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

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Table of Contents

PREFACE 4
ACKNOWLEDGEMENTS 5
ABBREVIATIONS AND ACRONYMS 6
EXECUTIVE SUMMARY 7
PURPOSE OF REPORT 7
PRINCIPAL FINDINGS 7
CHAPTER 1. KEY WEATHER AND CLIMATE HAZARDS IN CENTRAL ASIA 9
1.1. MAIN GEOPHYSICAL AND HYDROMETEOROLOGICAL CHARACTERISTICS 9
1.2. WEATHER AND CLIMATE RISKS, THEIR SOCIAL AND ECONOMIC IMPACTS, AND ECONOMIC LOSSES 9
CHAPTER 2 COMPARATIVE ASSESSMENT OF HYDROMETEOROLOGICAL SERVICES CAPACITY IN CENTRAL ASIA 11
CHAPTER 3. ASSESSMENT OF USER NEEDS IN HYDROMETEOROLOGICAL INFORMATION. 14
3.1. APPROACHES TO NEEDS ASSESSMENT 14
3.2. COMPARATIVE EVALUATION OF SECTOR NEEDS AND NMS CAPACITY. 15
CHAPTER 4. ECONOMIC BENEFITS OF IMPROVED HYDROMETEOROLOGICAL SERVICE DELIVERY 17
4.1. OBJECTIVES, SCOPE AND APPROACHES OF ECONOMIC ASSESSMENT 17
4.2. METHODS OF ECONOMIC ASSESSMENT 17
4.2.1. BENCHMARKING METHOD 17
4.2.2. SECTORSPECIFIC ASSESSMENT. 18
4.3. SUMMARY OF THE KEY ECONOMIC FINDINGS. 18
4.3.1. KYRGYZ REPUBLIC 18
4.3.2. REPUBLIC OF TAJIKISTAN. 19
4.3.3. TURKMENISTAN 19
CHAPTER 5. HOW TO IMPROVE WEATHER, CLIMATE AND HYDROLOGICAL SERVICE DELIVERY IN CENTRAL ASIA 21
5.1. POTENTIAL DIRECTIONS FOR IMPROVEMENT. 21
5.2. NATIONAL NMS MODERNIZATION PROGRAMS. 21
5.3. SERVICES. 22
5.4. REGIONAL COOPERATION. 23
5.5. SUMMARY OF NEXT STEPS 23
SELECTED BIBLIOGRAPHY AND SUPPLEMENTAL INFORMATION SOURCES 25
BIBLIOGRAPHY. 25
SUPPLEMENTAL INFORMATION SOURCES 27
APPENDIX I. MAIN GEOPHYSICAL AND HYDROMETEOROLOGICAL CHARACTERISTICS 28
KYRGYZSTAN 28
TAJIKISTAN 28
TURKMENISTAN. 29
APPENDIX II. KEY HYDROMETEOROLOGICAL AND CLIMATE HAZARDS. 30
KYRGYZ REPUBLIC 30
REPUBLIC OF TAJIKISTAN 30
TURKMENISTAN. 31
APPENDIX III. BASIC NMS MODERNIZATION OPTIONS FOR KYZGYZHYDROMET, TAJIKHYDROMET AND TURKMENHYDROMET 33

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 will contribute to the development of a broader Central Asia and Caucasus Regional Economic Cooperation Initiative on Disaster Risk Management (DRMI) which aims at reducing the vulnerability of the countries of Central Asia and Caucasus to the risks of disasters. This Program was recently launched, 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).

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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.

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
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 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 assessments of key weather, climate and hydrological hazards, evaluations of key users' needs, assessment of the National Hydrometeorological Service's (NMS) capacity and the potential economic benefits of the improvement of hydrometeorological service delivery. The results of this GFDRR work and summary report will directly contribute 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, hails, strong winds. Data suggests that on average these events constitute a major part of all economic losses attached natural hazards and vary from 0.4 to 1,3% of GDP per annum for the countries studied. There is a growing need for better quality of weather, water and climate information particularly for early warning and to support disaster reduction strategies in such sectors as agriculture, transport, water resources managements and hydropower generation.

Figure 1.1: Mudflow, Flood and Avalanche related Damages in Kyrgyz Republic

The decline in the capacity and capability of the National Meteorological and Hydrological Services (NMHSs) throughout Central Asia to meet the growing demand for weather, climate and water information and services by society reflects the overall reduction 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.

Simultaneous investment in NMS modernization in these three countries and in the whole Central Asia is also valuable since atmospheric processes are not constrained by political boundaries and understanding how the atmosphere is behaving over the entire region will improve forecasts and outcomes throughout Central Asia as well as in each of the three countries.

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

1. The technical design of hydrometeorological monitoring and telecommunication systems
2. Improving the system of hydrometeorological monitoring to provide timely warnings of extreme disasters and hazardous weather events, to manage water resources, and 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 the implementation of the modernization of the NMSs. It consists of the technical upgrading of the observational networks and the strengthening of the information technology base of the NMSs. The third component focuses on enhancing service delivery and 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 handinhand with building the capacity to deliver the services that users want. This way the value of the technical modernization will be realized as quickly as possible, and the long term sustainability of the NMSs will be 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 programs as an intrinsic part of the technical design component. Involving users of NMSs products and services in the modernization programs in each country is essential in order to develop a more effective provider and user interface for the delivery of services.

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: (a) Disaster Mitigation, Preparedness and Response; (b) Disaster Financing and Risk Transfer; and (c) 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 is important particularly for mitigating weather and climate risks and providing better services for agriculture, water resources management, transport, hydropower generation and other sectors.

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 – regional map). The Kyrgyz Republic is highly droughtprone, but this is offset by heavy precipitation associated with its high relief. More than 70% of the country is above 2000m. 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 semiarid with some desert areas. Over 50% of country's territory lies above 3000 m. Turkmenistan is extremely arid and about 80% of the country is flat desert. (See Country Reports and Annex 1).

1.2. WEATHER AND CLIMATE RISKS, THEIR SOCIAL AND ECONOMIC IMPACTS, AND ECONOMIC LOSSES

A similar, standard classification of hydrometeorological events and unfavorable weather conditions by intensity and impact on the economy and population is used in the Kyrgyz Republic, the Republic of Tajikistan and Turkmenistan.

By these criteria extreme (high impact) hydrometeorological hazards (EHHs), including hydrometeorological disasters, and hydrometeorological hazards (HHs) are identified. Meteorological, agrometeorological and hydrological events are classed as EHHs when, by intensity, territorial coverage (more than 30% 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 whose intensity, duration and territorial coverage do not exceed criteria of EHHs.

All three countries in the region are affected by similar EHHs; 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. They have a high impact because of food security for subsistence farmers as well as the importance of agriculture to the regional economies. In addition all three countries are affected by hail, and strong winds 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
Wind storms	4.5	0.1	8.1	0.8	28.4	0.2
Dust storms	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. by mudflows and floods, strong wind, frosts, drought).

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.

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

Floods and mudslides rank highest in their impact on the economies of all three countries with drought ranked 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 leading 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 NMSs, provide the international meteorological community access to data from the national observational network, and receive information from other countries' NMHSs.

The activities of a NMS are regulated by the laws and resolutions of their respective country. Each of the three countries has developed a legal framework for the provision of meteorological and hydrological services following independence. In each, the laws provide for the provision of public hydrometeorological observing networks, forecasting of hazardous events and provision of information to appropriate governmental bodies. Each country provides for 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, the NMS is governed by a National Committee under the Turkmenistan Cabinet of Ministers. 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 are operating with largely 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, with insufficient qualified staff even 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 of observational networks and other hydrometeorological infrastructure (telecommunications, facilities for forecasting weather conditions for each country, warning systems) of the region's hydrometeorological services, including the outcomes of assistance projects implemented by the donors in support of regional NMHSs have been conducted. They show that the current conditions of the hydrometeorological services fail to meet the needs of their respective governments and the weather and climate-sensitive social and economic sectors for hydrometeorological services. They also show that the NMS in each of the three countries reviewed fails to fulfill the country's international and regional obligations for weather and climate information including those under the World Meteorological Organization's Global Observation Network.

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 of 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:

- Many meteorological stations were closed due to lack of funds: 22% in Tajikistan: 52% in Turkmenistan and 62% in Kyrgyzstan (Table 2.1).
- The hydrological observing networks have also been reduced by 40–50% (Table 2.1) since mid-1980s. Most equipment has exhausted its service life and is obsolete; spareparts are non existent 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 3 countries, manifesting a dramatic decline in comparison to 13 stations operational 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

Table 2.1 Deterioration of hydrometeorological observation networks.

Component of observation network	Kyrgyz Republic		Republic of Tajikistan		Turkmenistan	
	Number, 2008	% Reduction since 1985	Number, 2008	% Reduction since 1985	Number, 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 3 operational upper air stations in Kyrgyz Republic
[b]There were 4 operational upper air stations in Republic of Tajikistan
[c]There were 6 operational upper air stations in Turkmenistan
[d]One radar was in pilot operation in Kyrgyz Republic
[e]One radar was in operation in Turkmenistan

regional meteorological model calculations for the Central Asian Region. At present only Kazakhstan keeps operational 8 upper air stations, 50% less than in 1980s;

- There is a lack of appropriate communication between 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;
- The available information technologies are obsolete and fail to ensure receipt and transmission of 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 non-existent both in the center and at 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;
- Meteorological support of measurement equipment is almost nonexistent leading to a considerable deterioration of the quality of the NMS observational data; and
- Staff training is inadequate.

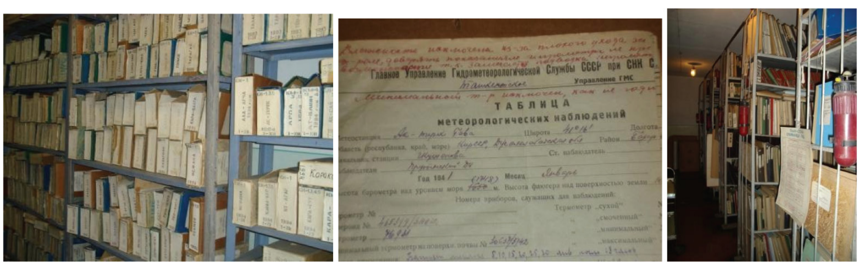
In addition, nearly all of the means of forecasting and production of information products fail to meet modern requirements for hydrometeorological services provided to public authorities, the economy and communities. Without adequate means of production, the capacity to provide services to users is 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 approach aims at improving forecast accuracy and timeliness. However, inadequate interaction with users usually prevents NMSs from taking into account their actual and especially potential information needs. A complete absence or under development of contacts with users at the modernization package development stage results in a gap between the opportunities and plans of hydrometeorological service provision and 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 their benefits from better hydrometeorological services during an NMS's modernization may further increase information misalignment between a hydrometeorological service and its users[1]. 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 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 improve its institutional structure. These include assessment and recognition of the current status and trends in the needs for hydrometeorological information on the part of 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 of cooperation with users; and (iii) propose to users how to integrate/apply hydrometeorological information and formulate their needs for it.

User needs for hydrometeorological information in each of the three countries 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 is based on the questionnaire developed during preparation of the National Hydrometeorological Modernization Project in Russia (2003–2004)[2] and further tailored to estimate the economic benefits from the improved quality of hydrometeorological services following the modernization of national meteorological services in ECA region (2005–2007)[3].

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 HydroMeteorological 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:

- HMH influence, by impact type/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 to 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.

[1] Information misalignment stems from the fact that NMHS experts do not know all of the details of specific sector operations and, therefore, cannot adjust their products to users' specific needs and requirements. At the same time, users do not know all of the opportunities of modern hydrometeorology and, therefore, cannot formulate their potential needs accurately and correctly.

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

[3] 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 & 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: a low-density network of weather and gauging stations resulting in inadequate coverage of the high-altitude zone by meteorological observations; an almost complete absence of automated technical facilities, weather radars, and modern technologies and means for remote data processing and telecommunication; and 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), on how efficiently public, sector-specific and user needs can be met, and how each country can fulfill its 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 both for the sectors as a whole and their core activities in terms of timely management decision making on protective actions and optimal performance. The experts noted the use of hydrometeorological forecast of an appropriate quality and with an appropriate lead time as an important means of improving their day-to-day operations and long-term planning.

The experts also formulated and specified their requirements to 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 forecasts with a view to obtaining 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 to new types of information products, forecast accuracy and lead time, information presentation formats, etc. That would allow structuring relations between NMS staff and users on the basis of new principles.

Therefore, the sector experts confirmed the need for NMS radical refurbishment, introduction of modern automated and distance observation methods and data collection/processing systems, and 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 forecasts 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.

Besides, the sector experts emphasized that significant economic losses were accounted for by inadequate interaction between the NMSs and key HMI users which was 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. Therefore, NMS modernization 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 assessing the benefits of the work for the 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 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 business activities in the country 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 improvement of human life and safety were not assessed.

The assessment approaches envisage generalization and calculation of countrywide 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 7-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 postimplementation stage). Therefore, the potential returns on modernization investments were calculated by comparing aggregate amount of incremental benefits during the 7-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 countries of ECA region 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 by the World Bank in 2005-2007 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[4]; (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 Tsirkunov V. 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;

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

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).

Finally, 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 NMS modernization is calculated as a ratio of the potential effect to 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 sectorspecific 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/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.

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, estimated at USD8.3million, range from USD2.9 million ("benchmarking" assessment) to $3.8 million (upper bound of "sectorspecific" assessment) per year. Assuming that this annual economic effect is sustainable; within 7 years of

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 (USD 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 (USD million)	10.1	5.8	23.0
Average expected annual incremental benefits due to improvement of hydrometeorological information and services (USD 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

implementation, the total benefits of Program implementation will equal from USD21 million to USD27 million. Economic efficacy of investments in Program implementation will vary from 244% to 318%, respectively, or, in other words, each dollar spent on Kyrgyzhydromet modernization may yield at least USD2.4–3.2 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 totally could be in the interval of USD 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 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 USD24.9 million (1.04% 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, hailing, windstorms, snowfalls, droughts and frosts). The resulting average annual weather-related economic damage was estimated to be TJS98 million, or USD30 million (1.3% 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 USD37 million (1.6% of GDP).

Potential annual economic benefits from the implementation of the proposed Modernization Program for Tajikhydromet, at an estimated cost of USD 6.1m, range from $1.7 million ("benchmarking" assessment) to $3.1 million (upper bound of "sector–specific" assessment) per year. Assuming that this annual economic effect is sustainable; within 7 years of implementation, the total benefits of Program implementation will equal from USD12 million to USD22 million. Economic efficacy of investments in Program implementation will vary from 200% to 357%, respectively, or, in other words, each dollar spent on Tajikhydromet modernization may yield at least USD2.0–3.6 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 totally could be in interval of USD 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 5 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 USD 42 million. Annual incremental benefits for the national economy that would result from a USD30million upgrade and development of the Turkmenhydromet may amount to USD18 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 or increase of production and better business opportunities. Therefore, the obtained values 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 Kyrgyz Republic, the Republic of Tajikistan and Turkmenistan economies and population from the entire range of hazardous hydrometeorological phenomena, it would be desirable:

• To 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);

• To 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 there after grounding on the estimates of weather hazards related damage (losses), potentially preventable due to the use of the improved hydrometeorological information in specific sectors; and

• To 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, facilities for forecasting weather, systems for warning of hazardous weather events) have shown that the current conditions of hydrometeorological services in the three countries under review do not meet modern requirements. Due to this the efficacy of the services provided to their respective Governments, sectors of the economy and economic entities, as well as the ability to fulfill international and regional obligations including those under the WMO Global Observing System, have been and continue to decline.

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;

The assessment of contemporary climate, in the context of broad-scale international efforts in the field of climate change study and adaptation to the changing climate, should be an integral part of NMSs' activities since these services are the Government institutions that hold archives of longterm climate information.

The key objective of the NMS modernization program is to reduce the risk to life and damage to the region's economies 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 of the NMSs, and retaining their capabilities by sustaining their institutions, staff and financial support. NMS modernization programs and recommendations on strengthening and technical upgrading of NMSs are based on the evaluation of their current status made by a team of international experts in close consultation with NMSs' management. 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 considerations on potential availability of funds for modernization and sustainability of investments. Basic modernization options are estimated to cost approximately USD 6.1 million, USD 8.3 million and USD 30 million for Tajikhydromet, Kyrgyzhydromet and Turkmenhydromet, respectively. The greater scope of investment program proposed for Turkmenhydromet is explained by greater deterioration of existing NMS infrastructure which needs urgent replacement and 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 which include: (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. Main activities proposed in modernization programs presented in Annex II, more detailed list and description of activities can be found in 3 country national reports.

Component A. The level of details provided in the proposed modernization options is comparable with the level of 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 of the NMS development approved by the government. Technical solutions should be based on the 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 in order to ensure a sustainable solution. Technical specifications and main tender documents for procurement are expected to be developed under this component. It is important to ensure compatibility of all technical devises and system. This component includes:

- Developing the detailed concept of NMS development
- Technical design of the hydrometeorological monitoring and telecommunication system
- Development of technical specifications and main tender documents
- Development of specific performance indicators and their monitoring system

Component B. 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 their consequences and better emergency preparedness is an important component of the modernization program. Improvement of the hydrological observing and forecasting systems is also essential for efficient national water resources management and to fulfill country's obligations under international agreements. Within this component the following main activities are proposed:

- Restoration and technical upgrading of the meteorological and hydrological observing networks
- Strengthening the information technology base of the NMSs
- Upgrading meteorological data receiving systems
- Providing 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. Within this component the following main activities are proposed:

- 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
- Easily accessible products through the web and other media
- Welldefined service agreements between the NMS and each customer
- Special attention to key user groups
- Specific focus on introducing 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 efficient operation 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 modernization programs will lead to substantial improvement of NMS performance and better service delivery. The following minimum performance indicators should be achieved after completion of NMS modernization. More specific verifiable sets of performance indicators and their monitoring procedures will be developed for each national programs as part of Component A activities.

- Improvement of accuracy of main meteorological and hydrological measurements, increase of forecast accuracy by 6–8% for 24 hours lead time and by 15% for 3–7 day lead time
- At least 10-fold increase volume of data received from various sources of meteorological information
- To reach a level of 90% timely collection and transmission of data from observation stations and improvement of data communication within NMS
- Increase of 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, improvement of staff qualification
- Strengthening of financial status of NMS and increasing 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 that the NMSs demonstrate tangible benefits. The task for the NNHS is to understand the needs of users of 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 in communicating the information to users and in the behavior of users in response to that information and ultimately 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 there areas where value could be increased: by improving the forecast or analysis, by improving communication or by improving the decision process. The modernization of observing systems will go far towards improving forecasts and analyses. Improving communication and decision processes 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 plans for specific actions to be taken in response to the information. Value is also 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 of weather, climate and water products and services. This collaboration ensures value is added where it is needed to make sure that the environmental information is properly considered and acted upon by users.

A practical approach to achieving this has been pioneered by the China Meteorological Agency (CMA), which has developed 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 has been to realize tangible and quantifiable benefits to 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, which are 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 with 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. This Initiative will be supported by WMO, ISDR, World Bank and other development agencies. There is a need for greater regional cooperation between the Central Asia countries caused by geographical, climatic, transboundary, economic and social considerations. National programs proposed under this study should be viewed as the most urgent investment and capacity building programs aimed 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 designed taking into account existing and planned national modernization programs. 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, in part because of the growing capacity of both the Russian Federation and China to provide advanced weather, climate and water information and 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 the need for 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.

Creation of regional numerical weather forecast capability, establishing centers or facilities for specialized support such as regional drought monitoring, regional calibration and metrological support, technical and operational support (O&M) are among directions which should be discussed with participating NMSs and donor agencies in Central Asia

5.5. SUMMARY OF NEXT STEPS

Preliminary results of the study were presented to the government stakeholders at the consultation workshops in all three countries. It is expected that the Action Plan for improvement of weather, climate and hydrological services delivery elaborated further in national reports and this Summary report will be supported by the Government. Financing of the Action Plans will likely be a combination of governmental funds, concessional financing from international financial institutions (IFIs), international and bilateral donors' support.

It is planned that results of this GFDRR work will become an integral part of a broader Central Asia (and Caucasus) Regional Economic Cooperation Initiative on Disaster Risk Management (CAREC DRMI) which aims at reducing the vulnerability of the countries of Central Asia and Caucasus 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 initiative would be coordinated by World Bank, the UN International Strategy for Disaster Reduction (UN/ISDR) Secretariat, and (for hydrometeorology) the World Meteorological Organization (WMO), under the CAREC umbrella. The Initiative will build on the existing cooperation that already exists in the region, and will complement and consolidate activities of the IFIs, the EU, the Council of Europe, the 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.

Main results of this GFDRR work will be reported in November 2009 at a regional Central Asia Workshop aimed at improvement of hydrometeorological services and early warning systems which will be supported by ISDR, WMO, EC and World Bank. It is planned that this Workshop will serve as a forum to all CA NMS to confirm and specify their commitments towards regional cooperation, it will launch a Regional Hydromet support Initiative and will facilitate regional cooperation among donors.

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GFDRR
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SDC in Central Asia
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APPENDIX I. MAIN GEOPHYSICAL AND HYDROMETEOROLOGICAL CHARACTERISTICS

KYRGYZSTAN

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

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

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

Inner Tyan Shan is characterized by the coldest and semiarid climate noted for little evaporation at low temperatures. In the highlands, where the amount of atmospheric deposition exceeds evaporation, large areas are occupied by glaciers and snow patches. The annual precipitation pattern is similar to the one in the third 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 the 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 Litlle Naryn Rivers, just above the town of Naryn, it collects the waters of several large tributaries such as the At Bashi and Kekemeren until flows into the Toktogul Reservoir and the flows south breaking through the Ferghana Range into the Ferghana valley and then amasses yet more tributaries until eventually it 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.

TAJIKISTAN

Wide valleys and plains rising up to 1000 m contain the main arable farming and cotton growing areas. These include: the south-western part of the country, Gissar, Vaksh, Lower Kafirnigan and Kulyab Valleys, as well as Fergana Valley with adjoining flatlands of the Sogd Region. These valley and plains are noted for high temperatures in summer associated with a summer thermal depression. Fair and hot weather predominate in summer months, the highest temperatures reaching between 43 and 47^0 C. The mean monthly temperature in July (the hottest month) is between 28 and 30^0 C.

The cold season is characterized by Arctic air intrusions where air temperatures, even in southern areas, can fall to between -24 and -30 ^{0}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 ^{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 South-Western Tajikistan have the longest frostfree periods (up to 260 days).

The transitory zone between valleys and highlands (up to 2500 m) includes: Zeravshan Valley, the mountain areas of Central Tajikistan, and a part of Western Pamir. In summer, fair and dry though cooler weather dominates. The zone is characterized by temperatures, which gradually decreasing with altitude. The impact of orography on the temperature is particularly pronounced. 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 ^{0}C to -26 ^{0}C. The absolute minimum is 63^0 C (Bulunkul). Summers are short and cool with the mean air temperature not exceeding +15^0 C. The absolute maximum temperatures are between 20 and 34^0 C. This region has up to 111 frostfree 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 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 Pyanj, Vakhsh, Syrdarya, Zeravshan, Kafirnigan, and Bartang. There are 947 rivers, which are more than 10 km long. 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, characterizing by an intensive snow melting and heavy rains (April–August), many rivers bear a lot of suspended particles (over 5 $kg\ m^{-3}$) (Tajikistan 2002, State of the Environment Report).

TURKMENISTAN

Semi-desert climatic zone has a mean annual temperature equals 15.6°C. Annual amount of precipitation varies from 180 to 250 mm. Cold season precipitation (85–95% of the annual amount) prevail 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 and low-wind weather. At the same time, frequent cold air outbreaks cause increased winds and cloud amount. Average air temperatures in January range from –1.6° in the west to 1.1° in the east, shortterm temperature falls are possible to –28° in the east and to –35° in the north, as well as temperature increases to +12°–16°. In summer, where the average July temperature is 31.4° temperature frequently reach 40–45°. Droughts, hot winds and dry weather conditions occur frequently in the semi-desert zone.

Desert climatic zone is a desert, which occupies the most part of Turkmenistan territory (about 80%) and includes three major types of deserts: clay, sandy and rocky. The zone is characterized by highly continental climate and low moisture content. Yearly evaporation rate exceeds precipitation amount by a factor of 10 or more, and by 20 to 70 times during the three summer months. Mean annual temperature rises up to 16.5° while the amount of precipitation decreases to 90–130 mm per year.

The climate in this zone is generally noted for a long hot summer, rather cold winter for these latitudes, large annual and daily temperature variations, dry air and small cloud amount.

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. The total amount of precipitation during the cold season makes up 60–84% of the annual amount. The passage of cold fronts is usually accompanied by dust storms. 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.

Winter is characterized by high weather instability and variability, 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 weather being stable and 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° while at nights during invasions it can occasionally drop down to 0°.

Mountain and piedmont areas in Turkmenistan demonstrate a marked vertical variation in climate. The change of vertical climatic zones occurs in the same way as that of horizontal ones.

APPENDIX II. KEY HYDROMETEOROLOGICAL AND CLIMATE HAZARDS

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 killing cattle and sometimes causing human losses. In spring and summer the whole territory of Kyrgyzstan is exposed to mudflows and floods. In addition there are 2000 highland outburst-risk lakes in the Kyrgyz Republic. For 200 of these, the probability of an outburst is high. Outbursts of such lakes damage not only the 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 the territory of 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 5 and 7 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 foehn snow slides with a total volume exceeding a million cubic meters are not infrequent events in highland areas.

In terms of the amount 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 an EHH if in the growing season air or soil surface temperature drops below 0 ^{0}C on the area covering more than 30% of the farmland territory. If in the growing season air or soil surface temperature drops on the area covering less than 30% of the farmland territory, frosts are classes as a 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 deficit of precipitation compared to longterm averages and is specific to location and season. Hydrological drought is a deficit of surface 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 hampers shipping operations.

Precipitation as **hail** occurs annually with damage to agricultural crops. Infrequent **Heavy precipitation** (40–75 mm per day) in winter, in addition to forming avalanche centers, precipitation damages houses and buildings (ruin roofs) and hampers traffic. In summer, rainstorms form mudflow centers and causes crust on farmlands and crop lodging.

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 in terms of both triggering other EHHs and impacts, including mudflows, floods and snow avalanches.

Heavy rains, exceeding 20 mm received per half a day, cause mudflows. Mudflows make rivers spill over the banks flooding them for dozens of kilometers. Heavy rainfall, over 30 mm a day, contributes to erosion, causes serious damage to agriculture and provokes mudflow and 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 the 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 from 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 has increased. In valleys and piedmont areas, the maximum number of days with heavy precipitation is observed in late winter and spring, in highland areas, these occur in summer. Heavy precipitation in areas below 2000m 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 a break-through in temporary (glacial) lakes. According to the data of the Republic of Tajikistan 2002 State of the Environment report (see Republic of Tajikistan, 2002), some 85% of the Republic's area is threatened with mudflows and 32% of the area is situated in the high mudflow risk zone.

High floodwaters are usually shortterm, but cause huge damage to settlements and the national economy. During the last 30–40 years an increase in the number of days with disastrous floods has been observed.

Heavy snowfalls most frequently occur in active orographic areas higher than 1400–1500 m (above sea level), i.e., in piedmont and mountain regions. **Snow avalanches** occur in the area higher than 1500–2000 m above sea level. Basic conditions for the formation of avalanches are slopes with a gradient of 30–50°, snow cover more than 30 cm, and relevant meteorological conditions. In the Republic of Tajikistan, the major reason for avalanches is fresh snow formation (60–70%). 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 (Khujand). Winds at a speed 20 ms^{-1} are annually recorded in the Northern Tajikistan and Eastern Pamir. **Dust storms** are distributed unevenly over the country and mainly occur in the southern deserts and arid regions for 1–4 months in the spring-summer period. They raise thousands of tonnes 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 republic. With increasing maximum temperatures, the number of days with temperature above 40°C increases. Observational data indicate an upward trend of 30% in the number of days with temperature above 40°C in almost all the plains of the republic.

Drought is one of the severe meteorological phenomena often closely associated with extended period of high temperatures. Agriculture is most often exposed to hazardous events and drought is the most important among them. For Tajikistan local droughts occur every year. Severe droughts have occurred 8 times in the last 60 years. In these years rainfed 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. They cause damage not only to fruit-farming and cattle breeding but also to water resources, energy and transport sectors.

TURKMENISTAN

In Turkmenistan, **floods and mudflows** often occur in mountain basins of small rivers flowing down from south-western, north-western and north-eastern slopes. Rainstorms are the main factor of mudflow generation in Turkmenistan. Intensive snow melting only occasionally can cause floods or mudflow. 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 off 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 the wind speed exceeds 15 m/s. The speed equal to 20 m/s is a criterion of a hazardous event, and 30 m/s – that of a particularly hazardous one. Strong wind damages buildings and industrial facilities, complicates all kinds of traffic, destroys crops and trees. Strong winds are classified into 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 the wind speed 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 the onset of droughts. 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. Droughts represent a critical problem for Turkmenistan since 80% of the country is occupied by the Kara Kum Desert. 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 before multi-year terms, and productivity of pasture vegetation may reduce by 50–70%.

Dry winds is a particular case of an atmospheric drought complicated by wind. Dry winds frequently cause very significant damage to the national economy. For example, cotton plant just once exposed to a strong dry wind may lose up to 60–80% of their blossoms. Weak dry winds annually occur throughout the whole country territory. Strong dry winds are observed in south-eastern, southern and south-western areas.

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

Heavy rainfall, 12 mm and more within less than 12 hours although infrequent, is considered a hazardous weather event. More than 30 mm of rain fall within the same period is especially hazardous. They 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 sector of economy.

Extreme heat, an air temperature exceeding 40° C regardless of duration of occurrence, is hazardous. These conditions can encompass the whole Turkmenistan territory except the mountain, far northern and Caspian coast areas. High temperatures cause large damages to agriculture, especially cotton and fruit trees. Recurrent heat represent a special risk to the economy. The impact of high temperatures (above 45° C) during several days may reduce cotton productivity by 10–30%. 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 are especially hazardous. At these temperatures many subtropical crops such as orange, mandarin, fig, pomegranate, walnut, grapes, etc. die or freeze down to roots. Severe cold (below -25° C) causes death of 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, north-eastern 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 shortterm event, it may cause enormous damage to the affected area. Hail, ranging from 5 to 30 mm, are observed in Turkmenistan. 6–8 mm hailstones may damage cotton and vegetable shoots, and those over 10 mm – sunflower, corn and orchards. Hails with hailstones of 30 mm and more cause significant damage to everything located in the open.

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 makes up 6–30 tons per hectare. Dust cyclones are usually accompanied with squally winds, hail and heavy rainstorms causing catastrophic destruction.

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

Kyrgyzhydromet – Main Modernization Components and Activities

Main components	Sub-components and activities	Estimated cost (USD 1000)
A.Technical design	Technical design of the hydrometeorological monitoring and telecommunication system	500
B. Improve the system of hydrometeorological monitoring to provide timely warnings of extreme and hazardous weather events and to manage water resources	B1. Technical upgrading of the observational network	4385
	Restoration and technical upgrading of the meteorological observational network	1175
	Resume temperaturewind atmosphere sounding	360
	Renew key observation sites of the hydrological network, and equipping the operating posts with the required additional instruments	1655
	Restore snow avalanche observation network	755
	Establish quality control of hydrometeorological data and products	440
	B2. Strengthen the IT base of Kyrgyzhydromet	2380
	Upgrading of data collection and communication system	300
	Improvement of data processing, adjusting numerical weather forecast and runoff modeling for Kyrgyzstan	830
	Creation of 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

Tajikhydromet – Main Modernization Components and Activities

Main components	Sub-components and activities	Estimated cost (USD 1000)
A.Technical design	**A. Technical design of the hydrometeorological monitoring and telecommunication system**	**400**
B. Improve the system of hydrometeorological monitoring to provide timely warnings of extreme and hazardous weather events and to manage water resources	**B1. Technical upgrading of the observational network**	**3450**
	Technical upgrading of hydrological gauges	950
	Restoration and technical upgrading of the meteorological observational network	975
	Introduce automatic snow survey systems	375
	Modernize meteorological radars	800
	Improve quality and reliability of measurements	350
	B2. Strengthen the IT base of Tajikhydromet	**1125**
	Introduce modern communication facilities and technologies of data reception and processing	585
	Creation of 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**

Turkmenhydromet – Main Modernization Components and Activities

Main components	Sub-components and activities		Estimated cost (USD 1000)
A.Technical design	**Technical design of the hydrometeorological monitoring and telecommunication system**		**940**
B. Improve the system of hydrometeorological monitoring to provide timely warnings of extreme and hazardous weather events and to manage water resources	**B1. Technical upgrading of the 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 the IT base of Turkmenhydromet		**5,150**
		Refurbishment of data collection and telecommunication centers, introduction of new technologies	2,250
		Archive equipment	2,900
C. Institutional strengthening and capacity building	**C1. Strengthen the institutional, legal and regulatory framework and staff training**		**1,480**
		Bring the 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, evaluation of efficacy of hydromet service delivery, users training	550
		Develop technologies and the Procedures for disseminating urgent information on natural disasters, technologies to present weather forecasts on TV and development of NMS Web site	380
		Improve National Climate Service	300
	C3. Improving the 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, data bases and introduce detailed visualization equipment	390
		Total cost	**30,000**