Towards effective climate services: Indian context

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The Global Framework for Climate Services formulated by the World Meteorological Organization envisages a transformative role for all the National Meteorological and Hydrological Services to provide climate services. This article discusses why it is necessary for India Meteorological Department to broaden its functions beyond the traditional hydro-meteorological focus, and what is required for it to transform to a world-class, weather-ready (already unparallel in South Asia) and climate-smart organization.

Keywords: Climate services, climate-smart, meteorological organization, weather-ready.

CLIMATE change and its pernicious impacts are now a reality. Not only was 2016 the warmest year recorded since 1901, it was also not an outlier – the six warmest recorded years in India's history have occurred since 2009. Another marker of India's changing climate is more intense and more frequent heat waves sweeping the country. According to the *Lancet*, there were 40 million more 'heat wave exposure events' in India in 2016 compared to 2012. To make matters worse, annual rainfall in 2018 over the country was 85% of the long period average (LPA). In face of such events, the theme of the world meteorological day for the year 2018 'weather-ready, climate-smart'[1], reiterates the looming threat of climate change and extreme weather events. Given its location, relatively low level of development and vast population, India is especially vulnerable to the impacts of climate change. In this article, we examine the role of India Meteorological Department (IMD) and what it needs to do to broaden its realm from weather to climate services.

IMD's journey: from measuring gauges to supercomputers

IMD may be regarded as the National Meteorological and Hydrological Service (NMHS) of the country, and serves as the nodal government agency for these services. It provides meteorological services in agriculture, aviation, shipping, disaster risk reduction, environmental monitoring, health, power and water sectors, to name a few. The spectrum of products offered by IMD include weather information across temporal scales, specialized forecast, rainfall information, satellite-derived products and data on positional astronomy through its vast network of sensors and observation platforms. Since its establishment in 1875, IMD has come a long way and significantly expanded its infrastructure for observations, forecasting, early warning and statistical services. Among the developing countries, IMD was the first weather office to have its own satellite system. It was also the first government agency to be allocated a supercomputer in 1988, for furthering its scientific capabilities. IMD is also one of the six tropical cyclone Regional Specialized Meteorological Centres (RSMCs) designated by World Meteorological Organization (WMO)[2]. Particularly over the last decade, IMD has modernized its scientific infrastructure to global standards in the fields of meteorological observations and information systems[3]. In 2018, it took a further quantum leap with acquisition of new super computers and downscaled its weather forecast from grids of 530 to 144 sq. km, thus enabling it to forecast severe weather conditions up to the sub-district or block level[4,5].

Impact assessment of climate change

A report of the Intergovernmental Panel on Climate Change highlights the large, multi-sector impacts with an increase in temperature of 1.5°C, especially in regions with vulnerable populations such as South Asia, including India[6]. Projected climate change impacts include heavy precipitation events, including flooding, tropical cyclones of category 4 and 5, sea-level rise and loss of coastal ecosystems, heat waves with severe impact on livestock, reduced food security, water resources, and increased risk of vector-borne diseases, all leading to significant reductions in economic growth[7].

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Global framework for climate services in the Indian context

WMO is a specialized agency of the United Nations (UN) which facilitates international partnerships on development of meteorology, operational hydrology and related geophysical sciences[8]. As an international response to the necessity for user-driven climate services, WMO and its partners formulated the Global Framework for Climate Services (GFCS) in 2009. The GFCS (http://www.wmo.int/gfcs/about-gfcs) envisions 'To enable better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale'[9]. The framework has five interdisciplinary and integrated pillars that support the development and delivery of climate services to users: (i) observations and monitoring; (ii) research, modelling, and prediction; (iii) climate services information system; (iv) user interface platform (UIP) and (v) capacity development. The first three are centred on the technical aspects of climate science, whereas the fourth pillar focuses on enabling end use of information. The fifth one obviously cuts across all the four pillars. IMD has a potential role that remains to be fully exploited as of now.

The first pillar of the GFCS comprises of the requisite infrastructure to generate metadata. The metadata are assimilated, processed, archived and distributed as the basic ingredient to develop climate products and services. The second pillar is necessary to improve the science, integrate multidisciplinary research, include socio-economic factors, forecast impacts and provide a range of adaptation options. The third pillar is responsible for collection, storage and processing of data, generation and distribution of information in the form of products and services. The fourth and fifth pillars, being the most important in the Indian context, have been dealt with in subsequent sections.

The GFCS focuses especially on five major priority areas: (i) agriculture and food security; (ii) disaster risk reduction (DRR); (iii) energy; (iv) health and (v) water[9].

The Population Census 2011 puts India's population at 1.21 billion[10]. India is an agrarian economy, and is highly sensitive to climate variability, climate change and natural hazards. The variations in Indian monsoon rainfall affect agricultural production and consequently impact the gross domestic product (GDP) of the country[11]. Also, in light of the large population and its growth, food security is a major issue.

Climate variability and climate change significantly impact public health. Temperature and rainfall conditions influence the spread of communicable diseases, while extreme weather events cause injury and death. There are demonstrated associations between high temperature and mortality[12], and between malarial mosquitoes and temperature in India[13].

As for the energy systems, both demand and supply are impacted by extreme weather and climate events. While temperature rise affects the energy demand-related activities; on the supply aspect, meteorological events impact a wide range of variables like availability of renewable resources, biofuels, technology downtime, transmission, distribution and transfers[14]. For a large-sized country like India, these supply and demand aspects of the energy sector play a critical role in energy security.

The adequate amount and timely availability of water is strongly influenced by climate variability and change, and an over or under supply impedes socio-economic growth.

The inter-linkages between global, regional and national frameworks

Capacity development is one of the strategic priorities for WMO. As part of the programme for 'Implementing the GFCS at regional and national level', WMO has an ongoing project to 'develop capacities for climate services in South Asian and Third Pole region'. The Third Pole comprises of the world's highest mountains, including the Himalaya and the Tibetan Plateau region. The aim of the project is coordination and exchange of climatological data and services at regional and national level. The process utilizes the pre-existing Regional Climate Outlook Forums (RCOFs) and the establishment of Regional Climate Centres (RCCs). The RCCs are regional centres of excellence for generating regional climate products.

For Regional Association II, i.e. the Asia region, there are five RCOFs. The South Asian Climate Outlook Forum (SASCOF) pertains to South Asian countries. IMD provides the annual regional forecast outlook for the southwest monsoon season rainfall for SASCOF. The Indian Institute of Tropical Meteorology (IITM), Pune is the designated RCC for the South Asian region since May 2017.

Why NMHS in climate change management?

The provisioning of climate services is vital to build climate resilience. They also serve as primary requisites to address the sustainable developmental goals (SDGs), the Priorities for Action in the Sendai Framework for disaster risk reduction, the Paris Agreement of the UN Framework Convention on Climate Change (UNFCCC) and other international conventions/agreements. The NMHS is a repository of observational networks and data which serve as metadata for climate services. The NMHS has technical competency to process metadata into customized products, applications and services[15]. Also, the NMHS is involved in dissemination of early warning to relevant stakeholders. The NMHSs is therefore the most suited for implementing climate services at the national level. The effective implementation of this role envisaged under the GFCS, requires transformation through broadening of horizons to render smart climate service as part of meteorological service that is weather-ready and also climate-smart.

IMD – Current status

Let us have a broader look at the current status of the weather and climate services being provided by IMD.

Weather services

IMD has a modern and extensive network for surface, upper air, radar and satellite observations and monitoring. It also employs global and regional modelling for numerical weather prediction, and provides short, medium, extended range and seasonal forecast. It undertakes observations, communications, forecasting and weather services.

In addition to a pan-India organizational network, with specialized divisions to deal with the respective subjects, IMD has provisioned for availability of weather information through its communication networks and also a dedicated web portal (http://www.imd.gov.in/). The web portal includes country-wide weather inference, weather forecast, weather warnings, weekly weather reports and extended range outlook, marine weather bulletins, heat waves information, now cast warnings, Telphigrams (upper air atmospheric profiles), city weather, information of land surface hydrology, etc. In addition, there are specialized forecasts for tourism, highway, mountain weather and specific routes (‘yatras’). The web portal also provides real-time updates on METARS (routine weather observations), satellite products and radar images. Specialized information on monsoon, cyclones, earthquakes and positional astronomy is also regularly provided as and when such needs arise.

Climate services

The National Data Centre of IMD located at Pune, is the repository of all observational data recorded through the network of various sensors and platforms, including ship data, covering over a century[16]. IMD has been providing climatological data services to numerous users (central and state governments, universities, research institutions, pubic undertakings, private enterprises and individuals) for a variety of applications; for example, laying of runways at airports, town planning, tourism, mountaineering, locations of ports, installations and industries, bridges and telecommunication structures, operation of multipurpose hydel projects, water and power management, exploitation of non-conventional energy sources, etc.

IMD is also involved in conducting primary research in climate science. The research contributions are regularly published in *Mausam*, extra departmental journals, Meteorological Monographs and others[3]. It is equipped with high-end computational facilities, physical infrastructure and technically skilled human resources, contributing to designing, development and dissemination of climate information products and services.

Under the GFCS, IMD has formed a new Climate Research and Services Division in 2017, by combining different offices in Pune, to enhance the quality of climate services[17]. The major services currently provided by this Division are: (a) operational long-range forecast and its verification, (b) climate monitoring and annual climate statement, and (c) supply of meteorological data[3]. The new Division would accelerate efforts to provide climate services to different sectors such as agriculture, hydrometeorology, health and energy[18].

To design and deliver user-oriented climate services is an additional responsibility of IMD. Though a beginning has been made by the organization, there is a long way to go. The stepwise approach suggested in the succeeding sections may help put matters into perspective.

Improving perceptions

The first step is to develop a clear understanding of what climate services are. The distinction between weather services and climate services is that of timescale and customizing the information to the specific requirements of different types of end-users. Weather services deal with imminent weather, whereas climate services deal with seasonal, decadal and much longer time-frames. The end-user product of climate services is ‘generally in the form of tools, products, websites, or bulletins’. This perception needs to strengthen across all categories of stakeholders of climate services. Another step is not to misread climate research as climate service. While climate research comprises of systematic studies to enhance understanding of the subject, climate services are meant to provide usable information tailored to end-user needs[19].

Strengthening climate services

The next step is to understand what IMD is currently doing for the cause of climate services and what can be done further or differently to maximize the outcomes and usability.

Let us first examine these technical aspects in greater detail. IMD has been performing considerably well in the first three technical aspects of GFCS. However, some ground needs to be covered in the remaining two aspects, i.e. user interface platform and capacity development.

User interface platform

The UIP provides a means of engagement between providers and services. The communication and collaboration through UIP lead to a better understanding of user-specific needs, and thus serve to improve the development and delivery of customized climate services. The outcomes of an effective UIP are feedback, dialogue, outreach and evaluation. Building a UIP requires a mix of formal and informal methods to promote understanding of user needs. The formal methods include committees, working groups, workshops, consultations, conferences, etc. The informal methods comprise of focused group discussions, social networks, etc. IMD is already using communication and outreach methods through public service announcements, its web portal and mobile apps. Public education initiatives like climate clearinghouses, map interfaces, podcasts, webinars, structured decision tools, graphical information systems, etc. can be considered as an add-on. Such initiatives ensure the efficacy of UIP in enabling availability of the right information to the right user to make the right decisions.

Capacity development

The capacity development needs can be broadly grouped into four categories, i.e. (a) infrastructural, (b) human resources, (c) procedural and (d) institutional. As far as weather services are concerned, IMD is already at par with the international standards with regard to these four categories. In the context of climate services, IMD has a robust infrastructural capacity. It has a modern and extensive network for surface, upper air, radar and satellite observations, data management systems and communication networks. There is, however, room for capacity development in the remaining three categories.

For human resources, understandably there is a gap between what information domain experts consider 'useful' and what information the end users consider as 'usable' in their decision-making. One of the major challenges is to address this gap between useful and usable information[20]. IMD staff are well equipped with technical skill; however, the desired change involves skills rooted in interdisciplinary and social sciences. To fill this gap, there is a need to acquire fresh skill sets and strengthen capacity. As suggested by WMO, some of the measures are capacity-building workshops on best practices, improve climate literacy among the user community, stakeholder engagement through regular dialogue, feedback, outreach and evaluation.

For strengthening procedural capacity, best practices for generating and using climate information may be studied across the globe and thereafter redefined for the Indian context and strategies worked out for their implementation and further improvement. For strengthening institutional capacity, there is a need to clearly formulate the terms of reference for IMD for its role in providing climate services. This would require policy decisions leading to inter- and intra-organizational processes and procedures.

Let us now focus on the priority areas provided by the GFCS.

IMD's engagement in priority areas of GFCS

Amongst the five major priority areas in GFCS, IMD has been actively engaged in agriculture and food security, DRR and water. It needs to expand its portfolio to include and enhance energy and health on a priority basis.

Energy is essential for social and economic growth of the country. It is also essential for implementation of the other four GFCS priority areas. The provisioning of customized climate services can be utilized for effective energy management decisions. An effective strategy would involve appropriate partnerships and stakeholder engagement[21].

Observational data need to be used to establish national and subnational level informal linkages between climate conditions and health outcomes. As part of the adaptation strategy to incorporate climate information in routine health decisions, integrated data management systems are needed to analyse and monitor social indicators from surveillance by the Health Department, alongside climate and environmental observations provided by IMD[22].

Agriculture and food security

For the agriculture and food security sector, IMD has a dedicated Agrometeorology Division which provides Agrometforecast and advisories to the farming communities. The information is disseminated at district level through mobiles, e-mails, television and radio. Krishi Vigyan Kendras (KVKs) are customarily linked with a local agricultural university and extend advisory services to farmers of the region. IMD also organizes farmer awareness programmes in collaboration with research institutions, local non-governmental organizations and other stakeholders to educate farmers on the use of services[23].

The end-user, i.e. the farming community needs a higher spatial resolution; hence a block-level advisory would be more useful as well as usable. Some work on an experimental basis is being carried out on these lines. However, the advisories need to be customized to be crop-specific. The availability of huge past weather data and parameters at IMD can be utilized for developing specific weather scenarios for different locations/zones, which will be of immense help in developing agro-advisories for specific scenarios. The ambit needs to include all the 22 crops rather than being limited to the major crops.

The other related miscellaneous issues of drought maps, pests breeding, etc. having basic dependence on climate predictions are also of equal importance to ensure that IMD proactively contributes towards ensuring food security in the country. A sufficient lead time in the issue of advisories would enable the farmers to devise suitable response strategies. An advisory issued with insufficient lead time maybe informative, but is neither useful nor usable. To better understand user-specific climate information/data/modelling needs, more involvement of the various stakeholders through a systems approach (especially the state government Agriculture and irrigation executives) cannot ever be overemphasized.

Water

The hydrometeorological services of IMD cover hydrology, water management and multipurpose river valley projects[24]. IMD has a Hydrometeorological Division for real-time monitoring and statistical analysis of district wise daily rainfall. The Flood Meteorological Unit provides meteorological support to the Central Water Commission for issuing flood warning for various rivers basins. These services are further utilized by various ministries, government institutions, railways, flood control authorities and state governments for the monitoring of water resources, designing of water resource projects, basin planning and management, flood forecasting, water management, dam safety and power generation.

In addition, there are several decisions that can be informed by hydrological outlooks[25] (extended forecast for longer duration), as illustrated in WMO website (http://www.wmo.int/pages/prog/hwrp/chy/chy14/documents/ms/Hydrological_services_in_gfcs.pdf). Besides catering to the emergency services for floods and management of water supply, these decisions include providing information on cropping strategies, markets and land management, amongst others. The temporal scales of these decisions range from hours, days, weeks, months, years to decades. IMD may either consider developing capacity in water modelling or effectively collaborate with the related departments to deliver a complete package of monitoring, forecasting and projections. This would require capacity building of the human resources as well as building partnerships with water science research institutions to develop customized products (as low as at the scale of reservoirs) for various operational users.

Disaster risk reduction

IMD provides early warning information on extreme weather events like cyclones, heavy rainfall, floods and earthquakes, and works in close quarters with the National Disaster Management Authority for DRR. An SMS-based warning system notifies the general public in case of imminent natural disasters[2]. The weather forecast is tailored sector-specific. The various end-users are power, tourism, defence, road transport, railways and other strategic operations[26]. The scope of coverage and delivery of these weather services by IMD in this sector is also quite appropriate from the point of view of climate services, and the same can be exploited well through collaborative arrangements. Importantly, there is a need to make these sector-specific departments aware of the potential of such vital climate data/information for generation of products at their end for the desired efficiency and effectivity.

Energy

Climate services are still under development in the energy sector all across developing countries. Reiterating its commitment to green energy, India has taken an early lead in providing weather services for the energy sector. The Ministry of Power, Coal, New and Renewable Energy, Government of India launched a weather portal for the power sector in June 2017, in association with Power System Operation Corporation Limited (POSOCO) and IMD[27]. The weather services made available in the portal assist in decision making in 'short-term and medium-term management processes and supply planning requirements[28]'.

The conventional energy sector is mostly sensitive to temperature and precipitation. With sustainable development agenda at the centre stage, mainstreaming of renewable energy requires different types of observations and forecasts. To develop climate services in the energy sector, IMD would need to develop suitable expertise in climate modelling in the domain. In addition to capacity building, partnerships with a diverse set of stakeholders would play an integral role in the energy sector. To name a few, these stakeholders would include 'exploration companies, transmission and distribution operators, private services companies, universities, national, state and local governments, non-profit organizations[29]'.

Health

The Environment Monitoring and Research Centre of IMD currently has a System for Air quality Forecasting and Research (SAFAR) operational at New Delhi, Pune, Mumbai and Ahmedabad. IMD can expand the coverage of air quality monitoring. These services can then be customized according to public health system requirements and used to reduce health risks. The System of Aerosol Monitoring and Research (SAMAR) network of IMD for black carbon and aerosol monitoring currently has coverage in limited cities, and can be similarly expanded. With capacity building, customized outputs can be developed to serve the climatic needs of the health sector. Research collaborations can also be explored in tele-epidemiology, wherein vegetation, meteorological and oceanographical data from satellites are used with hydrological and clinical data to build predictive mathematical models for epidemic monitoring[30].

IMD: an enabler institution with enormous possibilities

The discussion so far clearly indicates that for successful transformation from a traditional NMHS to a weather-ready and climate-smart organization, IMD should strive to broaden its functions beyond the traditional hydro-meteorological focus. This is possible through a dynamic vision at the apex level, which strengthens its capacity, consolidates its infrastructure, develops partnerships and further enriches the visibility of the organization. IMD should also consider investing in procurement and promotion of human resources and experts from other cross-cutting domains to supplement its needs. Fortunately, in recent times, a beginning has been made for lateral entry of specialists in the organization. This would enable this unique fountainhead of weather and climate services in the country to improve its capacity for effective implementation of the GFCS for climate services.

Before it is concluded by the readers that the proposal is overreaching its mandate and is usurping on other's domain, the matters need to be further put into perspective. The limited point we wish to make is that, all those sectors which have atmospheric conditions (weather) as a critical input, should ideally be dealt with by the national agency (a single interface of meteorological and hydrological services) in facilitating the availability of basic authentic and useable source of climate-specific data, information and products. IMD already has precedence of taking a proactive and lead role in providing such useable information in agriculture and DRR. The country's farmers as well as communities vulnerable to disaster risks have been immensely benefitted by these services, particularly during the last two decades. This suggested approach will result into requisite capability development, fiscal prudence and necessary synergy across cross-functional teams, much needed for allowing all the specific sectors to concentrate on their core competencies.

Convening convergence

The challenges of climate change cut across several domains. However, to holistically cover the entire spectrum of climate services, it would require knowledge resources of more than just one department (IMD).

Studying the architecture and best practices of the National Oceanic and Atmospheric Administration (NOAA), USA, could offer a few insights on how to effectively congregate the various knowledge resources. The NOAA is an umbrella organization comprising several staff, corporate and line offices as illustrated in NOAA website (https://www.noaa.gov/about/organization). The line offices include (a) National Environmental Satellite, Data and Information Service, (b) National Marine Fisheries Service, (c) National Ocean Service, (d) National Weather Service, (e) Office of Marine and Aviation Operations, and (f) Office of Oceanic and Atmospheric Research[31].

In addition to IMD, the Ministry of Earth Sciences (MoES), GoI, has several other departments, centres, autonomous bodies and subordinate offices under its umbrella, providing governance in the disciplines of atmospheric sciences, ocean sciences and technology, and geosciences as illustrated in MoES website (https://moes.gov.in/content/organization-setup). Several departments and scientific institutions under various other line ministries, as well as reputed academic institutions across the country undertake extensive research, not only in scientific but social/economic aspects of climate challenges. The National Mission on Strategic Knowledge for Climate Change is one of the eight national missions under the National Action Plan on Climate Change launched by the GoI in 2008. This Mission is anchored by the Department of Science and Technology, GoI, with the primary goal to develop appropriate institutional and human resource capacity in strategic knowledge on climate change.

An enabling and effective ecosystem like the MoES may consider taking up a convener role for convergence of these knowledge resources. The interdisciplinary resources can thereafter be amalgamated to provide user-specific climate services. This can perhaps be built into a national initiative, as an inter-ministerial mission led by the MoES. It is a known fact that the NOAA has benefitted immensely due to such a convergence during the past few decades.

In India, the repository of advanced research on climate change is MoES, whereas the Ministry of Environment, Forest and Climate Change, GoI looks after 'international negotiations and domestic policies and actions'[32] related to climate change. Thus, the proposed national initiative could also act as a platform to translate knowledge into action, wherein wide-ranging research serves as an instrument to inform climate change policy design.

To institutionalize this mechanism, the possibility of introducing a legislation may also be considered in line with the developed countries like the United Kingdom and the European Union.

Disclaimer: The views expressed in the article are those of the authors and not of the organization they are affiliated.

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