the various countries. The goal of these policy dialogues was to:

- Clarify national and regional priorities that the participating countries have in common;
- Promote sub-regional dialogue and cooperation on adaptation to climate change in mountain regions within the context of appropriate frameworks such the East African Community, the Interstate Commission for Sustainable Development in Central Asia, or the High Andean Initiative.

At each policy dialogue, a series of guidance documents (the final outcome and format varies from region to region) were prepared based on the Outlooks, stakeholder consultations and other sources. The guidance documents included a proposed list of policies, institutional measures and programmatic actions to promote adaptation to climate change in mountain regions. The list of measures and actions were organized around the policy sectors that were identified to be the most in need of adaptation measures, in alignment with national priorities. These processes were inspired by the Alpine and Carpathian Convention.

Stage 3: ***Follow-up actions at the sub-regional and national level:*** Both the sub-regional consultation meetings and Outlook process helped provide feedback and ideas for concrete follow-up actions at the national and regional level to address the specific needs of the countries, targeting specific sectors for action and using a variety of different international climate financing sources.

MOUNTAIN ADAPTATION SYNTHESIS REPORT

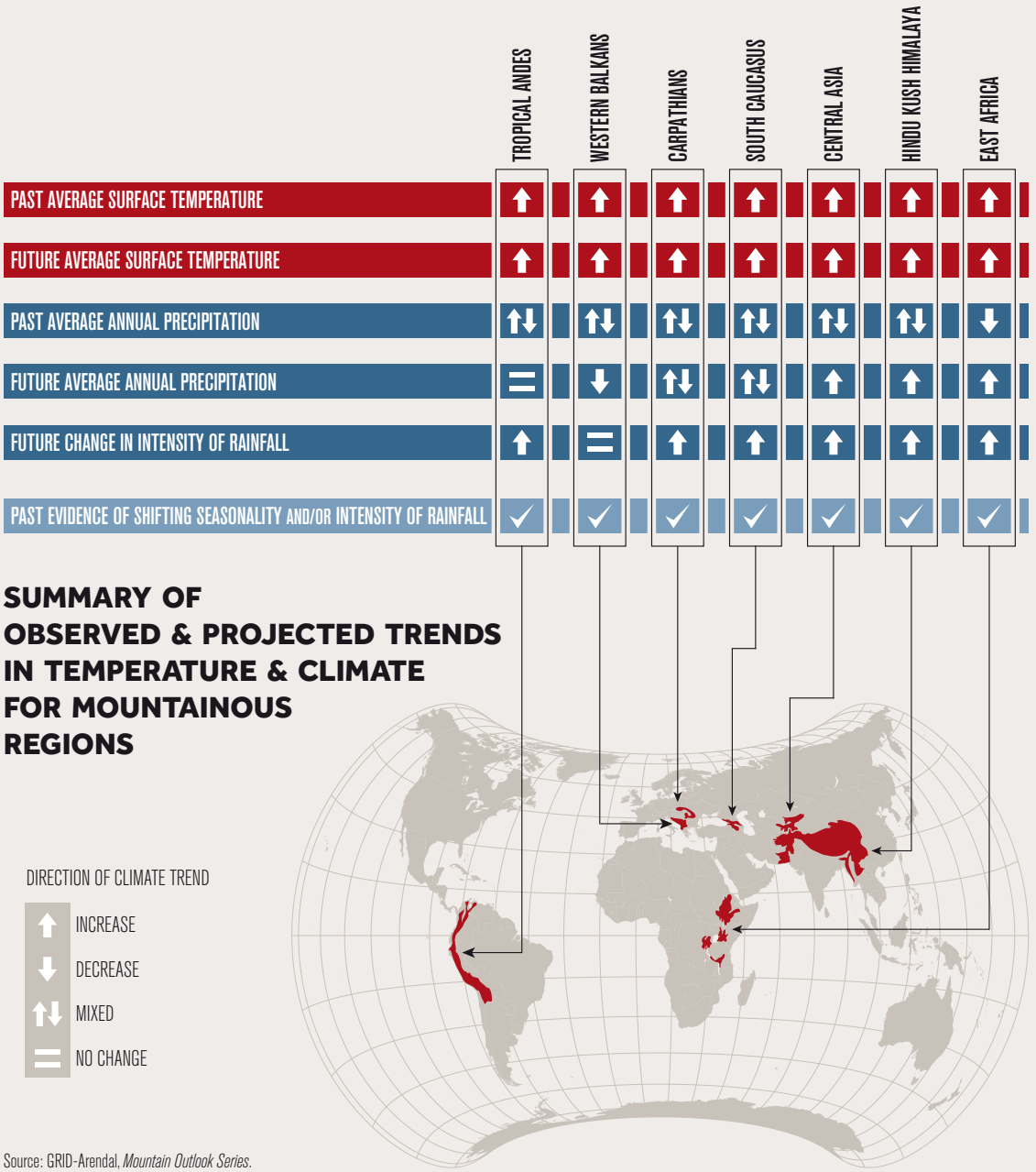
Climate change trends and risks for mountain societies

Uvac river canyon, Serbia

Mountains in a changing climate

Globally, human activities have caused approximately 1°C of global warming above pre-industrial levels (IPCC, 2018). Some areas have warmed faster than others, including the Arctic and in mountains. The global pattern of precipitation change is much more uncertain than for temperature: while there is high confidence that precipitation over the mid-latitude land areas of the Northern Hemisphere has increased in the latter part of the 20th century, there is low confidence in any observed trends for other latitudes, primarily due to issue of data quality and coverage. Global observations and projections, which are useful in identifying major trends, may not capture important local, country-level and regional trends. This is particularly true for mountainous regions where the topography is often too rugged to be captured by low resolution global models and complicated by an often-poor coverage of meteorological stations needed to validate and calibrate these models. For these reasons, the various Adaptation Outlooks examined country- and regional-level evidence, drawing from the latest scientific literature as well as national climate communications and other sources.

Landscape in the Cordillera Blanca, Peru



Past and future warming

According to the data presented in the various Outlooks, average annual temperatures have increased across all mountain regions and within all countries. The IPCC's observation that mountainous regions experienced above-average warming over the 20th century is confirmed by data from several national and regional level observations. Projections for all mountain regions and countries indicate that the warming trend will continue. Even under medium emission scenarios, many mountain regions will be facing unprecedented conditions, where the coldest years will be significantly warmer than the warmest years of today. Under high emission scenarios, all mountain regions are projected to experience between 4-5°C of warming by 2100 (even up to 8 °C in the Western Balkans).

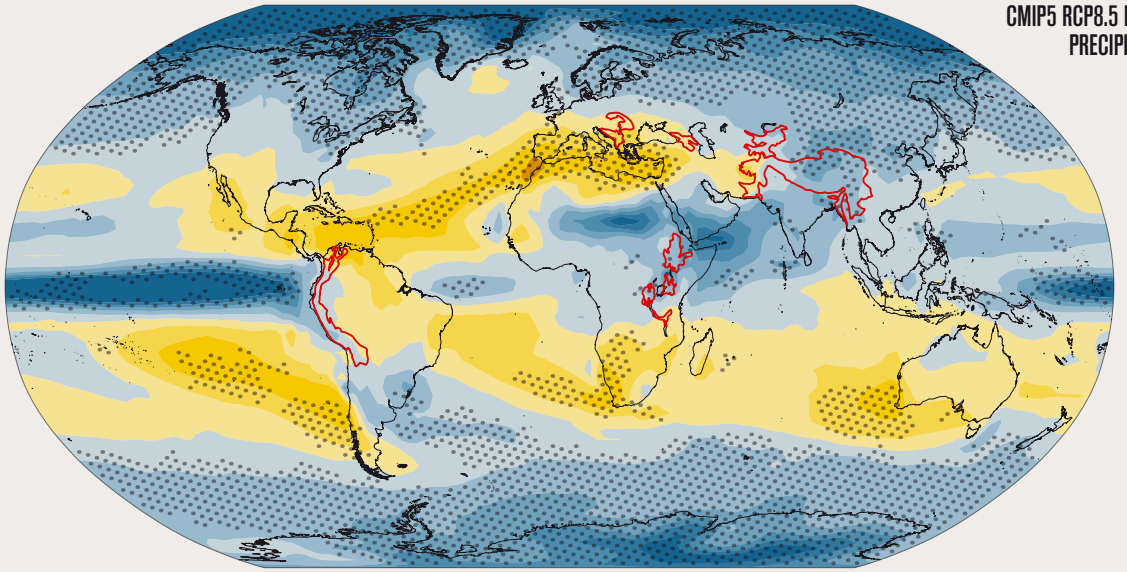
Past and future precipitation, including extreme precipitation

The pattern of past precipitation change in mountain regions has not been as consistent as for past temperature patterns. Some mountain countries have across their whole territories become wetter, others drier. Many mountain countries have become both wetter in some places and drier in others. Simply looking at annual

These trends are based on data in the Outlook series. There is a universal trend of increasing temperatures; precipitation trends are mixed. However, all regions have experience either shifting seasons or increasing intensity of rainfall over the past few decades.

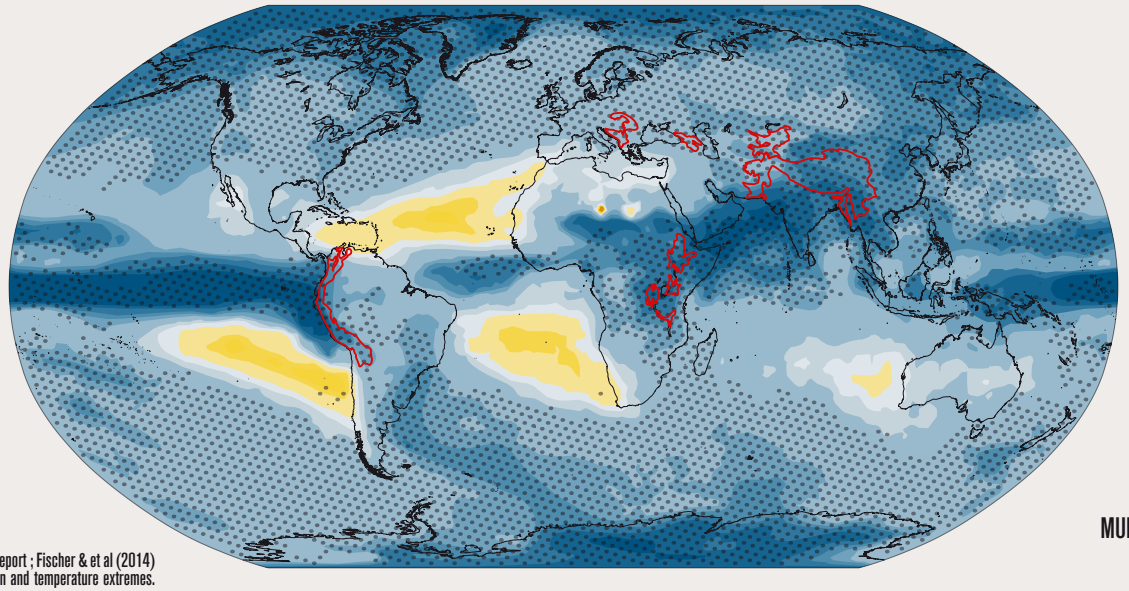
WHAT DO THE GLOBAL MODELS SAY ABOUT FUTURE PRECIPITATION?

CMIP5 RCP8.5 MULTI-MODEL MEAN ANNUAL AVERAGE PRECIPITATION (1986-2005 TO 2081-2100)



MOUNTAIN REGION UNDER STUDY

AREAS WHERE AT LEAST 90% OF MODELS AGREE ON THE SIGN OF CHANGE



MULTI-MODEL PERCENT CHANGE IN HEAVY PRECIPITATION BY DEGREE WARMING

Sources: IPCC (2014) Climate Change 2014: Synthesis Report ; Fischer & et al (2014) Models agree on forced response pattern of precipitation and temperature extremes.

precipitation change can also mask some important changes: all mountain regions have experienced changing rainfall seasonality and/or rainfall intensity in one form or another, even if annual rainfall has not changed. Future projections of precipitation are also less clear, especially regarding annual average precipitation, so any conclusions should be approached with caution. Precipitation is expected to decrease in the Western Balkans, and increase in East Africa, Central Asia and the Hindu Kush Himalaya, while no large annual change is expected at all in the Andes. In the Carpathians and South Caucasus precipitation is expected to have mixed trends, including less rainfall during summer and more during winter. However, almost all regions will experience more intense rainfall (i.e., more rain falling per event), translating into more floods. This is true even if certain regions are expected to get drier or experience more prolonged drought periods. Even in the Western Balkans, where extreme precipitation is not projected to increase, more floods are predicted because of more precipitation falling during winter. The projections of more intense rainfall across mountain regions are in line with global trends where almost all parts of the globe are projected to experience more intense rainfall.

There is general agreement amongst climate models that the future will bring an increase in heavy precipitation across most of the world, including in the mountain regions covered by the Outlooks (bottom map). There is much less agreement amongst models about trends in future average annual precipitation (top map), especially for mid-latitude areas (shown by the noticeably fewer dots on the map). Note: RCP refers to representative concentration pathway. RCP 8.5 assumes more or less unabated increasing gas emissions over time and absence of any climate mitigation measures.

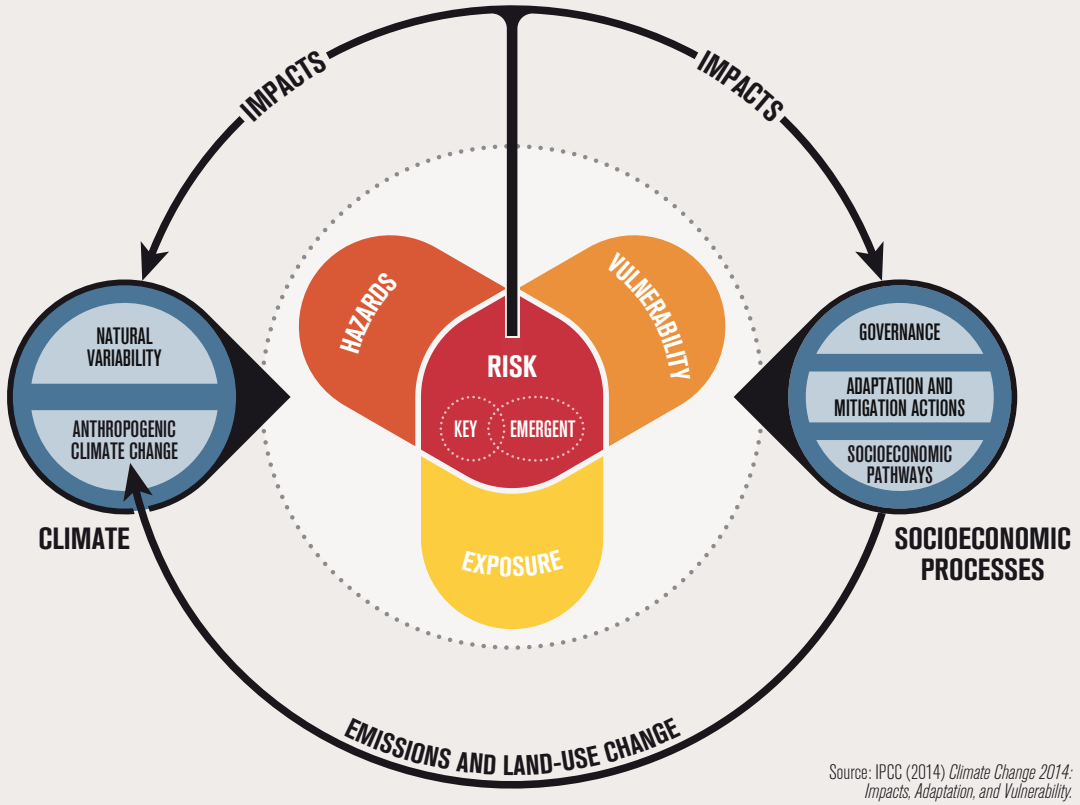
Meadow outside Stepanavan, Armenia

Risks for mountain societies

The risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems.

Mountains are generally hazardous places, even under conditions of natural climate variability. They are steep, often tectonically active and prone to earthquakes. With the help of gravity, storms and extreme precipitation events can unleash "fast-onset" hazards such as landslides, floods, and avalanches, the types of hazards that usually receive the most attention. However, mountains are not immune to slow-onset hazards, whose rate of impact is gradual, but which may nevertheless be as destructive as fast-onset events. Slow-onset hazards in mountains include increasing temperatures (the rate of which is increasing faster at higher altitudes), reduced precipitation, desertification, changes in ecosystems and melting glaciers.

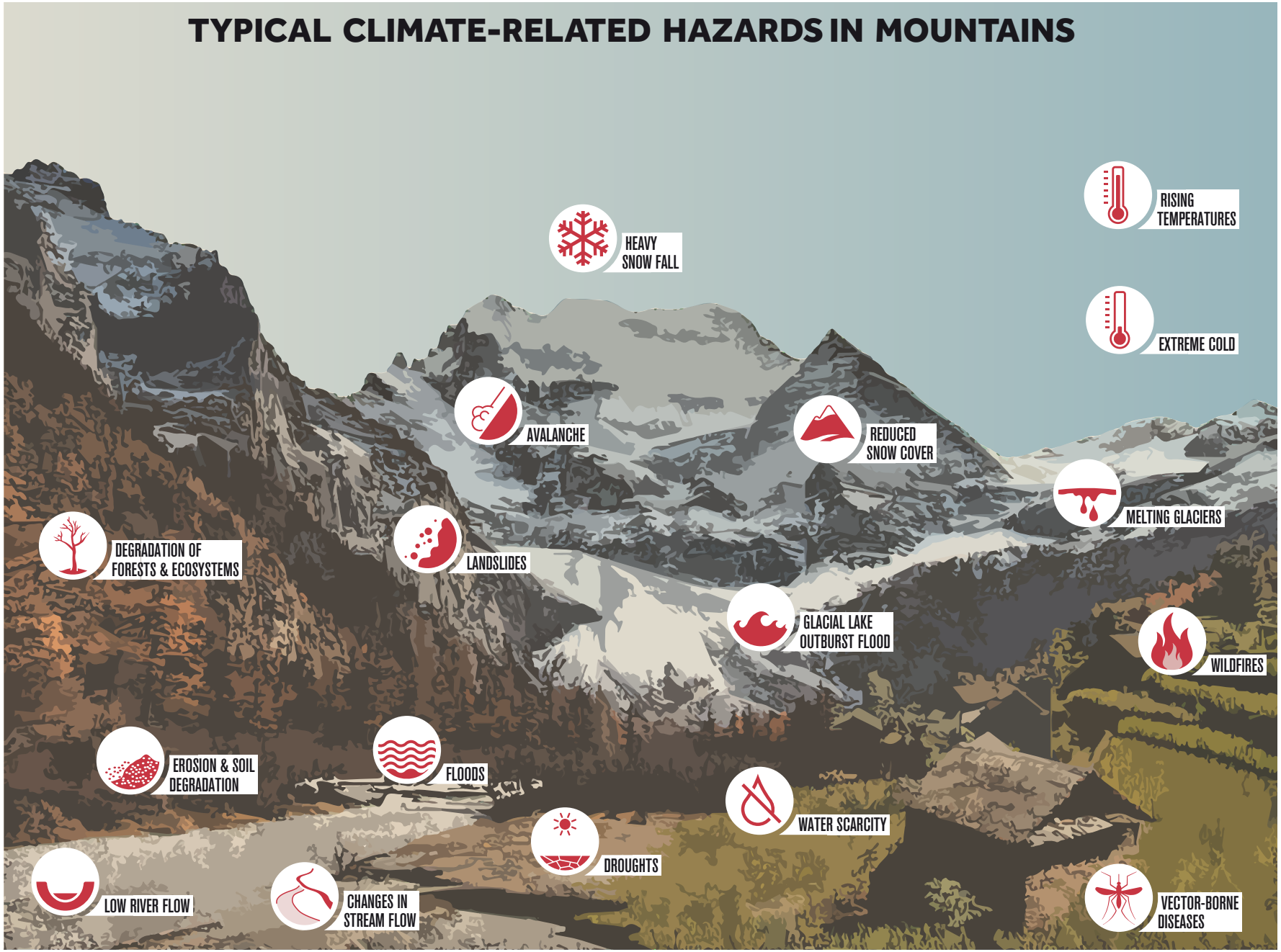
INTERACTION BETWEEN THE PHYSICAL CLIMATE SYSTEM, EXPOSURE AND VULNERABILITY PRODUCES RISK



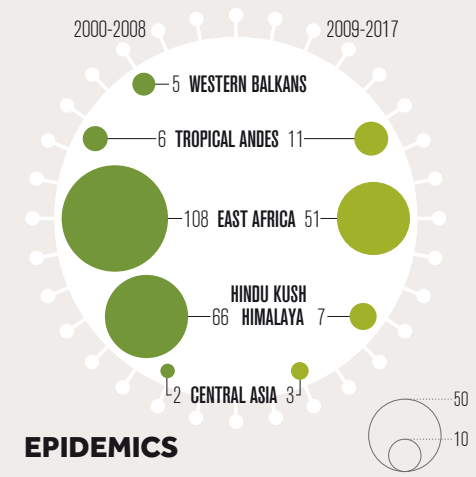
Source: IPCC (2014) *Climate Change 2014: Impacts, Adaptation, and Vulnerability.*

But hazards alone do not cause impacts or risk. As the IPCC states, the "severity of the impacts of extreme and non-extreme weather and climate depends strongly on the level of vulnerability and exposure to these events (Cardona et al. 2012). If no population (or ecosystem) is exposed to a hazard, then an impact or disaster would not occur. Similarly, climate-related disasters or impacts can be avoided if a population or ecosystem is exposed but has sufficient measures in place to avoid any harmful effects (i.e., is not vulnerable). Furthermore, vulnerability and exposure are "dynamic, varying across temporal and spatial scales, and depend strongly on economic, social, geographic, demographic, cultural, institutional, governance and environmental factors".

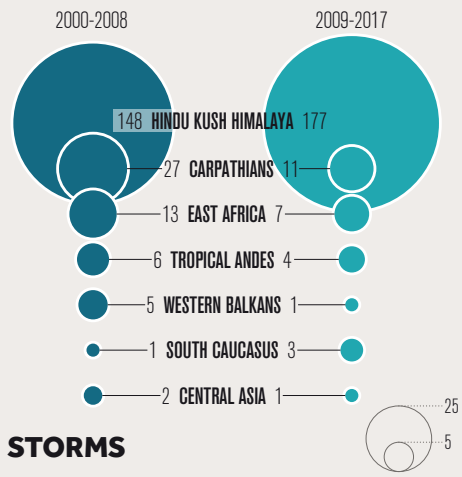
Being geographically dispersed around the world, mountain societies find themselves across different countries and continents, within often starkly varied physical and socio-economic settings. However, there are several commonalities, often termed "mountain specificities", which explain why mountain regions face similar impacts from climate change. As mentioned above, mountains have common physical attributes which result in climate hazards. Socio-economic processes determine vulnerability and exposure. Many mountain regions


TYPICAL CLIMATE-RELATED HAZARDS IN MOUNTAINS
RISING TEMPERATURES
HEAVY SNOW FALL
EXTREME COLD
AVALANCHE
REDUCED SNOW COVER
MELTING GLACIERS
DEGRADATION OF FORESTS & ECOSYSTEMS
LANDSLIDES
GLACIAL LAKE OUTBURST FLOOD
WILDFIRES
EROSION & SOIL DEGRADATION
FLOODS
WATER SCARCITY
DROUGHTS
LOW RIVER FLOW
CHANGES IN STREAM FLOW
VECTOR-BORNE DISEASES

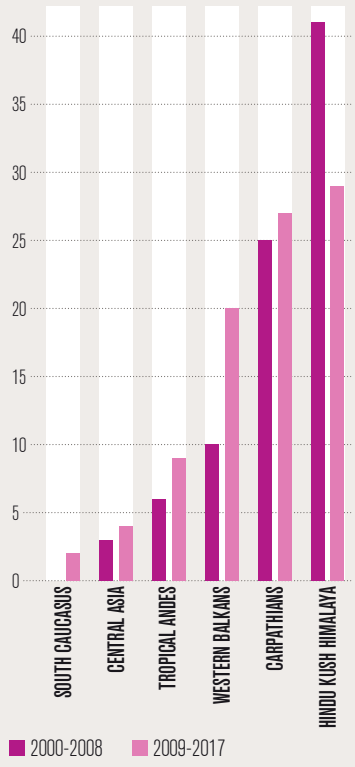
DISASTERS IN MOUNTAIN REGIONS



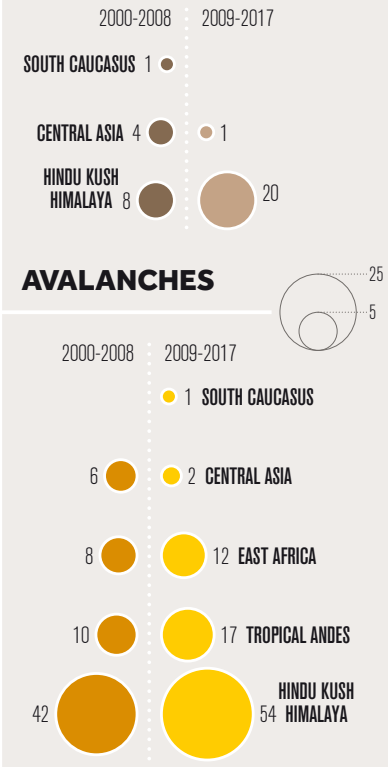
EPIDEMICS



STORMS

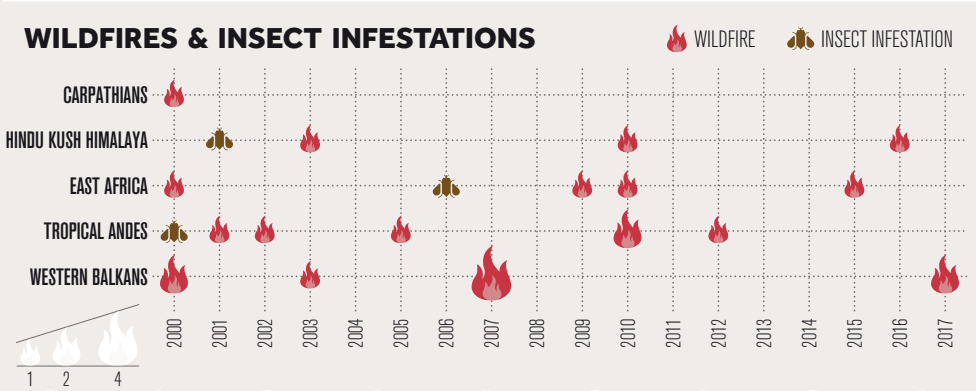


EXTREME TEMPERATURE

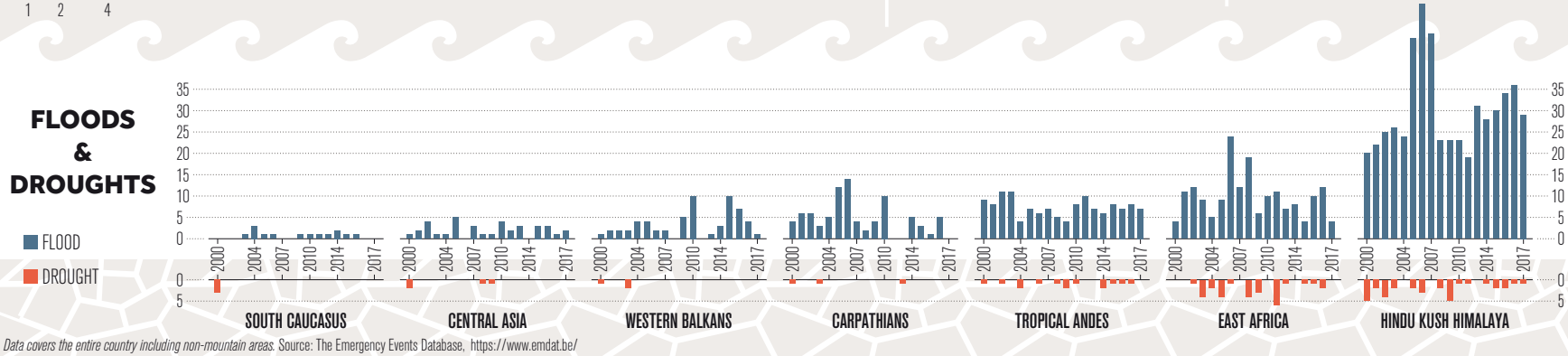


AVALANCHES

LANDSLIDES

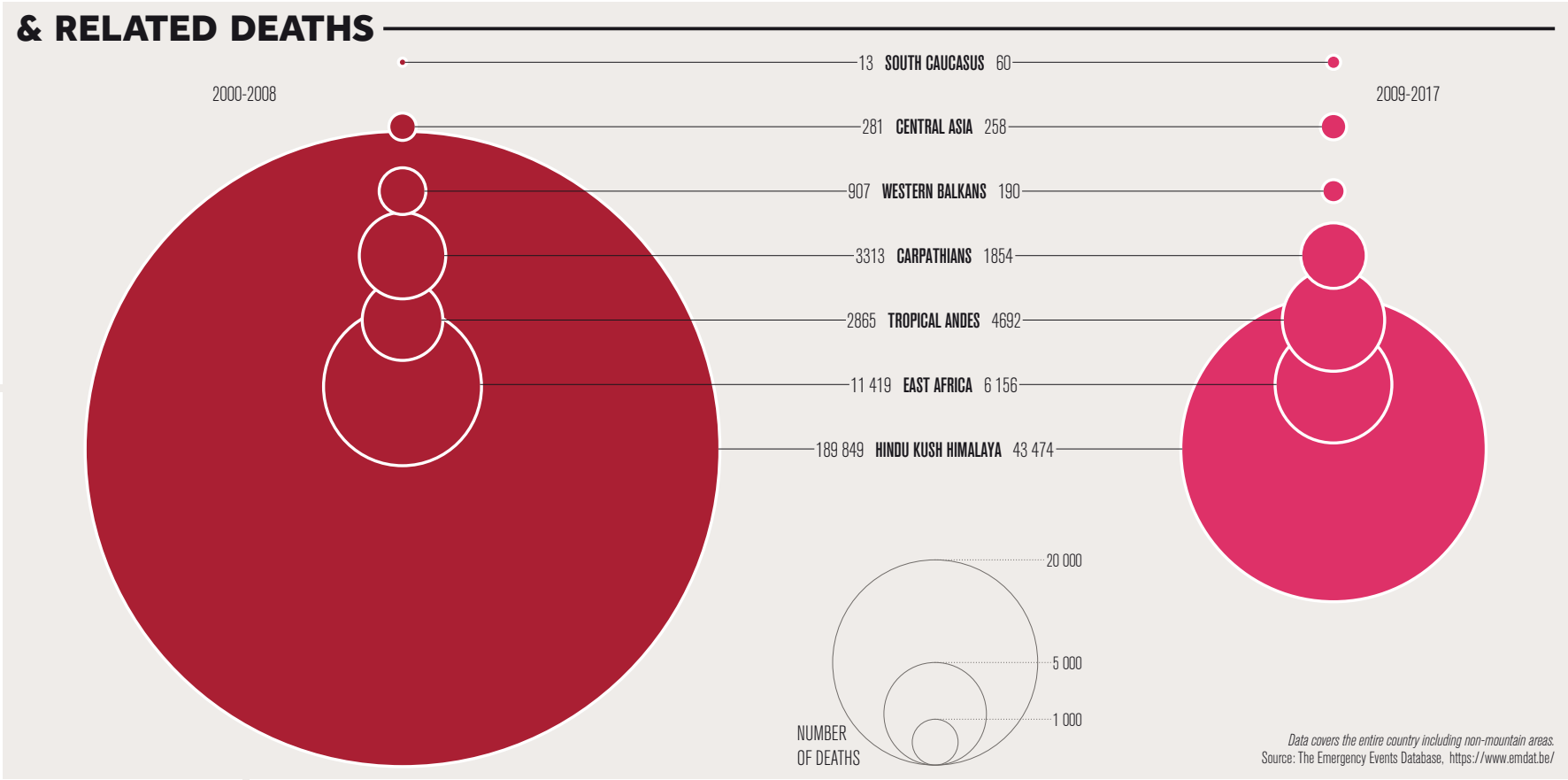


WILDFIRES & INSECT INFESTATIONS



FLOODS & DROUGHTS

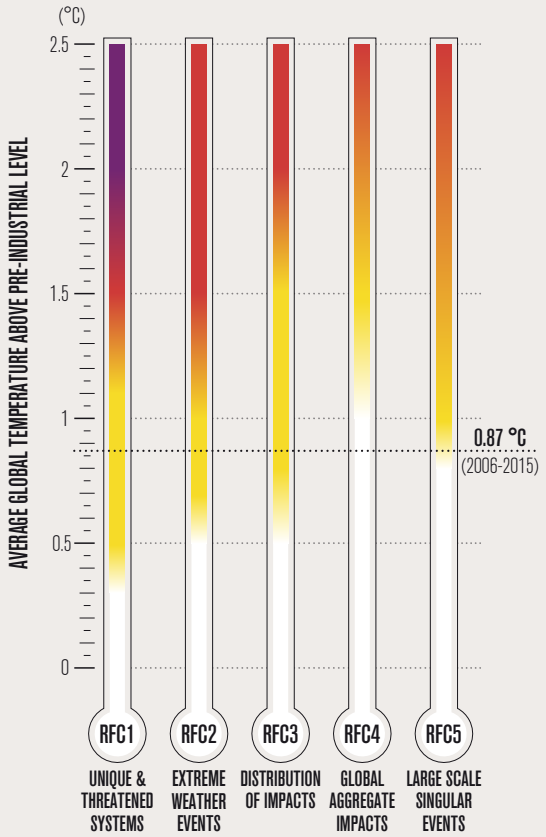
Data covers the entire country including non-mountain areas. Source: The Emergency Events Database, https://www.emdat.be/



Disasters trends over two time periods (2000-2008; 2009-2017) according to the International Disasters Database (EM-DAT). The analysis uses statistics at the national level. The absence of a region by disaster category indicates no events were recorded in the database for the countries of that region, for the time period in question.

are challenged by similar socio-economic factors which contribute to vulnerability and exposure: isolated populations; poor and costly access to markets; poor infrastructure; more widespread poverty and food insecurity; lower education levels; a lack of diversification of livelihoods, including a high dependence on agriculture as the main or only source of livelihood; and marginalization in decision-making. This is not to say that mountain societies do not have adaptive capacities. They have, after all, adapted to an already harsh – and changing - climate over hundreds if not thousands of years. However, the rapid and unprecedented rate of climate change now is challenging this adaptive capacity, as is evident through the already widespread impacts being felt across mountain regions.

RISKS ASSOCIATED WITH THE REASONS FOR CONCERNS (RFCs)



LEVELS OF ADDITIONAL RISK DUE TO CLIMATE CHANGE

- Very high risk of severe impacts and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impact
- Severe and widespread impacts
- Associated impacts are both detectable and attributable to climate change with at least medium confidence
- No associated impacts are detectable and attributable to climate change

Assessment of risks at 2°C, or higher are beyond the scope of the present assessment

Source: IPCC (2018) *Global Warming of 1.5 °C*, http://www.ipcc.ch/report/sr15/

There is already sufficient and growing evidence that the risks of climate change in mountains are being realized. In other words, climate change is not only a risk for the future, but is already leading to real, and often catastrophic, impacts across mountain regions. The evidence also indicates that these impacts are increasing over time. Mountains are also experiencing a disproportionately high number of disasters (compared to other environments) (Kohler & Maselli, 2009). In the face of these impacts, mountain countries and societies need to adapt, and there is an urgency to this task.

As a way of organising and communicating the many risks of climate change, the IPCC has developed a framework which groups global risks into five key Reasons for Concerns (RFCs). RFC1 (Unique and threatened ecosystems) includes mountain ecosystems. As shown in this graphic, a global temperature increase of 1.5°C will lead to severe and widespread impacts on unique and threatened ecosystems; warming of 2°C or more will lead to a very high risk of severe impacts.

MOUNTAIN ADAPTATION SYNTHESIS REPORT

Climate change impacts and policy response

Pamir Mountains, Kyrgyzstan

The Mountain Adaptation Outlooks were all built on the same foundation. First, the current and expected climate change impacts and risks for important sectors were identified. Second, a policy analysis examined the extent to which countries have adaptation policies in place to respond to these impacts and risks. Third, main gaps in existing policies were identified. Both national adaptation policies (when available) and sectoral policies were analysed. As each region has specific priorities for climate change adaptation, the sectors analysed in each regional report varies to some degree. The sectors analysed in each regional report were determined through consultation with regional experts, NGOs working on adaptation in the region and government representatives. This chapter synthesises the main climate impacts on sectors, existing national and sectoral policy responses, and key gaps.

Karakoram range, Pakistan

National Adaptation Policies

National climate change adaptation policies were analysed for all the mountain regions. These policies have been developed or are currently under development for most of the countries. National communication to the UNFCCC also forms an important part of national adaptation efforts on climate change, in addition to conventions such as the United Nations Convention to Combat Desertification (UNCCD), the Convention on Biological Diversity (CBD), along with the implementation of Sustainable Development Goals (SDG) relevant for climate change adaptation. The general trend in national adaptation efforts within the mountain regions, with a few exceptions, is that current policies offer a very limited focus on the importance of climate change adaptation in mountains. Although many of the countries acknowledge the importance of mountains and mountain ecosystems, and that climate change is projected to adversely affect these areas, there is a lack of specific strategies to deal with these issues.

Kilimanjaro, Tanzania

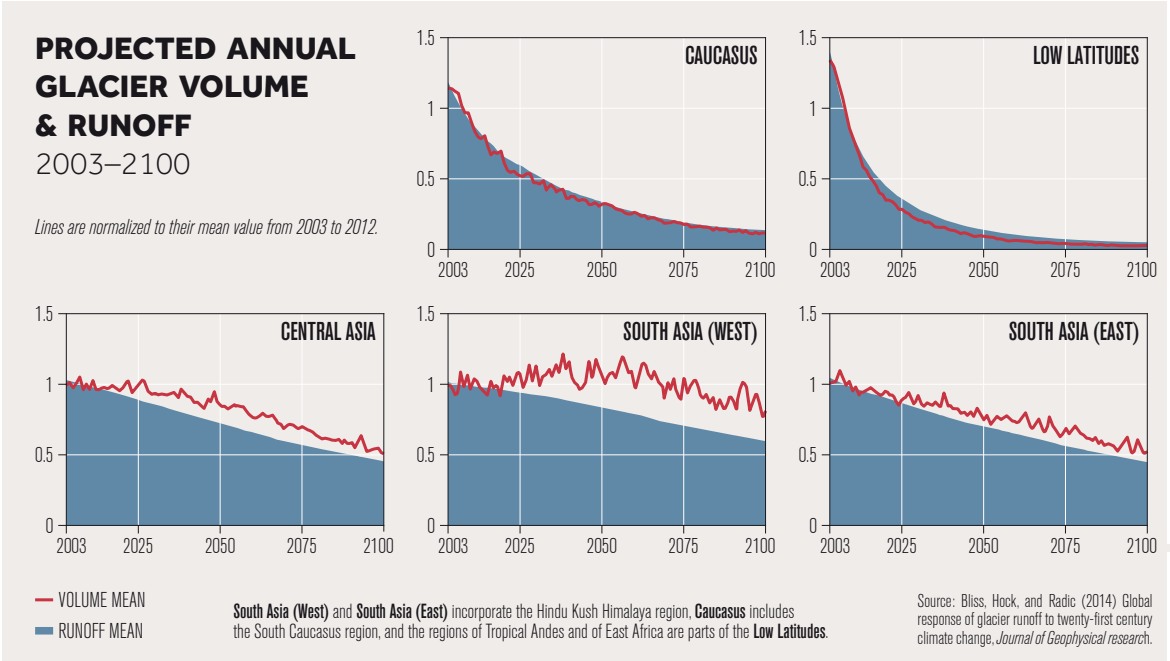
National climate change policies exist or are under development for the majority of the East African countries, and many of the countries have frameworks for environmental protection in place, although these have limited focus on climate change impacts. In the Hindu Kush Himalaya, every country has climate change adaptation policies in place or under development. This is also the case for the Carpathians, where adaptation policies or strategies have been implemented by almost all of the countries. In the South Caucasus, however, there has been limited focus on climate change adaptation in national policies, and the issue has mainly gained attention in the countries through the work of donors. National legislation or policies addressing climate change adaptation are absent, and the countries rely on international mechanisms with the intention of developing National Adaptation Plans (NAPs). The Central Asian countries also rely on international agreements and frameworks for their national climate change adaptation efforts. Although efforts have been made to develop plans and programmes for climate change action, mechanisms and strategies for implementation are still limited or inefficient. In the Andes, there is a growing recognition of the importance of having national climate change policies in place, although the formulation of such policies is still at an early stage. Of the Western Balkan countries, only Kosovo* and Bosnia and Herzegovina have specific national adaptation strategies in place, and Croatia has a policy under preparation, while the remaining countries rely on their national communication to the UNFCCC, or on adaptation efforts within sectoral policies.

* This designation is without prejudice to positions on status, and is in line with UNSCR 1244/99 and the ICJ Opinion on the Kosovo declaration of independence.

Sectors
Water

Climate impacts

Mountains are physical barriers which force air upwards to higher and colder elevation, causing it to condense to form clouds, which then provide rain and snow. For this reason, mountains around the world often receive more water than plains or lowland areas. They serve as natural "water towers", storing water, for example in glaciers and wetlands, and releasing it via rivers and groundwater to dryer lowland areas. Most water in the Western Balkans region, for example, originates in the mountain headwaters. In East Africa, the free-standing volcanoes, massifs and highlands receive significantly more rainfall (in some cases double) than their surrounding regions, and Mount Kenya alone provides water to over 7 million people. In the Andes, the mountains provide water to over 75 million people within the region, and a further 20 million people downstream. In the Hindu Kush Himalaya, the mountains are the source of 10 of Asia's largest rivers and home to 240 million mountain people. In Central Asia, the mountains provide water to almost 90% of the region's population. Seventy per cent of the water resources originate in just two mountain countries: Tajikistan and Kyrgyzstan.



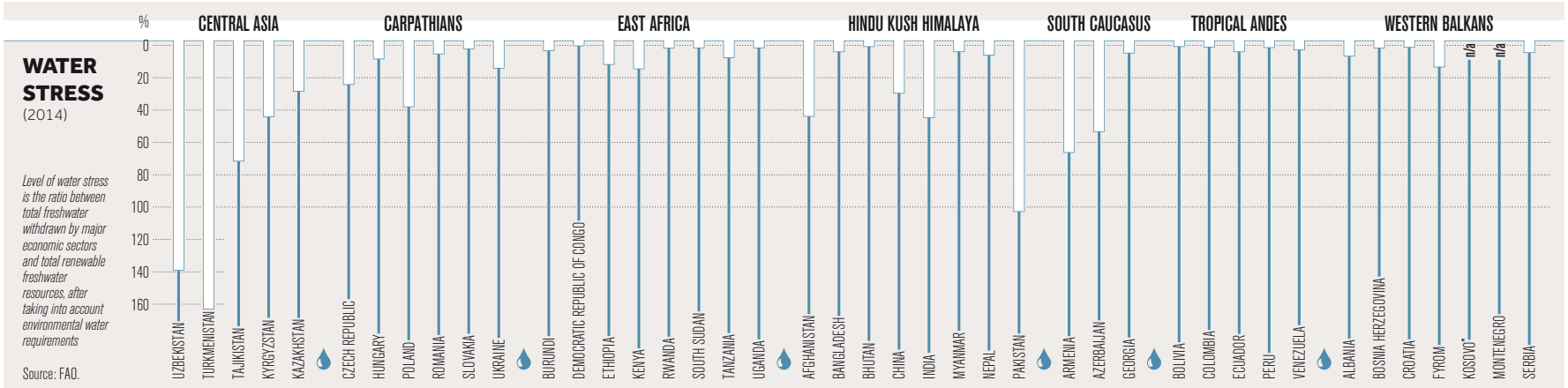
The vast majority of this water is used by the agricultural sector, as well as being essential for hydropower, municipal and freshwater needs, and other industries. The mountains of Central Asia, Caucasus, Tropical Andes, and Hindu Kush Himalaya also contain a significant number of glaciers. Glacial meltwater provides critical water resources to mountain ecosystems and communities and downstream communities and cities (East Africa and the Western Balkans also contain small glaciers). During dry periods in the Andes, for example, an estimated 800,000 people depend on glacial water for 25% of their water needs. In the Hindu Kush Himalaya, which has the greatest number and volume of glaciers outside the polar regions, major rivers receive a significant proportion of their water from glaciers.

The current and projected changes in climate (outlined in the previous chapter) will lead to significant impacts in the availability of water resources over the coming decades in all regions. Climate change will also influence the frequency and severity of water-related hazards, including floods and droughts. In terms of slow-onset events, run-off is expected to decrease in certain regions, although the magnitude of impacts depends

By the end of the century, most regions will see a significant decrease in glacial volume and runoff. In some regions (e.g. low latitudes, Caucasus), glaciers will almost completely disappear. The projected decline in runoff will create significant challenges for communities dependent on this water resource.

on the degree of warming. There will be important local differences too. In the Western Balkans, a two-degree warming could lead to a 15% decrease in river flow, four degrees of warming could lead to a decrease of 45%. In the Carpathians, precipitation decreases in summer are expected to lead to less groundwater infiltration. In the South Caucasus, the projected strong retreat of glaciers in the Greater Caucasus mountains is expected to reduce river flow significantly by 2100 (from 13% to 72% depending on the river). In the lesser Caucasus, where there are no glaciers, higher temperatures and less precipitation will also reduce river flow. Reduced river flow is generally expected to lead to water shortages for agriculture, reduce power output in the hydropower sectors, and have a number of knock-on impacts, including for aquatic ecosystems (including eutrophication) and affecting water quality (e.g., by triggering toxic algal blooms). In Central Asia, significant glacial retreat by mid-century (e.g., up to 83% in Kyrgyzstan) and almost complete disappearance in some places by 2100 will lead to significant reductions in river flow (around 40% by 2100). Despite the projected increase in precipitation over the region, a combination of increasing temperatures, increasing evapotranspiration and increasing water demand is expected to lead to very severe water shortages for the region.

In the Tropical Andes, the expected changes in total annual precipitation are generally low and uncertain. For southern Peru and Bolivia, climate models predict more intense and concentrated rainy seasons and longer dry seasons. Overall, wet areas (Northern Andes) will get wetter, while dry areas (Central Andes) will get dryer. The continued melting of glaciers in the Tropical Andes will create serious risks for certain regions (especially Bolivia and Peru), particularly during the dry season when the meltwater is most needed. Wetlands serve a similar purpose of storing water in the Tropical Andes and are also threatened by climate change. East Africa as a whole is expected to see an increase in precipitation (with the exception of the eastern part of the Ethiopian highlands), and most areas can expect an increase in groundwater recharge by 30 per cent or more by 2050. However, while the total water available may increase, per capita availability may decrease as water demand is projected to grow significantly. The Hindu Kush Himalaya (and Asia as a whole) is expected to see more precipitation. For some of the major rivers of the Hindu Kush Himalaya (Ganges, Brahmaputra, Indus, Mekong, Salween) there is likely to be no significant decrease in run-off until 2050, despite a significant change in the contribution of different water sources (glacial meltwater, snow, rainfall). Glaciers in this region will continue to melt, and eventually contribute less run-off over time.



Lake Titicaca stretches across the border between Bolivia and Peru

While some regions will get dryer and some wetter, all are expected to see an increase in the risk of water-related hazards and related disasters. For those regions with significant number of glaciers (Andes, Hindu Kush Himalaya, Caucasus, Central Asia), the risk of glacial lake outburst floods has been rising over the past few decades and will increase in the future as more, and larger, glacial lakes appear as glaciers continue to melt. Worldwide, the intensity of rainfall is expected to increase, and large amounts of rainfall over short periods of time will increase the risk of flooding and landslides. Certain mountain regions, including the Hindu Kush Himalaya, East Africa, Central Asia, and the Tropical Andes, are already particularly prone to these events which cause widespread damage to property and loss of human life. Warmer temperatures and higher precipitation may also contribute to an increase in wet-snow avalanches, such as has been shown in the Hindu Kush Himalaya. A combination of dryer conditions, which will harden soils, combined with periods of intense rainfall, will also increase the risk of flash floods, which is likely to be the case for example in the Western Balkans and the Carpathians. Finally, dryer conditions, particularly in summer, will increase the risk of wildfires. Wildfires are a particular risk for the Western Balkans, but for other regions as well.

Policy response and gaps

The East Africa Outlook differed from the other outlooks as the analysis largely focused on mountain policies and governance, and no specific sectoral policy analysis was done. The outlook give examples of watershed management in mountains for agricultural use, and highlighted Rwanda's strategy to address climate change impacts on water resources. The Mau Forest's status in Kenya as a water tower for the country has resulted in specific strategies for water conservation, and similar practises have been promoted for Mount Elgon in Uganda and Kenya, and Mount Kilimanjaro in Tanzania.

The water sector in the EU member countries of the Carpathians is regulated by the EU Water Framework and the Flood Risk Directives. These support policies at the national level which are predominantly concerned with infrastructural development and warning systems. Serbia and Ukraine, as non-EU countries, depend on national policies, but are also partners in the Drought Management Centre for Southeastern Europe, together with Hungary. The analysis provided in the Carpathian Outlook does not mention climate change adaptation specifically. The policies for the water sector in the Western Balkans are overall quite similar, and have no direct reference to climate change or adaptation in mountains. The policies do however deal with natural disasters such as floods. Two agreements, the Framework Agreement on the Sava River Basin (FASRB) and the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, are guiding mechanisms for regional cooperation on water management, and under the Barcelona

Convention, specific goals on climate change and natural disasters have been included. In the South Caucasus, a number of policies and legislation regulate the management of the water sector, although neither Georgia nor Azerbaijan consider climate change adaptation in their legal framework for water management. However, Armenia's legal framework for river management does. A pilot project on water management in the region led by the EU and USAID has, however, addressed climate change adaptation. All the Andean countries have included climate change adaptation goals, targets and implementation tools in relevant polices for the water sector, with the policies predominantly guided by the Integrated Water Resources Management Approach (IWRM). There is however a need for the Andean countries to invest resources in disaster risk reduction measures, such as early warning systems. The policies do not consider specific strategies for adaptation in mountains, and existing mechanisms are biased towards urban areas. In the Hindu Kush Himalaya, all the countries have relevant water acts and policies in place, most of which are focused on management and development, with an operational level of river basin or watershed. Policies for the water sector do acknowledge the need for climate change adaptation, and related hazards such as droughts, floods and flash floods. However, strategies addressing floods are mostly centred around urban areas with a focus on disaster response with little attention to mitigation. There is no reference in existing policies to water management in mountain areas with respect to climate change, and mountain-relevant hazards are not adequately addressed by the policies. All the Central Asian countries recognise the importance of, and have priorities for sustainable water management, with a number of policies addressing the sector. The countries also recognised that the water sector will be adversely affected by climate change. However, long-term strategies, including for climate change adaptation, is limited or still under development. Of the countries, Kyrgyzstan is the only one to have a specific adaptation program for the sector, the Program and Action Plan for Adaptation of Agriculture and Water Resources to Climate Change for 2016–2020.


Girdimanchay river near Lahij, Azerbaijan

Key Recommendations

- As water is a highly transboundary issue, regional cooperation should be a priority in mountain regions with an emphasis on hydrological data sharing (including groundwater aquifers) and the development of flood early-warning/ forecasting systems.

- Given that water availability is expected to become more unpredictable, innovative water management and storage solutions should be explored, particularly in areas prone to drought. Furthermore, solutions should be designed to capitalise on times of plentiful / "too much" water. In parallel, improvements in water efficiency are needed given that water demand is likely to further increase.

Agriculture and food

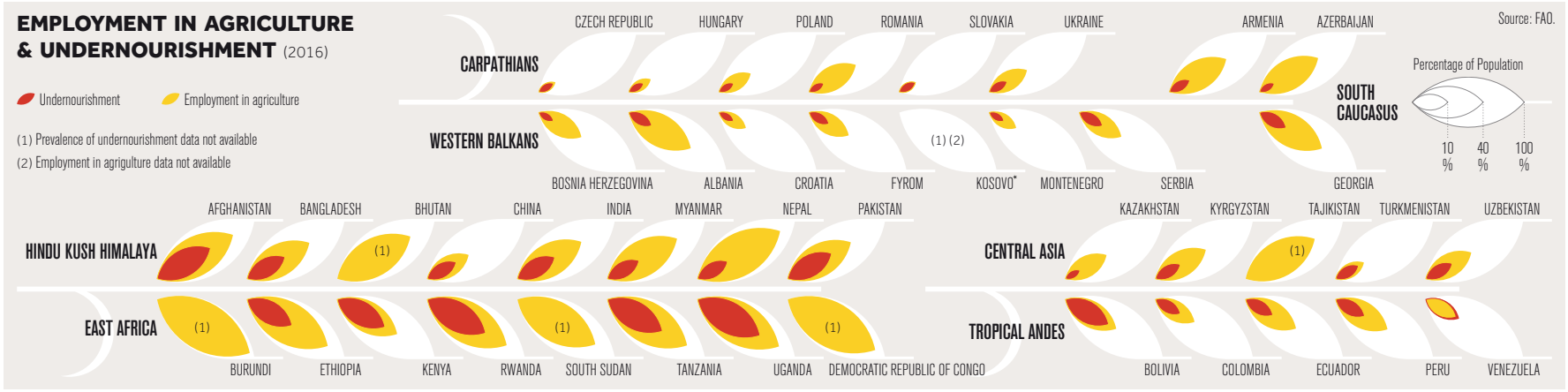
Climate impacts

Agriculture is a vital part of the economy in all mountain regions. In the Hindu Kush Himalaya and across the mountain slopes and highlands of East Africa, the vast majority of the rural population live off subsistence farming. In the Tropical Andes, Carpathians, Western Balkans, South Caucasus and Central Asia, agriculture remains the economic and development driver, employing a significant share of the population (despite the growing importance of industry and service sectors). In general, mountain agriculture is characterised by smaller and more fragmented plots of land compared to lowland agriculture, making cultivation time-consuming and labour intensive. For example, within the Hindu Kush Himalaya, households typically own less than one hectare of land. Similarly, in East Africa the high population densities translate into small land holdings. Pastoralism is more predominant in high mountain areas.

Worldwide, the agricultural sector is considered to be highly vulnerable to climate change because it is directly dependent on the climate and weather patterns. This is especially true for agriculture in mountains, which is mostly rain-fed with little storage or irrigation capacity. This makes mountain agriculture vulnerable to changes in precipitation. Changes in temperature, the length of the growing season, the timing of extreme or critical threshold events and atmospheric CO_2 concentrations can also have a significant impact, especially in areas that have traditionally supported a small selection of agricultural options (e.g., a single crop grown in the same location for centuries, or selective livestock). Changing climatic conditions may not only affect what can be sustainably grown, but may also facilitate the spread of pests.

Climate change may bring both positive and negative changes to mountain agriculture, but analysis suggests that there will generally be more losers than winners. The possible positive changes include increasing temperatures, reduced frost, and longer growing seasons at higher altitudes, which will allow the introduction of a wider variety of crops and potentially increased yields of some crops. Increasing temperatures are already having an impact on crop yield in mountain areas. For example, in Peru, the altitude at which maize can be cultivated has increased between 200–300 metres over the past two decades. Wheat yields at higher altitudes in the Western Balkans and South Caucasus and maize yields across the East African highlands and parts of Central Asia are expected to increase.

Changes in precipitation will also have variable impacts, depending on the region. In the Western Balkans, which is expected to become drier, the increasing occurrence of droughts is expected to bring lower harvestable yields, higher yield variability, and a reduction in the area suitable for growing traditional crops. In the Carpathians, reduced water availability, especially in spring and summer, and the increased



risk of droughts, as well as extreme weather events is projected to decrease yields and reduce areas suitable for cultivation. In the South Caucasus, there is a lot of variation between and within countries and between different seasons which makes it difficult to generalise trends for the entire region. However, most of the region is likely to be negatively affected by higher temperatures and evaporation and reduced river runoff (particularly in summer), and increased frequency and severity of extreme natural disasters. In contrast, agriculture in the mountainous areas of East Africa may experience an overall benefit from the projected warmer temperatures and increased precipitation. However, negative effects may also be felt, due to increased exposure of livestock and crops to diseases and pests. Increased evapotranspiration may also counteract gains in precipitation. In the Hindu Kush Himalaya, food production throughout the region is generally expected to be negatively affected, due to changes in the timing and duration of monsoons, higher rainfall variability, and increased extreme events, including floods and droughts. In parts of Central Asia, higher temperatures, including summer heat waves and droughts are expected to decrease yields of certain crops significantly (e.g., 20-57% decrease in Uzbekistan in a 2°C warmer world). This situation will be aggravated by decreasing river flow due to the decrease and/or eventual disappearance of glaciers, and the shift in melting to the end of the winter, instead of during spring/summer. Both factors are expected to significantly decrease water resources for irrigation.

The capacity of farmers to adapt to these changes will determine the severity of the impacts. Generally speaking, capacity across all mountain regions is challenged by limited financial resources which restrict the use of new technologies, the abandonment of traditional best practices due to a shift to market crops, inadequate support from and access to agricultural extension services, and poor access to weather and climate information. As a result of outmigration of the male population in certain mountain regions, such as the Tropical Andes and the Hindu Kush Himalaya, the responsibility for agriculture often lies in the hands of women, who often have fewer options for adaptation (including reduced access to finances and land, and a lack of decision-making power).

Tisza valley, Ukraine

Policy responses and gaps

The responsiveness of policy makers to climate change adaptation for agriculture and food vary across the regions, and there are great differences in how well the issue is addressed.

The East Africa Outlook makes it clear that there is growing momentum for the implementation of policies that promote climate-smart agriculture. All countries in the South Caucasus consider climate change adaptation vital for the continued health of the agricultural sector. Armenia specifically considers climate change impacts in high mountain regions, and aims to implement measures to protect pastures and highlands. Their policies also consider climate change as a threat to sustainable development of agriculture. Azerbaijan considers climate change a potential factor in food insecurity. The government is also concerned with the vulnerability of mountainous areas to erosion and foresees that land reclamation activities will be necessary. All the South Caucasus countries are parties to the United Nations Convention to Combat Desertification (UNCCD), and recognise that climate change is a contributing factor to desertification and land degradation in the region.

Although sustainable land management is promoted in policies for land use across the Western Balkans, agricultural legislation has not yet integrated climate change adaptation concerns and does not specifically address mountains. An exception to this is the Law on Agriculture in Croatia, which promotes agriculture that responds and adapts to climate change impacts. In the Carpathians, all the countries consider the need for sustainable agriculture in their climate change adaptation strategies, and Poland, Romania, Hungary and the Czech Republic have all considered technical adaptation measures in their policy development. In Central Asia, most of the countries have policies in place that recognise that climate change can potentially have adverse impacts on the agricultural sector. However, low levels of support from governments, the private sector and donors is hampering the development and implementation of adaptation measures and current strategies are limited. Furthermore, traditional knowledge is not integrated into adaptation practices and the level of awareness of farmers on the impacts of climate change remains low. As of now, Kazakhstan, Kyrgyzstan and Tajikistan have set out priorities for climate change adaptation, and Kazakhstan has started implementing some adaptation measures in the sector.

Food and agriculture policies exist for the Hindu Kush Himalaya, however none explicitly focus on climate change adaptation measures. Only Afghanistan has a strategy to address ecosystem degradation for the sector. Afghanistan, Bangladesh and Pakistan have strategies to address droughts. Bangladesh and Pakistan also have a strategy to address floods. Policies on food and agriculture in the Tropical Andes are limited in their consideration of climate change, and only Colombia has specific adaptation targets and implementation tools in place. Peru's Ministry of Agriculture and Irrigation has a plan for risk management and adaptation in place to assess climate change impacts. This is, however, not effectively linked to the existing sectoral policies. Overall, there is a lack of both policies targeting climate change impacts on agriculture in mountains and knowledge of the potential impacts of climate change in these communities. The land policies in the region do consider goals and targets for climate change adaptation, however only Colombia and Bolivia have implementation tools in place to achieve these.

Key Recommendations

- Promote climate-smart agriculture including improved water management and irrigation systems, agrobiodiversity and the use of resilient crop varieties. Best practises should be shared at all levels including between regions, as many mountain areas face similar challenges.

- Enhance the understanding of climate change impacts and associated risks on mountain agriculture and food security, which can inform the development of appropriate policies and risk-sharing and risk-transfer mechanisms (e.g. weather-indexed insurance).

Forest, ecosystems and biodiversity

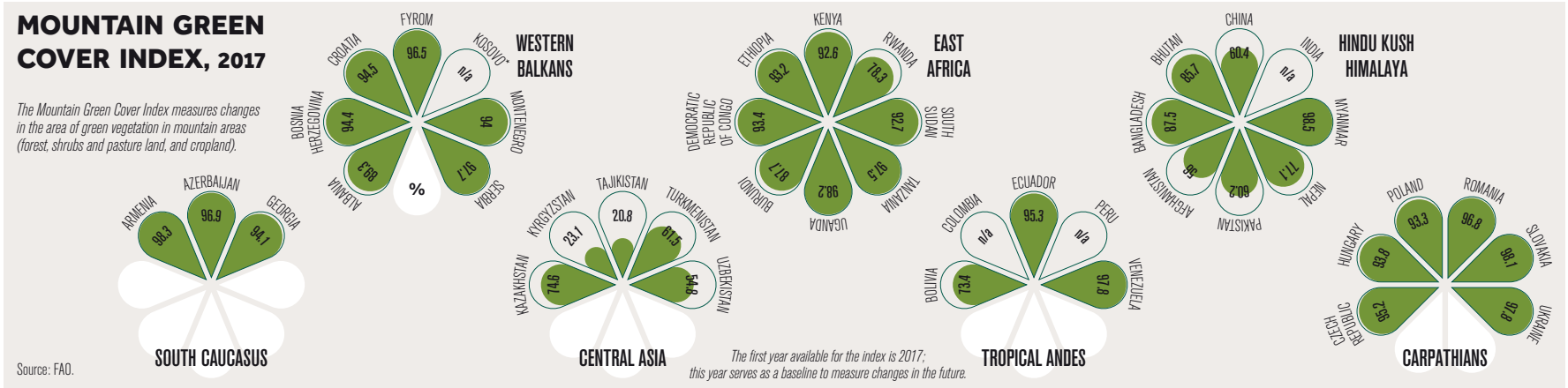
Climate impacts

Mountain regions host a significant proportion of the world's biodiversity and many are part of global biodiversity hotspots or important reserves for endemic species and ecosystems. For example, over 10,000 species are found in the Eastern Afromontane biodiversity hotspot (in the mountains of East Africa) and around one-third of them are endemic. The Carpathians host Europe's largest populations of large carnivores such as wolves. In the Tropical Andes, algae and aquatic plant diversity is highest above 3,000 m. The Hindu Kush Himalaya has 488 areas under varying degrees of protection, covering 39% of the region.

Mountain environments also offer several ecosystem services to local people, both in the highlands and lowlands. These include cycling of nutrients, water and greenhouse gases, disease regulation, living and non-living resources, medicines and protection from soil degradation, landslides and floods. Wetlands, such as Andean páramos, are one of the most important ecosystem service providers in the highlands because of their role in the hydrological cycle and the storage of carbon. However, in conjunction with stress from climate change, mountain ecosystems also face land-use changes, invasive species, poaching and pollution.

Climate change has severe impacts on biodiversity and ecosystems in the mountains as a result of rising temperatures and changes in precipitation. The survival of species and ecosystems depend on their ability to migrate or adapt to changes. The response to warming temperatures usually involves moving towards higher altitudes or to colder climates when possible. Generally, the temperature is rising faster in altitudes above 1,500m and often there is nowhere to migrate. Migration can require crossing even warmer valleys or over unsurmountable peaks. Some ecosystems, such as cloud forests in the Tropical Andes, have been unable to move to new areas, which makes them and associated species especially vulnerable.

Forestry plays a significant role in the economy and local livelihoods in timbered mountain areas. Tree growth is affected by rising atmospheric CO2 concentrations and temperatures, changes in precipitation, flooding and droughts. In addition to the growth of forest industries, forests face pressure from agriculture and infrastructure development, illegal logging, invasive species, pests and drought. Wildfires are also likely to increase in intensity and number as a result of rising temperatures and prolonged droughts. Many wildfires are caused by humans, either unintentionally or on purpose, as they have been traditionally used for land clearing and hunting. As forests take up carbon from the atmosphere, their role in climate change mitigation may also conflict with forestry livelihoods and adaptation measures.



Effects of climate change on forestry, land use and biodiversity in the mountains are already being observed. Treelines have shifted to higher altitudes in parts of the Hindu Kush Himalaya. In Nepal's Upper Mustang, the shifting treeline has caused conflicts between humans and wildlife as blue sheep and snow leopards are both being pushed to lower elevations in the search of food. In the Carpathian High Tatra Mountains, the Eurasian spruce bark beetle has caused mortality of Norway spruce (*Picea abies*) forests in recent decades. Over the past 25 years, the desertification zone has moved 500 metres upwards in the mountains of Kyrgyzstan. Forest fires have been increasing on Mount Kilimanjaro in East Africa. Some mountain areas have also experienced positive changes. Afforestation of abandoned agricultural land is occurring in the Western Balkans, resulting in improved water quality as a result of infiltration and decreased run-off.

In the future, impacts of climate change and human activities are likely to escalate. In the Tropical Andes, the area of páramos is predicted to decrease in area by 31 per cent by 2050 (even without factoring in destruction as a result of land-use change). In South Caucasus, climate change will likely threaten over 200 plant species, while at the same time expanding the habitat of 140 species. With the predicted rate of warming in the Andes, to maintain forest area, they would need to migrate more than 9 metres up slope every year to stay in their preferred climatic range. The treeline is also shifting in the north-western Himalayas and it is likely that by 2035 areas covered by ice, rocks and polar desert will be taken over by boreal forest, tundra and shrubland.

Policy response and gaps

Existing forest legislation in the Carpathians does not specifically address climate change adaptation. However, it has been argued that adaptation measures are achieved indirectly through several initiatives, for example through activities that support sustainable forest management and the preservation of ecosystems and biodiversity. The biodiversity within Carpathian forests is considered highly valuable and national adaptation measures are in place to monitor, restore and protect species and habitats especially sensitive to climate change. The EU member countries also take part in the LIFE+ project FUTMON, which provides data on forest ecosystems and climate change. In the Western Balkans, the number of protected areas has increased over the last decade. The forest policies in the region cover many adaptation and mitigation activities through the promotion of sustainable forest management, although the policies have not been developed with climate change in mind. Forest and conservation policy documents in the Hindu Kush Himalaya are generally concerned with sustainable forest management, complementing a number of global programs and regulations such as REDD+, the Convention on Biological Diversity (CBD), and regional cooperation for the management of protected areas. The policies however, do not adequately address climate change adaptation for the sector. Forest fires have been identified as an emerging concern for the region, and responding to this threat will require more comprehensive policies. In the Tropical Andes, climate change impacts on biodiversity and ecosystems have not been included in relevant policies, but Ecosystem-based Adaptation (EbA) is included in Peru's NDC's. Only Colombia has addressed climate change adaptation goals, targets and developed implementation tools for the forest sector. Overall, the Andean policies do not sufficiently cover the importance of ecosystem services for human livelihoods, which are highly relevant for mountain communities.

Forest in the mountains of Tien Shan, Kazakhstan

The Ecoregional Conservation Plan adopted by the South Caucasus countries considers climate change as a contributing factor in biodiversity loss. The plan also highlights the importance of mountain forests in the prevention of erosion and the regulation of water flow. However, only Georgia considers climate change issues in its existing policies on biodiversity, but all the countries do consider the issue in their communication to the Convention on Biodiversity. The National Forest Programmes of Armenia and Azerbaijan, and the National Forest Concept of Georgia all consider climate change, but more evidence-based research is needed to get a comprehensive understanding of the vulnerability of forest ecosystems to climate change in the region.

All the Central Asian countries have adopted policies or laws on the protection of biodiversity and forest ecosystems, but adaptation to climate change is not considered a priority in the sector. However, Turkmenistan and Kyrgyzstan do mention climate change adaptation for biodiversity in their national climate change plans, and existing sectoral policies include measures that potentially contribute to climate change adaptation, like reforestation and the expansion of protected areas. A big challenge in the region is the limited or weak capacity of governmental institutions governing the sector, making climate change adaptation a low priority.

For the East Africa outlook, some examples of good practises are available, although no forestry-specific analysis was undertaken. Burundi, Kenya and Uganda all promote reforestation, and Uganda, through its Forests Absorbing Carbon Emissions project, has restored 6000 ha of forest. Within several districts of Uganda, the government together with the United Nations Development Programme (UNDP) and UN Environment have promoted the Territorial Approach to Climate Change, which encourages climate resilient practices and knowledge generation for informed policy development.

Key Recommendations

- Projected species range and vegetation shifts, possible increases in human-wildlife conflict and other climate-related impacts call for adaptive management of national and regional protected area networks.

- Mainstream climate change adaptation into forestry practises and policies, including the establishment of mechanisms for monitoring climate impacts (e.g. fire detection, soil degradation).

- Promote ecosystem-based adaptation, which includes a range of low-cost options that promote sustainable management of natural resources while planning for and adapting to changing climate conditions.

Infrastructure and energy

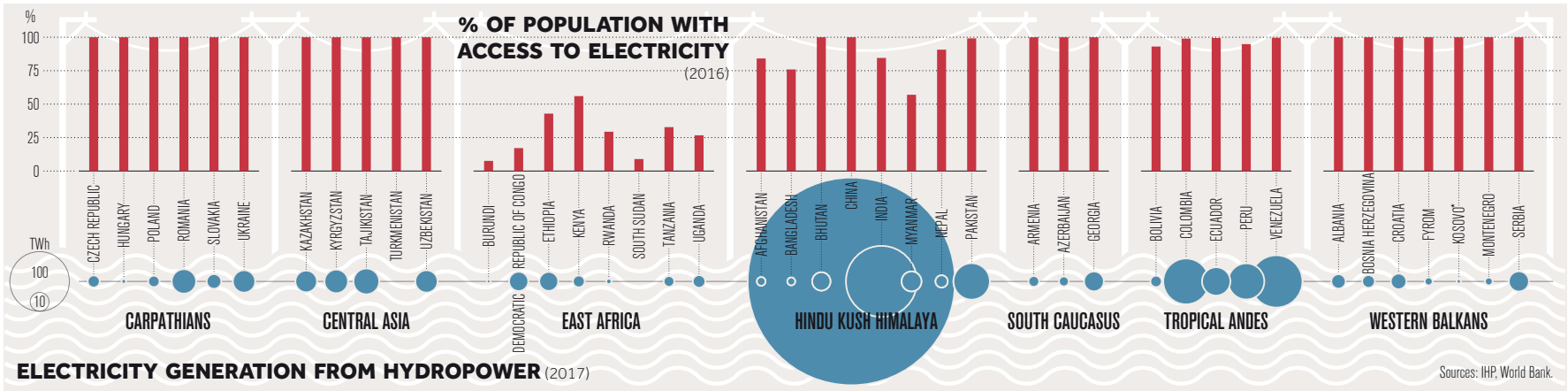
Climate impacts

Despite the remoteness and high construction costs in mountain areas, there is increasing infrastructural development. This includes buildings, roads, rail networks, water pipelines, electrical grids, communication systems and other infrastructure needed for society to function. Much of this infrastructure is located within urban areas and settlements. Mountains also host industry, including extractive industries (mining) as well as renewable energy (mostly hydropower, but also wind and solar). In general, climate change is expected to increase the risk of infrastructure damage or failure in mountain areas. Much of this infrastructure is ageing and poorly maintained. It has also been designed for historical weather patterns, while it will be exposed to more frequent and/or severe climate-related hazards.

Hydropower has significant potential in mountain regions due to the general abundance of water from rivers and glacier meltwater and large altitudinal differences. However, the sector is also vulnerable to changes in precipitation, the provision of water from ecosystems, evaporation, glacial melting, river flow and extreme events. In general, all mountain regions have the potential to further develop their hydropower resources, particularly East Africa and Hindu Kush Himalaya which have large untapped potential. In general, locations that are expected to receive increased precipitation and river flow will see an increase in production; areas with reduced river flow and/or reduced precipitation are expected to see a decrease in production. For example, a study from Croatia predicts a decrease up to 15–35 per cent in a 4°C world, while in the Tropical Andes, north-western Peru, Ecuador and Colombia may see an increase in precipitation, which can increase their hydropower production potential. Many facilities are at risk of damage from flooding, including Glacial Lake Outburst Floods (GLOFs). For example, in India, Bhutan and Nepal, 66 per cent of the 257 hydropower plants surveyed are currently at risk from a GLOF.

Mining is an important part of the economy and a driver for development in many mountain countries. However, mining activities are often harmful to the environment and compete for water with other sectors such as agriculture. Toxic mining waste is often stored in tailing ponds and dams and may collapse and cause severe pollution to downstream areas. The risk is increased if the tailing dams are poorly constructed, not maintained, or exposed to climate hazards such as flooding. In the Western Balkans and South Caucasus, abandoned mining sites are a significant concern and some pose transboundary risks, while in the Tropical Andes, large-scale open pit mining threatens local water resources and livelihoods. Climate change-induced extreme events also threaten industrial plants, and oil and gas pipelines crossing mountainous terrain.

Urbanisation trends vary across the regions. In the Carpathians, the urbanisation rate is relatively low. In



contrast, urban areas within the Hindu Kush Himalaya are expanding rapidly as a result of population growth and migration from rural areas. Rapid and poorly-planned urbanisation can lead to informal settlements and slums that are often located on areas prone to natural disasters, such as on flood plains or steep slopes. In the Tropical Andes, all countries have a high rate of population growth and urbanisation, which increases the pressure on ecosystem services and natural resources. The slums in the region are often found along the steepest slopes. Besides their poor quality construction, the lack of legal ownership limits the residents' resiliency and capacity to cope with natural hazards such as landslides.

Heavy snow and cold extremes have often caused problems to high-altitude settlements with poor access and infrastructure regions. In the future, warming temperatures are likely to reduce the costs of infrastructure maintenance related to cold extremes. However, in high altitude areas where permafrost is present, such as on the Tibetan Plateau, warming temperatures will lead to melting permafrost which can damage infrastructure.

Policy response and gaps

Infrastructure development in mountain regions is growing in importance, such as for the expansion of hydropower plants and for tourism. Projected climate change impacts on the sector will challenge this development, which calls for policies that are forward looking and responsive. The analysis shows that potential hazards for mountain regions are not adequately addressed. No energy or infrastructure policies were analysed for the Carpathian or the East Africa Outlook.

Infrastructure policies in the Western Balkans have little or no mention of climate change adaptation strategies, although existing legal documents for infrastructure development state that climate change should be considered. For the energy sector, a general trend in the region is the promotion of a transition to zero-carbon energy sources. Efforts to address climate change in the sector are highly linked to mitigation efforts, and the policies mainly reflect this aspect of action on climate change. None of the policies address adaptation targets in general or for mountain areas in particular. In the Hindu Kush Himalaya, mountain-relevant hazards are not well covered in existing policies. The policies mainly focus on transportation and increased accessibility, but there is a need for greater consideration of projected climate change impacts and related mountain-relevant hazards. At this time, Nepal, China and Afghanistan have specific strategies to address both landslides and floods, and Bangladesh has a specific strategy to address floods. For the energy sector, Nepal and Myanmar have acknowledged a majority of the identified mountain relevant hazards in their policies, but this is not addressed by the remaining countries of the Hindu Kush Himalaya. The existing energy policies in the region are mainly concerned with effective production and a transition towards low or zero greenhouse gas-emitting energy sources, although specific policies for renewable energy are lacking in several of the countries.

In the Tropical Andes, hydropower is the main source of energy, with the production primarily taking place in the mountains. All the countries have climate change adaptation strategies, however they offer different approaches to address the issue. Despite existing policies, there is still a gap in understanding the potential impact climate change might have on water availability, and the vulnerability of the hydropower sector to these changes. The renewable energy policies in Central Asia are mainly focused on energy saving systems, energy efficiency, and the introduction of renewable energy systems. The policies also focus on increased energy efficiency for infrastructural work in remote and sparsely populated areas. All the countries have signed the International Energy Charter and agreed to act in compliance with environmental standards. However, specific climate change adaptation measures are limited. None of the South Caucasus countries consider climate change adaptation for the energy sector, but some policies do consider climate change mitigation activities. There is little knowledge generated on the potential impact of climate change and the vulnerability on the sector. It is not considered a priority among policymakers, and limited adaptation action has been implemented thus far.

Key Recommendation:

- With a projected increase in the development of hydropower production in many mountain regions, it is essential that policies, plans and development projects consider changing hydrological regimes, extreme climate events, and possible ecological impacts.

- Infrastructure development across mountain regions should consider the projected impacts of climate change, for example by integrating vulnerability assessments into land-use planning and the timely sharing of information on potential risk zones.

Human health

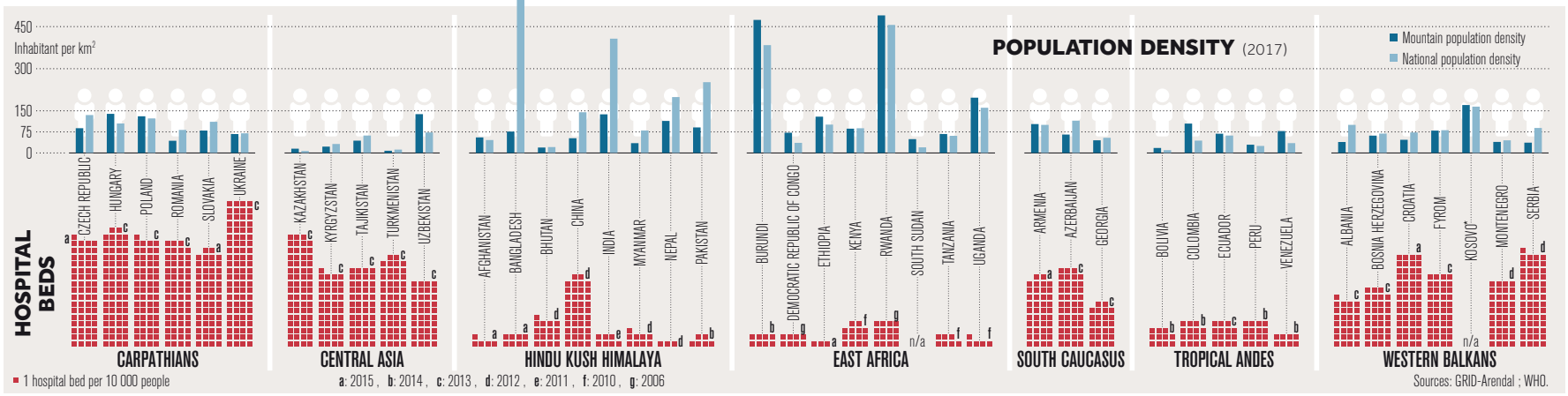
Climate impacts

Climate change affects human health in a number of ways. The direct impacts include extreme weather such as flooding and droughts, which can cause displacement, injury or fatalities. The indirect impacts include altering ecosystems, including temperature, precipitation and humidity, which can facilitate the spread of vector-borne diseases. These changes may lower crop yields, affecting nutritional and food security. Climate change may also be a contributing factor in hazards that are strongly determined by human systems. Examples include occupational health hazards such as heat exhaustion and heat stroke from working extended periods outside.

A lack of economic resources, underdeveloped waste management and other socioeconomic problems prevalent in mountain communities aggravate the negative impacts of climate change on human health. For example, poorer people in the HKH are less likely to afford professional health services, which undermines their resilience to climate shocks and their ability to adapt. In addition to populations living below the poverty line, particularly vulnerable groups across the mountain regions are women, elderly people and those working in hazardous jobs or with low safety standards. Women generally tend to have fewer financial resources than men, resulting in a reduced ability to cope with the impacts of climate change. This is even more prevalent in the mountains. In many regions, the main responsibility for maintaining households lies with women when men migrate to cities or abroad for employment. While the women have an active role in the community, they often have less influence on local decision-making processes which can limit their ability to make important investments and decisions to manage the risks associated with climate change.

In the HKH countries, an average of 76 disasters occurred annually between 1990 and 2012, about one-third of them being related to flooding. Between 2000–2013, flooding killed over 10,000 people and displaced over 50 million in the region, affecting far more people than extreme heat and droughts. In the South Caucasus, natural disasters have forced tens of thousands of people to leave their homes temporarily or permanently since the first recognised case of environmental migrants in Georgia in the 1980s. Reoccurring natural disasters can also contribute to a higher prevalence of mental disorders. In the natural disaster-prone area of Adjara, Georgia, the percentage of people with mental disorders is 13 per cent higher than the national average among all people, and 58 per cent higher than the national average for children.

Several significant climate-related effects are slower or more subtle than extreme events. Intense heat can worsen air pollution and ground-level ozone in addition to causing asthma attacks, decreased lung function and inflammation. For example, in Azerbaijan, the number of emergency calls related to blood, respiratory and neural diseases increase during heat waves. The length



*This designation is without prejudice to positions on status, and is in line with UNSCR 1244/99 and the ICJ Opinion on the Kosovo declaration of independence.

of the malaria season in the country has increased by 15–30 days in areas between 500 and 1,200 m.a.s.l. In the Western Balkans, the first local transmission of dengue fever was reported in Croatia in 2010.

Some mountain regions face more unique problems, which can be locally significant. In the Western Balkans, around 120,000 landmines and un-exploded ordnance (UXOs) remain in the ground after the 1992–1995 war. They can be shifted by the floods and explode, causing accidents. In both the Tropical Andes and the HKH, glacial lake outburst floods (GLOFs) pose a severe threat to communities located immediately (and in some cases, far away) downstream from glacial lakes.

In the future, climate-related health impacts are expected to increase. People in the mountains are likely to face an increase in the frequency and intensity of heat waves, GLOFs, flash floods, vector- and water-borne diseases, water scarcity, food and nutrition insecurity related to droughts. Drought-prone areas are expected to see more dry periods, which are projected to lead to poor agricultural productivity. Vector-borne diseases are expected to spread to higher altitudes and into new ranges in all mountain regions, spreading diseases including dengue fever, Chikungunya and tick-borne encephalitis in Western Balkans, leishmaniasis, malaria and several others in South Caucasus, and malaria, dengue and Zika in the Tropical Andes. In Tajikistan, malaria is expected to spread to areas located above 2,000 metres.

Although the overall impacts of climate change are negative, warmer temperatures can also have positive effects on human health. In the Western Balkans, it is likely to result in fewer deaths during the winter. In Hindu Kush Himalaya, the elderly in high mountains and herders on the Tibetan plateau have reported that milder temperatures have made winters more comfortable during the last decades. In addition, the likely increase in heat waves will have less severe direct consequences on human health in mountainous areas, as temperatures are generally lower than in lowland areas.

Policy response and gaps

Adverse impacts from climate change on human health can take many forms, and policies that respond to these issues must equally be diverse and comprehensive. The policy analysis made clear that the connection between climate change and human health is yet to gain proper attention, and that few of the policies consider climate change adaptation as a priority. No health policies were analysed for the Carpathian or the East Africa Outlook.

In the Tropical Andes, Colombia and Ecuador have climate change adaptation goals, targets and implementation tools in relevant polices for the health sector. Colombia, for instance, has included climate change adaptation as part of the 10-year Plan of Public Health 2012–2021. In Ecuador, there has been a strong focus on the connections between climate change and several diseases. Peru and Bolivia have made no reference to climate change impacts in their existing policies for human health, but Peru does have guidelines for disaster risk management. The Central Asian countries have introduced strategic documents, programs and action plans to address health issues, including those related to climate change. However, climate change adaptation in the health sector is not considered a priority in sectoral or national policies, apart from Kyrgyzstan which has developed and approved the programme on climate change adaptation of the health sector for the period 2011–2015. In the Hindu Kush Himalaya, the linkage between climate change and human health is not well considered in existing policies. Afghanistan and Bangladesh both mention the potential impact of floods and landslides, and Bangladesh also considers the impact of droughts on human health. The low quality of health care and low accessibility to services, along with limited attention given to children and maternal health, also remains a key challenge in the region. In the Western Balkans, existing legislation for the health sector does consider harmful ecological factors to be an issue, but does not directly address climate change adaptation. However, some strategies, for example those of Albania and FYR Macedonia, are specifically tailored to climate change adaptation and human health. In the South Caucasus, none of the countries have policies in place that address climate change related to health and no strategies have been developed to address the issue, however it is included in national communications to the UNFCCC.

Key Recommendations

- Climate change-related impacts on human health, and the consideration of mountain-specific vulnerabilities, need to be integrated in health policies as they are largely absent.

- The inaccessibility of many mountain communities, limited infrastructure and inadequate access to health care services, makes it urgent for policies to consider how projected climate change impact may affect human health in these areas.

Tourism

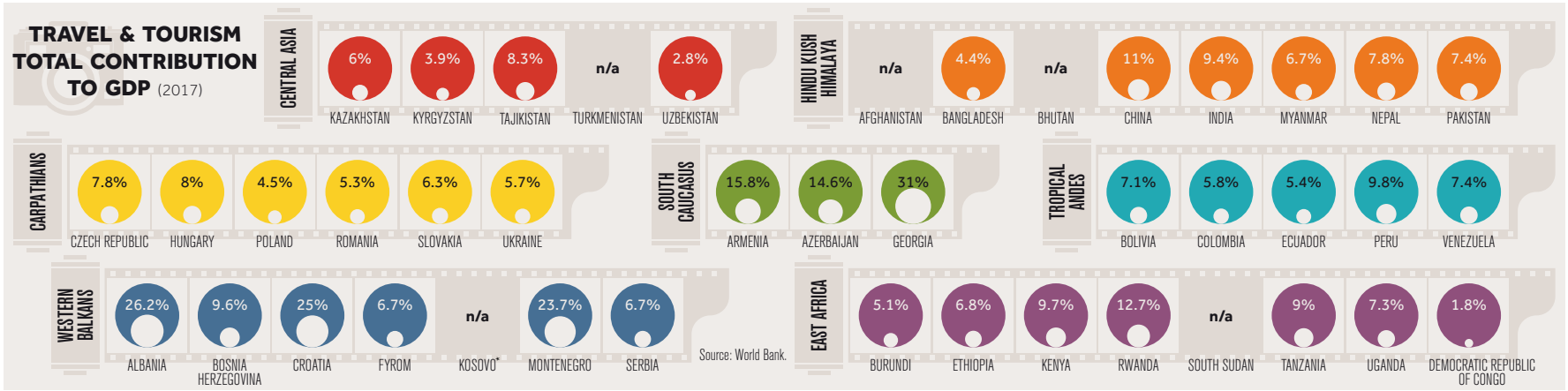
Climate impacts

Mountain regions attract tourists through their unique landscapes, ecosystems, sport possibilities and rich cultural heritage. In rural areas, tourism can provide an important alternative income for locals where there are few other livelihood options besides agriculture. Although tourism can have a negative impact on biodiversity, due to its economic importance, sustainably managed tourism can help to finance the protection of biodiversity and ecosystem services. In the Carpathians, 31 million overnight stays generated about 10 per cent of the region's GDP in 2011. In 2015, the total contribution of travel and tourism to GDP in Georgia was 20 per cent, while tourism revenue in Eastern Africa* averaged over USD 7 billion per country. While still relatively low, the Western Balkans region is expecting a significant increase in tourism-related jobs and increased contribution to GDP. Across the mountain regions, new initiatives such as ecotourism are developing fast and employing locals while seeking to preserve biodiversity.

Mountain tourism is recognised as especially vulnerable to climate change impacts by the World Tourism Organization. Direct impacts include the degradation of attractions, transportation networks, electricity and sanitation systems, which can both threaten lives and affect visitors' perception of safety, to indirect impacts including changes in the food and water supply. Analysis shows that rising mean temperature is the greatest concern related to mountain tourism. Warmer temperatures result in reduced snow cover and melting glaciers, which directly reduces the attractiveness of high-mountain and winter tourism resorts. Warmer temperatures and/or increased precipitation also increases the risk of landslides and floods. In the Carpathians and South Caucasus, winter tourism is a significant part of the tourism industry. Central Asia used to mainly rely on summer tourism, but winter sports activities are becoming more popular.

Skiing and related winter activities depending on snow may remain only at higher altitudes and may lead to the concentration of activities within a smaller surface area and a shorter period of the year. This could threaten fragile mountain ecosystems. High-altitude mountain tourism in the Tropical Andes and Hindu Kush Himalaya will also be affected, as some of the most popular attractions include distinctive snowy and glacial landscapes which may undergo significant changes. Avalanche risk will change based on the location. Increasing risk is projected, for example, in the Indian Himalayas, where warmer air temperatures during winter and spring have resulted in more wet snow avalanches. In East Africa, Mt. Kilimanjaro and other famous peaks attract many tourists. While it is unlikely that the complete loss of glaciers

* Kenya, Uganda, Ethiopia, Rwanda, Uganda, DRC and Tanzania



Climbers on Stok Kangri Mountain, Ladakh, India

would have a significant long-term impact on tourism on Kilimanjaro, a combination of increasing numbers of visitors and climate change pose other threats to the ecosystems and endemic species on this and other mountains in the region.

The number of visitors is likely to decrease after a disaster, whether it is climate related or not. In Nepal, for example, tourist numbers dropped from 790 000 in 2014 to 550 000 in 2015 after two devastating earthquakes. The tourism sector is also vulnerable to water scarcity in dry areas, which may become even drier in the future. In Ladakh, India, tourists are already asked to bring water from lower sources to help address the problem.

Along with negative impacts, climate change has also some positive impacts on tourism in mountain regions. In the Hindu Kush Himalaya, for example, warming temperatures have made the trekking season longer and more comfortable for more people, which has had a positive effect on tourism in parts of the region. In the Western Balkans and Carpathians, warming temperatures are extending the summer tourism season. In the future, the (relatively) cooler mountain areas may receive an influx of tourists as higher temperatures and summer heatwaves make the coasts and lowlands less bearable. However, changes in biodiversity and agro-ecosystems, and increases in vector-borne diseases may all impact summer tourism to varying degrees.

Policy response and gaps

The policy analysis provided in the outlooks shows that the way countries consider climate change impacts on the tourism sector is limited and there are significant gaps in approaches to adaptation in existing policies. There was no policy analysis done for the tourism sector in the East Africa, Central Asian or Andean outlooks, but examples of good practises were given for East Africa.

The potential negative impact that tourism can have on biodiversity and ecosystems is the main concern in existing tourism policies in the Hindu Kush Himalaya region. For instance, Bhutan operates a High Value, Low Impact Policy, which controls the volume of tourists allowed to enter the country through financial mechanisms, and thus limits impacts on fragile local environments. The impact of climate change for high mountain tourism, however, is only beginning to gain attention in the Hindu Kush Himalaya, and the issue is not adequately addressed in existing policies. Conversely, sustainable tourism is widely promoted in existing policies in the Carpathians. Climate change is understood to generate both negative and positive impacts on the sector. Romania and Slovakia, for example, promote a diversification of activities to make mountain resorts attractive for tourists all year round. Mountain tourism in the winter season is still important, and as an adaptive measure to address the negative consequences of a shorter season, Slovakia promotes increased production of artificial snow. In the Western Balkans, all the countries have tourism strategies in place, but they do not consider climate change. However, several stakeholders in the tourism sector do acknowledge the importance of considering climate change impacts, and there is a recognition of the need to include this in future policies. Of the three countries in South Caucasus, only Armenia had a tourism policy in place for analysis when the outlook was produced. The policy considers climate change impacts on the tourism sector, but primarily as a problem to be considered in the future when impacts can be observed. Furthermore, the policy mainly considers lower elevations as current tourism destinations, and mountain areas as potential destinations for further development. In East Africa, ecotourism is widely promoted in national parks and on mountains such as Mt. Kilimanjaro.

Key Recommendations

- While many countries seek to promote mountain tourism further, there is a great need to develop strategies that consider the risks of extreme events, and to put in place policies and regulations that promote the safety of tourists and the industry itself. This is especially important in areas with limited infrastructure and inaccessibility, such as high mountain areas.

- The tourism sector is closely interlinked with other sectors such as infrastructure, energy, water and human health, and adverse impacts on these will also affect tourism. There is thus a great need to generate more attention to the linkages and inter-dependencies between sectors.

MOUNTAIN ADAPTATION SYNTHESIS REPORT

Global and regional action on adaptation

Patchwork countryside, Ecuador

Global action on adaptation

Among the international strategies that make up the global policy response for action on climate change, the United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, is the leading institution for global cooperation. Initially, work primarily centred around mitigation efforts and the reduction of greenhouse gas emissions, with the adoption of the Kyoto Protocol in 1997 outlining binding reduction targets. Adaptation has been viewed as a complementary response to mitigation efforts, but as the impacts of climate change are already being felt by communities around the world, the issue has gained much greater attention in recent years. The Nairobi Work Programme (NWP) was established in 2005 as a mechanism to facilitate the development, dissemination and use of relevant knowledge to promote adaptation policies and practises. The programme has a particular mandate to support Least Developed Countries (LDCs) and Small Island Developing States (SIDS). As part of the Cancun Adaptation Framework (CAF) adopted in 2010, the Adaptation Committee (AC) was established to ensure more coherent adaptation action under the UNFCCC. The AC has 5 main functions:

Maasai herder, Kenya

- To provide the Parties with technical support.
- To facilitate information and knowledge-sharing, including good practices and experiences.
- To strengthen engagement and cooperation with national, regional and international networks, centres and organisations.
- To support the Conference of the Parties with information, recommendations and guidance when considering adaptation actions.
- To monitor, review and support the Parties in their adaptation actions.

Further action is promoted under the Nairobi Work Programme including through the Adaptation Knowledge Portal (AKP), the mandate of which is to provide free and open access knowledge and information on climate change adaptation.

The Paris Agreement entered into force in November 2016, with the aim to limit global temperature rise

to 1.5 degrees, and well below 2 degrees Celsius above pre-industrial levels. The agreement is based on nationally determined contributions (NDCs), where countries have to report regularly on implementation of the agreement and their national emissions. Under Article 7 of the Agreement, global goals for adaptation are mapped out, including strengthening adaptive capacity and national efforts. International financial mechanisms for climate change adaptation also exist under the UNFCCC, the main funds being the Special Climate Change Fund (SCCF), the Adaptation Fund (AF), the Least Developed Countries Fund (LDCF) and the Green Climate Fund (GCF). However, the volume of funding has remained low for both mitigation and adaptation measures. Other relevant UN agencies supporting climate change adaptation efforts include UN Environment, the United Nations Development Programme (UNDP), the United Nations International Strategy for Disaster Reduction (UNISDR) and the UN Food and Agricultural Organisation (FAO). Important multilateral processes related to adaptation efforts include The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework), the United Nations Convention to Combat Desertification (UNCCD), the Convention on Biological Diversity (CBD) and the Hyogo Framework for Action (HFA). The Sustainable Development Goals (SDG) are also a key component in global climate change adaptation efforts. Goal 13, Climate Action, is especially relevant in this respect with the aim to "Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries".

Ama Dablam mountain peak overlooking Dudh Kosi, Nepal

Village in Yunlong County, China

Regional and sub-regional responses

The UNFCCC requires national climate change adaptation efforts to be complemented by regional programmes and cooperation. Cooperation for adaptation in mountain regions often require a sub-regional approach, as these areas are located within a larger region or continent. Thus, cooperation at both levels, the regional and sub-regional, is important to enhance the effectiveness and consistency of climate change adaptation practises in mountain areas. All the mountain regions described in the outlook series have to some extent demonstrated both regional and sub-regional cooperation aimed at climate change adaptation practices.

In the Tropical Andes, regional cooperation for adaptation is taking place in the Andean Mountain Initiative. The countries in the region have developed the Strategic Agenda on Climate Change Adaptation in the Andes Mountains which lays out priority goals for adaptation, with concrete measures to reach each goal. The Agenda was developed by experts from the Andean countries with support from UN Environment and CONDESAN. Cooperation in the region has also taken place within a range of institutions, such as the organisation of the Andean Community (CAN), the Pacific Alliance and the Community of Latin American and Caribbean States (CELAC), and the Union of South American Nations (UNASUR). CAN has been involved in the establishment of the Environmental Andean Agenda, which promotes transboundary action on a range of climate change-related issues, and CELAC has facilitated regional discussions on climate change, including climate change and disaster risk reduction.

Regional and sub-regional cooperation in Central Asia exists through a number of institutions including The International Fund for Saving the Aral Sea (IFAS), The Interstate Commission for Water Coordination (ICWC), and The Interstate Commission on Sustainable Development (ICSD). Climate change has recently been incorporated into IFAS' work, and as a structural subdivision of IFAS and ICSD, The Regional Mountain Centre in Central Asia (RMCCA) is promoting sustainable mountain development in the region. However, there is still a need for relevant political institutions to draw on the knowledge generated within the centre, and for an overall improvement of the capacity of regional bodies to address climate change adaptation.

In the Western Balkans and the Carpathians, the European Union (EU) is one of the leading institution for regional and sub-regional cooperation, and the main entities for adaptation action are the European Environment Agency (EEA) and the European Adaptation Strategy adopted by the European Convention (EC). The EEA functions as a knowledge hub on adaptation-related information for EU member countries and EU institutions. The European Adaptation Strategy consists of a number of documents aimed at making the EU member states more climate-resilient. In the Carpathians, the Framework Convention on the Protection and Sustainable Development of the Carpathians (Carpathian Convention) is an important sub-regional body that promotes sustainable development of the Carpathians. The convention established a Working Group on Adaptation to Climate Change in 2011 that promotes regional cooperation on adaptation in the mountains. In 2017 the parties to the Convention also added an article on climate change adaptation and mitigation. There is still a need to implement the Strategic Agenda on Climate Change Adaptation as part of the Carpathian Convention. The Carpathian Convention together with the Alpine Convention,* can work as an inspiration and model for the development of a similar regional platform in Western Balkans as well as other mountain regions.

Regional cooperation in the Hindu Kush Himalaya is present at many levels with the most prominent political institutions in the wider region being the South Asian Association for Regional Cooperation (SAARC), The Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), and The Bangladesh, Bhutan, India, Nepal Initiative (BBIN). However, these institutions have only recently started to focus on how climate change will impact the work they do in the region, and lack strategies for the implementation of adaptation action. Regional cooperation specifically focused on mountains and climate change-related issues are addressed by the International Centre for Integrated Mountain Development (ICIMOD) and the South Asia Co-operative Environment Programme (SACEP). As an intergovernmental learning and knowledge-sharing centre serving the eight regional member countries of the Hindu Kush Himalaya, ICIMOD implements sustainable development

* The Alpine Convention is an international treaty between the European alpine countries of Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland, as well as the EU, for the sustainable development and protection of the European Alps.

projects and promotes the strengthening and sharing of scientific data in the region. However, there are still hindrances for effective cooperation due to the geopolitical landscape of the region. Furthermore, the many rivers of the region call for stronger cooperation in the water sector, and for all countries to address upstream-downstream issues.

In East Africa, a number of regional institutions exist, including the Common Market for Eastern and Southern Africa (COMESA), the New Partnership for Africa's Development (NEPAD), East African Community (EAC), and the Intergovernmental Authority on Development (IGAD). The large number of institutions in the region, however, is challenging the effective coordination and implementation of strategies, as well as putting a huge demand on resources. As of now, existing regional policies are not sufficiently enforced at the national level, and the governance system remains weak. Although not currently addressing mountain issues, the NEPAD's Action Plan for the Environment and The East African Climate Change Policy can provide key guidance for sustainable development and climate change adaptation for mountains in the region.

Due to the geopolitical situation in the South Caucasus, regional cooperation for sustainable mountain development remains limited. Ongoing border disputes, contested enclaves and certain regions claiming autonomy from the internationally recognised countries have significant implications for the geopolitical situation in the region. However, The Caucasus Network for Sustainable Development of Mountain Regions (Sustainable Caucasus) and the Caucasus Biodiversity Council are two regional institutions relevant for climate change adaptation. Relevant actors should still strive for the promotion of a regional approach to climate change adaptation in the region, including the sharing of scientific data, and build on the Ecoregional Conservation Plan recognised by all the countries.

CASE STUDY

The Alpine Climate Board and its adaptation stocktaking exercise

While the Mountain Adaptation Outlook Series did not include a report on the European Alps, this region offers many experiences and lessons learnt which can be relevant to other regions.

The Alpine Convention first adopted a Declaration on Climate Change in 2006, followed by an Action Plan on Climate Change in the Alps in 2009. Climate change has also been a priority focus of the Multi-Annual Work Programme since 2011. In 2016, the Alpine Convention established the Advisory Committee on the Alpine Climate (in short, the Alpine Climate Board), whose purpose is to group together climate change activities carried out under the framework of the convention, and to elaborate proposals for a system of objectives that works towards a "climate neutral Alpine space".

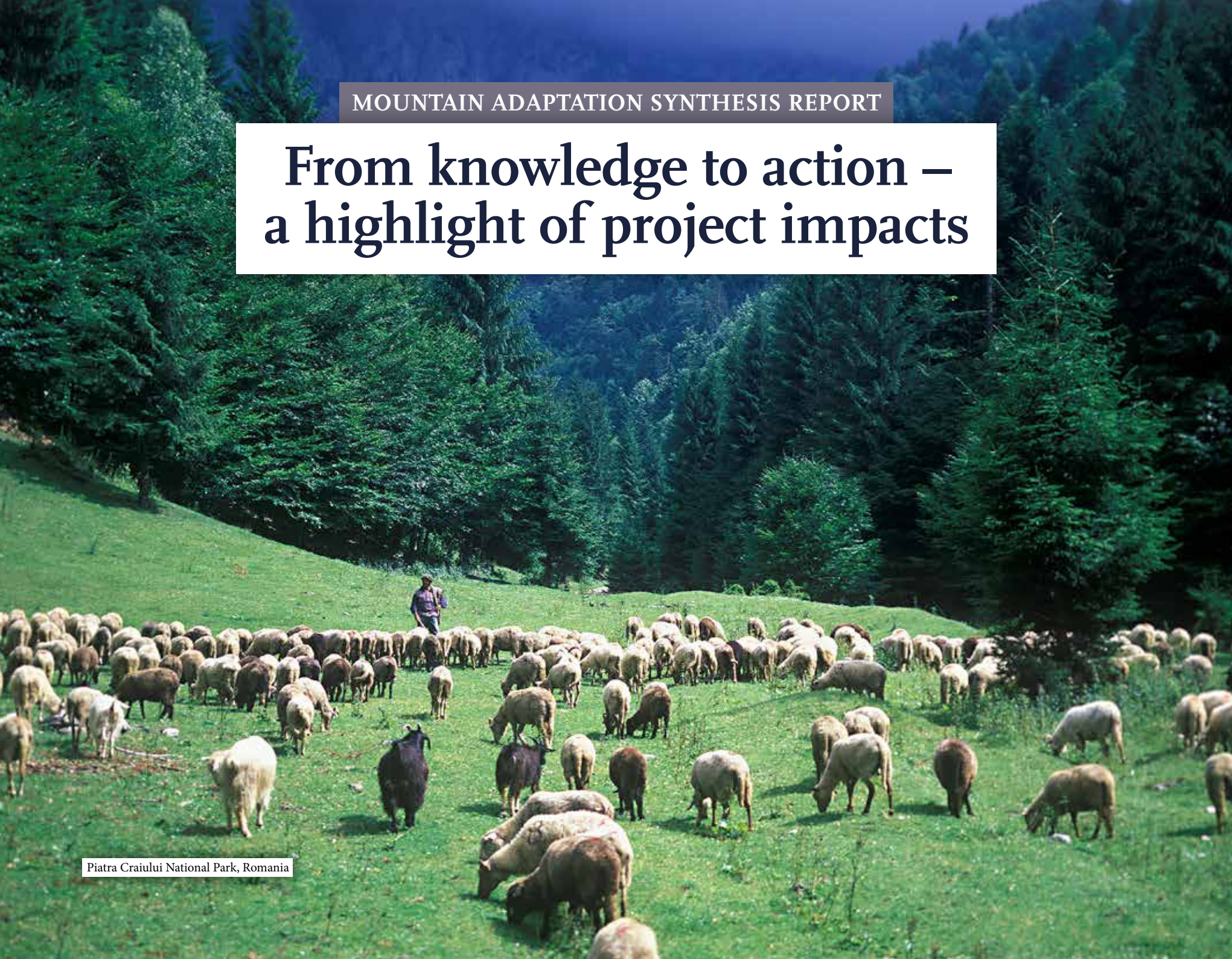
In 2017, The Alpine Climate Board undertook a stocktaking exercise of all the relevant stakeholders to the Convention, to identify existing activities related to mitigation and adaptation which have both an Alpine-specific character and for which a common approach on the level of the Alpine Convention creates an added value. The exercise also identified gaps and potential areas of action for the Board to pursue.

The stocktaking exercise shed light on the different types of adaptation activities currently being carried out in the various Alpine countries and the extent to which activities have a transnational focus. Amongst the findings, the analysis revealed that most adaptation and mitigation action takes place at the national and sub-national levels; soft-measures related to training and education are currently under-represented compared to other types of activities; and there is little focus on developing carbon-free lifestyles. The analysis further concluded that adaptation actions focusing on natural hazards, ecosystems, water and mountain forests are well-represented and there is a large existing knowledge base across the Alps. However, the analysis recommended, amongst others, strengthening the knowledge base for mountain agriculture and spatial planning. Based on the general findings of the stock-taking, a number of recommendations are put forward for the Climate Board to take up, including strengthening the above-mentioned gaps.

For further information, please visit the website of the Alpine Climate Board: http://www.alpconv.org/en/organization/groups/alpineclimateboard/default.htmln

MOUNTAIN ADAPTATION SYNTHESIS REPORT

From knowledge to action – a highlight of project impacts



Piatra Craiului National Park, Romania

As mentioned in the Introduction, the purpose of developing the Adaptation Outlooks for the respective mountain regions is to provide a baseline on key risks and impacts of climate change, both current and projected, on important sectors in mountain regions, and to identify key gaps in policies and provide prioritised actions for climate change adaptation in mountain ecosystems.

This section highlights some of the ongoing efforts by UN Environment and partners, through its inter-regional project "Climate change action in developing countries with fragile mountainous ecosystems from a sub-regional perspective", to foster regional dialogue and cooperation and both regional and national action on climate change adaptation.

Hilltop village overlooking Lake Ruhondo, Rwanda

Enhancing regional cooperation through policy dialogues

Based on the key risks and gaps identified in the various Outlooks, UN Environment has been working with partners, including national governments, in the respective regions to promote regional cooperation on adaptation to climate change in mountain regions. Regional meetings were organised in all mountain regions covered in this report to stimulate discussions towards a shared joint vision for climate change and adaptation in mountain ecosystems. The meetings aimed to clarify national and regional priorities that the participating countries have in common and to facilitate cooperation for adaptation to climate change. In addition, the workshops sought to gain input from various key designated governmental and non-governmental stakeholders and experts on climate change and sustainable mountain development from the various countries.

Existing institutional anchors, such as the Interstate Commission on Sustainable Development (ICSD) in Central Asia, The East African Community (EAC) in East Africa, CONDESAN and the Andean Mountain Initiative in the Andes, have proved useful for obtaining a mandate for regional dialogue and cooperative action. The guidance documents (format and outputs vary from region to region) prepared and reviewed at these meetings included a list of policies, institutional measures and programmatic actions that are necessary to reduce the risks of climate change, in alignment with national priorities. The goals and measures of the strategic guidance were organised around the policy sectors that were identified to be the most in need for adaptation measures.

Bus travelling on road through landslide terrain in Peruvian Andes

The outcome has been a series of regional agendas on climate change adaptation that have either been endorsed by governments at highest level, or are in development. Examples of the regional policy dialogues and outcomes include:

In the Tropical Andes, all Andean countries, in the context of the meeting of the Andean Mountain Initiative,* have developed a regional agenda on climate change and adaptation benefitting all Andean countries. This Strategic Agenda was finalised and agreed upon at the regional consultation meeting in Bogotá, Colombia 10-11 July 2017. The Andean Initiative serves as the regional institutional framework for the Strategic Agenda, with CONDESAN providing the interim technical secretariat for the Andean Mountain Initiative.

In Central Asia, a regional strategic guidance document for adaptation to climate change is currently being developed, in a partnership with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Regional Mountain Centre for Central Asia (RMCCA). The objective of the strategic guidance document is to promote synergies and a more coherent regional approach towards climate change adaptation and sustainable development in Central Asian mountain regions and to provide a better guidance for future efforts on adaptation taking into account specific challenges of mountain regions. It is intended to be endorsed by all five Central Asian countries Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan and anchored within the ICSD.

In East Africa the Outlook included key elements for a East African Mountain Agenda that were reviewed through the respective inter-governmental bodies of the East African Community.

* The Andean Mountain Initiative comprises the seven Andean countries (Venezuela, Colombia, Ecuador, Peru, Bolivia, Chile and Argentina). The aim is to generate and strengthen regional dialogue oriented at developing collaborative actions in the sub-region. The first meeting of the Andean Initiative was held in Tucumán Argentina in 2007, with support from the Mountain Partnership, where the countries subscribed to the 'Tucumán declaration' on the Initiative, and presented the 'Action Plan for the Sustainable Development of the Andes Mountains'. The latest meeting of the Andean Mountain Initiative was held in Quito, Ecuador in November 2018.

CASE STUDY

The Strategic Agenda for Climate Change Adaptation in the Andes Mountains

In 2017 in Bogotá, Colombia the seven Andean countries (Argentina, Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela) agreed on a strategic agenda for regional cooperation on climate change adaptation in the Andes Mountains. This document includes 10 objectives, each of which includes a list of concrete measures.

The Strategic Agenda highlights common priorities and consensus in the region. This includes a broad approach to adaptation to climate change, which addresses socioeconomic vulnerability, ecosystem protection and strengthening of governance structures for effective and fair adaptation.

The document was developed over several regional meetings with representatives from the countries from 2015 onwards. The process took place within the Andean Mountain Initiative. As an example, Objective 4 is described below (unofficial translation):

Objective 4: Adaptation to the effects of climate change on Andean ecosystems and biodiversity

Measures:

1. Strengthen the resilience of Andean ecosystems by reducing other anthropogenic pressures, with an emphasis on reducing over exploration of natural resources;
2. Support research to evaluate ecosystem functions and services with a focus on mountain ecosystems and how they are affected by climate change;
3. Strengthen the monitoring of species vulnerable to climate change;
4. Protect the habitat of species vulnerable to climate change, by for example establishing protected areas and other means for protection and conservation;
5. Strengthen the management of protected areas with increased participation of local communities;
6. Maintain or establish ecological corridors between protected areas to ensure ecological connectivity;
7. Implement Ecosystem based Adaptation in Andean ecosystems, as a means to reduce the impact of climate change both on Andean communities and ecosystems.

Adaptation actions within mountain countries targeting specific sectors

The consultation meetings and policy dialogues, combined with the Adaptation Outlooks, have also laid the ground for follow up activities on climate change adaptation targeting specific sectors for action, with the political support of countries. These follow up activities are focussed on building the capacities, from national governments to municipalities, to both understand the nature of the projected impacts of climate change and existing vulnerabilities, and put in place adequate adaptation plans and activities. For example, following the recommendations and the needs identified in the "Outlook on Climate Change Adaptation in the South Caucasus Mountains", technical assistance was sought from the Climate Technology Centre and Network (CTCN) in both Azerbaijan and in Georgia. In Azerbaijan, the technical assistance focusses on building capacities to undertake local vulnerability assessments in mountain areas. In Georgia, it focusses on building capacities in adopting ecosystem-based adaptation approaches in mountain areas. Climate financing has also been sought from the multilateral and bilateral donors working in the region, in order to address some critical gaps. These include focussing on adaptation actions in the tourism sector which is often one of the least prepared.

Barania Góra, Silesian Beskid Mountains, Poland

Many of the Outlooks identified the need – and opportunity – for managing ecosystems in ways that can help communities and mountain societies to adapt to climate change (a.k.a. ecosystem-based adaptation). At the same time, the Outlooks also revealed that climate change is impacting mountain ecosystems themselves, increasing human-wildlife conflict in certain areas and rendering existing protected area networks unsuitable or ineffective. One of the largest new initiatives is the "Vanishing Treasures" project, which is financed through climate funds from the Government of Grand Duchy of Luxembourg, and focusses on Virunga (Uganda, Rwanda), Hindu Kush Himalaya (Bhutan), and Central Asia (Kyrgyzstan, Tajikistan). The project focusses on several flagship mountain migratory species, including the snow leopard, Bengal tiger, and mountain gorilla. The project's aim is to better understand the animals' vulnerability to climate change and the ecosystem services being affected by it. In the long term, by working with local communities the programme also aims to promote alternative land-use practices that can contribute to climate mitigation and reduce pressure on species living close to the communities.

Based on the identified priorities for climate change adaptation, highlighted within the Mountain Adaptation Outlooks and strategic agendas, UN Environment will continue to work and support mountain countries to enhance adaptation at both the sub-regional and national levels. UN Environment will also work alongside other partners to target climate financing and help countries to mainstream mountain and adaptation considerations into relevant national sector-related processes. At the sub-regional level, UN Environment and its partners will continue to support policy processes within relevant frameworks and foster inter-regional exchange of knowledge and best-practices.

References

Please note that this report is based on a synthesis of the findings within the various Outlooks. Please refer to these Outlooks for more detailed sources of information:

East Africa:
EAC, UNEP and GRID-Arendal (2016). Sustainable Mountain Development in East Africa in a Changing Climate. East African Community, United Nations Environment Programme and GRID-Arendal. Arusha, Nairobi and Arendal

Western Balkans:
Alfthan, B.; Krilasevic, E.; Venturini, S.; Bajrovic, S.; Jurek, M.; Schoolmeester, T., Sandei, P.C., Egerer, H, and Kurvits, T. 2015. Outlook on climate change adaptation in the Western Balkan mountains. United Nations Environment Programme, GRID-Arendal and Environmental Innovations Association. Vienna, Arendal and Sarajevo. www.grida.no

Carpathians:
Alberton, M.; Andresen, M.; Citadino, F.; Egerer, H.; Fritsch, U.; Götsch, H.; Hoffmann, C.; Klemm, J.; Mitrofanenko, A.; Musco, E.; Noellenburg, N.; Pettita, M.; Renner, K.; Zebisch, M. (2017). Outlook on climate change adaptation in the Carpathian Mountains. United Nations Environment Programme, GRID-Arendal and Eurac Research, Nairobi, Vienna, Arendal and Bolzano. www.unep.org, www.grida.no, www.eurac.edu

South Caucasus:
Shatberashvili, N.; Rucevska, I.; Jørstad, H.; Artsivadze, K.; Mehdiyev, B.; Aliyev, M.; Fayvush, G.; Dzneladze, M.; Jurek, M.; Kirkfeldt, T. & Semernya, L. (2015). Outlook on climate change adaptation in the South Caucasus mountains. United Nations Environment Programme, GRID-Arendal and Sustainable Caucasus. Nairobi, Arendal and Tbilisi. www.grida.no, www.unep. org, www.sd-caucasus.com

Central Asia (full report in Russian):
Жолдошева, Э., Ручевска, И., Семерня, Л., Даиров, И., Кожахметов, П., Бариева, А., Маскаев, А., Митрофаненко, Т., Алексеева, Н. 2017. Адаптация к изменению климата в горных районах Центральной Азии. Серия Обзоров по Адаптации в Горных Районах. ООН- окружающая среда, ГРИД-Арендал, РГЦЦА. Найроби, Вена, Арендал, Бишкек. www.unep.org, www.grida.no

Hindu Kush Himalaya
Alfthan, B., Gupta, N., Gjerdi, H.L., Schoolmeester, T., Andresen, M., Jurek, M., Agrawal, N.K. 2018. Outlook on climate change adaptation in the Hindu Kush Himalaya. Mountain Adaptation Outlook Series. United Nations Environment Programme, GRID-Arendal and the International Centre for Integrated Mountain Development, Vienna, Arendal and Kathmandu. www.unep.org, www.grida.no, www.icimod.org

Tropical Andes:
Schoolmeester, T.; Saravia, M.; Andresen, M.; Postigo, J.; Valverde, A.; Jurek, M.; Alfthan, B. and Giada, S. 2016. Outlook on Climate Change Adaptation in the Tropical Andes mountains. Mountain Adaptation Outlook Series. United Nations Environment Programme, GRID-Arendal and CONDESAN. Nairobi, Arendal, Vienna and Lima. www.unep.org, www.grida.no, www.condesan.org

All Outlooks can be accessed here: www.grida.no/publications

Specific references included in the text of this report:

Cardona, O.D., M.K. van Aalst, J. Birkmann, M. Fordham, G. McGregor, R. Perez, R.S. Pulwarty, E.L.F. Schipper, and B.T. Sinh, 2012: Determinants of risk: exposure and vulnerability. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 65-108.

IPCC. 2018. Special Report on Global Warming of 1.5°C. Incheon, South Korea: Intergovernmental Panel on Climate Change (IPCC). Accessed 15 October. https://www.ipcc.ch/report/sr15/

IPCC, 2014: Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: Cli- mate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 117-130.

Kohler T. and Maselli D. (eds) 2009. Mountains and Climate Change - From Understanding to Action. Published by Geographica Bernensia with the support of the Swiss Agency for Development and Cooperation (SDC), and an international team of contributors. Bern.

Photo credits

9 iStock/Photodjo
10 iStock/Byelikova_Oksana
13 iStock/1255k
19 iStock/master-c
20 iStock/mantaphoto
21 iStock/WLDavies
24 iStock/rchphoto
25 Ilkin Kangerli
27 Ivo Dostál
30-31 iStock/Aureliy
37 www.mandalatravel.fi/Flickr CC BY-NC-ND
39 iStock/crisserbug
40 iStock/DavorLovincic
41 iStock/fotoVoyager
42 iStock/Kabir Uddin
45 Mircea Verghelet
46 iStock/Robert_Ford
47 iStock/tirc83
49 Jacek Kozak

This Mountain Adaptation Synthesis Report provides a concise summary of the findings of a series of reports focusing on adaptation to climate change in some of the world's major mountain regions, with a particular focus on developing regions and economies in transition. Those reports, published under the common title of ***Mountain Adaptation Outlooks***, were prepared for the Carpathians, Central Asia, Eastern Africa, Hindu Kush Himalaya, South Caucasus, Tropical Andes and the Western Balkan mountains.

UN environment

GRID ARENDAL