IMPROVING WEATHER, CLIMATE AND HYDROLOGICAL SERVICES DELIVERY IN CENTRAL ASIA (KYRGYZ REPUBLIC, REPUBLIC OF TAJIKISTAN AND TURKMENISTAN)

THE WORLD BANK

GFDRR
Global Facility for Disaster Reduction and Recovery

PREFACE

Improving weather, climate, and hydrological services in Central Asia is an important component of social and economic development in the region. This report is prepared as a part of a technical assistance project, ***An Action Plan for Improving Weather and Climate Service Delivery in High-Risk, Low-Income Countries in Central Asia***, funded by the Global Facility for Disaster Reduction and Recovery (GFDRR) and implemented by the World Bank. This summary report is based on the findings of the three national reports developed jointly with the National Hydrometeorological Services (NMSs) of the Kyrgyz Republic, the Republic of Tajikistan and Turkmenistan. It summarizes economic requirements for weather, climate, and water information, and the product and service improvements necessary to meet those needs.

The report contributes to the development of a broader Central Asia and Caucasus Regional Economic Cooperation Initiative on Disaster Risk Management (DRMI), which aims to reduce disaster risk vulnerability of the countries in Central Asia and Caucasus. Recently launched, this program is coordinated by the World Bank, the United Nations International Strategy for Disaster Reduction (UN/ISDR) secretariat, and for hydrometeorology, the World Meteorological Organization (WMO) under the umbrella of the Central Asia Regional Economic Cooperation (CAREC).

ACKNOWLEDGEMENTS

A number of people contributed to this study, and the authors would like to thank them. First of all, we thank the staff of the Kyrgyz, Tajik, and Turkmen NMSs in the central offices and regional centers, which supported the development of this study and facilitated the work of technical missions and consultation workshops with stakeholders. Preparation of country reports, which served as a basis for this summary report, was advanced significantly by substantive inputs and coordination efforts, especially those made by Mr. M. Bakanov and Ms. I. Mayatskaya (Kyrgyzhydromet), Messrs. B. Makhmadaliev and M. Safarov (Tajikhydromet), and Messrs. K. Yazyev and D. Boltaev (Turkmenhydromet).

The study benefited from valuable inputs provided by the Bank partners, such as UN/ISDR, World Meteorological Organization, and Swiss Agency for Development and Cooperation (SECO). Our special thanks go to Ms. P. Albrito (ISDR), Ms. M. Power (WMO), and Mr. H. Maag (SECO, Swiss Confederation).

The authors gratefully acknowledge the Global Facility for Disaster Reduction and Recovery (GFDRR) for their collaboration and generous financial support for this study and three national reports on which it is based. The GFDRR is a global partnership of national governments and regional and international organizations committed to helping developing countries reduce their vulnerability to natural hazards and adapt to climate change.

Finally, we would like to thank World Bank management for their interest to this topic. Messrs. S. Jha, J. Kellenberg, W. Zakout, R. Robinson, C. Bosch, R. Hoffer, Ms. C. Bronchi, Ms. A. Cave, and many World Bank colleagues based in Central Asia offered their support during implementation of this work and provided every practical help to ensure success.

The main authors of the report are David Rogers, Marina Smetanina, and Vladimir Tsirkunov who is also the Task Team Leader for this GFDRR project. Messrs. A. Korshunov, V. Kotov, and A. Zaitsev participated in the country missions and developed technical background documents and studies on climate vulnerability; capacity assessment of the hydrometeorological services of the Kyrgyz Republic, Republic of Tajikistan, and Turkmenistan; and modernization alternatives for each. Ms. L. Hancock and Ms. S. Sharipova contributed to the development of the study concept, provided valuable information, and participated in the report preparation.

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ABBREVIATIONS AND ACRONYMS

CA	Central Asia
CAC DRMI	Central Asia and Caucasus Disaster Risk Management Initiative
CAREC	Central Asia Regional Economic Cooperation
CIS	Commonwealth of Independent States
CMA	China Meteorological Agency
ECA	Europe and Central Asia
EHH	Extreme (high impact) Hydrometeorological Hazards
EU	European Union
FSU	Former Soviet Union
GFDRR	Global Facility for Disaster Reduction and Recovery
HH	Hydrometeorological Hazards
HMI	Hydrometeorological Information
IBRD	International Bank for Reconstruction and Development
IFI	International Financial Institution
IT	Information Technology
JICA	Japan International Cooperation Agency
Kyrgyzhydromet	State Agency for Hydrometeorology of the Ministry of Emergency Situations of the Kyrgyz Republic
NMHSs	National Meteorological and Hydrological Services
NMS	National Hydrometeorological Service or National Meteorological Service
O&M	Operations and Maintenance
SDC	Swiss Agency for Development and Cooperation
SECO	State Secretariat for Economic Affairs of Swiss Ministry of Economic Affairs
Tajikhydromet	State Agency for Hydrometeorology of the Committee for Environmental Protection under the Government of the Republic of Tajikistan
Turkmenhydromet	National Committee for Hydrometeorology under the Cabinet of Ministers of Turkmenistan
UNISDR	United Nations International Strategy for Disaster Reduction
WMO	World Meteorological Organization – a United Nations agency

EXECUTIVE SUMMARY

PURPOSE OF THE REPORT

The purpose of this report is to present the results of an assessment of national weather, climate, and hydrological services in Central Asia and to propose a program to improve these services. The report is based on the findings of three country assessments—the Kyrgyz Republic, the Republic of Tajikistan and Turkmenistan—and supporting regional documentation. These and other countries that form the Central Asian region share common concerns, regarding economic development and the vulnerability of their economies and people to weather, climate, and hydrological extremes. National assessments are based on evaluations of weather, climate, and hydrological hazards; key users' needs; National Hydrometeorological Services' (NMS) capacities; and potential economic benefits from improvement of hydrometeorological service delivery. The results of this GFDRR work and summary report will contribute directly to the development of the Regional Initiative to Improve Weather, Climate, and Hydrological Service Delivery in the Central Asia.

PRINCIPAL FINDINGS

Improving weather, climate, and water services in Central Asia region is essential for stable social and economic development. Central Asian countries are vulnerable to a wide range of weather-related disasters, including floods and mudflows, droughts, frosts, avalanches, hail, and strong winds. Data suggest that on average these events constitute a major part of all economic losses attached natural hazards and vary from 0.4 to 1.3 percent of GDP per annum for the countries studied. There is a growing need to provide better quality weather, water, and climate information particularly for early warning and to support disaster reduction strategies in such sectors as agriculture, transport, water resources management, and hydropower generation.

Figure 1. Mudflow, Flood, and Avalanche Related Damage in Kyrgyz Republic

Source: Presentations at Consultation Workshop, Bishkek, December 16, 2008.

The decline in the capacity and capability of the National Meteorological and Hydrological Services (NMHSs) throughout Central Asia to meet society's growing demand for weather, climate, and water information and services reflects the overall decline in spending on public services since early 1990. Obsolete and broken equipment, poor telecommunications, inadequate training, and problems with retaining qualified staff all contribute to this problem. The lack of access to timely and accurate weather, climate, and water information substantially impedes civil society and economic performance. Economic assessments of key sectors show a measurable improvement in economic benefit is possible even with a modest investment in improving the capabilities of the NMSs of the Kyrgyz Republic, the Republic of Tajikistan, and Turkmenistan.

In addition, simultaneous investment in NMS modernization in these three countries, and in the whole of Central Asia, is valuable since political boundaries do not constrain atmospheric processes. Understanding how the atmosphere behaves over the entire region will improve forecasts and outcomes throughout Central Asia, as well as in each of the three countries.

Proposed programs for strengthening and technical upgrading of NMSs in the Kyrgyz Republic, the Republic of Tajikistan, and Turkmenistan consist of three components:

1. Technical design of hydrometeorological monitoring and telecommunication systems;

2. System improvements for hydrometeorological monitoring to provide timely warnings of extreme disasters and hazardous weather events, to manage water resources, and to provide support to other sectors;

3. Institutional strengthening and capacity building.

The *first component* focuses on the concept of hydrometeorological development, the technical design of the system and the development of technical specifications and tender documents based on the national reviews and supporting documentation. The *second component* focuses on implementing the modernization of the NMSs. It consists of technical upgrading of the observational networks and strengthening of the information technology base of the NMSs. The *third component* focuses on enhancing service delivery, staff training, and professional upgrading.

The renewal of the observing networks, which are the backbone of weather, climate, and water forecasts and analyses, must go hand-in-hand with building the capacity to deliver services users want. This approach will realize the value of technical modernization as quickly as possible and make long-term sustainability of the NMSs more likely.

Implementation of the proposed modernization programs will lead to substantial improvement of NMS performance and better service delivery. Preliminary performance indicators have been developed; more specific verifiable sets of indicators and their monitoring procedures will be developed for each national program, as an intrinsic part of the technical design component.

To develop a more effective provider and user interface for service delivery, it is essential to involve users of NMSs products and services in the modernization programs in each country.

The proposed NMS Modernization Program is a part of a *Central Asia and Caucasus Disaster Risk Management Initiative (CAC DRMI)* initiated by the World Bank and the UN/ISDR secretariat in collaboration with international partners in September 2008. The initiative includes three main components: (i) Disaster Mitigation, Preparedness, and Response; (ii) Disaster Financing and Risk Transfer; and (iii) Improvement of Weather, Climate, and Hydrological Service Delivery. NMSs modernization and better service delivery will also contribute to the Central Asia Regional Energy-Water Development Framework announced recently by the World Bank and other development partners. NMSs' modernization, strengthening, and capacity building are important particularly for mitigating weather and climate risks and for providing better services for agriculture, water resources management, transport, hydropower generation, and other sectors.

Figure 1.1. Map of Central Asia

CHAPTER 1 KEY WEATHER AND CLIMATE HAZARDS IN CENTRAL ASIA

1.1 MAIN GEOPHYSICAL AND HYDROMETEOROLOGICAL CHARACTERISTICS

Central Asia is a land-locked region of the Eurasian continent with multiple climatic regimes, ranging from heavy precipitation in the mountains to arid deserts (Figure 1.1 – regional map). The Kyrgyz Republic is highly drought prone, but this is offset by heavy precipitation associated with its high relief. More than 70 percent of the country is above 2,000 m. Most of the country is located in a moderate climate zone while its southern areas are subtropical. The Republic of Tajikistan, which borders the Kyrgyz Republic, is mostly subtropical and semi-arid with some desert areas. Over 50 percent of the country's territory lies above 3000 m. Turkmenistan is extremely arid and about 80 percent of the country is flat desert. (See Country Reports and Annex 1).

1.2 WEATHER AND CLIMATE RISKS: THEIR SOCIAL AND ECONOMIC IMPACTS AND RELATED ECONOMIC LOSSES

The Kyrgyz Republic, the Republic of Tajikistan, and Turkmenistan use a similar, standard classification of both hydrometeorological events and unfavorable weather conditions to measure intensity and impact on the economy and population.

These criteria identify extreme (high impact) hydrometeorological hazards (EHHs), including hydrometeorological disasters and hydrometeorological hazards (HHs). Meteorological, agrometeorological, and hydrological events are classed as EHHs when by intensity, territorial coverage (more than 30 percent of the region's territory), or duration they could cause or have caused significant damage to the economy and population and could result or have resulted in a disaster.

Meteorological, agrometeorological, and hydrological events are classed as hydrometeorological hazards (HHs) when, by certain criteria, they could cause damage but their intensity, duration, and territorial coverage does not exceed the criteria of EHHs.

Similar EHHs affect all three countries in the region; the most severe are mudflows, floods, and avalanches caused by snowmelt or heavy precipitation. Droughts are also common to all three and are becoming more frequent. EHHs have a high impact because agriculture is important to all the economies, and food security is an issue for regional subsistence farmers. In addition hail and strong winds affect all three countries with the Republic of Tajikistan and Turkmenistan having a particular problem with dust storms. A comparison of annual frequency of occurrence of major hazards, using all available data since 1985, and the annual average economic losses for each country is shown in Table 1.1.

Table 1.1. Average Annual Frequency of Occurrence of Major Hydrometeorological Hazards and Associated Annual Average Economic Losses (US Dollars in 2006 prices)

Type of Event	Kyrgyz Republic		Republic of Tajikistan		Turkmenistan	
	Frequency of occurrence	Average annual economic losses	Frequency of occurrence	Average annual economic losses	Frequency of occurrence	Average annual economic losses
Floods and Mudslides	43.0	11.0	42.0	15.7	2.17	14.5
Drought	0.5	7.3	0.12	8.6	0.61	n/a
Spring and Autumn Frosts	2.0	7.5	n/a	n/a	9.9	n/a
Severe Frosts	n/a	n/a	1.1	0.4	4.3	n/a
Rainstorms	5.6	0.4	3.0	1.5	8.35	n/a
Hail	1.6	0.5	7.7	1.6	1.13	n/a
Snowstorms	2.6	0.2	3.0	0.6	0.91	n/a
Avalanches	15.1	0.3	26.6	0.8	0	n/a
Windstorms	4.5	0.1	8.1	0.8	28.4	0.2
Duststorms	0	-	0	-	22.0	n/a
Dust Cyclones	0	-	0	-	0.09	n/a
Dry Hot Winds	0	-	0	-	31.0	n/a
Total cost		27.3		29.8		n/a

Socioeconomic impacts of meteorological risks (in the aggregate and by types of EHHs and HHs) were estimated on the basis of the integration of losses suffered by the economy due to specific hydrometeorological events (e.g., mudflows and floods, strong wind, frosts, drought, etc.).

Two parameters are used to estimate the meteorological risk of impact of certain events on the economy:

- *Hazard* of event impact (or its climate frequency/frequency of its occurrence);
- *Vulnerability* to event impact (an absolute value of economic losses caused by the event in case of both correct and incorrect forecasts/warnings).

Economic damage caused by unfavorable weather conditions and hazardous hydrometeorological events is estimated in two stages: (i) the climate hazard of impact of different events (their climate frequency) is estimated on the basis of climate data; and (ii) the vulnerability of the economy to impact of specific HHs and EHHs is estimated.

In general no single source provides a complete set of information on the impact of hydrometeorological hazards on the economy. The information sources included data supplied by the respective hydrometeorological services; where available, data from the ministries responsible for coping with emergency situations; and data from various economic studies.

Floods and mudslides rank highest in their impact on the economies of all three countries and drought ranks second (Table 1.1). During the 2007-2008 winter, for example, Central Asia experienced extremely cold temperatures for a prolonged period, resulting in a surge in demand for power that led to large water releases and sharp declines in reservoir water levels. This was followed by abnormally low precipitation and hot weather in the following spring and summer, resulting in extensive drought.

CHAPTER 2 COMPARATIVE ASSESSMENT OF HYDROMETEOROLOGICAL SERVICES CAPACITY IN CENTRAL ASIA

As members of the World Meteorological Organization (WMO), the Kyrgyz Republic, the Republic of Tajikistan, and Turkmenistan, through their National Meteorological Services (NMSs), provide the international meteorological community access to data from the national observational network and receive information from the National Meteorological and Hydrological Services (NMHSs) of other countries.

National laws and resolutions regulate the activities of an NMS. Following independence each of the three countries developed a legal framework for the provision of meteorological and hydrological services. In each, the laws allow for the provision of public hydrometeorological observing networks, forecasting of hazardous events, and provision of information to appropriate governmental bodies. Each country has a different governance structure for its National Hydrometeorological Service. In the Kyrgyz Republic, the NMS is part of the Ministry of Emergencies; in the Republic of Tajikistan, the NMS is a state agency (enterprise) of the Committee for Environmental Protection; in Turkmenistan, a national committee under the Turkmenistan Cabinet of Ministers governs the NMS. In practice, however, they have similar day-to-day operating procedures. Each of the three countries is a member of the World Meteorological Organization, and each discharges this obligation through its respective NMS.

In practice, each NMS continues to operate largely according to procedures established during the Soviet era. Staffing levels are high overall but with insufficient skills to provide for the needs of a modern economy. In particular, technical qualifications are inadequate, and there is limited experience in providing an effective interface with the users or potential users of weather, climate, and water information.

Throughout the region, NMSs operate largely with obsolete equipment and lack access to modern forecasting methods, which limits their capacity to provide the products and services needed by the public and the economy. All of the meteorological services' facilities assessed in this study are in a poor state of repair; they have insufficient qualified staff to adequately maintain current observation networks and inadequate training opportunities to retain qualified staff.

Figure 2.1. On-site Meteorological Equipment and Instruments (Tajikistan, 2008)

Extensive technical reviews have been conducted of observational networks and other hydrometeorological infrastructure (telecommunications, facilities for forecasting weather conditions for each country, warning systems) and of the region's hydrometeorological services, including the outcomes of assistance projects implemented by the donors in support of regional NMHSs. The reviews show that current conditions of the hydrometeorological services fail to meet the hydrometeorological services needs of either their respective governments or the weather and climate-sensitive social and economic sectors. They also show that the NMS in each of the three countries reviewed fails to fulfill the country's regional and international obligations for weather and climate information, including those under the World Meteorological Organization's Global Observation Network.

Table 2.1. Deterioration of Hydrometeorological Observation Networks

Component of observation network	Kyrgyz Republic		Republic of Tajikistan		Turkmenistan	
	Number in 2008	% Reduction since 1985	Number in 2008	% Reduction since 1985	Number in 2008	% Reduction since 1985
Meteorological stations	32	62	57	22	48	52
Hydrological stations and posts	76	48	81	41	32	45
Upper air	0[a]	100	0[b]	100	0[c]	100
Meteorological radars	0[d]	100	1	75	0[e]	100
Agromet observation stations	31	55	37	46	48	15

[a]*There were three operational upper air stations in Kyrgyz Republic*
[b]*There were four operational upper air stations in Republic of Tajikistan*
[c]*There were six operational upper air stations in Turkmenistan*
[d]*One radar was in pilot operation in Kyrgyz Republic*
[e]*One radar was in operation in Turkmenistan*

Overall, the observing networks are unsatisfactory. In each country there has been a persistent downward trend in the quantity and quality of measurements at most stations in the ground-based meteorological network due to the deterioration and obsolescence of all of the measurement facilities, equipment, and communications, which have been in operation for a long time and have exhausted their service life. In particular, the following examples are notable:

- Many meteorological stations were closed due to lack of funds: 22 percent in Tajikistan, 52 percent in Turkmenistan, and 62 percent in Kyrgyzstan (Table.2.1).
- Hydrological observing networks have been reduced by 40-50 percent (Table 2.1) since the mid-1980s. Most equipment has exhausted its service life and is obsolete; spare parts are nonexistent or limited.
- Where avalanches are a problem, snow surveys have declined or are nonexistent, preventing timely forecasts and warnings of avalanche hazards.
- Aerological measurements have stopped in all three countries—a dramatic decline compared to 13 operational stations some 20 years ago (Table 2.1). The absence of aerological measurements, exacerbated by elimination of all upper air soundings in Uzbekistan, significantly affects the quality of weather forecasts, as well as the results of global and regional meteorological model calculations for the Central Asian Region. At present only Kazakhstan keeps eight upper air stations operational—50 percent less than in the 1980s.
- There is a lack of appropriate communication between the stations and monitoring sites of the meteorological and hydrological observation networks and the data collection center at the NMS.
- The system of data collection and dissemination is inefficient and fails to ensure reliable data collection, archiving, and provision of information products to regional and district-level users.
- Available information technologies are obsolete and fail to ensure receipt and transmission of the large data amounts required to produce modern information products.
- Technologies required to produce and transmit data and information products from NMS offices to users are nonexistent at both the central and regional hydrometeorological centers.
- Funds allocated from the NMS budget to finance operational costs are insufficient to adequately support the operations of stations and monitoring sites;
- Scientific and methodological support of the NMSs' operations is weak.
- Metrological support of measurement equipment is almost nonexistent, leading to a considerable deterioration of the quality of the NMS observational data.
- Staff training is inadequate.

In addition, nearly all of the means of forecasting and producing information fail to meet modern requirements for hydrometeorological services provided to public authorities, the economy, and communities. Without adequate means of production, the capacity to provide services to users is very limited. Overall forecasts have relatively low skill compared with NMSs outside of the CIS region.

Figure 2.2. Checking and Calibrating Instruments and Facilities in Central Office of Turkmenhydromet

Figure 2.3. Hydrological and Meteorological Stations Buildings and Facilities in the Republic of Tajikistan

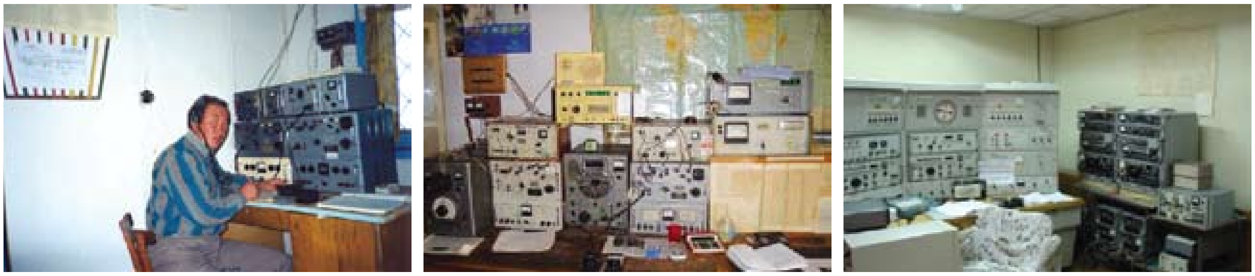

Figure 2.4. Current Communication and Data Transmission Equipment at Meteorological Station (photo 1 and 2 – Kyrgyz Republic), and Message Switching Center (photo 3 – Central Office of Turkmenhydromet

Figure 2.5. Data Archive in Kyrgyzhydromet Central Office and Data Records from Observation Sites

CHAPTER 3 ASSESSMENT OF USER NEEDS IN HYDROMETEOROLOGICAL INFORMATION

3.1 APPROACHES TO NEEDS ASSESSMENT

When preparing their modernization programs, NMSs have traditionally focused on the technological aspects of hydrometeorological service development. Such an approach aims to improve forecast accuracy and timeliness. Inadequate interaction with users, however, usually prevents NMSs from taking into account actual and especially potential user information needs. A complete absence or underdevelopment of contacts with users at the modernization package development stage results in a gap between the opportunities and plans for hydrometeorological service provision and the understanding of what, how, and where NMSs' information can be used most effectively to support management and operational decisions in specific sectors of the economy.

This lack of attention to end users' current and potential understanding of benefits from better hydrometeorological services during an NMS's modernization may further increase information misalignment between a hydrometeorological service and its users. To avoid this, it is essential for NMSs to build their interaction with users on the basis of modern principles, taking into account users' interest in NMS development and demonstrating to them both their own and national benefits, including the economic ones.

There are several key factors, which determine the priority, scale, and sequence of activities to modernize the National Hydrometeorological Service and to improve its institutional structure. These include assessment and recognition of the current status and trends in the needs for hydrometeorological information for governmental institutions, users in major producing and nonproducing sectors of the economy, and the population.

The objectives and expected results of user needs assessment are to (i) identify the causes and factors of poor interaction between the NMS and its users; (ii) recommend to the NMS the most efficient way to cooperate with users; and (iii) propose to users how to integrate and apply hydrometeorological information and formulate their needs for it.

In each of the three countries, user needs for hydrometeorological information were assessed in two stages:

First, NMS experts identified the NMS development priorities, proceeding from the analysis of its current conditions, user needs (as perceived by the NMS), and knowledge of opportunities provided by modern hydrometeorology. This survey was based on the questionnaire developed during preparation of the National Hydrometeorological Modernization Project in Russia (2003-2004)[1] and further tailored to estimate

[1] Tsirkunov, V., M. Smetanina, A. Korshunov, and S. Ulatov. 2004.

the economic benefits from the improved quality of hydrometeorological services following the modernization of national meteorological services in ECA region (2005-2007).[2]

Second, the key users' needs in hydrometeorological services were assessed in order to prepare recommendations on building NMSs' capacity to provide synoptic meteorological and hydrological services and information, as well as hydrometeorological hazard and disaster warnings to the national government, economy, and population. The assessment targeted the most significant (in terms of GDP share) industries and sectors that are vulnerable to EHHs and HHs.

The user needs assessment was based on a special checklist (World Bank, 2008b) developed using WMO materials, World Bank earlier studies, and the Questionnaire on Assessment of User Needs in Hydro-Meteorological Information previously used for a survey conducted with the assistance of the regional project, *Swiss Support to NMHS in the Aral Sea Basin* (Tajikhydromet, 2008).

The checklist used to assess the needs of specific weather-dependent sectors included the following substantive survey blocks:

- HH influence by impact (type and degree) and damage significance (one-time and total);
- Relevance of forecast products and barriers to their uses;
- Hydrometeorological information (HMI) sources, types, and delivery channels and formats;
- Quality assessment of delivered forecast products;
- Requirements of NMS products formulated with due regard for NMS modernization;
- Assessment of and methodologies for estimating economic damage from EHHs and HHs; and
- Recommendations and proposals to the NMS to improve and customize hydrometeorological services.

The results of the sector expert survey may be divided into two major groups:

- General information on the sector's dependence on weather conditions and hydrometeorological hazards, on the amount and quality of HMI used by the sector, and on the current efficacy of HMI uses; and
- Information on the potential demand for various information types and presentation formats, accuracy and timeliness of each hydrometeorological element/event forecast required for sector operations, HMI requirements necessary for optimal performance, as well as recommendations and proposals on hydrometeorological service improvement and customization.

[2] World Bank. 2008c.

3.2 COMPARATIVE EVALUATION OF SECTOR NEEDS AND NMS CAPACITY

The results of the survey, consultations with NMS staff and sector experts, and discussion of HMI needs of weather-dependent sectors of each of the three economies were discussed at country-level consultation workshops on improving the efficacy of weather and climate service delivery (Table 3.1). Each of the workshops demonstrated that the pressing issue of hydrometeorological service improvement was well understood by both the NMS (the provider of products and services) and all key users and stakeholders.

Table 3.1. Comparative Assessment of User Needs for Weather, Climate, and Water-related Information

Sector	Kyrgyz Republic	Republic of Tajikistan	Turkmenistan
Emergencies	Weather forecasts up to 15 days, long term forecasts (4-6 months), climate outlooks, emergency forecasts and warnings	Weather forecasts up to 5 days Emergency forecasts and warnings	Weather forecasts up to 7 days, hydrological forecasts up to 10 days, monthly forecasts
Agriculture and water resources	Weather and hydrological forecasts up to 5 days or longer, daily standard meteorological data, emergency forecasts and warnings for water management and crop protection, seasonal forecasts for crop management	Weather and hydrological forecasts up to 5 days Emergency forecasts and warnings Weather forecasts for the paths of cattle drive	Weather forecasts up to 15 days Long range forecasts (up to 4-6 months) Climate outlooks for 1-month and 1-year periods Emergency forecasts and warnings Agriculture-specific products related to crops
Transport	Impact forecasts and weather forecasts up to 15 days, daily standard meteorological data Emergency forecasts and warnings,	Stream-flow forecasts	Impact forecasts and weather forecasts up to 10 days, daily standard meteorological data Emergency forecasts and warnings
Energy and power	Weather forecasts up to 15 days, long-term forecasts (4-6 months), climate outlooks, emergency forecasts and warnings	Stream-flow forecasts Weather forecasts up to 5 days Emergency forecasts and warnings	Very short-range forecasts Weather forecasts up to 3 days Emergency forecasts and warnings Climate predictions of water availability 2-3 years ahead
Media	Communication channel for weather, climate and water information used by several sectors	Weather forecasts up to 5 days Emergency forecasts and warnings	Communication channel for weather, climate, and water information used by several sectors
Planning, public services		Climate data Emergency warnings and emergency monthly forecasts	Climate data Emergency warnings and emergency monthly forecasts
Health	Climate data	Climate data Health-related forecasts	Climate data
Heating	1-3 day forecasts, current data, seasonal and longer term forecasts and analyses		1-3 day forecasts, current data, seasonal and longer term forecasts and analyses

Many users need information that the NMSs cannot provide at present. Users are well informed that the NMS has serious weaknesses, such as (i) a low-density network of weather and gauging stations resulting in inadequate coverage of the high-altitude zone by meteorological observations; (ii) an almost complete absence of automated technical facilities, weather radars, modern technologies, and means for remote data processing and telecommunication; and (iii) critical conditions of facilities and data archive.

The situation has a negative impact on the quality of observation data and forecasts (especially forecasts of hydrometeorological disasters), the efficiency with which public, sector-specific, and user needs can be met, and the fulfillment of each country's international and regional obligations, including those under the Global Observation System.

All sector experts indicated that prognostic and other information products provided by NMHS were highly relevant for the timely management of decision making on protective actions and for optimal performance both for the sectors as a whole and their core activities. The experts noted that the use of hydrometeorological forecast of an appropriate quality and with an appropriate lead time would be an important means of improving their day-to-day operations and long-term planning.

The experts also formulated and specified their requirements for hydrometeorological information (hydrometeorological elements and types of observations) necessary for optimal performance, as well as recommendations and proposals to the NMSs, so that they can improve and customize hydrometeorological services. Some noted the need to demonstrate the significance of an efficient use of hydrometeorological information and forecast to obtain additional economic benefits, to conduct targeted advisory activities, and to improve communication with users.

Joint advisory and training workshops on the use of new hydrometeorological information and forecasts are expected to be organized through the establishment of training centers. They would support workshops that could provide for exchange of experience and develop common requirements for new types of information products, forecast accuracy and lead time, information presentation formats, etc., which would allow for structuring relations between NMS staff and users on the basis of new principles.

The sector experts, therefore, confirmed the need for NMS radical refurbishment, for introduction of modern, automated, and distance observation methods and data collection/processing systems, and for provision of customized hydrometeorological forecast and services to users in the key weather-dependent sectors of the economy. The experts noted not only their interest in NMS development and modernization but also their preparedness for higher quality forecast and new types of information products developed on the basis of modern HMI presentation technologies and accessibility of data and information products. Some expressed sectoral readiness to provide compensation to their respective NMS for customized or tailor-made hydrometeorological data and information; other sectoral experts were categorically against compensation to the NMS.

Nonetheless, the sector experts emphasized that significant economic losses resulted from inadequate interaction between the NMSs and key HMI users, which related to the fact that the NMSs had no technical or technological capacity to provide requisite hydrometeorological information and forecast, especially on the regional level. NMS modernization, therefore, was a critical and topical issue.

They also noted the importance of involving experts from a number of ministries and agencies in determining user needs for hydrometeorological information and services and in assessing the benefits of the work for NMS and their users. The work should continue with a view to estimating the optimal level of budget funding required to minimize economic losses and should identify the most efficient investments.

CHAPTER 4 ECONOMIC BENEFITS OF IMPROVED HYDROMETEOROLOGICAL SERVICE DELIVERY

4.1 OBJECTIVES, SCOPE, AND APPROACHES OF ECONOMIC ASSESSMENT

The economic assessment carried out under this study sought to estimate the potential aggregate benefits that accrue to national business activities from the improved quality (accuracy and timeliness) of the hydrometeorological information and services delivered by the NMS following its modernization. The benefits associated with the economic value of hydrometeorological information for the household sector and the improvement of human life and safety were not assessed.

The assessment approaches envisage generalization and calculation of country-wide losses from EHHs and HHs and estimation of possible variation of the share and absolute amount of incremental effects (benefits in terms of potentially avoided losses) due to more accurate and timely hydrometeorological information and forecasts as a result of modernization program. It was assumed that benefits of modernization would be realized within seven years (implementation of the program and minimum effective operation of the new technologies, hardware, and equipment, as well as the NMS fixed assets at the post-implementation stage). The potential returns on modernization investments, therefore, were calculated by comparing an aggregate amount of incremental benefits during the seven-year period and the program's costs.

There are a number of complexities in the assessment of economic benefits for the countries under review similar to that observed in the other ECA region countries where the team has undertaken economic review of weather-related damages. The main concern is the absence of systematic recording of damage/ losses (both in physical and value terms) incurred by the economy, its sectors, and population from the entire range of EHHs and HHs. Thus it was necessary to apply several complementary approaches to validate the data and ensure the integrity of the results.

4.2 METHODS OF ECONOMIC ASSESSMENT

4.2.1 Benchmarking method

When preparing information for the assessment of economic benefits, no statistical data on the value of damage caused by hydrometeorological hazards was available from the official sources of statistics (at the national level, in the ministries, agencies, and in NMSs). In order to obtain the corresponding information, special consultations with NMSs specialists and experts of the weather-dependent sectors were conducted.

The initial assessment of economic benefits was based on the benchmarking method developed in the course of the regional review of the ECA national hydrometeorological services. This review was carried out in 2005-2007 by the World Bank for the countries of Southern Caucasus (Azerbaijan, Armenia, Georgia), some Balkan countries (Albania and Serbia), as well as for the Republic of Belarus, the Ukraine, and Kazakhstan. Most of these countries do not record data on the actual total and sector-specific economic losses caused by hydrometeorological hazards and unfavorable weather conditions.

Benchmarking was developed to estimate economic benefits from the use of hydrometeorological information and services for the national economy. The assessment was based on (i) available national official macroeconomic and sector-specific statistics; (ii) weather-dependence of the economy; (iii) vulnerability of the country's territory to weather hazards;[3] (iv) the NMS status and the quality of hydrometeorological service provision in a given surveyed country; and (v) the values of the key parameters obtained through the surveys of experts and studies carried out in other countries.

Benchmarking is a simplified method, and it does not require detailed analytical studies or time-consuming surveys. Despite the limitations in the application of this method, its findings provide a reasonable estimate to identify the levels of direct economic losses from weather hazards and disasters, as well as the economic benefits from the use of hydrometeorological information in a specific country. (A detailed description of the benchmarking approach, including its main assumptions and limitations, is given in V. Tsirkunov et al., 2006).

Benchmarking comprises a staged approach:

The first stage defines the average values of two key parameters, which are adjusted against the GDP of the country. These key parameters are

- **The level of annual direct economic losses** caused by hydrometeorological hazards as a share of GDP;
- **The level of annual prevented losses** (i.e., losses that are potentially avoided due to the use of improved weather forecasts and warnings, as a result of modernization) expressed as a percentage of the total losses.

In the second stage, the benchmarks are adjusted following assessment of the key country-specific parameters (weather and climate conditions, structure of economy, NMS status, and so on).

In the final stage, the estimates obtained for a country are used for calculating the marginal efficacy of the potential improvement of hydrometeorological services following the proposed modernization program.

4.2.2 Sector-specific assessment

The assessment of the economic efficacy of the NMS modernization is based on comparing the amount of potentially preventable losses with the required expenditures on the prevention of these losses and planned expenditures on the modernization of an NMS. With this approach, the economic efficacy the

[3] The vulnerability of each territory to weather hazards was assessed as a function of the observed extreme and threshold values of major meteorological parameters, among which temperature (minimum and maximum), precipitation, and wind were considered with characteristics of their statistical distributions.

NMS modernization is calculated as a ratio of the potential effect of the planned expenditures on the modernization. The potential effect is expressed as the additional prevented losses from weather hazards expected due to the improved timeliness and quality of forecasts and warnings with the deduction of expenditures needed to produce these forecasts and warnings.

This assessment method is based on sector studies for the most important (as a share of GDP) weather-dependant sectors of the national economy. The sector studies calculate the following two key parameters: (More details on the method assumptions and sample questionnaires can be found in Tsirkunov, et al., 2006.)

- The potential preventable losses as percentage of the total losses, which could be avoided through modernization (multiplication of two ratios: ***Ri·Si***), where ***Ri*** is a percentage of the possible preventable losses with the current quality of hydrometeorological forecasts (i.e., prior to modernization), and ***Si*** is the percentage of the possible preventable losses that would accrue due to improved hydrometeorological services;

- Percentage of the changes in the level of expenditures on preventive (protective) measures as a result of more accurate and timely hydrometeorological information and services (***Δi***).

The findings of the sector experts' assessments can be divided into two main groups: (i) general information concerning the scope and quality of the hydrometeorological information used, as well as the level of the losses incurred due to weather hazards, and (ii) assessment of the key ratios (key parameters) required to assess the economic benefits from the NMS modernization.

The key parameters are assessed in two stages:

- The first stage includes an expert assessment of these parameters for specific sectors. As the basic parameters (***Ri*** and ***Si***) are determined using expert assessments, it would be expedient to perform a scenario analysis, that is, to use a few (rather than one) values of a coefficient within a certain range. The extreme values of the coefficients shall be used for the best and worst (most unlikely) cases and the mean value shall be used for the base (most likely) case.

- At the second stage, the base case mean estimate is used to calculate the mean values of basic coefficients required for a comprehensive assessment of the economic efficacy of the NMS modernization.

On the basis of statistical data or expert assessments of economic losses from weather, the mean values of basic coefficients, the potential effect, and economic efficacy of the NMS modernization are calculated respectively.

4.3 SUMMARY OF THE KEY ECONOMIC FINDINGS

Assessment of the economic benefits from improved weather service delivery to the economies and populations of the Kyrgyz Republic and the Republic of Tajikistan as a result of NMS modernization used three methods: "meteorological risk assessment," "method of sector-specific assessment," and "benchmarking approach." For Turkmenistan, initially the sector-specific assessment and benchmarking approach were tested. It became apparent later that baseline macroeconomic data for Turkmenistan are not sufficiently reliable to make quantitative economic assessment. The lack of regular records of economic losses and damage (both in physical and value terms) caused by the complete spectrum of hydrometeorological phenomena was the main challenge in the economic assessment in all countries.

All assessments indicated that significant economic benefits could be realized from the use of improved hydrometeorological information and services. The investments in the NMS modernization would yield significant benefits with relatively high potential returns on investments.

The results of the benchmarking studies, meteorological risk assessments (in parentheses), and sector-specific assessments (marked with *) where available are summarized in Table 4.1. The benchmarking studies provide a lower bound on losses and the sector-specific assessments or meteorological risk assessments provide an upper bound.

Table 4.1. Comparative Results of Economic Assessments Using the Methods of Benchmarking, Sector-specific Assessments and Meteorological Risk

	Kyrgyz Republic	Republic of Tajikistan	Turkmenistan[1]
Average annual losses incurred caused by weather hazards (US$ million)	24.9 (27.3) 39.6*	24.9 (29.8) 37.0*	42.0
Average annual losses incurred (% of GDP)	1.0 (1.1) 1.5*	1.04 (1.3) 1.6*	0.57
Average annual preventable losses (US$ million)	10.1	5.8	23.0
Average expected annual incremental benefits due to improvement of hydrometeorological information and services (US$ million)	2.9 /(3.8*)	1.7 /(3.1*)	17.7
Investment efficacy (% across 7 years)	244 /(318*)	199 /(357*)	413
[1]Results for Turkmenistan are indicative due to lack of reliable macroeconomic indicators			

4.3.1 Kyrgyz Republic

Based on Table 4.1, the potential annual economic benefits from the implementation of the proposed Modernization Program for Kyrgyzhydromet (cost estimated at US$8.3 million) range from US$2.9 million ("benchmarking" assessment) to US$3.8 million (upper bound of "sector-specific" assessment) per year. Assuming that this annual economic effect is sustainable, within seven years of implementation the total benefits of program implementation will range from US$21 million to US$27 million. Economic efficacy of investments in program implementation will vary from 244 percent to 318 percent or, in other words, each dollar spent on Kyrgyzhydromet modernization may yield at least US$2.4-3.2 of revenues as a result of avoided damage.

Sector-specific assessments conducted for selected economic sectors (agriculture, water resource management, and electricity production, which together produce about 3/4 of the GDP generated by key weather-dependant economic activities of Kyrgyz economy), based on experts' data and assumptions, showed that aggregated annual benefits for those segments of the economy in total could be in the range of US$0.6-1.2 million. Cost-benefit analysis, using data on average annual losses obtained by sector-specific assessments, also supported the economic feasibility of the program implementation. The cost-benefit ratio was 2.1, and discounted payback period was estimated as 4.4 years.

4.3.2 Republic of Tajikistan

The results of the benchmarking assessment for the Republic of Tajikistan showed that the total average annual amount of direct damage associated with hydrometeorological hazards is not less than US$24.9 million (1.04 percent of the average annual GDP in 2000-2007). Economic assessments of the impact of meteorological risks of major weather hazards on the national economy were performed on the basis of available information on the average annual recurrence and damage per event (for mudflows, floods, avalanches, rainstorms, hail, windstorms, snowfalls, droughts, and frosts). The resulting average annual weather-related economic damage was estimated to be TJS 98 million, or US$30 million (1.3 percent of the average annual GDP in 2000-2007). According to the sector-specific assessment using official data from Committee of Emergency Situations and estimates of potential indirect losses, average annual economic losses from EHHs and HHs were evaluated in TJS 122 million, or US$37 million (1.6 percent of GDP).

Potential annual economic benefits from the implementation of the proposed Modernization Program for Tajikhydromet (estimated cost of US$6.1 million) range from US$1.7 million ("benchmarking" assessment) to US$3.1 million (upper bound of "sector-specific" assessment) per year. Assuming that this annual economic effect is sustainable, within seven years of implementation the total benefits of program implementation will range from US$12 million to US$22 million. Economic efficacy of investments in program implementation will vary from 200 percent to 357 percent or, in other words, each dollar spent on Tajikhydromet modernization may yield at least US$2.0-3.6 of benefits as a result of avoided damage. Sector-specific assessments conducted for selected economic sectors (transport, agriculture, irrigation and water supply, and electricity production, which together produce about 2/3 of the GDP generated by key weather-dependant economic activities of the Republic's economy), based on experts' data and assumptions, showed that aggregated annual benefits for those segments of the economy in total could be in the range of US$1.9-2.6 million. Cost-benefit analysis, using data on average annual losses obtained by sector-specific assessments, also supported the economic feasibility of program implementation. The cost-benefit ratio was 2.2, and discounted payback period was estimated as five years.

4.3.3 Turkmenistan

The results of the benchmarking assessments of hydrometeorological services provided by the Turkmenhydromet indicate that the Turkmenistan economy currently loses annually on average US$42 million. Annual incremental benefits for the national economy that would result from a US$30 million upgrade and development of the Turkmenhydromet may amount to US$18 million. It was impossible to undertake a sector-specific assessment for Turkmenistan due to lack of reliable macroeconomic indicators and lack of data on sectoral losses.

The above estimates for all three countries do not take into account incremental socioeconomic benefits associated with better performance by the household sector, increases of production, or better business opportunities. The obtained values, therefore, may be considered a "lower bound:" actual economic benefits may be much larger.

In the absence of systematic registration of economic losses suffered by the economies and populations of the Kyrgyz Republic, Republic of Tajikistan, and Turkmenistan from the entire range of hazardous hydrometeorological phenomena, the following would be desirable:

- Intensify efforts to develop and improve sector-specific methodologies for calculating economic benefits from (economic efficiency of) the use of hydrometeorological information and systematization of collected data on economic losses both from specific weather hazards across the national economy ("natural" integration of losses) and on a sector-specific basis ("sectoral" integration of losses through the summation of sector-specific losses caused by all types of HH).

- Elaborate basic principles and mechanisms of interaction with entities in major weather-dependent sectors in order to develop and improve the range of standard and specialized hydrometeorological products and services promoting, and thereafter grounding on the estimates of weather hazards related damage (losses), potentially preventable due to the use of the improved hydrometeorological information in specific sectors.

- Conduct expert assessments of NMS modernization efficacy for specific regions and the most significant weather-dependent sectors in the regions, taking into account the country's diversity of regional climatic and economic conditions.

CHAPTER 5 HOW TO IMPROVE WEATHER, CLIMATE, AND HYDROLOGICAL SERVICE DELIVERY IN CENTRAL ASIA

5.1 POTENTIAL DIRECTIONS FOR IMPROVEMENT

The reviews of the observational networks and other hydrometeorological infrastructure (telecommunication systems, weather forecasting facilities, warning systems for hazardous weather events) have shown that the current conditions of hydrometeorological services in the three countries under review do not meet modern requirements. These substandard conditions have led to a continual decline in the efficacy of services provided to their governments and to their economic sectors and entities, as well as a deterioration in their ability to fulfill international and regional obligations, including those under the WMO Global Observing System.

A mechanism to properly identify user needs and find adequate ways to meet them has not been established. There are no regular user-focused activities encouraging stakeholders to utilize weather, agrometeorological, and hydrological forecasts, and only a very basic set of information products is available. The quality of services delivered to national and regional users is not satisfactory: the NMSs do not have the technologies and skills required to produce information and information products and to communicate them from the NMS to users.

In the context of broad-scale international efforts to study climate change and adaptation, the assessment of contemporary climate should be an integral part of NMSs' activities, since the NMSs are the government institutions that hold archives of long-term climate information.

The key objectives of the NMS modernization program are to reduce both the risk to life and the economic damage caused by weather and climate-related events and to fulfill regional and international obligations. The assessment of water resources within the region is critical. This requires improving the interaction and cooperation between NMSs and users of hydrometeorological information and information products. It also requires strengthening the technical and technological basis of each NMS and retaining their capabilities by sustaining their institutions, staff, and financial support. Recommendations for NMS modernization programs are based on the evaluation of their current status made by a team of international experts in close consultation with each NMS management team. These programs and recommendations were discussed and supported by stakeholders at national consultation workshops.

5.2 NATIONAL NMS MODERNIZATION PROGRAMS

Several modernization options were developed for each NMS based on various improvement outcomes and on potential availability of funds for modernization and sustainability of investments. Basic modernization options are estimated to cost approximately US$6.1 million, US$8.3 million and US$30 million for Tajikhydromet, Kyrgyzhydromet, and Turkmenhydromet, respectively. The greater scope of the investment program proposed for Turkmenhydromet reflects the greater deterioration of existing NMS infrastructure, which needs urgent replacement, and the potential availability of national funds both for modernization and future maintenance.

All modernization programs were structured as investment projects with similar sets of activities or components. There are three main components in all modernization programs: (A) Technical Design of the Modernized System; (B) Improvement of the System of Hydrometeorological Monitoring to Provide Timely Warnings of Extreme and Hazardous Weather Events and to Manage Water Resources, and (C) Institutional Strengthening and Capacity Building of NMS. The main activities proposed in the modernization programs are presented in Annex II; a more detailed list and description of activities can be found in the three national reports.

Component A. The level of detail provided in the proposed modernization options is comparable with the prefeasibility study. More detailed work on the technical design of the hydrometeorological monitoring and telecommunication system is needed, which ideally should be based on the overall concept for NMS development approved by the government. Technical solutions should be based on a comprehensive review of NMS and the existing international experience gained in establishing such systems, which are adapted to the particular circumstances and capabilities of each country to ensure a sustainable solution. Technical specifications and main tender documents for procurement should be developed under this component to ensure compatibility of all technical devices and systems. In this component, it is crucial to develop the following:

- A detailed concept of NMS development;
- Technical design of the hydrometeorological monitoring and telecommunication system;
- Technical specifications and main tender documents; and
- Specific performance indicators and their monitoring system.

Component B. The main objective of this component is to restore performance of basic observation, communication, and IT networks, which are the backbone of modern NMS. Improving the system of hydrometeorological monitoring will enable the NMS to provide timely warnings to agencies responsible for reducing and preventing damage to the economy and population caused by natural weather events. Mitigation of weather consequences and better emergency preparedness is an important component of any modernization program. Improvement of the hydrological observing and forecasting systems is also essential for efficient national water resources management and for fulfillment of country’s obligations under international agreements. The following are the main activities proposed for this component:

- Restoration and technical upgrade of the meteorological and hydrological observing networks;
- Strengthen the information technology base of the NMSs;
- Upgrade meteorological data receiving systems; and
- Provide modern computer technologies for processing, forecasting, and presentation of information.

Component C. The main purpose of this component is to provide institutional strengthening and capacity building to enhance service delivery and to provide staff training and professional upgrading. The following are the main activities proposed for this component:

- Improve the capacity to understand and interact effectively with stakeholders using staff trained appropriately;
- Provide continuous engagement of stakeholders through frequent meetings and workshops to understand the changing needs of users;
- Establish a customer advisory body, which includes representatives of all stakeholders;
- Offer easily accessible products through the web and other media;
- Provide well-defined service agreements between the NMS and each customer;
- Pay special attention to key user groups; and
- Focus on introducing specific climate services.

Operating and maintenance costs. Preliminary assessment of operation and maintenance costs for the proposed modernization programs were estimated for three national programs. In all cases proposed modernizations will increase the operational costs, which are necessary to ensure efficiency of observational networks, data collection, and processing centers. Commitments of the national governments to meet the costs of adequate operation and maintenance will be one of criteria to mobilize and provide donor support for hydromet strengthening.

Performance indicators. Implementation of the proposed NMS modernization programs will lead to substantial improvement in performance and better service delivery. After completion of NMS modernization, the following minimum performance indicators should be achieved. More specific verifiable sets of performance indicators and their monitoring procedures will be developed for each national programs as part of Component A activities.

- Improve accuracy of main meteorological and hydrological measurements; increase forecast accuracy by 6-8 percent for 24 hours lead time and by 15 percent for 3-7 day lead time.
- At least ten-fold increase in volume of data received from various sources of meteorological information.

- Achieve a 90 percent level of timely collection and transmission of data from observation stations and improved data communication within NMS.
- Increase accuracy of flow measurements in main national river basins.
- Transfer to improved model of NMS functioning, including strengthening its institutional and technical base, introduction of new techniques, and improvement of staff qualification.
- Strengthen financial status of NMS and increase sustainability of operations.

5.3 SERVICES

The blending of social, economic, and environmental information is central to sound planning and decision making. Timely and accurate weather, climate, and water information and forecasts have many applications, but the utility of these services is poorly understood, resulting in low demand and lack of investment. It is very important, therefore, that the NMSs demonstrate tangible benefits. The task for the NMHS is to understand the user needs for weather, climate, and water information and to create a demand for them. Most of the value of weather, climate, and water information added or lost in the so-called value chain between weather and its impact occurs (i) in communicating the information to users, (ii) in the behavior of users in response to that information, and (iii) ultimately in the effect of their decisions on the societal or economic outcome. If the user cannot make changes or if there is no effect on the outcome, the information has no direct value.

There are three areas where value could be increased: (i) improve the forecast or analysis, (ii) improve communication, or (iii) improve the decision process. The modernization of observing systems will go far to improve forecasts and analyses. Improving communication and decision processes, however, requires the development of a new way of thinking about services.

Improving decision outcomes depends on cooperation between the provider and user of weather, climate, and water information to combine this information with vulnerability assessments and with plans for specific responses. Value is added by increasing the speed with which this information is available and analyzed.

Increasingly weather, climate, and water services are viewed as a collaborative enterprise between producers and users. This collaboration ensures value is added where needed and that environmental information is properly considered and acted upon by users.

The China Meteorological Agency (CMA) has pioneered a practical approach to achieving collaboration by developing a Public Service Platform for fast, efficient, and unified meteorological service delivery. CMA has used this approach to strengthen collaboration with many other organizations, including Ministries of Agriculture, Health, Transportation, Environmental Protection, Land Resources, and Information Technology, as well as Administrations of Forestry and Tourism. The aim is to realize tangible and quantifiable benefits for the community by exploiting new operating partnerships between user and provider to share responsibility for effective delivery of services. This has included the development of new tools and methods to strengthen dialog and collaboration between provider and user, especially the implementation of more interactive early warning systems integrated into every level of governance from the community level to the national infrastructure.

By separating the service platform from product delivery, emphasis is placed on information sharing, joint information dissemination, joint research and training, and joint product development between the meteorological and hydrological service and the user. In addition to information generated by the NMS, the platform also integrates data from outside partners, both national and international, so that users have access to all relevant information through a single source through which they can work directly.

5.4 REGIONAL COOPERATION

The work undertaken within this GFDRR project is now conceived as a part of a broader regional Hydromet Initiative aimed at NMS strengthening in Central Asia. WMO, ISDR, World Bank, and other development agencies will support this initiative. Geographical, climatic, transboundary, economic, and social considerations create a need for greater regional cooperation among the Central Asia countries. National programs proposed by this study should be viewed as the most urgent investment and capacity-building programs to improve hydromet service delivery. These programs will work better if complemented by and embedded in a broader regional framework program. It is hoped that additional regional activities will be designed with existing and planned national modernization programs in mind. Regional cooperation may significantly reduce the total costs of investments necessary to provide reliable services for the region, particularly for basic weather forecasts (collecting upper air data), nowcasting (radars), and climate information and services.

Opportunities for greater regional cooperation exist in Central Asia. This is in part because of the growing capacity of both the Russian Federation and China to provide advanced weather, climate, and water information and due to their adoption of modern methods in service delivery.

Establishing a regional approach to training for all Central Asia countries would be efficient and cost effective. Such a regional training program should also include cross-sectoral training between the providers and users of weather, climate, and water information, as suggested in the development of the service platform and in response to the requests from many different user representatives in each of the three countries.

Directions to be discussed with participating NMSs and donor agencies in Central Asia include (i) creation of regional numerical weather forecast capability, (ii) establishment of centers or facilities for specialized support, such as regional drought monitoring, regional calibration, and meteorological support, and (iii) technical and operational support (O&M).

5.5 SUMMARY OF NEXT STEPS

Preliminary results of the study were presented to government stakeholders at the consultation workshops in all three countries. It is expected that governments will support the action plan for improvement of weather, climate, and hydrological services delivery elaborated further in national reports and in this summary report. Financing of the action plans will likely combine governmental funds, concessional financing from international financial institutions (IFIs), plus international and bilateral donors' support.

Plans call for results of this GFDRR work to become an integral part of a broader Central Asia (and Caucasus) Regional Economic Cooperation Initiative on Disaster Risk Management (CAREC DRMI), which aims to reduce the vulnerability of Central Asia and Caucasus countries to the risks of disasters. The CAC DRMI incorporates three focus areas: (i) coordination of disaster mitigation, preparedness, and response; (ii) financing of disaster losses, reconstruction and recovery, and disaster risk transfer instruments, such as catastrophe insurance and weather derivatives; and (iii) hydrometeorological forecasting, data sharing, and early warning.

The World Bank, the UN International Strategy for Disaster Reduction (UN/ISDR) Secretariat, and (for hydrometeorology) the World Meteorological Organization (WMO), under the CAREC umbrella, would coordinate the initiative. It will build on the cooperation that already exists in the region and will complement and consolidate activities of the IFIs, EU, Council of Europe, UN agencies, regional cooperation institutions, bilateral donors, such as the Swiss Agency for Development and Cooperation (SDC), Japan International Cooperation Agency (JICA), and others to promote more effective disaster mitigation, preparedness, and response.

In November 2009, the main results of this GFDRR work was reported at a regional Central Asia workshop (supported by ISDR, WMO, EC, and World Bank) aimed to improve hydrometeorological services and early warning systems. This workshop served as a forum for all CA NMS to confirm and specify their commitments towards regional cooperation and launched a regional hydromet support initiative to facilitate regional cooperation among donors.

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APPENDIX I. MAIN GEOPHYSICAL AND HYDROMETEOROLOGICAL CHARACTERISTICS

1. KYRGYZSTAN

Northern and northwestern Kyrgyzstan, which includes Chuisk and Talas Valleys with surrounding mountain ridges, is noted for a moderately warm and sufficiently moist climate with maximum precipitation in spring and early summer and moderate amount of winter precipitation. The second half of summer in the valleys is dry.

Northeastern Kyrgyzstan includes Issyk Kul hollow. Maximum amount of precipitation in summer and insignificant amount in winter are typical for this region. Due to the presence of the ice-free, sub-saline Lake Issyk Kul located in the lower part of the hollow, the climate in this region is close to a marine one. The water body of Lake Issyk Kul tends to decrease air temperature in winter, though in summer this influence is almost negligible.

Southwestern Kyrgyzstan includes Fergana, Alai, and Chatkal Valleys with surrounding mountain ridges. This is the warmest and most moist area with considerable amount of winter precipitation. Otherwise the annual precipitation pattern is similar to the northwest region: maximum precipitation occurs in spring in the lower part of the region and shifts toward early summer in the highlands. The second half of summer has small amounts of precipitation with droughts occurring in the lower areas in August and September. This climatic region has the highest air temperatures in the warm season.

Inner Tyan Shan is the coldest and has a semi-arid climate noted for little evaporation at low temperatures. In the highlands, where the amount of atmospheric deposition exceeds evaporation, glaciers and snow patches occupy large areas. The annual precipitation pattern is similar to the southwest climatic region with maximum deposition occurring in May, June, and July.

There are more than 40,000 rivers and streams in the Kyrgyz Republic with a combined length of roughly 150,000 km and draining some 47 cubic km of water a year. The main source of water for the rivers is melt water from numerous glaciers and snowfields in the mountains. The contribution of rainfall amounts to less than one fifth of the water flow. The River Naryn is the longest river in the Republic (535 km in length). Formed by the confluence of the Big and Little Naryn Rivers, just above the town of Naryn, it collects the waters of several large tributaries, such as the At Bashi and Kekemeren, until it flows into the Toktogul Reservoir and then flows south breaking through the Ferghana Range into the Ferghana valley, amassing yet more tributaries until it eventually flows as the Syr Darya into the Aral Sea. The water is used extensively for hydroelectric power generation, flowing into the giant Toktogul reservoir, and for cotton farming in neighboring Uzbekistan.

2. TAJIKISTAN

Wide valleys and plains rising up to 1,000 m contain the main arable farming and cotton growing areas, including the southwestern part of the country, Gissar, Vaksh, Lower Kafirnigan, and Kulyab valleys, as well as the Fergana valley with adjoining flatlands of the Sogd region. In the summer, these valleys and plains are noted for high temperatures associated with a thermal depression. Fair and hot weather predominate in throughout the summer months with the highest temperatures between 43-47°C. The mean monthly temperature in July (the hottest month) is between 28-30°C.

The cold season is characterized by Arctic air intrusions where air temperatures, even in southern areas, can fall to between -24°C and -30°C on some days. Mean monthly temperatures in January are, however, mostly positive, though in some northern areas (Khujand) the average temperature may be below freezing.

Large temperature variations, frequently passing through 0°C, are typical for this zone. Spring frosts in most areas end in late March, and the first autumn frosts occur in the second half of October. The valleys of southwestern Tajikistan have the longest frost-free periods (up to 260 days).

The transitory zone between valleys and highlands (up to 2,500 m) includes the Zeravshan Valley, the mountain areas of Central Tajikistan, and a part of Western Pamir. In summer, fair and dry though cooler weather dominates. Temperatures gradually decreasing with altitude characterize this zone. Orography in particular impacts temperature. In winter months, air temperatures on open slopes and in passes are higher than in the closed depressions where strong cooling occurs. Correlations between concave and convex terrain forms are opposite in summer.

High-altitude areas (above 2500 m) include Central and Eastern Pamir, and mountain ridges. At these altitudes, the diurnal and seasonal temperature variations are high. Eastern Pamir has especially severe climate conditions. Winters are long and cold with mean January temperatures ranging from -14°C to -26°C. The absolute low is -63°C (Bulunkul). Summers are short and cool with the mean air temperature not exceeding 15°C. The absolute maximum temperatures are between 20-34°C. This region has up to 111 frost-free days, but frosts occur daily in the coldest areas.

The distribution of precipitation depends mainly on the location and orientation of mountain ranges and consequently on the air mass circulation. Tajikistan has two distinct humid zones. An arid climate zone encompasses the valley in Western and Northern Tajikistan, piedmonts of the Turkestan Ridge, as well as the vast high-mountain area in the Eastern Pamir with 50-300 mm of precipitation per year. The remainder of the country, referred to as the semi-arid zone, has up to 900 mm of rainfall everywhere except on the upwind southern slopes of the Gissar Ridge where precipitation can exceed 1800 mm per year.

The rivers of Tajikistan are important sources feeding the Aral Sea. They are essential for cotton growing and for the hydropower industry of Central Asia and Tajikistan. There are four main watersheds: Syrdarya River (northern Tajikistan), Zeravshan River (central Tajikistan), Pyanj River (southwestern Tajikistan and the Pamirs), and the basin of saltwater lakes in the Eastern Pamirs. The major rivers of Tajikistan include the Pyanj, Vakhsh, Syrdarya, Zeravshan, Kafirnigan, and Bartang. There are 947 rivers of more than ten km in length, and the total length of rivers is 28,500 km with an average flow of about 56 $km^3 y^{-1}$. Mean annual runoff varies from 1 l $s^{-1}km^{-2}$ in the plains up to 45 l $s^{-1}km^{-2}$ in the mountains. In high-water periods, characterized by intensive snow melting and heavy rains (April-August), many rivers bear a lot of suspended particles (over 5 kg m^{-3}) (State of the Environment Report, Tajikistan, 2002).

3. TURKMENISTAN

Semi-desert climatic zone has a mean annual temperature of 15.6°C. Annual precipitation varies from 180 to 250 mm. Cold season precipitation (85-95 percent of the annual amount) prevails in this zone. The western part of the zone is affected by Atlantic, Black Sea, and Caspian cyclones while the eastern part is usually influenced by southern cyclones (South Caspian, Murghab, and Upper Amu Darya). The central part is subject to the influence of northwestern and northern cold invasions and dry masses of Arctic air.

A high-pressure belt is located over the semi-desert zone during the cold season, which is associated with fair weather and low winds. At the same time, frequent cold air outbreaks cause increased winds and clouds. Average air temperatures in January range from –1.6°C in the west to 1.1°C in the east, short-term temperature drops are possible to –28°C in the east and to –35°C in the north, as well as temperature increases to 12-16°C. In summer where the average July temperature is 31.4°C, temperatures frequently reach 40-45°C. Droughts, hot winds, and dry weather conditions occur frequently in the semi-desert zone.

Desert climatic zone is a desert, which occupies about 80 percent of Turkmenistan's territory. There are three major types of deserts: clay, sandy, and rocky. A highly continental climate and low moisture content characterize the zone. Yearly evaporation rate exceeds precipitation amount by a factor of ten or more and by 20 to 70 times during the three summer months. Mean annual temperature rises up to 16.5°C while the amount of precipitation decreases to 90-130 mm per year.

The zone has a long hot summer and rather cold winter for these latitudes with large annual and daily temperature variations, dry air, and few clouds. January is the coldest winter month with average temperatures ranging from –3.2 to –4.8°C. At the same time, even during the coldest winter months, temperatures can occasionally reach 12-22°C. Cold season precipitation makes up 60-84 percent of the total annual amount. Dust storms usually accompany the passage of cold fronts. Anomalously high summer air temperatures are related to the development of thermal depressions. The warm season is noted for frequent droughts, occurring during hot winds, moderately dry, and dry weather conditions.

High weather instability and variability characterize winter, especially in the northern part of the zone where frequent changes of positive and negative temperatures are observed. Summer in the desert zone is long, hot, and dry with stable weather noted for dryness, dustiness, lack of clouds, and large daily variations of air and soil temperatures. In the daytime, the soil surface may warm up to 78°C while at nights during inversions it can occasionally drop down to 0°C.

Mountain and piedmont areas in Turkmenistan demonstrate a marked vertical variation in climate. The change in vertical climatic zones is similar to that of horizontal zones.

In the cold season, highland areas are exposed to snow avalanches. According to avalanche survey reports produced by Kyrgyzhydromet, about a half (105 thousand km^2) of the overall territory of the Kyrgyz Republic is exposed to the risk of avalanches annually.

APPENDIX II. KEY HYDROMETEOROLOGICAL AND CLIMATE HAZARDS

1. KYRGYZ REPUBLIC

Among EHHs in the Kyrgyz Republic, **mudflows and floods** generated by snow thaw and rainstorms are the most hazardous. They cause significant economic damage by destroying roads, railways, bridges, dams, irrigation facilities, agricultural crops, and livestock, and sometimes cause human losses. In spring and summer the whole territory of Kyrgyzstan is exposed to mudflows and floods. In addition there are 2,000 highland outburst-risk lakes in the Kyrgyz Republic. For 200 of these, the probability of an outburst is high. Outbursts damage not only industry and population but also neighboring countries. For example in 1998, an outburst of the Kurban-Kul highland lake triggered a mud flood on the Shakhimardan River, which flowed through neighboring Uzbekistan, causing human losses. In the Kyrgyz Republic more than 300 settlements are located in areas of probable lake outbursts.

In the cold season, highland areas are exposed to **snow avalanches**. According to avalanche survey reports produced by Kyrgyzhydromet, about a half (105 thousand km^2) of the overall territory of the Kyrgyz Republic is exposed to the risk of avalanches annually. The avalanche season is between five and seven months long. Depending on terrain elevation, however, avalanches can occur at any time. Annually, from 800 to 1500 avalanches of various volumes are recorded. Most of them cannot be surveyed since vast highland areas are inaccessible and unknown. Gigantic avalanches and with a total volume exceeding a million cubic meters are not infrequent events in highland areas.

In terms of harm, **late spring and early fall frosts** have a significant impact on agriculture. While events, such as hail, squall, etc., are local in character, frosts can cover vast territories at a time. Frosts are classed as EHH if air or soil surface temperature drops below 0°C in the growing season over an area covering more than 30 percent of farmland territory. If air or soil surface temperature drops in the growing season over an area covering less than 30 percent of the farmland territory, frosts are classed as HH. The risk of frosts in the warmest regions of Kyrgyzstan, the cotton growing areas, while infrequent can be particularly harmful. Early fall frosts in October are also a problem.

Meteorological and hydrological droughts are becoming more frequent in the Kyrgyz Republic similar to other countries of Central Asia. Meteorological drought refers to a precipitation deficit compared to long-term averages and is specific to location and season. Hydrological drought is a deficit of surface water or surface water supply resulting from precipitation shortfalls. Since farming is mainly irrigated, the next significant risk factor is **low precipitation** and **lack of water** in rivers in the growing season (April-September). Drought is very dangerous, particularly in spring or early summer.

Strong winds affect a limited region but damage houses, power and communication lines, and crops, and they hamper shipping operations.

Precipitation as **hail** damages agricultural crops annually. Infrequent **heavy precipitation** (40-75 mm per day) can occur in winter, damaging houses and buildings (ruining roofs), hampering traffic, and forming avalanche centers. In summer, rainstorms form mudflow centers and causes crust on farmlands and crop lodging.

2. REPUBLIC OF TAJIKISTAN

In the Republic of Tajikistan, hazardous events are associated typically with precipitation in the form of **heavy rains, snowfall, and hail** with most of the emergency situations caused by heavy rains. Heavy precipitation presents the highest hazard by triggering EHHs and other impacts from mudflows, floods, and snow avalanches.

Heavy rains, exceeding 20 mm per half day, cause mudflows. Mudflows make rivers spill over the banks, causing floods for dozens of kilometers. Heavy rainfall, over 30 mm a day, contributes to erosion, causes serious damage to agriculture, and provokes mudflow, landslide events, and floods.

Snowfalls trigger descent of avalanches. Heavy snowfall and avalanches create snowdrifts on the roads resulting in traffic disruption. They also increase loads on roofs of buildings, break fruit and ornamental trees, worsen conditions for feeding animals, and create poor visibility at airports.

Hail frequently damages agriculture. Large hailstones not only damage farmlands and orchards but also kill animals and birds. Starting in 1970s, the number of days with hail in lowland and foothill areas has decreased. In mountainous areas, the occurrence of hail has not changed, and in some areas it has increased. In valleys and piedmont areas, late winter and spring have the highest number of days with heavy precipitation; in highland areas, these occur in summer. Heavy precipitation in areas below 2,000 m contributes to the formation of high **floodwaters and mudflows**, which are observed frequently in the foothills and mountainous areas of Tajikistan. In high-altitude areas, floods can result from breakthroughs in temporary (glacial) lakes. According to data in the Republic of Tajikistan 2002 State of the Environment Report (see Republic of Tajikistan, 2002), mudflows threaten some 85 percent of the Republic's area, and 32 percent of the area is situated in the high mudflow risk zone.

High floodwaters are usually short term but cause huge damage to settlements and to the national economy. Observations during the last 30-40 years show an increase in the number of days with disastrous floods.

Heavy snowfalls occur most frequently in active orographic areas higher than 1,400-1,500 m (above sea level), i.e., in piedmont and mountain regions. **Snow avalanches** occur in areas higher than 1,500-2,000 m. Basic conditions for the formation of avalanches are slopes with a gradient of 30-50°, snow cover of more than 30 cm and relevant meteorological conditions. In the Republic of Tajikistan, the major reason for avalanches is fresh snow formation (60-70 percent). Avalanches normally occur between November and April, and occasionally in May. Avalanches in March are the most hazardous.

Strong winds are often observed in the bottlenecks of valleys (Khudjand). Winds at speeds of 20 ms^{-1} are annually recorded in the Northern Tajikistan and Eastern Pamir. **Dust storms** are distributed unevenly over the country, mainly occurring in the southern deserts and arid regions for one to four months in the spring-summer period. They raise thousands of tons of soil and sand into the air, considerably increasing the concentration of suspended particles in the atmosphere. A lot of farms suffer from these events, which decrease crop productivity.

Extremely high temperatures, greater than or equal to 40°C, occur over the entire plain areas of the country. With increasing maximum temperatures, the number of days with temperature above 40°C increases. Observational data indicate an upward trend of 30 percent in the number of days with temperatures above 40°C in almost all the plains territory.

Drought is one of the severe meteorological phenomena often closely associated with an extended period of high temperatures. Agriculture is most often exposed to hazardous events of which drought is the most important. Local droughts occur in Tajikistan every year. Severe droughts have occurred eight times in the last 60 years. In these years, rain-fed farmlands and winter pastures suffered the most. In contrast in the area of irrigated agriculture, high temperatures facilitated early ripening of fruits and berries. Drought, combined with increasing poverty and decline in productivity of agriculture, aggravates the problem of food security in Tajikistan.

Low temperatures, where the daily mean temperatures are less than or equal to -10°C, are also considered dangerous weather events. These drops cause damage not only to fruit farming and cattle breeding but also to water resources, energy, and transport sectors.

3. TURKMENISTAN

In Turkmenistan, **floods and mudflows** often occur in mountain basins of small rivers, flowing down from southwestern, northwestern, and northeastern slopes. In Turkmenistan rainstorms generate mudflows with intensive snow melting only occasionally the cause. Short destructive floods and mudflows frequently occur in mountain and piedmont areas in spring. Mudflows cause enormous damage to populated areas and economy: they wash out crops, destroy dams and irrigation facilities, take out bridges, and erode unpaved roads, highways, and railways.

Strong winds represent one of the most widespread hazardous weather events in Turkmenistan. The wind is considered strong if wind speed exceeds 15 m/s. Speed equal to 20 m/s is a criterion of a hazardous event, and 30 m/s is a particularly hazardous one. Strong wind damages buildings and industrial facilities, complicates all kinds of traffic, and destroys crops and trees. Strong winds are classified as local and frontal ones. Local winds occur in specific geographical areas; frontal winds occur at the interface of two air masses.

Dust storms usually start at wind speeds of 8-12 m/s, and cause significant deterioration of visibility. Vast masses of sand in the Kara Kum Desert facilitate dust storms all year round.

Drought is a major natural disaster, however, there are no reliable drought forecasts in Turkmenistan. Agricultural meteorology uses various techniques and approaches to identify drought onset. Indices for drought evaluation include the amount of precipitation, air temperature, evaporation rate, and heat balance. Reduced productivity of agricultural crops is an agronomical drought indicator. Since the Kara Kum Desert occupies 80 percent of the country, droughts represent a critical problem for Turkmenistan. Successful operation of cattle-breeding farms directly depends on pasture productivity defined by climate conditions of the territory. In dry years grasslands burn out in the sun, and productivity of pasture vegetation may be reduced by 50-70 percent.

Dry winds complicate atmospheric drought and frequently cause very significant damage to the national economy. For example, a cotton plant exposed to a strong dry wind just once may lose up to 60-80 percent of their blossoms. Weak dry winds annually occur throughout the whole country. Strong dry winds are observed in southeastern, southern, and southwestern areas.

Frosts occur when air or ground temperature falls below 0°C during the growing season against the background of positive daily average air temperatures. Frost information is, above all, required to evaluate an area's frost susceptibility, to calculate the timing for sowing, to decide on the appropriate location for heat-loving crops, and to perform agricultural and climate assessment of agricultural crop growing in spring and autumn seasons. Spring and autumn frosts occur annually in Turkmenistan, creating unfavorable conditions for the growth and development of agricultural crops and often restricting the use of climatic resources in growing season. In some years, frosts cause considerable damage to agriculture, reducing yields in certain areas.

Heavy rainfall of 12 mm and more within less than 12 hours, although infrequent, is considered a hazardous weather event. More than 30 mm of rainfall within the same period is especially hazardous. These events result in mudflow, congested traffic, erosion of roads, flooding of foundation ditches and basements. Long periods of rain may be especially hazardous, causing catastrophic damage to many economic sectors.

Extreme heat, an air temperature exceeding 40°C regardless of duration of occurrence, is hazardous. These conditions can encompass the whole of Turkmenistan's territory except the mountain, far northern and Caspian coast areas. High temperatures cause extensive damage to agriculture, especially cotton and fruit trees. Recurrent heat represents a special risk to the economy. The impact of high temperatures (above 45°C) over several days may reduce cotton productivity by 10-30 percent. The annual number of days with high air temperature (above 45°C) ranges from 14 to 50.

Severe frost, air temperature below -10° C, is hazardous, and persistent cold temperatures below this are especially hazardous. At these temperatures many subtropical crops, such as orange, mandarin, fig, pomegranate, walnut, and grapes die or freeze down to roots. Severe cold (below -25°C) kills animals in pastures. Low temperatures also significantly impede the operation of main gas and oil pipelines, motor and railway transport, and communal facilities.

Heavy snowfalls occur mostly in northern, northeastern, and piedmont areas. Large accumulations followed by abrupt increases in temperature in the spring create the risk of floods and mudflows, causing significant damage to dams, populated areas, agricultural crops, and power lines.

Heavy hail causes considerable damage to agriculture. The amount of damage depends on the size of hailstones, their density, deposition intensity, as well as on the type agricultural crops. Although hail is a rare and short-term event, it may cause enormous damage to the affected area. Hailstones, ranging from 5 to 30 mm, are observed in Turkmenistan. Hailstones of 6-8 mm may damage cotton and vegetable shoots, and those over 10 mm hurt sunflower, corn, and orchards. Hailstones of 30 mm and more cause significant damage to everything outside.

Apart from local dust storms, catastrophic **dust cyclones** occur every 8-15 years, transporting vast amounts of loamy dust from Arabian and Iranian deserts. The amount of dust deposited on the ground after a dust cyclone can be up to 6-30 tons per hectare. Squally winds, hail, and heavy rainstorms usually accompany dust cyclones, causing catastrophic destruction.

APPENDIX III. BASIC NMS MODERNIZATION OPTIONS FOR KYRGYZHYDROMET, TAJIKHYDROMET, AND TURKMENHYDROMET

1. KYRGYZ REPUBLIC

Kyrgyzhydromet: Main Modernization Components and Activities

Main components	Subcomponents and activities	Estimated cost (US$1000)
A. Technical design	Technical design of hydrometeorological monitoring and telecommunication system	500
B. Improve system of hydrometeorological monitoring to provide timely warnings of extreme and hazardous weather events and to manage water resources	B1. Technical upgrading of observational network	4385
	Restoration and technical upgrade of meteorological observational network	1175
	Resume temperature-wind atmosphere sounding	360
	Renew key observation sites of hydrological network and equip operating posts with required additional instruments	1655
	Restore snow avalanche observation network	755
	Establish quality control of hydrometeorological data and products	440
	B2. Strengthen IT base of Kyrgyzhydromet	2380
	Upgrade data collection and communication system	300
	Improve data processing; adjust numerical weather forecast and runoff modeling for Kyrgyzstan	830
	Create data base management system and archives; data digitizing, storage, printing, and dissemination of information products	750
	Provide software and hardware for recognition of information on paper and storage of digitalized paper records	500
C. Institutional strengthening and capacity building	C1. Enhance service delivery	625
	C2. Staff training and professional upgrading	400
	Total cost	8,290

2. REPUBLIC OF TAJIKISTAN

Tajikhydromet: Main Modernization Components and Activities

Main components	Subcomponents and activities	Estimated cost (US$1000)
A. Technical design	**A. Technical design of hydrometeorological monitoring and telecommunication system**	**400**
B. Improve system of hydrometeorological monitoring to provide timely warnings of extreme and hazardous weather events and to manage water resources	**B1. Technical upgrade of observational network**	**3450**
	Technical upgrade of hydrological gauges	950
	Restoration and technical upgrade of meteorological observational network	975
	Introduce automatic snow survey systems	375
	Modernize meteorological radars	800
	Improve quality and reliability of measurements	350
	B2. Strengthen IT base of Tajikhydromet	**1125**
	Introduce modern communication facilities and technologies for data reception and processing	585
	Create data base management system and archives; data digitizing, storage, printing, and dissemination of information products	540
C. Institutional strengthening and capacity building	**C1. Enhance service delivery**	**660**
	C2. Staff training and professional upgrading	**455**
	Total cost	**6,090**

3. TURKMENISTAN

Turkmenhydromet: Main Modernization Components and Activities

Main components	Subcomponents and activities	Estimated cost (US$1000)
A. Technical design	**Technical design of hydrometeorological monitoring and telecommunication system**	**940**
B. Improve system of hydrometeorological monitoring to provide timely warnings of extreme and hazardous weather events and to manage water resources	**B1. Technical upgrade of observational network**	**20,020**
	Surface observing network	5,100
	Upper air sounding systems and meteorological radars	9,590
	Modernize the hydrological network	4,270
	Creation of quality control system for data and hydromet products	860
	B2. Strengthen IT base of Turkmenhydromet	**5,150**
	Refurbish data collection and telecommunication centers; introduce new technologies	2,250
	Archive equipment	2,900
C. Institutional	**C1. Strengthen institutional, legal, and regulatory framework and staff training**	**1,480**
D. strengthening and capacity building	Bring scientific and methodological framework into compliance with WMO guidelines and recommendations	300
	Draft and enforce guidelines on how to conduct observations (including remote sensing), and how to process, store, and submit information	580
	Prepare training, professional development, and staff motivation program; launch its implementation, including procurement of equipment for training center	600
	C2. Enhance Service Delivery	**1,230**
	Study user needs; evaluate efficacy of hydromet service delivery and user training	550
	Develop technologies and procedures for disseminating urgent information on natural disasters, technologies to present weather forecasts on TV, and develop NMS web site	380
	Improve National Climate Service	300
	C3. Improve natural disaster and hazardous hydrometeorological event warning system	**1,180**
	Procure an autonomous emergency hydrometeorological support system and introduce meteorological drop kits	790
	Develop warning procedures and data bases; introduce detailed visualization equipment	390
	Total cost	**30,000**

Special thanks and appreciation are extended to the partners who support GFDRR's work to protect livelihood and improve lives: ACP Secretariat, Australia, Belgium, Brazil, Canada, Denmark, European Commission, Finland, France, Germany, India, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States, UN International Strategy for Disaster Reduction, and the World Bank.

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IMPROVING WEATHER, CLIMATE AND HYDROLOGICAL SERVICES DELIVERY IN CENTRAL ASIA
(KYRGYZ REPUBLIC, REPUBLIC OF TAJIKISTAN AND TURKMENISTAN)

Cover photo: Boomskoye gorge, flood-lands of River Chous in Kyrgystan
(from Kyrgyzhydromet's photomaterials)

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