Annex to the Implementation Plan of the Global Framework for Climate Services – Observing and Monitoring Component

World Meteorological Organization
Weather • Climate • Water

GFCS
GLOBAL FRAMEWORK FOR CLIMATE SERVICES

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ANNEX

TO

THE IMPLEMENTATION PLAN OF THE GLOBAL FRAMEWORK FOR CLIMATE SERVICES -

OBSERVATIONS AND MONITORING COMPONENT

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EXECUTIVE SUMMARY

The Observations and Monitoring Pillar is one of the foundational pillars upon which the success of the Global Framework for Climate Services will rest. For effective climate services to be delivered, observations of appropriate types and of adequate quality and quantity must be made, and these observations must be available at the right place and at the right time. Both surface-based and space observations are required of physical and chemical climate variables of the atmosphere, land, and oceans, including hydrologic and carbon cycles and the cryosphere. In addition, delivering useful climate services also requires the availability of socio-economic, biological, and environmental data, for national use in particular. Physical and chemical climate observations, along with complementary socio-economic and other data, must be effectively integrated to develop and provide users of climate services—farmers, public health officials, disaster risk reduction managers, water resources administrators and the like—with information that will help them minimize losses due to climate variability and change and to manage natural and human systems effectively.

Despite the fundamental importance of observations for delivering climate services in general, many key regions and climatic zones remain poorly observed. Significant gaps in observations exist, especially in developing countries, and timely access to observational data is still problematic in many locations. The need for complementary socio-economic, biological, and environmental data raises additional challenges in ensuring that such data are collected, quality assured, archived, and made accessible in standardized formats. This Observations and Monitoring Pillar identifies needs and gaps in climate observing systems, including their associated data management and data exchange infrastructures, and underlines the importance of socio-economic, biological, and environmental data in developing and delivering effective climate services. It proposes actions to address these gaps and needs, placing particular emphasis on the areas of greatest need in Developing and Least Developed Countries (LDCs) and Small Island Developing States (SIDS) in adherence to GFCS Principle 1. It also draws attention to the importance of the inter-connections between the Observations and Monitoring Pillar and other pillars.

The Observations and Monitoring Pillar of the GFCS relies heavily on existing observational programmes, activities, and initiatives, of which an overview is presented. This Plan will increase the focus of observational programmes on the data needed to provide climate services to users, particularly in the key sectors of agriculture and food security, health, water, and disaster risk reduction.

Implementation of the Observations and Monitoring Pillar will require full engagement of partners at the global, regional, and national levels in its programmes and working mechanisms. At the global level, these include a number of UN agencies such as WMO, UNEP, UNESCO and its IOC, IMO, FAO, and WHO, as well as systems these organizations co-sponsor such as the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), and the Global Terrestrial Observing System (GTOS). They also include initiatives fostering integration of different observing systems such as the WMO Integrated Global Observing System (WIGOS). Equally important on national and regional levels are the contributions made by National Meteorological and Hydrological Services (NMHSs), national and regional space agencies, and national environmental, natural resources, and oceanographic agencies. The important observational contributions of non-governmental organizations and universities will receive attention, as will the potential for greater engagement of non-governmental and private sector observational networks.

This document outlines the initial implementation activities proposed for addressing observational needs that are the initial focus of the GFCS Implementation Plan: agriculture, health, water resources, and disaster risk reduction. Each activity will address these needs in at least one of the four sectors. The plan also includes a more extensive list of relevant activities that partners will seek to implement over a longer period of time.

While observations of some new types of physical or chemical climate variables may be required, there is clearly a need for greater observational density in both space and time for those variables that are already being monitored. Since it will not be possible to do everything necessary in the first few years of the GFCS, an initial focus will be on rehabilitating silent stations, activating key stations in data poor areas, ensuring the sustainability of observations from key stations, and sustaining space-based observations concerned with climate. The latter is especially important since these particular observations are critical to improving climate services. The plan proposes greater efforts to rescue historical data and manage it in secure, accessible data management systems in order to make use of existing observational data.

Where socio-economic, biological and environmental data are concerned (perhaps with some additional physical and chemical observations as well), more consultation is needed before specific actions can be identified. Consequently, the Plan proposes several early activities that can be undertaken, starting with establishing a formal consultation mechanism with users and assessing the need for, and the role of, climate observations in adapting to climate change.

Proposals for initial projects have been formulated with the preceding considerations in mind and are included in the plan. These projects, developed in consultation with international experts and coordinators of observational programmes, address the following issues and will be initiated during the first two years of the Plan. Some, but not all, will be completed in the initial period. Much will remain to be done in the 6- and 10-year timeframes.

- Establishing a formal mechanism for consulting with users;
- Assessing the role of observations in adapting to climate variability and change;
- Rehabilitating silent stations and key stations in data poor areas;
- Designing baseline networks to underpin climate services;
- Supporting the operation of baseline networks in LDCs and SIDS by setting up a Trust Fund;
- Improving ground-based and space-based networks for measuring precipitation;
- Developing guidelines to improve discovery of climate observational data and products;
- Developing an integrated global greenhouse gas information system, including enhancing regional scale chemical measurements;
- Establishing best practices for air quality observations and for monitoring in urban environments;
- Providing information for sustainable water resources development and management in important shared international river basins;
- Large-scale data recovery, digitization, and homogenization of climate records;
- Monitoring coastal regions to support adaptation and understanding of vulnerabilities;
- Establishing a coordination mechanism for collecting, managing, and exchanging climate and related food security data;
- Establishing a coordination mechanism for architecture for climate monitoring from space.

Concluding sections of the plan draw attention to the need for mobilizing resources to fund planned initiatives as well as to important operational issues including approaches to implementation, risk management, and project monitoring and evaluation.

1 INTRODUCTION

1.1 Objective, scope and functions

This document presents a high-level implementation plan for the Observations and Monitoring Pillar of the Global Framework for Climate Services. The plan identifies priority needs for observations supporting climate services, encompassing needs for climate data in atmospheric, oceanic, and terrestrial domains and for observations of the impacts of climate. The plan:

- Specifies key actions and activities required to address these needs;
- Pays special attention to the observations and associated data management and data exchange systems needed to support services in four key areas—agriculture and food security, water resources, health, and disaster risk reduction;
- Draws attention to some of the non-physical climate-related data and information, including socio-economic data, that will also be required for developing climate services;
- Identifies organizations that are expected to take the lead in implementing these actions.

1.2 The Requirement for the Observations and Monitoring Pillar of the GFCS

The High Level Taskforce for the GFCS noted that *to support climate services, high quality observations are required across the entire climate system and of relevant socio-economic variables. Existing capabilities for climate observation and data exchange provide a strong basis for improving climate services globally. However, there are major gaps in climate observations, particularly over the oceans, Polar Regions, unpopulated regions, and in many developing countries. There are shortcomings in the organized and standardized observation of biological, environmental, and socio-economic variables and a need to ensure these can be adequately integrated with climate data.* The plan for the Observations and Monitoring Pillar of the GFCS will address these gaps and shortcomings, building on existing observational, data management, and exchange systems and initiatives, and adding enhancements where needed to support provision of climate services.

Long-term, well-calibrated, global observations of variables such as air temperature, rainfall, sea-surface temperature, sea-level, and concentrations of greenhouse gases and aerosols are critical for defining the evolving state of the Earth's climate. Observing systems must accurately record the constantly changing physical, chemical, and biological conditions of the atmosphere, oceans, and land, identifying climate extremes and consequent vulnerabilities and contributing to enhancing our understanding of the causes of climatic variations and their impacts. Building this knowledge base requires a significant investment in monitoring biological, environmental, and socio-economic variables.

The instrumental climate record has largely been constructed from surface weather observations acquired from the 19th Century onwards. Balloon-based upper-air observations became well-established in the mid-20th century, and operational temperature and humidity sounding by satellites began in the 1970s. Significant developments in both surface-based and space-based observations have continued since then, along with development of much-improved capabilities for data management, analysis, modelling, and prediction. Significant gaps remain in surface-based network coverage nevertheless, and for some networks there has been an overall decline in observational coverage and dissemination capacity.

Observations needed for providing climate services include those directly related to user needs such as measurement of precipitation, soil moisture, and surface air temperature, as well as observations of phenomena (e.g. thunderstorms, hail, fog, dust, cloud type and amount), and those observations required for preparing useful forecasts and other applications. The observational data record is fundamental for defining the initial states for model runs, for validating the numerical models used for weather and short-term climate forecasting, and for longer-term scenario-based

projections of climate change. In conjunction with appropriate socio-economic, biological, and environmental data, observations of climate variables provide inputs to application models and indices that link climatic conditions to user-relevant measures such as disease incidence, crop yield, and energy demand. In such applications, data on biological, economic, and social systems must be organized and combined with regional or local climate observations to derive indices that can be used in decision-making. Examples of the latter include heating and cooling degree days, growing degree days, and indices for drought, wind chill, and UV exposure and for monitoring climate change.

Acquiring and exchanging meteorological observations are generally carried out on a managed, well-established, and usually securely funded basis, although, as indicated earlier, gaps do exist in some atmospheric networks. Other types of data are required, however, for providing climate services comprehensively, including:

- Terrestrial, cryospheric, and marine (open-ocean and coastal) observations;
- Observations of ecosystems;
- Observations of additional physical and chemical variables beyond those normally included in weather observations (e.g., measurements of atmospheric pollutants and solar and terrestrial radiation).

For many of these variables, enhancing observation collection, exchanging data, and/or funding stability are still required. Furthermore, the quality and duration of the time series of historical data held in global data centres show considerable variation from country to country. In consequence, continuing efforts must be devoted to recovering and analyzing historical data. This will involve paleo-climatic reconstructions, reprocessing and reanalyzing the modern instrumental record, and sustaining and improving observations aimed at the future in order to extend these vital historical records. The Climate Data Management Systems (CDMS) initiative being developed through international efforts led by the WMO Commission for Climatology provides technological solutions for modern archiving and for quickly retrieving historical and near-real-time climate time series. NMHSs in developing and least developed countries should be assisted and encouraged in using modern CDMSs on a sustainable basis.

A particular deficiency is that there is as yet no system in place for sustained monitoring of climate from space. Nonetheless, space-based observation has demonstrated potential for contributing valuable information on important climate variables such as albedo, snow cover, soil moisture, and sea ice. Consequently, there is also a need to assess the quantitative value of new measurements available from space having possible climate service applications and, where appropriate, ensure sustained monitoring. Calibrating space-based sensor outputs against conventional surface and upper-air observations will require continued research attention.

As noted previously, biological, environmental, and socio-economic data are needed for translating these observations and forecasts into indices and other products that address user concerns, such as disease incidence, crop yield, and energy demand.

One of the primary constraints affecting climate and related data access and data exchange is the restrictive data policies of some data providers. Agencies responsible for data management and exchange have generally developed their own data policies, often based on national legislation, and many are not able to provide free and unrestricted access to their data. As a fundamental principle of data sharing within the GFCS, an open door policy should be pursued, as expressed by GFCS Principle 6. Thus countries should continue to be encouraged to adopt free and unrestricted (non-discriminatory and without charge) international exchange of climate-related data and products. The WMO Congress, for example, has adopted WMO Resolutions 40 and 25 to guide its Members concerning access and exchange of meteorological and hydrological data. These Resolutions provide a useful model for developing broader, overarching data access and exchange policies addressing all components of the climate system across geographical and time scales, including biological, environmental, and socio-economic data requirements under the GFCS. Nevertheless, where exchange of socio-economic and other data is sensitive, as it often will be,

the availability of such data *at the national level* is still crucial for developing national climate services.

1.3 Inter-linkages with Other Pillars

1.3.1 Linkage with Research, Modelling, and Prediction

The Research, Modelling and Prediction (RMP) Pillar of the GFCS stresses the vital importance of climate observations, pointing out that climate predictions from a week to a season are strongly dependent on the availability of accurate initial conditions for all components of the climate system having longer memory than the atmosphere. Achieving progress in such predictions is dependent, to a significant degree, on more comprehensive observations that not only serve as the main means of initializing climate models but are also the foundation of improved understanding and representation in models of key phenomena and processes. Equally, the conduct of research into the impacts of climate requires access to climate data as well as to biological, environmental, and socio-economic data. Conversely, research support is essential for continued evolution of observing systems and practices, including improving the economic efficiency of existing technology and techniques, more effective designing of observing networks, and migrating research-based observing systems to operational status where appropriate. Moreover, research funding continues to be an important source of support for climate monitoring, particularly in providing resources for acquiring oceanographic, atmospheric chemistry, as well as some important cryospheric and atmospheric observations.

The GFCS will facilitate and accelerate transitions from research-based to operational observing capabilities, which will generate corresponding needs for research and development. As an example, to enable climate prediction modern observing systems should include variables necessary for initializing climate models through coupled data assimilation. Research is also required on how climate variability and change interact with air pollution on regional to global scales. This will improve our understanding of the links between climate, ecosystems, and biogeochemical cycles. Other research areas relevant to the Observations Pillar include coordinated climate data reprocessing, extending meteorological reanalyses, and initiating new types of reanalysis culminating in integrated Earth system reanalyses. Research groups, such as those coordinated by the World Climate Research Programme (WCRP), will provide key inputs to the activities proposed in the area of observations and monitoring. Similarly, research constituencies affiliated with GCOS, GOOS, GTOS, WIGOS and other observing programmes will be important contributors to achieving GFCS objectives in the research, modelling, and prediction domains. The WMO Global Atmosphere Watch (GAW) Programme, as one example, will provide the mechanism for changing greenhouse gas, aerosol, and air pollutant observations from a research to an operational mode. The preceding considerations clearly underline the need for developing and maintaining effective linkages and coordination between the Observations and Research Pillars of the GFCS.

1.3.2 Linkage with the Climate Services Information System

The Climate Services Information System (CSIS) Pillar is the principal mechanism through which information about climate – past, present and future – is routinely collated, stored and processed to generate products and services that help inform decision-making processes across a wide range of climate-sensitive activities and enterprises. Fundamentally, the climate services produced and delivered by the Climate Services Information System (CSIS) of the GFCS will be based on observations of the climate system, on products derived from these observations, and on relevant socio-economic data and information for the sectors of concern, such as, for example, statistics on disease incidence, crop and livestock production, and deaths and losses associated with disasters. It is to some extent the domain of the CSIS Pillar to specify what observations are needed for developing specific climate services and, correspondingly, the domain of the Observations and Monitoring Pillar to deliver those observations or, if they are not available, to determine what is needed to make them available. Hence, structured ongoing communication will need to be established between those engaged in the work of the Observations Pillar and the CSIS to generate feedback on how well observing and data collection systems are meeting CSIS needs.

They will need to identify gaps and deficiencies, and propose remedial action. By specifying what observations are needed, the CSIS can also serve as an important link between the Observations Pillar and the User Interface Platform and, ultimately, user needs. Similarly, where observations are needed that require research, the CSIS can reinforce the connection between the observation and the research pillars.

1.3.3 Linkage with the User Interface Platform

The User Interface Platform (UIP) is the Pillar of the GFCS that provides a structured means for users, climate researchers, and climate service providers to interact at the global, regional, and national levels. The managers of operational observing networks need to know what observations users require, while users need to be able to communicate what they need and to understand the limitations of what can be delivered. By assessing user needs, the process will inevitably be an iterative one since capabilities are matched to requirements. A related initiative will be undertaken as part of this implementation plan, namely, one or more workshops organized by the GCOS programme (see section 2.2 below) to focus on identifying specific needs for observations for adapting to climate change and for developing climate services.

1.3.4 Linkage with the Capacity Development Pillar

The availability and targeted application of adequate financial, technical, and human resources will be essential for implementing the GFCS successfully. The GFCS addresses all components of the climate system although its initial emphasis will be on the four key priority areas of application discussed in the Exemplars (agriculture and food security, health, disaster risk reduction, and water). Given this broad perspective, its implementation engenders a need for new types of environmental and socio-economic data that are either not being collected at present or are being obtained, processed, and stored by a variety of agencies and institutions. Remedying gaps and deficiencies in existing observational networks and systems, acquiring new types of observations, as well as processing and integrating this information, will require significant capacity-building efforts spanning GFCS partner agencies and institutions at all levels, especially in developing countries. Establishing and maintaining effective liaison and partnership between the Observations and Monitoring Pillar and the Capacity Development Pillar will be essential to a successful response to the capacity development challenge presented by GFCS implementation.

1.4 Relevant Existing Plans and Activities and Identification of Gaps

This section provides a brief overview of some of the most important existing mechanisms, activities and plans for defining and coordinating observational networks and systems (further details are provided in Appendix 1).

The ***Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*** includes acquiring observational data for purposes directly aligned with those of the GFCS, highlighting the need to encompass all components of the climate system. The Plan is based on extensive consultations with a broad, representative range of scientists and data users. The Plan pays special attention to the need for observing 50 Essential Climate Variables (ECVs) covering the three physical domains (atmosphere, land, and oceans).

The ***World Climate Programme (WCP)*** aims primarily at enhancing climate services, with a focus on user interaction, in order to facilitate ever more useful applications of climate information leading to optimal socio-economic benefits. It is an integral part of the GFCS. The scope of the WCP is to determine the physical basis of the climate system, thus allowing for increasingly skilful climate predictions and projections. WCP also develops operational structures for providing climate services, along with developing and maintaining an essential global observing system capable of meeting climate information needs.

The ***World Climate Research Programme (WCRP)*** analyzes Earth system variability and change to determine the extent to which climate change can be predicted as well as the degree of human influence on climate.

The ***World Climate Services Programme (WCSP),*** whose scope spans climate data and analysis; climate monitoring, watch, and prediction; climate system operation and infrastructure;

and climate adaptation and risk management, contributes to improving the availability of and access to reliable data, advancing knowledge of climate data management and climate analysis, defining technical and scientific standards, and developing activities to support them in countries.

Defining and implementing ***architecture for sustained climate monitoring from space*** will bring the same structure and rigor to climate monitoring currently in place for weather monitoring and forecasting.

The ***Rolling Review of Requirements*** **(RRR)** routinely updates observational requirements in twelve Application Areas, identifies gaps, and thus guides WMO Members through the evolution of both surface- and space-based global observing systems. The review includes wide community consultation with scientific experts, WMO Technical Commissions, and other interest groups.

The ***WMO Integrated Global Observing System Implementation Plan (WIGOS-IP)*** is an overarching framework for the evolution of observing systems that will continue to be owned and operated by a diverse array of organizations and programmes. WIGOS will focus on integrating governance and management functions, mechanisms, and activities that will be accomplished by contributing observing systems according to the allocation of resources on the global, regional, and national levels.

The ***Framework for Ocean Observing*** will deliver a collaborative ocean observing system based on a set of principles and best practices. This system will deliver needed physical, bio-geochemical, and biological data to respond to societal issues and scientific inquiry.

Climate System Monitoring delivers timely and authoritative information on the status of the climate system on multiple temporal (sub-monthly, monthly, seasonal, annual, decadal, and multi-decadal) and spatial (local, regional, and global) scales, assessing the uncertainty associated with this information.

The ***World Weather Records (WWRs)*** global datasets include monthly mean values of pressure, temperature, precipitation, and where available, station metadata notes documenting observation practices and station configurations. Since 1920 data have been updated on a decadal basis, and while once-a-decade provision of WWRs has served the climate community's needs very well, annual dissemination of these data is now required to support improved climate assessment.

There are various efforts to ***improve on the availability of observational data***, whether through Data Rescue and Digitization (DARE&D) or by supplementing the observational network, for example by integrating satellite data or community operated networks.

Significant gaps and deficiencies in observations can be summarized as follows:

- Shortcomings in atmospheric observations that include non-reporting by some climate stations (due to inability to sustain observational networks, lack of training and capability, inadequate communication systems or other factors), limited space and surface-based remote sensing capabilities, and the absence of operational monitoring of some important air quality, radiation, and other variables;
- Weaknesses in observational coverage of important oceanographic variables that include incomplete moored buoy networks for monitoring ocean currents, mass flux, ocean salinity, and sea ice parameters; uncertainties regarding the continuity of satellite monitoring programmes such as microwave sensing, high precision altimetry, and Light Detection and Ranging (LIDAR) and Synthetic Aperture Radar (SAR) coverage of sea ice parameters;
- Gaps in terrestrial observing networks, such as for river discharge, ground water, lake levels, permafrost, glaciers and ice caps; the absence of designated networks for soil moisture, Leaf Area Index (LAI), Fraction of Absorbed Photo-synthetically Active Radiation (FAPAR) and above ground biomass; and uncertainty regarding the continuity of satellite missions that monitor land cover;
- Need for complementary biological, environmental, and socio-economic data (e.g., records of disease incidence, crop yield, energy demand, and disaster losses) to enable the production of indices and other products that assist user communities in planning and management;

- Data policies and information infrastructures that need to be enhanced to improve data management as well as access to historical observational and other relevant data and derived products;
- Continuing need to improve local, regional, and global monitoring systems to enhance efficiency and improve data management, including careful attention to minimizing data losses and inhomogeneities when observational systems change or are upgraded;
- Need to rescue, digitize, and develop (e.g., time series quality control and homogenization) historical climate and sectorial user data that are currently held in perishable paper formats or available only on obsolete or degrading media, and placing re-analysis, which is a substantial technical as well as scientific undertaking, on a firmer operational footing.

2 IMPLEMENTING THE OBSERVATIONS AND MONITORING PILLAR

2.1 The Necessary and Sufficient Conditions for Successful Implementation of the Pillar

Successful implementation of the Observations and Monitoring Pillar requires that all data needed by climate services be measured and available on a sustained basis. Satisfying this condition will depend on several factors:

- Entities that develop and operate observing networks (such as NMHSs, research institutes, universities, and the private sector) will need to make their observations, data, and observational products available (including historical data and products), on the basis of mutual agreements, for improved climate services as defined by the GFCS;
- Technological developments and national, regional, or global economic circumstances must enable these entities to collect and deliver observations and data sustainably over the long term.

Coordinating bodies, such as UN organizations acting either individually or collectively, along with international and regional groupings (such as GEO, EUMETNET and ASECNA) play a catalyzing role in ensuring both the availability of data and, to the extent possible, coordinated, interoperable observing networks. Mechanisms should be supported that influence the implementation and evolution of observing systems to meet global, regional, and national needs. Ensuring global and regional coordination of observing system operations and development is another necessary condition, along with strong partnerships nurtured by close collaboration among partners irrespective of their socio-economic circumstances or political differences.

Addressing observing system gaps is also necessary for enabling uninterrupted functioning of the observing systems to provide equivalent services in all parts of the world and to all in need, giving special attention to the most vulnerable developing countries and populations. To meet these overarching conditions fully, the following subsidiary conditions must be satisfied:

- Effective engagement among entities operating or coordinating observing systems, including their users, in conducting interdisciplinary rolling reviews of requirements (RRR) for data and observing system capability analyses;
- Implementing agreed observing standards and best practices among entities operating or coordinating observing systems, along with mutual development of new standards in cooperation with international standardization bodies such as the International Organization for Standardization (ISO) and the Bureau International des Poids et Mesures (BIPM);
- Identifying data gaps (using information from the RRR and capability analyses) and building of capacities and technical support to fill them;
- Providing adequate funding, human resources, and observation and IT technology for operating observing systems, as well as for implementing QA/QC procedures (including calibration and maintaining the systems), while ensuring the reliability of data delivery, ensuring staff competence, ensuring delivery using interoperable formats, and distributing data and information worldwide in real or near real-time;
- Ensuring within-country capacity to ingest, quality control, backup, and manage their observational/climate data, and to link it to climate services, all via a sustainable CDMS capability;
- Implementing policies for open and broad access to all data needed for providing climate services at the frequencies required;
- Ensuring the relevance of observed variables and data to climate services required by users;

- Political commitment and accountability of entities operating or coordinating observing networks that help implement this Pillar.

It may take many years for the Observations and Monitoring Pillar of the GFCS to satisfy each of these conditions fully. Consideration should therefore be given to a two-stage implementation process, comprising 'Initial Implementation' and 'Full Implementation' actions.

The highest observational priorities from a climate services perspective for the four sectors that are the initial focus of the GFCS are discussed in the following sections. However, it should be stressed that additional climate observations and other climate-related data required to support the GFCS will need to be determined over time through an interactive process involving the providers of climate data and the various user communities. Defining such requirements should incorporate and build upon information gained during previous consultations undertaken under the aegis of the GFCS and other programmes. It is recognized that most countries will have explicit policies about releasing socio-economic data beyond national borders and that much such data will not be released. Nevertheless, for national and local use socio-economic, biological, and environmental data will be essential for developing climate services.

2.1.1 Important Observing System Needs for Agriculture and Food Security

The Exemplar on Food Security points out that greater frequency, severity, and intensity of weather and climate extremes have continued to increase food deficits despite technological advances that range from improved crop varieties and farm management systems to enhanced decision support tools and have benefited agricultural productivity. Concerns regarding climate and its impacts led the Committee on World Food Security and Nutrition (CFS) to request its High Level Panel of Experts on Food Security and Nutrition (HLPE) in 2010 to prepare a report on Food Security and Climate Change. The HLPE report calls on the Committee to "*facilitate a dialogue on improved global data collection efforts for climate change and food security,*" providing encouragement for an early initiative by the Observations and Monitoring Pillar to engage the agricultural community in coordinated efforts to refine and address needs for observational and other data related to the impact of climate on food security.

Long-term monitoring of basic climate variables related to fluxes of energy at the surface is essential if we are to plan for changes in the location, extent, and productivity of agricultural and grazing lands. Providing climate services for agriculture (as reflected in priority action areas 4 and 5 of the Agriculture and Food Security Exemplar) requires, *inter alia*, observations of the following types:

- In addition to standard weather parameters such as air temperature, precipitation, relative humidity, wind speed/direction, evaporation, and solar radiation, it is also important to collect soil moisture and soil temperature data at strategically located stations and, as appropriate, from space;
- Other observations useful for agricultural applications include those yielding vegetation indices (e.g., on photosynthetic activity), snow depth and snow cover, sand and dust loads, evapotranspiration measurements, and dew;
- Phenological observations record the dates of recurrence of the important phases of plant and animal life. Examples of these include the dates of such events as leafing, flowering, fruiting and leaf-fall of trees, migration of birds, and the appearance of insects;
- Since air pollutants can decrease crop yields, air pollutant observations, particularly of ozone, are also very important.

Other types of data and socio-economic information also contribute to producing climate services for agriculture. For example:

- Data on crop yields, area, and production statistics; livestock production; water quality (salinity, BOD/COD); information on biodiversity (species migration and extension); societal impacts; and assessments of vulnerability are all relevant for identifying and recording impacts on agriculture from climate and other natural hazards;

- Some vulnerability-related measures that include gender; age; ethnicity; political status; dependency on agriculture; level of wealth/poverty and human development; level of education; access to natural assets; access to alternative supplies of water and fodder; access to markets; baseline health; livelihood and employment options; access to alternative or supplemental employment and social networks; level of isolation; access to infrastructure; underlying climate variability; and exposure to previous droughts, floods, and other hazards.

Particularly relevant to the GFCS, the HLPE report on Food Security and Climate Change also stresses the need for:

- Expanded monitoring of agricultural emissions of GHGs;
- Enhanced and better coordinated collection and international exchange of climate and food security data;
- Strengthening of national and international meteorological, statistical, and data services, including the adoption of common metadata standards to maximize all possible synergies;
- Improved dissemination of forecast information to farmers, enabling them to cope with increased climatic variability and extreme events.

2.1.2 Important Observing System Needs for Health

The GFCS Health Exemplar identifies a range of observations required for providing climate services to the health sector:

- Local measurements of precipitation, humidity, soil moisture, and surface air temperature are needed to identify malaria risk by correlating health and population information with observations of local ecological and other conditions (e.g., such as vulnerability of population and type of habitation) conducive or non-conducive for transmission;
- Historical observations of temperature, humidity, satellite estimates of rainfall, the predicted start date of the rainy season, and the likelihood of extreme temperatures during the coming season are required to help manage diseases that are sensitive to climate (e.g., malaria, acute respiratory infections, intestinal helminths, and diarrhoea);
- Observations of chemical variables that contribute to air pollution, such as ozone, sulphur dioxide, oxides of nitrogen, and aerosols, along with wind observations, are important for identifying risks to the body's respiratory and the cardiovascular systems.

In general, information on related socio-economic variables is needed to support climate services for the health sector.

In many areas, an important constraint to climate analysis for health is the limited access to sufficiently long time series of quality-controlled daily observations. Such information must be made broadly available in a timely manner for it to have optimal value. Since many health effects tend to be localized, it is also important that climate observations are maintained on a local scale, whether in urban or rural areas. Substantial improvements are needed in the availability of relevant and reliable climate data on the local scale, especially in regions such as Africa where vulnerability to climate is high and information is often insufficient for local point-scale analyses. Last but not least, it is important to recover and digitize historical climate and health data that are still stored in obsolete media. This will enable cause-and-effect studies on climate and health and will develop the necessary interoperable climate-health databases for health risk monitoring and analysis.

2.1.3 Important Observing System Needs for Water

In many regions of the world, availability of fresh water is becoming an important limiting factor for socio-economic development. Water availability governs agricultural practices including animal husbandry, and influences inland fishing and aquaculture potential. It is essential for municipal water supplies, industry, transportation, and energy. Monitoring climate variables associated with the availability and quality of fresh water involves:

- Systematic observation of the basic atmospheric variables, such as precipitation, temperature, evaporation and wind;
- Systematic monitoring of hydrological variables that characterize the storage and movement of water, including stream flow, lake volume changes, groundwater, soil moisture, and water bound in snow and glaciers in high mountain areas and cold climates.

Observations of atmospheric variables allow the flux of water across the atmosphere-land interface to be estimated, while observations of hydrological variables, such as stream-flow and soil moisture, enable water budgets to be calculated for catchment areas.

Three main actions can help improve and adapt water management, including integrated management of extremes such as floods and droughts:

- At the global scale, there is a need for hydrological monitoring of changes in water resources availability and changes, including fluxes, of freshwater from continents in the world's oceans. This could be implemented through the GTN-H;
- At the regional and trans-boundary basin scale, implementation of the WHYCOS concept should be pursued through individual Hydrological Cycle Observing System (HYCOS) projects, based on agreed basin-wide and regional requirements;
- Finally, at the national level a need exists to strengthen the capabilities of National Hydrological Services for monitoring and assessing water resources, for forecasting extremes, and for improving water management practices in a changing climate.

As in other application areas, it is essential that information on relevant socio-economic variables be available to support the provision of climate services for the water sector. While more research is required to identify the most critical variables, the following aspects are certainly relevant:

- Socio-economic changes in the patterns of water use and consumption that are caused by general socio-economic development processes;
- Changes in population dynamics, including rapid urbanization and migration movements;
- Assessment of the adequacy of national policies and strategies in water resources management, including the management of extremes;
- Perceived societal value of water and ability to pay for improved water services.

The Water Exemplar highlights the fact that gaps and mismatches are often evident between the nature and distribution of atmospheric observing networks and water monitoring networks. This is seen to be a pressing problem in view of a progressive decline in the size and quality of meteorological and hydrological observing networks during recent decades, especially in countries most at risk of climate-water-related impacts. Improved coordination between atmospheric and water monitoring networks is, therefore, urgently needed to achieve compatible observation networks, to extend them to meet user needs, and to ensure the quality of the data. Given the increasing use of ground water for human consumption in many parts of the world, greater effort will need to be devoted to monitoring ground water storage and change. This further underlines the importance of developing and maintaining close linkages and effective coordination between the Observations and Monitoring and the other Pillars of the GFCS.

2.1.4 Important Observing System Needs for Disaster Risk Reduction (DRR)

Disaster risk arises when hazards interact with physical, social, economic, and environmental vulnerabilities. The DRR Exemplar stresses that:

- The basis for effective disaster risk management is the quantification and understanding of risks associated with natural disasters;
- Climate information is critical for analyzing hazard patterns and trends;

- Climate information must be complemented for vulnerability assessment by socio-economic data and analysis.

The identified need to develop hazard, vulnerability, and risk analyses and to implement effective multi-hazard early warning systems (MHEWS) brings with it requirements for systematic, high quality, and reliable observational data on appropriate spatial and temporal scales. In order to understand vulnerability and manage weather and climate-related extreme events, it is vital to have good-quality observational records. Moreover, since extreme events are rather infrequent, these records need to be long-term and temporally homogeneous. In addition to hydrological, oceanographic, atmospheric, and other physical observations, such information must also be complemented with socio-economic data and analysis for vulnerability assessments.

More specifically, observation and monitoring-related requirements from the Disaster Risk Reduction Exemplar include:

- Historic and real-time hazard observational records at appropriate spatial and temporal resolution, including relevant metadata, to allow for related decision-making;
- Observation and real-time monitoring of extreme events, including associated impacts;
- Interoperability of data across climate, health, socio-economic and biological observations.

With risk knowledge, governments can manage risks through early warning systems and preparedness, sectorial planning, and insurance and financing mechanisms. Collecting loss data is also essential to enabling cost-benefit analysis providing economic justification for investing in DRR systems.

The Observations and Monitoring Pillar of the GFCS addresses several of the Hyogo Framework's priorities for action directly. However, providing effective support for Disaster Risk Reduction will also require close coordination with other pillars of the GFCS to ensure that the requirements of the DRR community for observations and socio-economic data are clarified and addressed in an optimal manner, drawing on research capacities to enhance observational techniques, monitor new variables, and improve data analysis and delivery systems. Among other things, the DRR community has a strong interest in accelerating data rescue and in digitizing climate records, given that a significant amount of NMHS and other data that would be valuable in developing operational climate early warning for DRR. These data are still stored in obsolete media and face the risk of loss and degradation.

2.2 Engagement in the Working Mechanisms of Potential Partners at Global, Regional, and National Levels

A key factor for successfully implementing the GFCS is the coordinated and integrated engagement of relevant partners at global, regional and national levels. Appendix 2 provides an overview of major stakeholders in the Observations and Monitoring Pillar including the Global Climate Observing System (GCOS), the WMO Integrated Global Observing System (WIGOS), the World Hydrological Cycle Observing System (WHYCOS) and its regional components, UN Agencies and programmes, National Environmental and Natural Resources Agencies, research institutions, etc.

2.3 Criteria for Identifying Projects/Activities at Global, Regional, and National Levels

The criteria for selecting observation and monitoring projects should adhere closely to the overall guiding Principles of the GFCS, including being directly relevant to the four priority areas of agriculture, health, disaster risk reduction and water. Where climate observation networks and systems are concerned, however, a most important imperative is to sustain the level of what already exists that respond to demands for climate services, particularly since observational coverage has been declining in many countries in recent years. In general, therefore, projects should be aimed at enhancing these observational programmes where this is essential to providing the data needed to support services to the priority sectors and to implementing the GFCS overall.

Such enhancements might include filling observational gaps, increasing observational frequency, measuring new climate-system variables, and/or implementing improvements to telecommunications systems for data exchange.

Among specific questions that should serve as criteria for selecting and prioritizing observation and monitoring projects for the near term are the following:

- Does the project provide the data most needed to build the capacity to provide climate services to those in need of such services?
- Does the project address the data needs of the priority activities of the UIP, CSIS, and RMP Annexes?
- Does the project give priority to the immediate needs of climate-vulnerable developing countries, especially the least developed countries in Africa and the small island states?
- Does the project achieve synergies where collective efforts produce results that would not have otherwise been possible?
- Does the project build upon rather than duplicate partnerships that are already in place?
- Does the project encourage free and open exchange of climate data and promote climate information as, primarily, an international public good?
- Can the project be completed within the time frame and proposed budget?

Ideally, projects should also address observational needs on all spatial scales, contributing data that are relevant at the global, regional, national, and local levels.

The projects for near-term action that are introduced below are aligned with at least one of the four priority sectors, will contribute to building regional and national capabilities to provide climate services, and will address needed improvements in relevant climate networks.

2.4 Initial Implementation Activities/Projects

A large number of improvements are needed in climate observing systems on global, regional, and national scales. This section identifies 14 initial implementation priorities that address the needs and gaps discussed in section 1.4. Appendix 5 gives a more extensive list of actions and activities that are also important for implementing as resources become available.

Cost implications of the 14 initial implementation priorities are introduced in section 5, Table 1. Appendix 3 provides a more detailed description of these proposed priority activities. All of the activities meet at least one of the criteria for selection cited in section 2.3, but most meet multiple criteria.

Some of these projects are intended to increase and sustain consultation with users of climate information through the UIP mechanism in order to clarify evolving requirements for physical observations and socio-economic data, highlight deficiencies, and facilitate response. Another group of activities recognizes needs that have been clearly expressed for greater densities in both space and time for the types of observations already being produced (including, but not limited to, the ECVs). Consequently, early emphasis is placed on filling gaps and sustaining existing observational networks. Since it will not be possible to do everything during the first few years of the GFCS, initial priorities will be to reactivate silent stations in accordance with the criteria identified in section 2.3 above and rehabilitate key stations in data poor areas as well as pursuing complementary efforts regarding space-based observation and atmospheric chemistry. Urgent needs for enhancing hydrological observation networks and for coastal monitoring are likewise addressed. In addition, expanding observational databases needed to support applications in the key sectors implies that all existing data should be utilized and made accessible to providers and users of climate services. It is proposed, therefore, that concerted efforts be made to rescue, digitize and manage historical data and capture observations from external sources such as community groups, the private sector, and research institutions.

A more extensive list of proposed activities is given in Appendix 5, Tables 5.1 and 5.2. These latter Tables list additional projects that can be undertaken during later phases of implementation as and

when resources become available and priorities dictate. Table 5.1 provides a highly condensed synthesis of the more detailed information included in Table 5.2. This synthesis draws attention to the expected deliverables issuing from implementing the proposed initiatives and provides a sense of the related timelines, indicating the involvement of many key partners and presenting very preliminary cost estimates. It also draws attention to potential risks that could slow or otherwise negatively affect implementation. All of the projects proposed respond to at least two of the eight GFCS Principles and represent a subset of an even larger number of needed observing system improvements that is especially relevant to the GFCS.

Project 1.1: Establishing a formal mechanism for consulting users

a) Description: By means of brainstorming workshops co-ordinating closely with liaison activities proposed in the four Exemplars, representatives of user communities and representatives of observation providers will convene to discuss mutual concerns on the global, regional and national levels. Linkages to the User Interface Platform and the Climate Services Information System will be especially important for identifying implicit observation needs.

b) Objective: Establishing a continuing mechanism, in line with GFCS Principle 8, whereby representatives of different user communities, including but not limited to the four focal areas of the GFCS Implementation Plan, can consult with providers of climate observations and access relevant socio-economic, biological, and/or environmental data to clarify data needs at the global, regional and national levels to orient climate service provision.

Project 1.2: Assessing the role of observations in adapting to climate variability and change

a) Description: An international, multi-stakeholder workshop will be organized to assess the adequacy of, and future requirements for, observations to support adaptation to climate variability and change;

b) Objectives: Assess the adequacy of observations in supporting adaptation to climate variability and change. Identify the need for new observations useful in monitoring and supporting climate services that address adaptation needs. Identify requirements for observations to support research into adaptation, such as those offered by the Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) and/or the WCRP.

Project 2.1: Rehabilitating silent stations and key stations in data poor areas

a) Description: Silent stations and key stations in data poor areas will be rehabilitated, including GSN and GUAN stations, in order to sustain, improve, and generally expand the comprehensive atmospheric, oceanic and terrestrial surface- and space-based networks, including air quality and cryospheric networks. Agreed standards for observing practices will be applied to ensure that data are suitable for climate purposes. Priority will be given to those stations whose data are needed for meeting observational needs derived from the four Exemplars;

b) Objectives: Enable improved climate service provision at national, regional and global levels. Silent stations and key stations in data poor areas, including GSN and GUAN stations, will be rehabilitated to address the need for basic climate services as well as the need expressed in all Exemplars for climate observations on appropriate temporal and spatial scales.

Project 2.2: Designing baseline networks to underpin climate services

a) Description: In order to incorporate new observing requirements for GFCS sectors and to sustain and generally expand the comprehensive atmospheric, oceanic, and terrestrial surface- and space-based networks (including air quality and cryospheric networks) across all geographical scales, baseline (core) networks will be designed and included in global, regional, and national near- and long-term plans. These baseline networks will respect standard observing practices and will be managed according to agreed QMS to ensure that data are suitable for climate purposes;

b) Objectives: To enable and underpin improved, operational climate services using well-designed, sustained baseline (core) networks on national, regional and global scales.

Project 2.3: Supporting the operation of baseline networks in LDCs and SIDS by setting up a Trust Fund

a) Description: In order to underpin improved climate service provision as discussed in the Exemplars, it is necessary to sustain, improve, and generally expand the comprehensive atmospheric, oceanic and terrestrial and surface- and space-based networks, including air quality and cryospheric networks as well as the related standard climate data management capabilities including data rescue and basic communication infrastructure. Support for operating baseline networks and related (climate) data management in LDCs and SIDS should be provided by the international community;

b) Objectives: To enable improved, operational climate services on the national scale that contribute to regional and global services by supporting the operation of baseline networks including related (climate) data management systems (CDMS) and basic communication infrastructure in LDCs and SIDS through a Trust Fund.

Project 2.4: Improving ground-based and space-based networks for measuring precipitation

a) Description: Measuring precipitation will be improved by filling gaps and enhancing surface- and space-based monitoring networks in order to respond to users' need, including that expressed in the Exemplars, for more accurate and representative precipitation data on national, regional and global scales. Agreed standards for observing practices will be applied to ensure that data are suitable for climate purposes;

b) Objectives: Improved climate services based on reliable, spatially-representative precipitation data from atmospheric, oceanic, and terrestrial as well as surface- and space-based networks in near-real time.

Project 2.5: Developing guidelines to improve discovery of climate observational data and products

a) Description: Guidance will be developed and training provided for GFCS contributors and users on how climate observations and products can be found, based on Discovery Metadata records, so that the benefits from investing in observations and products can be achieved. Further tools may be developed to assist users in easy data discovery. Once accessed, the data will only be usable if they can be exchanged and processed unambiguously. WMO achieves this within its own community by using standard data representations; however, this approach becomes increasingly complex when collecting and exchanging information from widely different communities. The increasing need for more frequent and more detailed climate information reporting means that these data standards must be enhanced using a flexible approach that adapts easily to representing new information but does not prevent those unable to make use of this additional information as yet from using other information within the same report;

b) Objectives: To provide guidance and training for potential user communities on how climate observations and products are described in WIS Discovery Metadata records. To enhance the usability of climate observations by developing an abstract data model that allows seamless transition between the data formats of different communities.

Project 2.6: Developing an integrated global greenhouse gas information system, including enhancing regional scale chemical measurements

a) Description: Effective and cost-efficient adaptation requires an understanding of the anticipated rates and ultimate extent of climate change. Ground- and space-based observations, carbon-cycle modelling, fossil fuel use data, and land-use data will be combined by meta-analysis and modelling to provide an extensive distribution system of information on changing sources and sinks of greenhouse gases and their consequences on policy-relevant temporal and spatial scales. Climate system projections can be improved, on the basis of such information, to respond for example to the call from the UN

World Food Summit for improved early warning and forecasting systems for food insecurity and vulnerability as highlighted in the Agriculture and Food Security Exemplar;

b) Objectives: To improve climate projections by improving information and understanding of greenhouse gas sources, sinks, transport, and impacts through enhanced research with increased, coordinated observations and improved analysis.

Project 2.7: Establishing best practices for air quality observations and for monitoring in urban environments

a) Description: According to the World Bank (2008), to combat the effects of climate change, targeted research is needed at the city level to enable policymakers to understand the magnitude of the impacts and the alternatives to improve resilience of cities. In this project, case studies will be developed for understanding air pollution, health, and climate connections in large urban complexes in Africa, Asia, and Latin America. This will lead to improving and harmonizing air quality measurements and related modelling and to an international network of institutional partnerships supporting air quality-related services.

b) Objectives: To establish guidelines and networks of quality-assured air quality measurement sites in order to provide accurate knowledge of pollution levels in cities to support decision-making. The Health Exemplar cites “air quality, pollens and allergens, ultra-violet radiation, and their impacts on human health, especially in cities,” as a particular concern.

Project 3: Large-scale data recovery, digitization, and homogenisation of climate records

a) Description: The project will provide support to global and regional Data Rescue, Digitization, and Homogenization (DARE&D&H) initiatives and develop new initiatives as required. The target initiatives are those using modern techniques, procedures, and tools to safeguard climate records risking damage or loss and to recover and digitize them. The project will promote the use of these techniques in developing and least developed countries, including through training workshops for NMHSs and other organizations working in climate data collection. Ensuring appropriate CDMS capabilities to integrate rescued data into the national climate record is an integral part of the project. The ultimate goals of the project are to enable access and use of high-quality long-term climate data with daily time resolution, to reconstitute and assess the changing behaviour of climate extremes affecting water, agriculture, and health, and to provide adequate databases on climate hazards to support DRR;

b) Objectives: Enabling and underpinning improved national, regional and global climate services based on historic climate data by: (i) enhancing the capacity of NMHSs and other climate data communities to accelerate the recovery, digitization, and homogenization of climate records, and to use modern data archiving and management tools including CDMS; and (ii) setting up an internationally coordinated initiative for Climate Assessment and Data sets (ICA&D) for the developing and least developed countries and providing high-quality climate assessments and data sets based on the output of enhanced DARE activities worldwide. This responds to the call for “strengthening data recovery and digitization to support disaster loss accounting and cost-benefit analysis” in the DRR Exemplar.

Project 4: Providing information for sustainable water resources development and management in important shared international river basins

a) Description: The WHYCOS initiative, focusing on improving data collection, storage, dissemination and sharing as well as on developing water resources management products, provides an opportunity for implementing integrated hydrometeorological and climate-related networks aimed specifically at improving sustainable water resources management in a changing climate. WHYCOS is a global WMO Programme, developed in response to the scarcity or absence of accurate data and information on freshwater resources caused primarily by deteriorating observation networks and insufficient data management capabilities. The programme is implemented through various components

(HYCOSs) at the regional and/or basin scale, three or four of which are the focus of this project, which is aligned with the pilot projects addressed in the Water Exemplar;

b) Objectives: Promoting and facilitating collection, analysis, exchange, dissemination and use of water-related information, using modern information technologies and capacity building.

Project 5: Monitoring coastal regions to support adaptation and understanding of vulnerabilities

a) Description: This activity will address weaknesses in the observational coverage of climatically-important Essential Ocean Variables (EOV) and Essential Climate Variables (ECVs) needed for coastal region monitoring, thus responding to the requirements of the Framework for Ocean Observations in this regard (see section 1.4 and Appendix 1). This will allow better understanding and prediction of changes in the coastal environment (e.g., sea level rise, coastal erosion) and natural disasters (e.g., storm surges, extreme waves, tsunamis) to benefit coastal communities and to protect peoples' lives and property better;

b) Objectives: To improve coastal region monitoring and related services by increasing the percentage of completion from 62 to 80 per cent of the initial global ocean observing system, as defined by the JCOMM Observations Programme Area Implementation Goals. It addresses needs for strengthening the capacity for observations and monitoring in order to inform risk assessments as outlined in the DRR Exemplar.

Project 6: Establishing a coordination mechanism for collecting, managing, and exchanging climate and related food security data

a) Description: This project will engage the climate community and the agriculture and food security sector in coordinated efforts to address needs for climate and related food security data, consistent with the High Level Recommendation to the Committee on World Food Security and Nutrition to "facilitate a dialogue on improved global data collection efforts for climate change and food security." As indicated in the Exemplar on Food Security, effective delivery of climate services depends critically on the two communities working together and learning from each other;

b) Objectives: To achieve enhanced, better coordinated collection and international exchange of climate and food security data and derived products, maximizing all possible synergies by adopting agreed data and metadata standards and improving data analysis and exchange capacities.

Project 7: Establishing a coordination mechanism for architecture for climate monitoring from space

a) Description: A sustained, coordinated architecture for climate monitoring from space is an essential building-block of the GFCS Observations and Monitoring Pillar, supporting all four priority sectors and all ECVs observable from space. A broad range of international partners contribute to this architecture, and their coordination was begun in 2011 with an ad hoc team including satellite mission operators and user representatives and involving WMO, GCOS, and WCRP. A standing coordination mechanism needs to be agreed and established over the next two years to bring the coordination of space-based observing systems, processing activities, and user services that support climate monitoring to the same level as currently in place for weather forecasting;

b) Objectives: A coordination mechanism will be internationally agreed and established.

2.5 Implementation Approach (including operational and organizational aspects)

The implementation approach is composed of several phases and includes projects that will satisfy the necessary conditions described in section 2.1 while complying with the criteria for selecting observation and monitoring projects identified in section 2.3. For many, if not most types of observations needed by the GFCS, networks and coordinating mechanisms have already been established. Thus the implementation approach will be to work with existing entities wherever possible and to build upon activities that are already underway. Where adequate coordinating mechanisms do not exist, the User Interface Platform suggests that the organizational entities most

involved should be identified and brought together to exchange views on what is needed and on how progress can be made. This is the intent of Project 1.1 with respect to observations.

In general, projects that can address significant gaps will be undertaken first. Several of the projects listed in Table 1 (e.g. Project 1.1) are discrete activities that will be concluded within the initial two-year phase of the GFCS. Others, in particular gap-filling projects, will be launched during this period but are expected to continue well beyond the initial phase. The emphasis on the early implementation activities in Table 1 does not preclude implementing the larger set of actions and activities shown in Table 5.2. These actions will be implemented by the various GFCS partner organizations as time and resources permit.

Many of the projects identified for early action are relevant on more than one scale. For example, while the project to improve the GSN and GUAN networks principally addresses globally-coordinated networks, data from individual stations also make substantive contributions at regional and local levels. Implementation of HYCOS projects is undertaken regionally at river basin scale, but there will be interest at the local level in river stage and discharge measurements. Air pollution measurements, while primarily of local concern, also contribute to regional scale analyses of pollutant loadings.

2.6 Monitoring and Evaluating the Implementing Activities (including monitoring success)

A review mechanism is an important tool for managing the operation and the development of observing systems and for rectifying deviations from plans. The observing systems under this Pillar are operated, managed, and evaluated by a number of UN, intergovernmental, or international bodies, programmes, and coordinating mechanisms. For example, both GCOS and WIGOS have well-established mechanisms for monitoring the implementation of their ongoing activities. Because of the possible interdependence of activities of different entities and/or pillars, however, it is foreseen that an overarching GFCS monitoring and evaluation mechanism will be required to assess the performance of the observing systems in their entirety and to introduce corrective measures when necessary. Such a system does not yet exist, and it may be difficult to agree upon one, but nonetheless it is still important. A useful first step, therefore, will be to engage key partners and stakeholders in discussions aimed at clarifying the need for, scope, and focus of such an overarching system, drawing on experience with established GCOS, WIGOS, and other review and adjustment mechanisms.

At a more micro level, it will also be necessary to monitor and evaluate implementation progress for each project falling under the Observations and Monitoring Pillar in order to:

- Ensure that implementation milestones and targets are being met;
- Identify needs for, and initiate, remedial actions when necessary to ensure that project implementation remains on track;
- Assess the extent to which completed projects contribute to the overall goals of the Pillar as defined in response to needs identified in other GFCS Pillars as well as in the Exemplars. Project monitoring and assessment by the responsible project managers will assume critical importance during the first two years of GFCS implementation.

2.7 Risk Management in Implementing Activities

A Risk Management Plan (RMP) that includes risk mitigation will be developed for each project and group of related projects in the Observations and Monitoring Pillar during the initial stage of project implementation. The RMP of the Pillar should be linked to the RMP of the overall GFCS. A reasonable amount of time will need to be allocated for identifying specific risks and for devising risk mitigation strategies. The following general risk areas have, however, already been identified:

- The need for a firm commitment from all stakeholders to implementing projects under this Pillar within the agreed time frame and to provide the required human and financial resources;

- The need for appropriate leadership for implementing the Framework, including clarity regarding authority and the responsibilities of entities and individuals in project implementation;
- The risk posed by inadequately coordinating interdependent projects;
- The need for an effective interface between users of services (agriculture, water resources, health, and DRR sectors) and entities operating observing systems, especially for integrating socio-economic data with physical variables;
- Lack of transparency in managing the implementation of the project or activity;
- The potential for inadequate implementation if sufficient human or financial resources are not available.

To minimize potential risks, Risk Management Plans must be agreed and monitored by the partners of each project.

3 ENABLING MECHANISMS

The Observations and Monitoring Pillar will build on existing observational and monitoring programmes and activities, including those of partnering UN agencies. Increased coordination and cooperation along with strengthened partnerships and as a specific communication strategy are key enablers for implementing the Observations and Monitoring Pillar. Appendix 4 addresses relevant issues in more detail.

4 RESOURCE MOBILIZATION

4.1 National level (e.g. governments, the private sector, foundations, bilateral and multilateral funding mechanisms, international agencies, etc.)

Implementing the actions identified in this Annex will depend heavily on the availability of financial, technological, and human resources. The organizations and other entities listed in the "stakeholder" column of Tables 5.1 and 5.2 in Appendix 5 are typically those that will have a principal role in resource mobilization. Of necessity, resource mobilization will be pursued at global, regional, and national levels at the same time. Inevitably, national efforts to mobilize resources will be of the highest importance, even in many developing countries. While the national governments of the least developed countries will have difficulty funding more than a small part of their countries' observing needs, even these countries are not without recourse. At COP 17, for example, the Global Environment Facility confirmed that both the Least Developed Countries Fund and the Special Climate Change Fund could be used to address observing system needs. It is also foreseen that the Green Climate Fund, which is being established through UNFCCC processes, should be available eventually to fund the adaptation activities of developing countries, including activities to improve climate observations. There is almost certainly additional scope for working through the UNFCCC and its subsidiary bodies (the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI)) to augment funding for improving observations to support the GFCS and for other climate-related needs. The COP has on various occasions urged Parties to support observing system improvements. Furthermore, the SBSTA has shown considerable interest in the GFCS and has requested updates on progress in implementing it.

4.2 Regional level (e.g. regional development banks, regional organizations, etc.)

At the regional scale, regional development banks can play an important role. In Africa, for example, the African Development Bank has become a principal partner (along with the African Union Commission and the UN Economic Commission for Africa) of the Climate for Development in Africa Programme (ClimDev Africa). Beginning in 2012 it will be possible for NMHSs, regional climate organizations and others to submit proposals for inclusion in the annual ClimDev Africa Work Programme. Proposals that address observing requirements in support of the GFCS will be given high priority. Regional organizations, such as the African Centre of Meteorological Applications for Development (ACMAD), the Caribbean Community Climate Change Centre (CCCCC), and CIIFEN all work to facilitate resource mobilization for their members.

4.3 Global level

At the global scale, international organizations have both general and specific responsibilities to help meet the funding needs of their members, and these organizations can be supportive. For example, the GCOS Programme, through its reporting link with the UNFCCC, highlights the funding needs mainly (but not exclusively) of developing countries for observing system improvements. It can also, to a limited extent, seek funds to use in developing countries through its GCOS Cooperation Mechanism.

5 COSTED SUMMARY OF ACTIVITIES/PROJECTS

Table 1 provides a cost estimate of the initial implementation initiatives as proposed and described in section 2.4 and in Appendix 3.

Table 5.1 of Appendix 5 presents a synthesis of proposed initiatives addressing observational gaps and needs in the major components of the climate system. Table 5.2 of the same Appendix provides additional detail on the individual initiatives that have been synthesized in Table 5.1. As noted earlier, these projects were selected from a larger number of proposed projects addressing needs for observing system improvements because they were deemed to be especially relevant to the GFCS. They were developed in consultation with key partners engaged with the existing mechanisms and programmes relating to observational systems discussed in earlier sections of this Annex.

Table 1. Initial Implementation Activities

	ACTIVITY	PRIORITY SECTOR(S)	IMPLEMENTATION PRIORITY(IES)	GEO-GRAPHIC SCOPE	LEAD ORGANI-ZATIONS	OTHER ORGANI-ZATIONS	COST USDxM
1	**Rolling consultations with users, in particular to better understand data and product needs from the GFCS priority sectors and other sectors**.	All Sectors	1.1. Establishing a formal mechanism for consulting users 1.2. Assessing the role of observations in adapting to climate variability and change	Global, Regional, National	WMO	All stakeholders	0.1M 0.2M
2	**1) Translate data and product needs from GFCS users/ sectors into specific observational requirements and incorporate them into near-to-long-term observing baselines** **2) Sustain, improve, and generally expand the comprehensive atmospheric, oceanic, and terrestrial surface-based networks, including air quality and cryospheric networks, and increase the frequency of observations**	All Sectors	2.1. Rehabilitating silent stations and key stations in data poor areas 2.2 Designing baseline networks to underpin climate services 2.3. Supporting the operation of baseline networks in LDCs and SIDS by setting up a Trust Fund 2.4. Improving ground-based and space-based networks for measuring precipitation 2.5. Developing guidelines to improve discovery of climate observational data and products 2.6. Developing an integrated global greenhouse gas system, including enhancing regional scale chemical measurements 2.7. Establishing best practices for air quality observations and for monitoring in urban environments	Global, Regional, National	WMO, IOC, FAO, Space agencies	All stakeholders, Funding agencies	5M 1.5M 0.5M 30M 0.7M 0.35M 0.35M
3	**Large-scale data recovery and digitization, integrating data from community observation networks.**	All sectors	3. Large-scale data recovery, digitization and homogenisation of climate records	National	WMO	RAs, RCCs, ACMAD, CLIMDEV, UNFCCC, UNEP, ACRE, Nairobi Work Programme	1.0M/y

4	**Fully implement HYCOS in important shared international river basins to provide information for sustainable water resources development and management.**	Water	4. Providing information for sustainable water resources development and management in important shared international river basins	Regional	WMO	NMHSs, NHSs, UNESCO	15M
5	**Monitor coastal regions to support adaptation and understanding of vulnerabilities**	All sectors	5. Monitoring coastal regions to support adaptation and understanding of vulnerabilities	Regional, National	IOC	WMO	8.0M/y
6	**Climate and Food Security**	Agriculture	6. Establishing a coordination mechanism for collecting, managing, and exchanging climate and related food security data	Global	FAO, CFS	WMO	0.1M
7	**Develop and fully implement architecture for climate monitoring from space**	All sectors	7. Establishing a coordination mechanism for Space-based Architecture for Climate Monitoring	Global	CEOS, CGMS, WMO Space Programme	All stakeholders, GEO	1M

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