COUNTRY HYDROMET DIAGNOSTICS

Informing policy and investment decisions for high-quality weather forecasts, early warning systems, and climate information in developing countries.

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Ethiopia Peer Review Report

Reviewing Agency: Norwegian Meteorological Institute and Finnish Meteorological Institute

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List of acronyms and abbreviations

ACMAD	African Centre for Meteorological Applications for Development
ACPC	African Climate Policy Centre
AfDB	African Development Bank
AFTN	Aeronautical Fixed Telecommunication Network
AMO	Aerodrome Meteorological Offices
ATA	Agricultural Transformation Agency
AWOS	Automated Weather Observing System
AWS	Automatic weather stations
BREFONS	Build Resilience for Food and Nutrition Security
BUFR	Binary Universal Form for the Representation (of meteorological data)
CAP	Common Alerting Protocol
CDMS	Climate Database Management System
CHD	Country Hydromet Diagnostics
CIARE	Climate Information and Assets for Resilience in Ethiopia
CR-WASH	Climate Resilient Water Sanitation and Hygiene
CSO	Civil Society Organisation
DWD	Deutscher Wetterdienst (German Meteorological Service)
ECMWF	European Centre for Medium-Range Weather Forecasts
ECAA	Ethiopian Civil Aviation Authority
EDRMC	Ethiopia Disaster Risk Management Commission
EGENCO	Electricity Generation Company Limited
EMI	Ethiopian Meteorology Institute
ENACTS	Enhancing National Climate Services
EOS	Ethiopian Occupational Standards
EPA	Environmental Protection Authority
ETB	Ethiopian Birr
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EW4All	Early Warning for All
FAO	Food and Agriculture Organisation
FDRE	Federal Democratic Republic of Ethiopia
FMI	Finnish Meteorological Institute
FTF	Flood Task Force
GBON	Global Basic Observations Facilities
GCF	Green Climate Fund
GHACOF	Greater Horn of Africa Climate Outlook Forum
GEF	Global Environment Facility
GFS	Global Forecast System
GHG	Greenhouse Gases
GISC	Global Information System Centre
GPRS	General Packet Radio Service
GRMS	Grass Root Meteorological Services
GTS	Global Telecommunication System
HPC	High-performance computing
IBF	Impact Based Forecasting
ICPAC	IGAD Climate Prediction and Applications Centre
ICT	Information Communication Technology
IFRC	International Federation of Red Cross and Red Crescent Societies

IGAD	Intergovernmental Authority for Development
IGAD	Intergovernmental Authority on Development
IMTR	Institute for Meteorological Training and Research
IP	Internet Protocol
IRI	International Research Institute of Columbia University
ISO	International Standardisation Organisation
IT	Information Technology
ITCZ	Intertropical Convergence Zone
KOICA	Korea International Cooperation Agency
KPI	Key Performance Indicators
LAN	Local Area Network
LST	Local Standard Time
MET Norway	Norwegian Meteorological Institute
MHEWS	Multi-hazard Early Warning System
MILL	Ministry of Irrigation and Lowlands
MoA	Ministry of Agriculture
MoH	Ministry of Health (MoH),
MoU	Memory of Understanding
MoWE	Ministry of Water and Energy
MQTT	Standard based messaging protocol (machine to machine communication)
NCOF	National Climate Outlook Forum
NDRMC	Former Ethiopian Disaster Risk Management Commission
NDVI	Normalised Difference Vegetation Index
NFCS	National Framework for Climate Services
NGO	Non-Governmental Organization
NHS	National Hydrological Services
NMA	National Meteorological Agency
NMHS	National Meteorological and Hydrological Services
NMP	National Meteorological Policy
NMS	National Meteorological Services
NMSA	National Meteorological Services Agency
NORAD	Norwegian Agency for Development cooperation
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Model
N-WIP	National WIGOS Implementation Plan
OGC	Open Geospatial Consortium
OpeNDAP	Open-source Project for a Network Data Access Protocol
OSCAR	Observing System Capability Analysis and Review Tool
PPPs	Public-Private Partnerships
PUMA	Preparation for the Use of Meteosat Second Generation in Africa
PWS	Public Weather Service
QC	Quality Control
QMS	Quality Management System
RCOF	Regional Climate Outlook Forum
RIC	Regional Instrument Centre
RSCM	Remote sensing-integrated crop model
RSMC	Regional Specialized Meteorological Centre
RTH	Regional Telecommunication Hub
RWC	Regional WIGOS Centre
SAREPTA	Institutional Support and Capacity Building for Weather and Climate Services

SEB	Socio economic benefits
SIDS	Small Island Developing States
SMHI	Swedish Meteorological and Hydrological Institute
SNNP(R)	Southern Nations and Nationality and People (Region)
SOFF	Systematic Observations Financing Facility
SOP	Standard Operating Practices
SWFP	Severe Weather Forecasting Programme
TBC	To Be Confirmed
TCP	Transmission Control Protocol
TSC	Technical Sub Committee
UKMO	United Kingdom Met Office
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-OCHA	United Nations Office for the Coordination of Humanitarian Affairs
USAID	United States Agency for International Development
USD	United States Dollar
UTC	Universal Coordinated Time.
VSAT	Very Small Aperture Terminal
WB	World Bank
WCIS	Weather and Climate Information Services
WDQMS	WIGOS Data Quality Monitoring System
WFP	World Food Programme
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization
WMS	Web Map service
WRF	Weather Research and Forecasting model
WRSI	Water Requirement Satisfaction Index

Executive Summary

This Country Hydromet Diagnostics report is prepared alongside work for the Systematic Observations Financing Facility (SOFF) initiative in Ethiopia. The report is intended to provide a high-level strategic assessment of Ethiopia Meteorology Institute (EMI), their operating environment, and their contribution to high-quality weather, climate, hydrological and environmental services, and warnings through peer-review approach. The peer reviewers have evaluated the ten elements provided by the CHD methodology to provide a maturity score across for each element based on the operations of EMI including general recommendations on how to advance maturity score.

The peer review assessment involved extensive literature study, in-person, and online meetings with the SOFF team at EMI. This also included extensive email and online correspondence. In addition, a questionnaire on each element was developed based on the CHD EW4All data inventory and review sheet indicators provided. This made expert interviews more convenient. This process allowed the peer-reviewers to get a good overview of the institutional capacity at EMI and its governance setting, as well as the main challenges the department faces in providing the numerous services in its mandate. This provided enough insight to see opportunities to provide information to make specific recommendations.

EMI is a crucial player in Ethiopia's weather and climate service provision including meeting international meteorological commitments. There exist formal structures for governance and institutional settings, and EMI has strong partnerships with key sectors and stakeholders especially under the National Framework for Climate Services (NFCS) and the National Climate Outlook Forum (NCOF) platform. EMI have also demonstrated their capacity for international, regional, and local private-sponsored projects. There is however a need for urgent development in other aspects e.g., increasing government funding that is sustainable and matches the institute's needs, achieving GBON compliance, including modernising surface observation techniques, re-designing data management systems, and further improving weather forecasting value chain. Ethiopia has mechanisms for collaboration with stakeholders and ministries, but there is room for future improvements.

In the end, the overall maturity level for EMI in this peer-review process can be assessed as three (intermediate level of maturity). Successful implementation of ongoing projects including SOFF project by EMI and the recommendations provided will significantly improve EMI’s maturity score. The following are the major gaps and or recommendations identified:

- Financial constraints are hindering EMI's ability to fulfil its various roles. Progress has been made but insufficient funds affect human capacity building, infrastructure installation, and sustainable project implementation, necessitating urgent resolution.
- Limited human resource capabilities. EMI requires regular recruitment of dedicated staff, improved training, and ICT expertise for sustainability of increased observational infrastructure. Gender equality and promoting affirmative actions to bridge the gender gap at EMI should also be considered. Expertise in different fields including research and climatology will be an asset to EMI.
- The observational infrastructure, mostly the ICT infrastructure and services including skilled specialists for the increased data management capabilities is generally lacking at EMI. To achieve a progressive target toward GBON compliance, urgent development needs are required. Improved capabilities and standard operating procedures (SOPs) regarding organisational datasets management throughout the entire value chain will be beneficial. A review of EMI’s data sharing policy should also be considered.

- Efforts should be maximised to improve numerical model and forecasting tool application capabilities at EMI including re-incorporating data assimilation practices. New technologies and improvements in the observational capabilities through SOFF would facilitate increased effectiveness of the weather forecasting process.
- The development of existing structures can significantly improve the contribution of EMI to hydrology in Ethiopia, enhancing the capabilities of hydrometeorological cooperation in Ethiopia.
- EMI can enhance stakeholder engagement and visibility through grass-root workshops and partnerships with media platforms and broadcasting companies, thereby promoting early warnings for societal benefit.

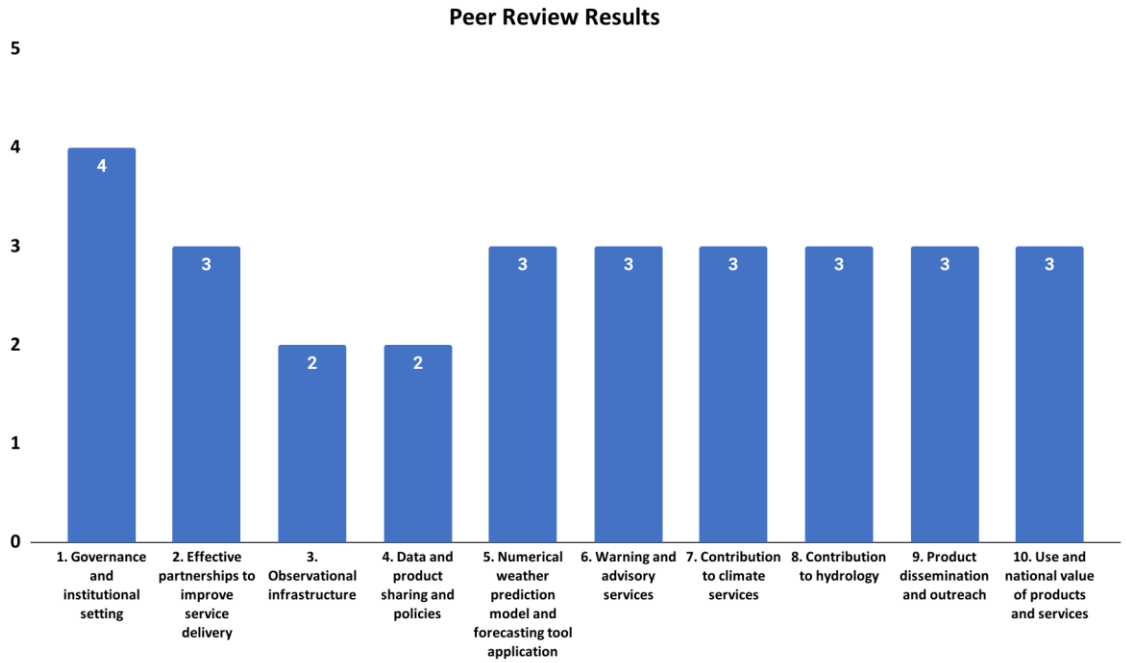

Fig 1. Maturity level scores for EMI based on the CHD Methodology

Element	Maturity level score
1. Governance and institutional setting	4
2. Effective partnerships to improve service delivery	3
3. Observational infrastructure	2
4. Data and product sharing and policies	2
5. Numerical weather prediction model and forecasting tool application	3
6. Warning and advisory services	3
7. Contribution to climate services	3
8. Contribution to hydrology	3

9. Product dissemination and outreach	3
10.Use and national value of products and services	3

Chapter 1: General information

Introduction

Ethiopia is a landlocked country in the Greater Horn of Africa (Latitude 3° to 15° N and longitude from 33° to 48° N) bordering Eritrea, Sudan, South Sudan, Kenya, Somalia, and Djibouti. It has a total approximate area of 1,4 million square km and is characterised by a wide variety of landscapes, with marked contrasts in topography. The complex topography in Ethiopia's landscape including its physiography with varied relief and altitudes has the country experiencing diverse climatic conditions ranging from semi-arid desert-like conditions in the northeast, northwest, east and southeast lowlands to that typical of equatorial highlands with high rainfall and humidity in the south, southwest and Ethiopia's central highlands.

For these reasons, and Ethiopia's geographic position close to the equator and the Indian Ocean, the country is subject to large spatial variations in temperature and precipitation (see Fig 3, Fig 4 and Fig 5)). The climate of Ethiopia is mainly controlled by the seasonal shifts in the location of the Inter-tropical Convergence Zone (ITCZ) and associated atmospheric circulations as well as by the complex topography of the country. Ethiopia generally exhibits largely arid weather with high variability of precipitation.

Spatial variation in annual rainfall distribution results in three rainfall regimes in the country. The central and most of the eastern half of the country experience two wet seasons (locally called Kiremt and Belg) and one dry season (locally called Bega). The two rainy periods are separated by a short dry period in May. In southern and south-eastern lowlands, the annual rainfall is concentrated in two wet seasons (September-November and March-May). The annual rainfall distribution is characterised by one long rainy season or monomodal or single peak over south-western and general western parts of the country (Regime B) (Fig 2). The length of the rainy period generally decreases as we progress northward from the southwest. The annual mean rainfall is below 500 mm over the dry part and more than 2500 mm over the wettest part.

Annual mean maximum temperature exceeds 35°C over the hottest part of the lowlands of the country and mean annual minimum temperature lower than 10°C over the highlands.

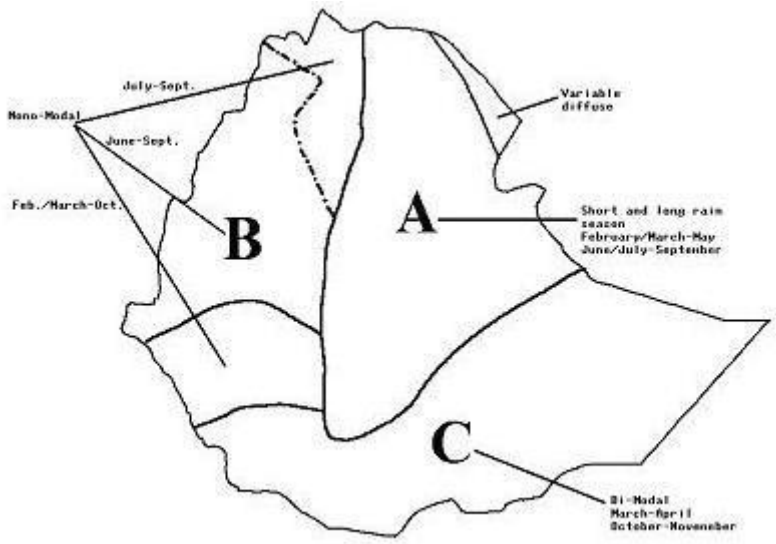

Figure 2: Rainfall regimes over Ethiopia (NMSA, 1996)

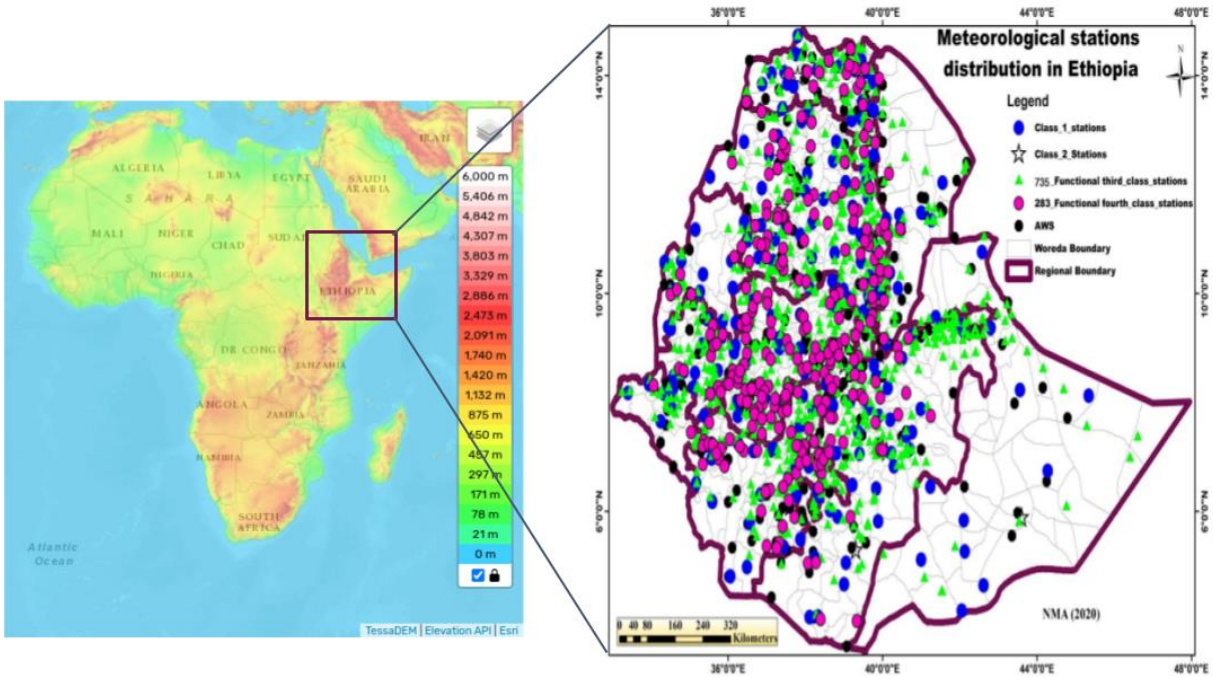

Figure 3. Location map of Ethiopia in Africa with elevation range (Esri) and distribution of meteorological stations network of different class types in Ethiopia. (Source EMI,2023)

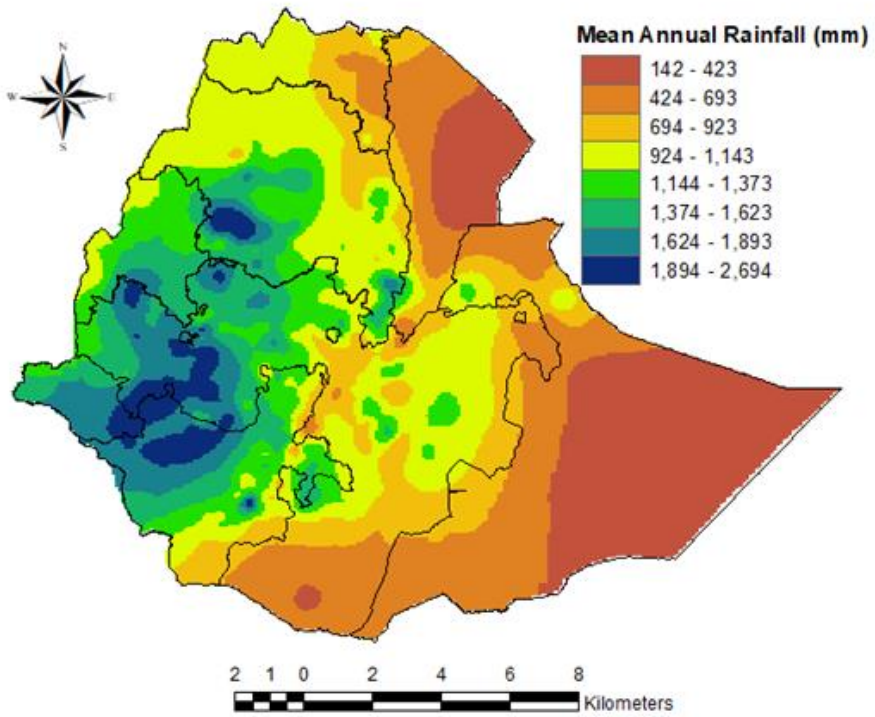

Figure 4. Average annual precipitation in Ethiopia for the period 1991-2020. (Source EMI, 2023)

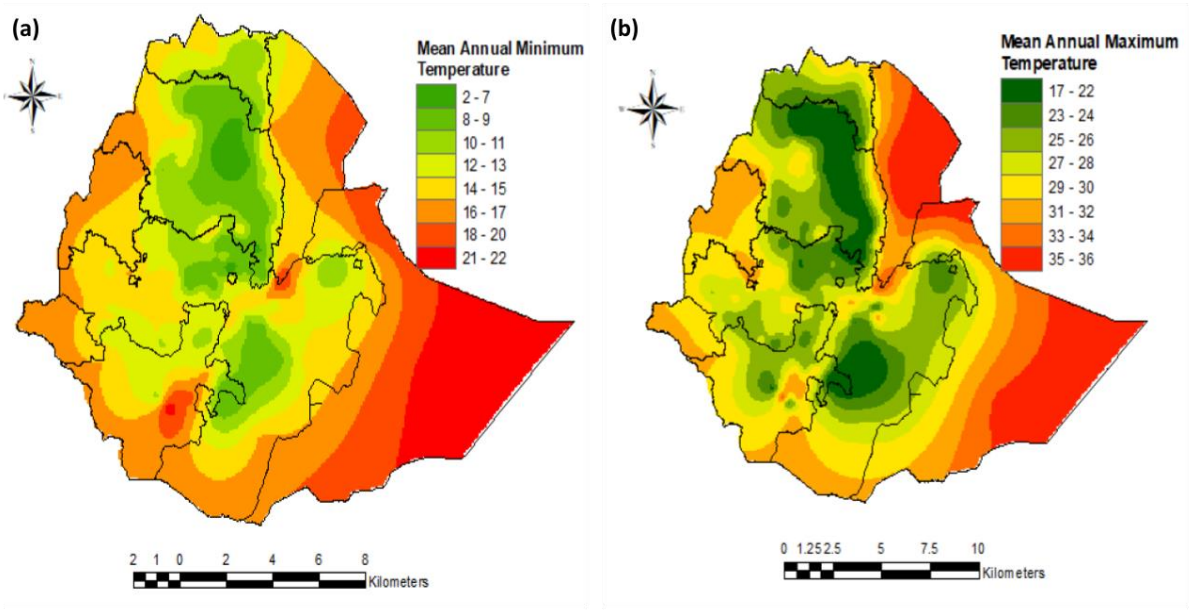

Figure 5: Maps of the average annual minimum (a) and average maximum temperatures (b) in Ethiopia for the period 1991-2020. (Source EMI, 2023)

CHD methodology

This Country Hydromet Diagnostics (CHD) report is a peer-to-peer, standardized review of the Ethiopian Meteorology Institute (EMI) operating environment as well as their contribution to high-quality weather, climate, hydrological and environmental information services, and warnings prepared as part of the Systematic Observations Financing Facility (SOFF) project in Ethiopia. This report has been prepared as a result of a peer-peer review of EMI by the Norwegian Meteorological Institute (MET Norway) and the Finnish Meteorological Institute (FMI) as peer advisors with some collaboration from United Nations Development Program (UNDP)'s in-country focal point as the implementing entity.

The diagnostics supplement the SOFF's Global Basic Observing Network (GBON) National Gap Analysis report and the GBON National Contribution Plan reports for Ethiopia. It aims at highlighting where additional focus and support are needed in EMI, based on defined maturity levels for each of ten critical elements of the hydromet value cycle. This in turn will inform policy and investment decisions, particularly investments pertaining to the hydromet services in Ethiopia.

The CHD will therefore create a strategic level assessment across ten elements (Figure 6), with peer review serving as the overall approach. To carry out the peer-to-peer review, the Norwegian Meteorological Institute (MET Norway) adopted a variety of methods, including three in-person consultation sessions (one of which was an in-country stakeholder meeting), questionnaire and biweekly online meetings held during the peer-

review process (Annex 1) to peer-review EMI. WMO guidance material and survey data as well as various published documents and online content were also employed.

The findings of the peer review are summarised in this report and maturity level for each of the ten elements of the meteorological value cycle assigned including description of each component describing critical capacity gaps and recommendations for improvement. The highest possible maturity level is five. The findings will strongly enhance EMI's development especially in support of better hydrometeorological services in Ethiopia.

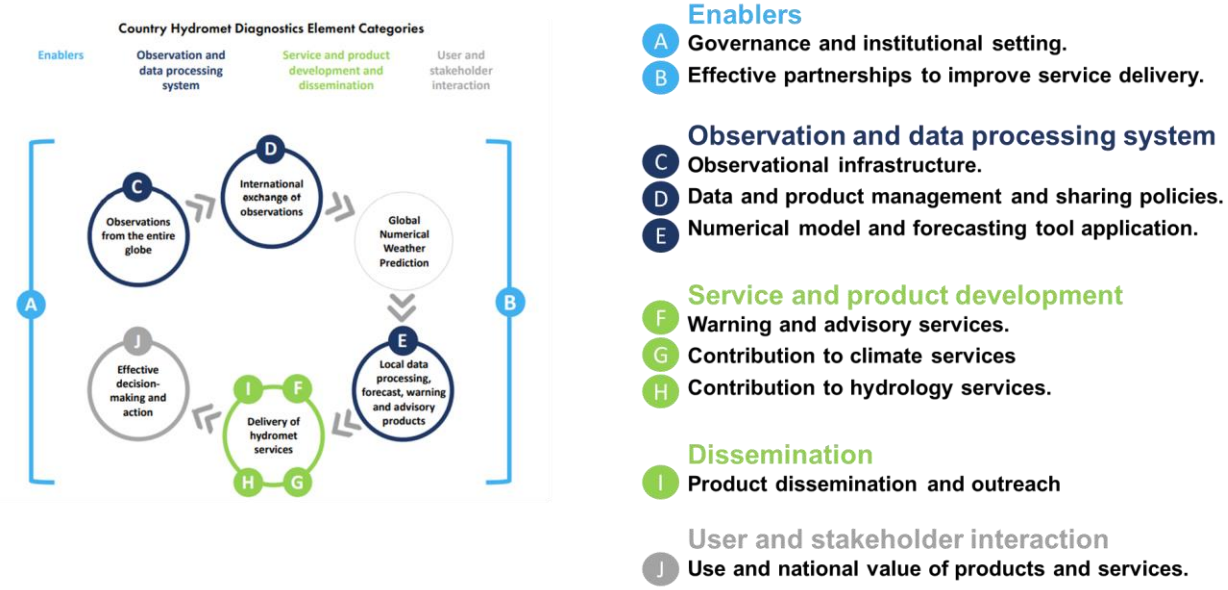

Figure 6. Main elements of the hydromet value chain (A-J) that are evaluated in this Country Hydromet Diagnostics (CHD) report

Chapter 2: Country Hydromet Diagnostics

Element 1: Governance and institutional setting

1.1 Existence of Act or Policy describing the NMHS legal mandate and its scope

The Ethiopian Meteorology Institute (EMI), formerly known as the National Meteorological Services Agency (NMA) and National Meteorological Agency is an autonomous government organization in Ethiopia under the Ministry of Water and Energy (MoWE). The meteorological agency was officially established in 1980 by the Federal Democratic Republic of Ethiopia (FDRE), under the "National Meteorological Services Agency (NMSA) establishment Proclamation No. 201/1980[1]". The three main purposes of establishment of the institute include: to provide meteorological services; to control air pollution and maintain the natural balance of the air; and to discharge Ethiopia's international obligations regarding meteorological activities.

Definition of power and duties of EMI as provided in the NMSA Establishment Proclamation No. 201/1980, including but not limited to:

- Establish and operate a national network of meteorological stations designed to represent Ethiopia's; climatic regions;
- Collect all meteorological data;
- Exchange meteorological data in accordance with international agreements to which Ethiopia is a party;
- Establish and operate communication systems, in accordance with the law for the collection and dissemination of meteorological data;
- Publish and disseminate analysed and interpreted meteorological data and meteorological forecast;
- Give advance warning on the adverse weather condition;
- Collect and centrally administer any meteorological data collected by any person in the country;
- Control air pollution and maintain the natural balance of the air in the country;
- Permit any person to register and collect meteorological data when it deems it necessary;
- Ensure the implementation of international agreements regarding meteorology which is ratified by the Government;
- Undertake meteorological studies and research.

There also exists another act that describes EMI's mandate as part of an executive organ of the FDRE cited under the "Definition of Powers and Duties of the Executive Organs Proclamation No. 1263/2021[2]:" EMI shall have the following power and duties:

- Provide meteorological and climate related services;
- Lead national climate services;
- Execute the international obligations signed by Ethiopia with respect to meteorological and climate change; implement support;
- Lead and coordinate climate change adaptation and mitigation activities;
- Collect, analyse and forecast meteorological, air pollution and climate change information;
- Provide educational information, early warning and advisory services with respect to weather condition, climate and climate change;
- Examine requests for collection of meteorological information and issue permits for the same.

[1] Ethiopia Meteorological Institute proclamation 201 of 1980

[2] Proclamation No.1263-2021

EMI also shares responsibility with other institutes and ministries in Ethiopia in different capacities especially under the National Framework for Climate Services (NFCS)[3] where there are continuous engagements and strong collaborations on climate service co-production. The executive organs and ministries included in the NFCS in Ethiopia include, Ministry of Water and Energy (MoWE), Ministry of Agriculture (MoA), Ministry of Irrigation and Lowlands (MILL), Ministry of Health (MoH), Environmental Protection Authority (EPA) and the Ethiopian Disaster Risk Management Commission (EDRMC) and Ethiopian Public Health Institute (EPHI). EMI therefore collaborates on the following:

- Air quality standards is the mandate of the EPA while EMI monitors, forecast and conduct research;
- In agrometeorological services, MoA prepares advisories jointly with EMI in the spirit of Co-Production;
- Hydro-meteorological advisory services is prepared jointly with the MoWE;
- Bio-meteorological advisory is prepared jointly with the MoH;
- Disaster Risk Reduction Advisory is prepared with EDRMC;
- Irrigation specific scheduling and advisory services are prepared in collaboration with MILL.

EMI is the designated Meteorological Institute providing Aviation Meteorological Services in Ethiopia. EMI has installed observation stations including over 100 staff in four international and 18 domestic airports for the provision of aviation meteorology service in Ethiopia. The mission of the Aviation Meteorological Services (AMS) is to enhance the safety, regularity, and efficiency of national and international civil aviation operations through the provision of accurate, timely and relevant forecasts, warnings, and other information. Ethiopia needs to ensure that aviation meteorological services provided by EMI meet Ethiopia's obligations under international agreements for the provision of meteorological services for international air navigation.

The Ethiopian Multi-Hazard Early Warning System (MHEWS) is an initiative of the Ethiopian Disaster Risk Management Council (EDRMC), working with the EMI alongside other key stakeholders. The commission is charged with specific duties and responsibilities, including providing a legal framework for disaster and risk management in Ethiopia. In 2022, the EDRMC released the MHEWS Roadmap[4] in an effort to close major gaps in the country's early warning system and upgrade it to a Multi-Hazard, Impact-Based Early Warning and Early Action System. This initiative is expected to have a substantial impact on building resilient communities and a resilient nation against natural and man-made disasters. The proposed system will reduce resource constraints, harmonisation, and interoperability challenges by leveraging technology, as well as the optimal use of disaster risk information through the mainstreaming of disaster risk plans across relevant sectoral ministries and specialised agencies.

In Ethiopia, sector-specific ministries and organisations have clearly defined roles and responsibilities for issuing specific warnings for different hazards. The NFCS, is likewise an authoritative instrument with regards to MHEWS. The Ministry of Mines is in charge of landslide and slope failure related hazards, while the MoWE is mandated to handle riverine floods. The EPA handles forest/bush fire and environment pollution related hazards, and EMI is required by law to provide alerts on hydrometeorological hazards, such as drought and flood. The coordinating function for each of these hazards is held by the EDRMC.

The MHEWS Roadmap list four pathways:

- Enhanced Disaster Risk Knowledge
- Robust Disaster Detection, Monitoring, and Forecasting Services
- Effective Early Warning Dissemination and Communication System
- Preparedness, Early Action, and Faster Response Capabilities

[3] National Framework for Climate Services – Ethiopia Coordination Guideline

[4] A Roadmap for Multi-Hazard, Impact-Based Early Warning and Early Action System 2023-2030

Cross-border exchanges of warnings with neighbouring countries are realized through collaborations with regional climate centres i.e. the IGAD Climate Prediction and Application Centre (ICPAC), including humanitarian bodies such as the International Federation of Red Cross and Red Crescent Societies (IFRC)'s East Africa.

Summary and comments for Element 1.1

The Ethiopian Meteorology Institute (EMI) is an autonomous government organization established in 1980 under the Ministry of Water and Energy (MoWE). Its main purposes include providing meteorological services, and meeting Ethiopia's international meteorological commitments.

EMI has specific legislative Act/Policies in place describing the NMHS legal mandate and its scope. The NMSA Establishment Proclamation No. 201/1980 and Proclamation No. 1263/2021 offer legislation on the national duty for delivering weather services.

EMI collaborates with other Ethiopian institutes and ministries, particularly under the National Framework for Climate Services (NFCS). The Ethiopian Multi-Hazard Early Warning System (MHEWS) is an initiative of the Ethiopian Disaster Risk Management Commission (EDRMC), working with EMI and other key stakeholders to provide a legal framework for disaster and risk management in Ethiopia. The MHEWS Roadmap aims to upgrade the country's early warning system to a Multi-Hazard, Impact-Based Early Warning and Early Action System, reducing resource constraints and enhancing interoperability. Sector-specific ministries and organisations have clear roles and responsibilities for sending specific warnings for different hazards, with the NFCS acting as an authoritative instrument.

1.2 Existence of Strategic, Operational and Risk Management plans and their reporting as part of oversight and management.

EMI has a ten-year strategic development plan in place for the years 2020-2029. The detailed strategic plan is in Amharic but an English[5] translation is provided. The plan has five main objectives which are formulated to accomplish the Institute's activities in short-, medium- and long-term time periods. These key objectives are:

1. To provide meteorological data designed to represent the geography and ecology of the country;
2. To provide Meteorological forecast, early warning and advisories;
3. Implement meteorological research and study;
4. Develop the capacity of the Institute in terms of infrastructure, modernization and human resource development;
5. Service Effectiveness and Efficiency.

The strategic plan, approved by Ethiopia's Ministry of Plan and Development, is in its 4th year of implementation and is re-aligned with the 10-yr national development plan. It is usually updated every three years. The most recent 2020-2023 first mid-term evaluation report is available in Amharic. In addition, annual plans of the institute are always constituted from the revised strategy. Six government-supported EMI capital projects[6] are also in line with the 10-year strategic plan. EMI's six government funded projects focus on station network expansion, provision of full-scale aviation service, infrastructure development setup, modernising, fulfilling facilities needed for weather studio and calibration unit.

[5] Ethiopian Meteorological Institute_10 years plan in Eng

[6] There are six capital projects currently running

Currently however, EMI has no Risk Management Plan but is considering implementing such plans in its operations.

Summary and comments for Element 1.2

Ethiopian Meteorological Institute (EMI) has a ten-year strategic development plan for 2020-2029, focusing on providing meteorological data, forecasting, research, infrastructure development, human resource development, and service effectiveness. The plan, approved by Ethiopia's Ministry of Plan and Development, is in its fourth year of implementation and is updated every three years. Six government-supported capital projects aim to expand station networks, provide full-scale aviation services, and modernise facilities. EMI currently lacks a Risk Management Plan but is considering implementing such plans.

1.3 Government budget allocation consistently covers the needs of the NMHS in terms of its national, regional, and global responsibilities and based, among others, on cost-benefit analysis of the service. Evidence of sufficient staffing to cover core functions

The total annual budget at EMI from the government and other sources for the financial year 2022/23 exceeds 813 million Ethiopian Birr (ETB) (table 1). The governmental budget allocation has been somewhat consistent in the last 10 years, but not yet sufficient to cover the needs of the institute. Only 37% of the entire actual budget for 2022/23 was from the government, with the remainder coming from development assistance. Capital expenditure took up the majority (61%) of the government budget allocation at EMI, while staff cost, and operational expenditure accounted for 24 % and 15% respectively. EMI's capital expenditure covered capital projects such as meteorological station establishment, 1st class station office construction, mercury-free instrument procurement, historical data rescue, mobile data exchange services, Automated Weather Observing System (AWOS) station establishment and sensor procurement, Secure Aviation Data Information Service (SADIS) upgrade, Aircraft Meteorological Data Relay (AMDAR) observing system, procurement and installation of X-band weather radar, QMS implementation, and NFSC actors and RMSCs capacity building.

The main funding sources for 2023 fiscal year for EMI has been development assistance (63%) mainly from the Ethio-Finland project. The project includes one weather radar maintenance, three new weather radar and other stations installation agreement with Vaisala. Other development assistance, such as the Climate Resilient-Water Sanitation and Hygiene (CR-WASH) project and a World Bank (WB) Flood Management project in Ethiopia, are detailed in Part 1.5.

Cost recovery sources of funding to EMI are mainly from the aviation services (Ethiopian Civil Aviation Authority (ECAA)) and data provision services. This corresponds to less than one percent of the total financing for the 2023 fiscal year. EMI provides aviation meteorological services to four international and eighteen domestic airports in Ethiopia. The cost recovered funds from ECAA is therefore significantly lower than the services provided. An evaluation team with representatives from EMI, Ethiopian ECAA should be set up to evaluate cost of EMI services to ECAA, the quality of the services received from EMI against the revenues EMI receives such that funding allocated to EMI can be adjusted accordingly to match the full cost of the aviation services provided.

A cost-benefit analysis of the services provided by EMI has been conducted to evaluate the socio-economic benefits of using weather and climate information and services in the Agricultural sector in Ethiopia, January 2013. Compared to the last three years, the governmental budget to EMI has increased.

EMI's primary areas of responsibility (mandate) budget wise is: -

- Basic meteorological data generation
- Meteorological Forecast, Early warning and Advisory
- Develop the capacity of the Institute in terms of infrastructure, modernization and human resource development

Table 1. EMI's annual budget vs Actual Financing for the year 2002/2023.

	Revised budget for 2022 (in ETB)	**Actual Financing for 2023 (in ETB)**
Expenditures		
Capital expenditures	52,791,537.00	179,606,393.00
Total operating costs	42,691,891.00	43,399,821.00
Staff costs	63,943,879.00	69,537,720.00
Total Expenditure	**159,427,307.00**	**292,543,934.00**
Income		
Basic funding from government department/ministry	215,000,000.00	297,090,000.00
Turnover related to provision of aviation services and data services	800,000.00	1,000,000.00
Development assistance	87,000,000.00	515,193,250.00
Total Income	**302,800,000.00**	**813,283,250.00**

Summary and comments for Element 1.3

The EMI has received an annual budget exceeding 813 million Ethiopian Birr (ETB) for the 2022/23 fiscal year from the government and other sources. The government's budget allocation has not been sufficient to cover the institute's needs.

The main funding sources for 2023 fiscal year were from development assistance including the Ethio-Finland project, weather radar maintenance, and the CR-WASH project. Cost recovery sources of funding for EMI are mainly from the Ethiopian Civil Aviation Authority (ECAA) and data provision services, accounting for less than one percent of the total financing.

To assess the cost of EMI services, an evaluation committee should be formed. A cost-benefit study to demonstrate the economic and social benefits of EMI services will be useful for adjusting funds EMI receives on a cost-recovery basis, e.g. from the aviation sector.

1.4 Proportion of staff (availability of in-house, seconded, contracted- out) with adequate training in relevant disciplines, including scientific, technical, and information and communication technologies (ICT). Institutional and policy arrangements in-country to support training needs of NMHS.

The EMI has a total of 948 staff working in different capacities at EMI's head office in Addis Ababa and 11 regional meteorological offices distributed across the country. Table 3 shows the number of staff at EMI by profession and gender as of July 2023. Based on the July 2023 estimates, 42% of staff have a higher education (bachelor's degree or higher). EMI operates under the Ministry of Water and Energy (MoWE) and is governed by a Director General and two Deputies. The hierarchical structure of EMI is shown in Fig 7.

The proportion of the staff working in different fields at EMI differs with gender especially among technical staff. Overall, EMI has a relatively higher percentage of men (64%) than women (36%). 43% women work as support, but only 20% women work in meteorological science research with BSc or higher education.

50% of EMIs total staff (473) perform technical capacity duties, most of whom work at their regional offices. 49% of technical staff have a BSc or higher education. This is the proportion of technical staff with a higher education at the time of writing this report. There was a total of 56 technical staff who were pursuing graduate degrees: MSc (49), PhD (7).

EMI is exclusively a meteorological institute, with no hydrological functions hence no hydrological staff. There are currently no staff members dedicated to climatology as well as research. The meteorologists at EMI informally assume these functions. The Remote Sensing and Climatology Desk reports to the Meteorological Data and Climatology Lead Executive and is in charge of climate monitoring, among other responsibilities.

According to the staff composition at EMI, there is a lack of qualified ICT experts as well as staff dedicated to research and climatological studies.

Table 2: Composition of all staff at EMI with information on education and gender.

Ethiopian Meteorology Institute Staff numbers by profession and gender, updated in July 2023									
	Head office			**Regional meteorological services centres**			**Overall total**		
	Male	**Female**	**Sum**	**Male**	**Female**	**Sum**	**Male**	**Female**	**Sum**
Support staff	**97**	**100**	**197**	**174**	**104**	**278**	**271**	**204**	**475**
BA Degree	31	40	71	38	36	74	69	76	145
MA Degree	5	4	9	4	2	6	9	6	15
Diploma	19	23	42	22	35	57	41	58	99
12 grade and lower	42	33	75	110	31	141	152	64	216
Meteorological Science/ Researcher	**58**	**20**	**78**	**130**	**26**	**156**	**188**	**46**	**234**
BSc. Degree	37	19	56	119	25	144	156	44	200
MSc. Degree	20	1	21	11	1	12	31	2	33
PhD Degree	1	0	1	0	0	0	0	0	1
Meteorological Technicians	**22**	**8**	**30**	**129**	**80**	**209**	**151**	**88**	**239**
Diploma	19	6	25	71	32	103	90	38	18
Lower than 12 grade	3	2	5	58	48	106	61	50	111
Sum	**177**	**128**	**305**	**433**	**210**	**643**	**610**	**338**	**948**

EMI assessment of staff competency is based on the Ethiopian Occupational Standards (EOS) for Level II to Level V. Level II corresponds to assistant observers, Level III, meteorological observers, Level IV, assistant meteorologist, and Level V corresponds to meteorological forecasters. EOS is based on a unit of competency in Ethiopia and identifies the tasks that should be done in each category, based on which curriculum would be developed. This is therefore only applicable to the meteorological technicians. Regular assessment for the rest of EMI staff and their competency framework is not specified. EMI has no training policy for staff and its members in place. There however is an *education and training guide for staff members (in Amharic).*

EMI has institutional arrangements for capacity building with national or regional institutions. EMI has existing collaborations with academic and research institutions in Ethiopia and has signed an MoU with Arba Minch University, Ethiopia Artificial Intelligence Institute, Addis Ababa University and Space Science and Geospatial Institute. In addition, EMI actively participates in capacity building workshops and training both on a short- and long-term basis. On a regional basis, EMI is part of the Severe Weather Forecasting Programme (SWFP) - Eastern Africa, which is administered by the Regional Specialised Meteorological Centre[7] in Nairobi Kenya and the IGAD Climate Prediction and Application Centre (ICPAC)[8]. EMI has seconded staff both for capacity building workshops and training including internships to these regional institutes. On a continental level EMI has had staff on secondments to the African Centre of Meteorological Applications for Development (ACMAD)[9]. The WMO regional office in Nairobi (Institute for Meteorological Training and Research (IMTR)) also offers project-related short training sessions.

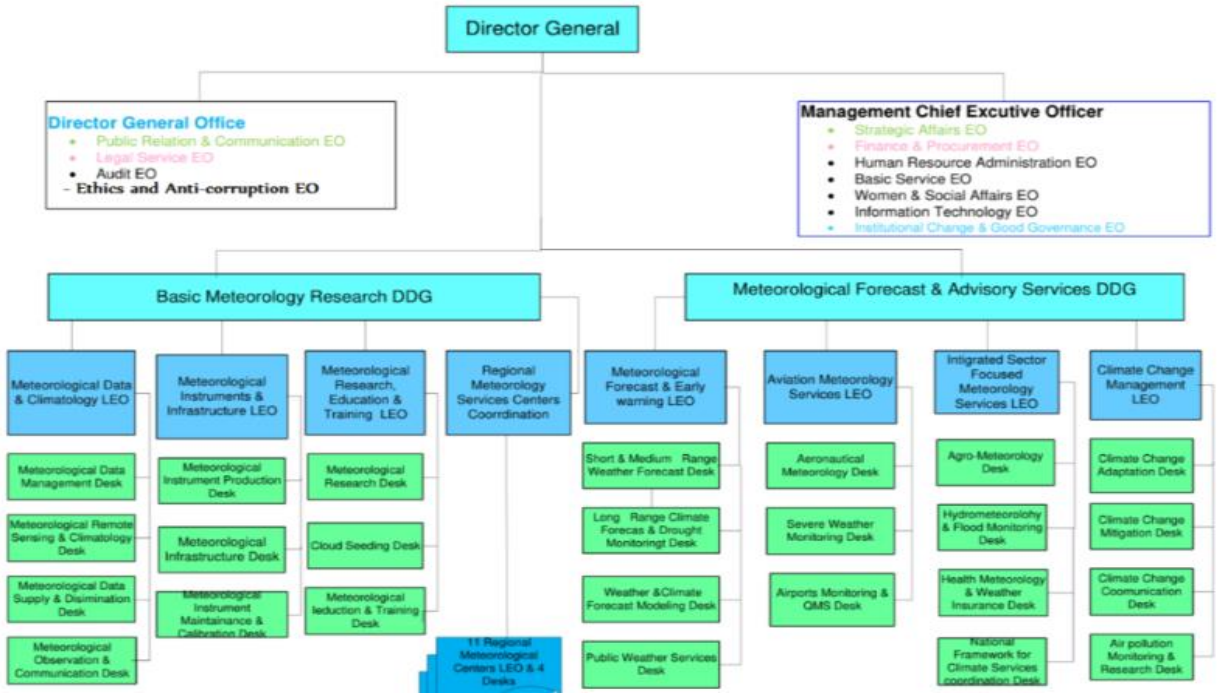

Figure 7. EMI's organisational chart

[7] http://rsmc.meteo.go.ke/rsmc/index.php

[8] https://www.icpac.net/

[9] https://acmad.org/

Table 3: Composition of EMI's technical staff with information on education, age, and gender

	Head-quarters	Regional Centres	Education (BSc or higher)	Age (Percent staff older than 50 years)	Gender
Corporate support[10]	12	11	23		Total: 23
Meteorologist	78	156	234	10 %	Women: 188 Men: 46 Total:234
Meteorological technicians	30	209	239	41 %	Women: 151 Men: 88 Total:239
Hydrologists	NA	NA	NA	NA	NA
Hydrological technicians	NA	NA	NA	NA	NA
Climatologists	*	*	*	*	*
Researchers	*	*	*		*
IT[11]	5	-	5	20 %	Women: 1 Men: 4 Total 5
Other	NA	NA	NA	NA	NA
Total					Women: Men: Total:473

*Meteorologists also work informally as researcher and climatologists;

Summary and comments for Element 1.4

The Ethiopian Meteorological Institute (EMI) has 948 staff working in various capacities at its head office in Addis Ababa and 11 regional meteorological offices. The institute operates under the Ministry of Water and Energy and is governed by a Director General and two Deputies.

The proportion of staff differs with gender, with a higher percentage of men (64%) than women (36%). Most technical staff (473) have a BSc or higher education. Skilled ICT personnel are lacking.

EMI has no formal training policy for staff and its members, however there is a competency assessment based on the Ethiopian Occupational Standards (EOS)for Level II to Level V employees. There exists an institutional arrangement for capacity building with national or regional institutions.

1.5 Experience and track record in implementing internationally funded hydromet projects as well as research and development projects in general.

[10] These number is incorporated with meteorologists total
[11] These number is incorporated with support corporate staff

The EMI has over the last decade been involved in several internationally funded projects and development projects. These includes and not limited to:

Water and Climate Change Services for Africa (WACCA) project: The project aims to contribute to development of welfare, health, and social life in Ethiopia by strengthening the capability of the national meteorological and hydrological services to provide better weather, climate, and water services toward a more climate resilient society. The project mainly focused on development of capacity: the project's first phase (1 December 2017- to 31 December 2022) and second phase (2023-2025) on a total Budget of approximately 5 million USD for three implementing institutions namely Ethiopian Meteorology Institute, Ministry of Water and Energy and Ethiopian Disaster Risk Management Commission.

Ethio-Finland project: As part of the project, EMI has a 3-year extended maintenance agreement with Vaisala on the 3-Weather Radar installed under the project. This is with a focus on improving meteorological observation and forecasting capabilities of EMI with an aim to minimise the impact of frequent Weather Hazards. Finland's strategic goals in Ethiopia are described in Finland's Country Strategy for Ethiopia 2021-2024 programme[12]. The latter focuses on development cooperation. In 2021–2024, Finland will focus on diversifying and deepening the relations between the two countries, supporting Ethiopia's political, social and private sector reforms, and strengthening Ethiopian institutions.

SAREPTA[13] a project from MET Norway/NORAD; An Institutional Support and Capacity Building for Weather and Climate Services. For EMI the focus on capacity building is related to website development, verification, IT infrastructure and data management, use of weather data and observations. There is a MoU between EMI and MET Norway for the period 2023-2027 with a possibility for an extension.

Ethiopia Flood management project (2022-2028)[14] by the World Bank aimed at strengthening Ethiopia's institutional capacity for disaster risk management (DRM), and flood risk management in selected basins. EMI, MoWE and EDRMC are implementing partners in this project.

Build Resilience for Food and Nutrition Security (BREFONS) project[15] by the African Development Bank (AFDB) in Ethiopia implemented by the Ministry of Agriculture in collaboration with EMI. The principal goal of the overall project is to build resilience to food and nutrition insecurity in the project intervention areas in the Horn of Africa 2022-2027.The initiative will improve the living conditions of women, youth, and the general public.

Climate Resilient Water Sanitation and Hygiene (CR-WASH) project[16]; the aim of which was to assist countries to respond to changes in health risks as a consequence of climate variability and change, through improved and more resilient health and WASH adaptation practices.

World Food Programme (WFP) project for the implementation of Satellite Index Insurance for Pastoralists in Ethiopia (SIIPE)[17]

WFP project: From 2005 to 2014, WFP and EMI worked together to modernise meteorological observation networks and improve agro-meteorological services in

12 Finland's country strategy for Ethiopia 2021–2024

13 Institutional Support and Capacity Building for Weather and Climate Services

14 Ethiopia Flood Management Project

15 Build Resilience for Food and Nutrition Security (BREFONS)

16 Climate resilient water sanitation and hygiene (WASH) initiatives from 2013–2018

17 Final Evaluation Of Satellite Index Insurance For Pastoralists In Ethiopia (SIIPE) Programme In Ethiopia (2019 – 2022)

Ethiopia. WFP assisted EMI in the procurement of 57 AWS in four phases from 2009 to 2014. WFP was also instrumental in introducing AWS to EMI, as well as in developing a capacity chain for the installation, operation, and maintenance of AWSs. WFP also assisted EMI in developing capacity in the use of the Livelihood Early Assessment and Protection (LEAP) software program and a variety of other agro-meteorological service delivery capabilities.

Resurgence or Consortium led to implement DARAJA project[18] which aims to improve weather and climate information services (WCIS), including early warnings of extreme weather, for urban users.

African Development Bank (AfDB) Climdev Project[19] "Strengthening climate information and early warning system for climate resilient development and adaptation to climate change in Ethiopia (SCIEWS-CRDACC)" was funded by AfDB, from Climdev Africa Special Fund, with a 1 million Euros budget for a period of 2015-2018. The overall goal of the project is to improve socio economic development, cope with climate variability, and build resilience to climate change for Ethiopia through high quality weather and climate services. Under this project EMI procured 18 AWS and three field vehicles, sensors checking instruments, and associated training and research capacity buildings. In addition, parts of historical data were rescued (Paper data were scanned and stored in softcopy).

Global Environment Facility (GEF) through UNDP have supported EMI mostly on initial investments e.g. providing and procurement of AWS, spare parts, mobile calibration facilities. The project's official title was "Strengthening climate information and early warning Systems in Africa for Climate resilient development and adaptation to climate change - Ethiopia". This project assisted EMI in installing 40 AWS, one upper air station, installing a message switching system (GTS) from COROBOR in France, a High-Performance Computer (HPC) with a capacity of more than 360 TB, upgrading EMI's Clidata Climate Database Management System in 2017, funding climate outlook forums and a number of short-term capacity building trainings for both technical and support staff, and sponsoring experience sharing visits abroad.

Christian Aid Ethiopia Climate Information and Assets for Resilience in Ethiopia (CIARE) project[20], a DFID-funded project implemented in Ethiopia under the global Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) programme. A follow up of the BRACED project (BRACED-X) was implemented during 2018-2019. EMI received four AWS stations and a number of capacity-building trainings as part of the CARE project. Another project in conjunction with Christian Aid - Ethiopia resulted in the establishment of 8 AWS stations. BRACED -X - was crucial in the creation of the National Framework for Climate Services (NFCS). Christian Aid, Mercy Corps, Farma Africa, and EMI were implementing partners in the project. The project employed consultants and, in collaboration with EMI and the personnel of the aforementioned organisations the following three documents were published:

- Baseline research to inform establishment of National Framework for Climate Services - Ethiopia
- Ethiopia Strategic Plan: 2021-2023 National Framework for Climate Services
- Ethiopian National Framework for Climate Services - Coordination Guideline

ATA-NMA Project: (2015–2017) - The Ethiopian Meteorology Institute, then NMA and the Ethiopian Agricultural Transformation Agency (ATA) signed a two-year agreement in March 2015, with funding from DANIDA totalling around $1 million USD. The project's goal was to increase the EMI's ability to track agricultural meteorological events in Ethiopia and

18 Resurgence

19 ClimDev Special Fund

20 Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) programme

offer user-specific advisory services and information for the 50 ATA-targeted districts (Woredas) across the country's four main regions (Amhara, Oromia, Tigray, and SNNP). 50 AWS, four mobile calibration facilities with field vehicles, and related capacity development training were procured by EMI as part of this project. All 50 districts were to receive location-specific agro-meteorological advisories from EMI using information gathered from those AWS and other inputs.

The Korea International Cooperation Agency (KOICA) Supported Project: KOICA sponsorship provided funding for a project named "Disaster Risk Reduction", through which there were installations of Meteorological Observation and Early warning systems," with a budget of roughly $4,000,000 USD for the years 2014–2017. The project's major objective was to develop countermeasures for reducing meteorological disasters across the Awash River by providing EMI and MoWE employees extensive training and capacity building on how to operate, manage, and maintain the flood early warning system over the Awash River basin. Ten AWS, ten ARS, five river level gauge stations, two Station wagon field vehicles were procured in addition to two women's scholarships for MSc study in meteorology. An upgrade of the EMI Data Centre Facility, and a flood early warning system over the Awash River Basin were all acquired by EMI under this project. There were visits to the South Korean Meteorological Services to share experiences, and more and over sea and in-land training.

Irish Aid project through WMO: The project's purpose was "improvement of agro-meteorological information for small-scale agricultural production in Tigray and Southern Nations and Nationality and People Region SNNPR/, Ethiopia," and it was supported in two phases by Irish-Aid via WMO. (174,000 EUR in Phase I and 203,000 EUR in Phase II) from 2013 to 2017. The overarching purpose of the project was to increase EMI staff's capacity to produce localised weather information in Tigray and SNNPR in Phase II. Under this initiative, EMI purchased 5 AWS, created a local climate atlas, provided capacity building training to local stakeholders and farmers, and performed experiments on the effectiveness of localised climate services, with encouraging results.

Farm-Africa Merc Corps supported project: In order to generate location-specific agro-advisory for the livestock industry, local NGOs supported the Ethiopian livestock community by introducing 25-AWS between 2016 and 2018. This initiative also involved building expertise on the use of climatic information for livestock activity decision making and engaging stakeholders.

Promoting Autonomous Adaptation (PAA) project[21]**:** The PAA Community Level ran in four different districts and woredas around the country. The Federal Environmental Protection Agency carried out the project in collaboration with other partner organisations. EMI was a partner and was directly involved in the implementation of the activities outlined in Outcome 3: "Improving the Capacity for Community-Based Climate Change Adaptation," during which a set of actions were planned to develop the competence of local planners for integrating climate information for planning purposes. As a result, eight AWS were installed and integrated into the EMI station network. The project was part of GEF-UNDP compliance.

The Pastoralist Resilience Enhancement Through Market Expansion (PRIME) project was implemented in partnership between EMI and CARE Ethiopia during 2014-2015. The purpose of this project was to enhance seasonal weather forecasting and climate information delivery and use in pastoral areas where the project operates. The project was funded by USAID under the PRIME program. The project was aimed at fostering the use

[21] Promoting Autonomous Adaptation at the Community Level in Ethiopia

of real-time, lead-time forecast and localised climate information over the pastoralist regions of Afar, Oromiya and Somali National Regional States of Eastern Ethiopia. Four AWSs were procured and installed in the project area. Capacity building on downscaled weather and climate forecasts was given to the EMI's regional meteorological centres.

African Climate Policy Centre (ACPC) project, Support EMI, in Capacity Building of Climate Monitoring and Early Warning Activities for Climate Change This project covered the labour costs associated with data rescue activities in EMI. In addition, 12 PCs were purchased in 2012 for a data recovery operation.

Climate change adaptation project over highland and lowland areas of Ethiopia. These are climate adaptation programs that are functioning in specific regions of the country and have assisted EMI in building AWS, raising knowledge about the benefits of climate services for agricultural productivity, and financing NCOFs and RCOFS.

The IRI-Enhancing National Climate Services (ENACT) project is an ambitious effort to simultaneously improve the availability, access, and use of climate information by working directly with National Meteorological and Hydrological Services (NMHS). In Ethiopia this project was able to merge satellite derived rainfall data with gauge stations and model reanalysis temperature data with maximum and minimum temperature data collected at conventional stations. The merged data is available at 4 Km X 4 Km grid spacing from early 80's up to 2022 and different graphical and map outputs produced through this project available on EMI website[22] and Maproom and is updated regularly.

In Their Lifetime (ITL).2 Ethiopia project is a project by Christian Aid in collaboration with EMI and Ethiopian Public Health Institute to develop climate thresholds for different weather and climate related diseases." Preparedness and early warning response to public health emergencies in Konso and South Omo, Ethiopia" was the name of the project which had three major objectives one of which was threshold development for predicting climate sensitive diseases over the project operating areas. Experts from EMI and the MoH collaborated to create a study titled "Developing Climate Threshold for Certain Climate Sensitive Diseases (CSD's) over Konso and South Omo, Ethiopia". It was aimed to explore the nexus between climatic conditions and selected CSDs in Konso and South Omo Zones through the development of empirical climatic thresholds.

WMO-Finnish Project: This project aided EMI in acquiring CLIDATA, a modern climate data management system developed by the Czech corporation ATACO in partnership with the Czech Meteorological and Hydrological Institute. EMI also received 1 server, 2 cameras, 12 scanners, 12 PCs, 1 printer, and other consumables through this project, which were later used for data recovery. It was, however, in 2012.

The broad list of globally, regionally, and locally financed projects demonstrates that EMI is a worthy partner in weather and climate initiatives in Ethiopia. The projects' track record can be measured by the increased number of weather observation network infrastructure in Ethiopia. This is equally true for developing long-term capabilities for EMI employees.

Summary score, recommendations, and comments for Element 1

[22] http://www.ethiomet.gov.et/

EMI's maturity level on "Governance and Institutional Setting" is assessed as **Level four*:*** *"An effective service but with a few shortcomings related to its mandate, governance, and resourcing and in the process to address the gaps".*

EMI plays a crucial role in weather and climate service provision in Ethiopia including meeting Ethiopia's international meteorological commitments. EMI has national strategies and specific legislative Act/Policies in place describing the NMHS legal mandate and its scope. In addition, EMI has a strategic development plan formulated to accomplish the institute's activities in short-, medium- and long-term time periods:

Recommendations:

Budget allocation: -

- Implement a Risk Management Plan that will be beneficial for the capital projects at EMI.
- Lobby for increased government funding that is sustainable and matches the institute's needs. This will reduce dependency on development assistance funding sources.
- Re-evaluate cost-recovery funding arrangements with the ECAA such that funding allocated to EMI should be adjusted accordingly to match the full cost of the aviation services provided.
- EMI is a worthy partner in weather and climate initiatives in Ethiopia based on the number of internationally funded hydromet projects, most of which led to an increased number of weather observation network infrastructure. Sustainability of the observation network was however not clearly assessed, including alignments to available national funds in the long run.

Human resources: -

- EMI could benefit from better documented training procedures and policies for all personnel. This could include having dedicated staff with expertise in climatology as well as research.
- EMI requires continued and regular recruitment of highly qualified staff to meet, for example, the institute's priorities for network expansion.
- Promote gender equality by establishing minimum thresholds for female participation, with affirmative actions to bridge the gap between female and male staff, especially for technical staff.
- Develop specific expertise within EMI staff including ICT staff, research, and climatology and - retaining of staff.

Element 2: Effective partnerships to improve service delivery

2.1. Effective partnerships for service delivery in place with other government institutions.

EMI has effective partnership with several governmental entities in Ethiopia for service delivery. These entities include:

- Ministry of Water and Energy (MoWE)
- Ministry of Agriculture (MoA)
- Ministry of Irrigation and Lowlands (MILL)
- Ministry of Health (MoH)
- Ethiopian Public Health Institute
- Environmental Protection Authority (EPA)
- Ethiopian Disaster Risk Management Commission (EDRMC)
- Ethio-telecom
- Ethiopian Civil Aviation Authority (ECAA)
- Ministry of Education (MoE)
- Ethiopia Agricultural Institute (EAI)
- Agricultural Transformation Institute (ATI)
- Ethiopian Airlines (EAL)
- Ministry of Defence
- Ministry of Education/Universities
- Regional government entities in the agriculture, water, health, environment, and disaster sectors.

Key governmental partners (MoWE, MoH, MoA, MILL, EDRMC and EPA) make up the National Framework for Climate Services Partners (NFCS) and engage continuously on specific climate service co-production and climate services delivery. The role and responsibility of each institute are well articulated in NFCS coordination guidelines and the National Climate Outlook Forum (NCOF) guidelines[23]. Recently, EMI has signed an MoU with Regional State Bureaus of the NFCS implementing partner institution. This will further strengthen the partnership and service delivery to the lowest administration level (up to district-woreda level) in Ethiopia. In support of this, EMI has designed the SOPs for Grass Root Meteorological Services (GRMS) at principal and synoptic stations which can improve local area specific climate services to the wider community. EMI also partners with the Ethiopian Civil Aviation Authority and the Ethiopian Airlines Group.

Summary and comments for Element 2.1
EMI collaborates with various Ethiopian governmental entities, some of which form the National Framework for Climate Services Partners (NFCS), which engages in specific climate service co-production and delivery. EMI has also designed SOPs for Grass Root Meteorological Services (GRMS) to improve local climate services.

2.2. Effective partnerships in place at the national and international level with the private sector, research centres and academia, including joint research and innovation projects.

[23] National Climate Outlook Forum (NCOF) Guide - Ethiopia

There is no specific legislation concerning private sector participation in the delivery of information, but there is a general Public-Private Partnerships (PPPs) proclamation[24] to which EMI is mandated. Currently, most formal agreements that exist between EMI and other public and private sectors have a focus on service delivery. EMI however has limited to no relationships and partnership with the private sector for the design, maintenance and operation of the basic observation infrastructure. For service delivery, there is a Memorandum of Understanding (MoU) with:

- **World Food Programme** for the implementation of Satellite Index Insurance for pastoralist.
- Ministry of Agriculture to implement Build Resilience for Food and Nutrition Security (BREFONS) project in Ethiopia.
- Resurgence or Consortium led to implement DARAJA project which aims to transform urban WCIS.
- Other partnerships at national and international levels are summarised in section 1.5.

For network management and maintenance, there is a collaboration through the Ethio-Finland project, in which EMI has a 3-year extended maintenance agreement with Vaisala on the project's three weather radars. Development partners such as the African Development Bank (AfDB) and the Global Environment Facility (GEF) through UNDP have mostly supported EMI with initial expenditures, such as the provision and procurement of AWS, spare parts, and mobile calibration facilities. This absence of broad partnerships and legal framework leaves room for potential future developments.

EMI participates in several multi-sector consultative platforms with regular meetings or when needed (e.g. when extreme rainfall is forecasted). These multi-sector consultative platforms include:

- National and Regional Seasonal Climate Outlook Forum (NCOF/RCOF): - 3 times in-year-round, organized by EMI
- National Disaster Prevention and Preparedness Committee led by the Deputy Prime Minister of FDRE, activated during extreme rainfall event is predicted
- Disaster risk management technical working groups (DRMTWGs): - Every two weeks and Chaired by EDRMC and the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA)
- Agro-Meteorology Platform: - every ten day: - Chaired by MoA & EMI, guided by ToR
- Flood Task Force (FTF): - Activated when extreme RF is forecasted, led by MoWE
- Drought Response Meeting (DRM-ATF), chaired by MoA and scheduled to take place on a monthly basis
- Climate Change and Health Technical Working Group: - Quarterly basis
- Seminars and conference organized by Ethiopian Meteorological Society (EtMS): - led by the society

EMI's management team sets up research priorities at the institute based on EMI's strategic plan. Research activities at EMI are dependent on the government funding and donor- supported projects. EMI collaborates with different academia and research institutions including, Arba Minch University, Mekelle University, Addis Ababa University, Adama Science and Technology University, Ethiopian Artificial Intelligence and Ethiopian Space Science Institute.

At the international level, the EMI collaborates with various institutions, including ICPAC for capacity building workshops for the Greater Horn of Africa (GHACOFs). EMI also

[24] Private Public Partnership Proclamation.pdf

recently signed a MoU with the Norwegian Meteorological Institute for Institutional Support and Capacity Building for Weather and Climate Services under the SAREPTA project.

Summary and comments for Element 2.2

EMI partnership with the private sector is mandated by the Public-Private Partnerships proclamation. However, it has limited private sector partnerships for observation infrastructure design and maintenance. EMI has a Memorandum of Understanding with several private partners including World Food Programme and a 3-year extended maintenance agreement with Vaisala.

Most of the international and private sector partnerships are mostly project based and as such have short-term benefits.

2.3. Effective partnerships in place with international climate and development finance partners.

EMI works with several international climate and development finance partners (e.g., AfDB, WB, UNDP, WFP and WMO) with numerous historical and current projects. For example, through collaboration between EMI and UNDP, EMI got 40 AWS stations, one upper air station, lots of capacity building training, refresher course to meteorological technicians and support staff. Some other projects are summarised in detail in section 1.5. The main source of funding for the research activities at EMI is mostly through donor-supported projects while government budgets supplement this.

2.4. New or enhanced products, services or dissemination techniques or new uses or applications of existing products and services that culminated from these relationships.

As a result of these collaborations and partnerships, several services and products have been delivered, and the net impact/benefit is discussed in section 1.5. They include the installation of HCP clusters, radiosondes, and 40 autonomous weather stations through GEF/UNDP collaborations, as well as capacity building training and refresher courses for meteorological technicians and support staff. The International Research Institute of Columbia University (IRI) presented the concept of combining station data with satellite estimated data to EMI, trained EMI specialists on it, established the IRI data library, and made the EMI map room web accessible. The EMI map room has collections of maps, figures, and graphs containing information about Ethiopia's climate. Subsequently, IRI trained EMI experts and installed the Climate Data Tool (CDT). Features for data merging and quality testing are included in this potent application/tool. In 2012, the WMO assisted EMI to obtain a database server along with CLIDATA climate database system, twelve cameras, twelve scanners, twelve computers and consumables. With the use of these resources and funding provided by the African Climate Policy Centre, EMI started a data rescue operation. Recently, through the government budget, during the 2022-23 project phase, 1.5 million pages of data have been rescued. Phase will continue 2023-24.

Verification reports[25, 26] were published by EMI as a result of the AfDB-Bank-Climdev Africa Special Fund initiative and the CIARE project.

Summary score, recommendations, and comments for Element 2

[25] NMA_Forecast_Verification_final_draft.pdf

[26] Verification Of Forecasts Given To Ciare Project Intervention Areas

EMI's maturity level for "Effective partnerships to improve service delivery" is assessed as **Level three:** "*Moderately effective partnerships but generally regarded as the weaker partner in such relationships, having little say in relevant financing initiatives*".

EMI has effective partnership with key governmental sectors especially under the National Framework for Climate Services Partners (NFCS) and the National Climate Outlook Forum (NCOF) where the exits guidelines for continuous engagements and strong collaborations on climate service co-production. EMI has also demonstrated their capacity as worthy partners for international, regional, and local private sponsored projects initiatives.

Recommendations:

- EMI should establish strategies to enhance their position in project financial decision-making and resource allocations. This will streamline projects in-line with EMI's strategic development plan and their capacity.
- Establish sustainable and meaningful partnerships with the private sector, e.g. telecommunication companies and the Information Network Security Authority (INSA), especially for operation and maintenance of observation networks.
- Strengthen the relationships with the academia with formal agreements and arrangements for collaboration on key areas of science and advancement of weather and climate services in Ethiopia.
- Strengthen sub-regional collaboration

Element 3: Observational infrastructure

3.1. Average horizontal resolution in km of both synoptic surface and upper-air observations, including compliance with the Global Basic Observing Network (GBON) regulations.

The surface weather observation network infrastructure in Ethiopia consists of 1543 surface meteorological observation stations of different class types distributed across the country. 287 stations of the total station network in Ethiopia are automated, measuring temperature, wind, Humidity, precipitation, and global radiation at sub-hourly intervals. EMI has three radio sounding stations, however, only one is currently operational. Moreover, at the time of writing this report, EMI still used GTS through the Nairobi RTH for international data transmission.

The GBON surface observation network in Ethiopia consists of 16 stations and the average coverage of one surface weather station is 70000 km^2 (ca. 265 km x 265 km). All the 16 stations are manual and observe and transmit data every 3 hours to the GTS from 06 LST to 18 LST. Only two stations send data from 00 UTC to 24:00 UTC. As such none of these stations are GBON compliant. The network of automatic stations at EMI lacks pressure sensors, a key GBON variable for GBON compliance. The GBON gap analysis report for Ethiopia (2023) provides a detailed overview of network distribution in Ethiopia.

There are also some notable challenges within the observation network. Some of the stations are not functioning, also impacting the data collection and acquisition of data for the service production, monitoring and forecasting. About 50% of the automatic stations and from the manual station 90% were operational at the time of writing this report. Geographical, financial, and logistical constraints result in some areas of the country having poor observation infrastructure coverage. For example, the lowland (peripheral) areas bordering Somalia, due to geographical and infrastructure reasons and sometimes due to security concerns have had poor coverage. These limitations further hinder comprehensive hazard monitoring and these regions have been factored in for SOFF support.

With regards to specific warnings for different hazards, EMI monitors variables relevant to all hazards especially drought/dry spell, flash flood and water dam related hazards. For hazard monitoring, EMI collaborates with other relevant ministries including the National Flood Technical Working Group. The following main gaps have been identified at EMI capacity to monitor priority hazards in Ethiopia:

- Flash flood modelling needs to be further developed
- Making stations more operational and additional network coverage, higher frequency
- More dense observation time series on precipitation
- National Hazard mapping for all hazards needed
- Staff capacity in knowledge of diverse hazards
- Sounding network for nowcasting is not dense enough
- Development of heatwave index for Ethiopia - Heatwaves have become increasingly strong and there is need for intense monitoring.

Summary and comments of Element 3.1

Ethiopia's surface weather observation network comprises 1543 stations, with 287 automated stations. EMI has three radio sounding stations, but only one is operational.

The GBON surface observation network comprised 16 stations, with an average coverage of 70000 km^2 None of the stations at EMI are GBON compliant. The lowland (peripheral) areas of Ethiopia bordering Somalia have missing observations, due to geographical, infrastructural, and sometimes security concerns. EMI collaborates with other ministries for hazard monitoring, but there are gaps in capacity to monitor some priority hazards in Ethiopia.

3.2. Additional observations used for nowcasting and specialised purposes.

EMI currently has two weather radars, with plans underway to install two more. Additional radars are required to cover all of Ethiopia's area.

3.3. Standard Operating Practices in place for the deployment, maintenance, calibrations, and quality assurance of the observational network.

EMI possesses only limited capability to perform calibration, quality control, and maintenance of its observing systems. EMI has in place a field calibration equipment, but there is only a limited spare part stock in EMI to replace the instruments under calibration maintenance. Lack of adequately trained technicians also make it difficult to conduct regular maintenance schedules. Currently however, EMI is modernising its building infrastructure and in the new Headquarter building there is a reserved space for the calibration laboratory facilities.

The EMI has established manual quality control procedures for data management, as well as Standard Operating Procedures (SOPs) for observation station maintenance procedures. However, developing the digital SOPs has been under way using Dokuwiki software.

As for a national governance mechanism within the World Meteorological Organization Information System (WIGOS) framework, Ethiopia currently does not have such a mechanism established. The absence of this governance structure may impact the coordinated management and utilisation of observational data and resources.

In terms of staff training related to the WMO Information System for the WMO Global Observing System (OSCAR/Surface), there is currently no record of staff trained in this specific domain.

Furthermore, there is no established national process in place for acting on quality problem information received from the WMO Information System (WIS) Data Quality Monitoring System (WDQMS). The absence of a structured procedure for addressing data quality issues may require attention to ensure the reliability and accuracy of observations.

Summary and comments of Element 3.3

EMI has limited capabilities for calibration, quality control, and maintenance of its observing systems due to limited capacity to acquire spare parts and trained technicians. EMI is modernising its infrastructure and developing digital SOPs using Dokuwiki software. However, Ethiopia lacks a national governance mechanism within the World Meteorological Organization Information System (WIGOS) framework, which could impact data management and resource utilisation. Additionally, there is no record of staff training in the WMO Information System for the WMO Global Observing System.

3.4 Implementation of sustainable newer approaches to observations.

Sustainability of the observation network operations and maintenance is still an issue at EMI. There are no local calibration laboratory facilities or an arrangement with a Regional Instrument Centre (RIC) to assist in the calibration of observation stations. Moreover, there is a lack of capacity (number of people and knowledge capacity) for data exchange compatible with the WIS2.0.

To meet the National WIGOS Implementation Plan (N-WIP) for sustainable newer approaches to observations, EMI has through SOFF project conducted GBON National Gap Analysis and identified the estimated number of surface and upper-air observing stations needed to close basic observational data gaps requirement for Ethiopia. Ethiopia's GBON National Contribution Plan (2023) has identified infrastructure and the human and institutional capacity needed to achieve a progressive target toward GBON compliance, including the sustained operation and maintenance of the national observing network. In addition, EMI in collaboration with MET Norway held a SOFF stakeholders meeting in Adama, Ethiopia. The aim of the stakeholder workshop[27] was to bring together relevant stakeholders across the meteorological value chain in Ethiopia to facilitate dialogue and consultations that will maximise synergies relevant for the sustainability of observation networks.

SOFF investment funding request captured the needs identified for the sustainability of observation networks in Ethiopia but further support through WMO and international partners would be beneficial.

Summary and comments of Element 3.4

EMI faces sustainability issues in its observation network operations and maintenance due to lack of local calibration facilities and capacity for data exchange compatible with WIS2.0. To meet the National WIGOS Implementation Plan, EMI conducted a GBON National Gap Analysis and identified the number of surface and upper air observing stations needed. A stakeholder meeting in Ethiopia with MET Norway aimed to maximise synergies for sustainability. Further support through WMO and international partners is needed.

3.5. Percentage of the surface observations that depend on automatic techniques.

Based on gap analysis, Ethiopia operates both automatic and manual surface weather stations and based on the full surface station list (including synop stations), currently only 18,6% of all the stations are automated. Over the past five years, the EMI has deployed a total of 45 stations (out of AWS network's 287) new automatic weather stations. The data is delivered in real-time or near-real-time to EMI headquarters from the AWS network every 15 min, however this is subject to the network connection availability/quality. As

[27] Report of Consultative Meeting of Stakeholders on Systematic Observations Financing Facility

EMI has not yet migrated to WIS 2.0 for data transmission, data is not exchanged in real-time internationally to the global NWP centres.

Summary and comments of Element 3.5
EMI has a large observation network of different class types distributed across the country. Only 19% depend on automatic techniques. In the last five years there has been 45 new (16%) new stations have been deployed

Summary score, recommendations, and comments for Element 3

EMI's maturity level for "Observational infrastructure" is assessed as **Level two**: "*basic network, large gaps, mostly manual observations with severe challenges and data quality issues.*"

At EMI there are urgent development needs required for EMI to achieve GBON compliance. This includes modernization of the outdated surface observation techniques and re-design the data management system and of the ICT infrastructure and services for international data exchange through WIS 2.0 to Global NWP Centres.

Recommendations:

- Implement Ethiopia's GBON National Contribution Plan (2023) during the investment phase which identified infrastructure and the human and institutional capacity needed to achieve a progressive target toward GBON compliance (Fully implement the National WIGOS Implementation Plan (N-WIP) through SOFF)
- Ensure improved station operational rates through enhanced maintenance efforts and calibration capacity. EMI should develop a proper maintenance and management plan of the existing station network through improved standard operating procedures (SOPs).
- Initiates the process of implementing a WMO Information System for the WIGOS national governance mechanism and adopting the national plan to enhance coordination and resource management.
- EMI will need support from international and development agencies collaboration partners in this area.
- Promote more consultations and partnerships through stakeholder workshops to facilitate dialogue and consultations that will maximise synergies relevant for the sustainability of observation networks.
- Build and improve capacity of EMI staff with regards to AWS and upper-air station operations and maintenance

Element 4: Data and product sharing and policies

4.1. Percentage of GBON compliance – for how many prescribed surface and upper-air stations are observations exchanged internationally. Usage of regional WIGOS centres.

EMI currently has no stations that are GBON compliant. Observations from 16 operational surface stations and one upper air station are exchanged internationally via the GTS but are not compliant due to the reporting frequency (three-hourly) and are manual. In addition, all existing and operational (287) AWS in Ethiopia have few to no pressure sensors, a key variable for GBON compliance. EMI has not yet migrated to WIS 2.0 for transferring data but uses GTS through Nairobi RTH as the Global Information System Centre (GISCs) used for data transmission.

EMI has no greenhouse gases (GHG) stations under its mandate to monitor GHG parameters in the country. This is notwithstanding that EMI has a duty to control air pollution and maintain the natural balance of the air in the country. While the EPA has the mandate for air quality standards in Ethiopia. Absence of a clear framework on how EMI fulfils its duty to control air pollution leaves room for potential future developments and streamlining of functions including procurement of GHG stations through collaborations and funding proposals.

Summary and comments of Element 4.1
EMI has no stations that are GBON compliant. Observations from 16 stations are exchanged internationally via GTS every three hours as EMI has not yet migrated to data sharing using WIS 2.O protocol. EMI also has no greenhouse gas (GHG) stations.

4.2. A formal policy and practise for the free and open sharing of observational data.

EMI has no free and open data policy, but EMI's data is free for non-funded national researchers and development applications upon request. This does not apply to international data exchange for research. Currently there is also no national WIGOS partnership agreement in place for integration and open sharing of observations from EMI and non-EMI sources.

The EMI database system, CLIDATA, has been operational since 2004. The system has inbuilt features to collect observations, generate products, create metadata, and archive information. This also includes geospatial QC and HQC features. The system however currently possesses some challenges including having a low server capacity with outdated functionalities. The hard disk capacity is somewhat low to effectively manage large amounts of data and delivery for effective data management and the long-term preservation of critical meteorological information. EMI therefore requires the framework to enhance capabilities of its existing database system for long-time archiving and sustainable international observational data. This should be allocated both for the system upgrade and especially for capacity development of personnel.

A document governing EMI's data policy[28] provides frameworks for provisions of observational meteorological data. The policy provides for open sharing of observation

[28] EMI's Data Policy- English

data in compliance to GBON regulations: "In accordance with international agreements and regulations of World Meteorological Organization unrestricted and non-discriminatory exchange of meteorological data and services are to be rendered to all member countries of the World Meteorological Organization".

EMI has to some extent within the NFCS set up guidelines that allow data exchange of monitoring systems and baseline data necessary to produce data products for major priority hazards. There is for example limited data sharing agreement with specific projects on the hydrology sector and multi-institution data sharing with agricultural institutions. A comprehensive Standard Operating Procedure (SOP) is under development.

Summary and comments of Element 4.2

EMI has no free and open sharing of observational data policy but offers free data for non-funded national researchers and development applications upon request. There is currently no national WIGOS partnership agreement for integration and open sharing of observations. The outdated CLIDATA database system needs a framework for long-term archiving and compliance with GBON regulations.

4.3. Main data and products received from external sources in a national, regional and global context, such as model and satellite data.

Satellite data is crucial for weather monitoring and forecasting and EMI uses different satellite products to monitor the extreme weather events (especially for floods and drought). EMI has access to different freely available satellite source products including GFS. EMI doesn't receive satellite products from ECMWF and the Regional Specialized Meteorological Centre (RSMC) but would like to have access to ECMWF data and products. Some of EMI staff received training on remote sensing e.g. Meteosat image interpretation. The training, however, has not been efficient enough to produce results and warning by using remote sensing products.

EMI accesses satellite data via the EUMETCast (PUMA) and Geonetcast satellite receiving stations. In addition, EMI relies on LAN, Internet and GTS for data and product access. GPRS is used for AWS data collection and VSAT for radar weather data access. EMI uses fibre optics internet with a upload and download bandwidth speed of up to 100Mbps.

Summary and comments of Element 4.3

EMI uses satellite data for weather monitoring, particularly for floods and droughts. They access various satellite products, including GFS via the EUMETCast (PUMA) and Geonetcast satellite receiving stations. EMI staff have received some remote sensing training EMI uses fibre optics internet with up to 100Mbps bandwidth.

Summary score, recommendations, and comments for Element 4

EMI's maturity level for "Data and product sharing and policies" is assessed as **Level two**: "*A limited amount of GBON compliant data is shared internationally. The existing data sharing policies or practices or the existing infrastructure severely hamper two-way data sharing*".

Recommendations:

- Implement GBON National Contribution Plan including re-design of the ICT infrastructure and services for international data exchange through WIS 2.0 protocol.
- Build local capacity of data management including enhancing capabilities of the CLIDATA database system for long-time archiving and sustainable international exchange of observational data.
- The lack of a clear framework for EMI's responsibilities with regards to GHG stations leaves room for future developments and streamlining of functions, including procurement of GHG stations through collaborations and funding proposals.
- Fully develop a comprehensive Standard Operating Procedure (SOP)
- Review of EMI's data sharing policies

Element 5: Numerical model and forecasting tool application

5.1. Model and remote sensed products form the primary source for products across the different forecasting timescales.

EMI has access to a wide range of forecast products, including those provided by the WMO's Regional Specialized Meteorological Centre (RSMC)-Nairobi[29] and other institutes offering global Numerical Weather Prediction (NWP) model outputs including ECMWF, DWD, Meteo-France and GFS. The GFS is the only model output that is ingested to the EMI systems, otherwise model data is only used through ready-made plots and maps through the internet (visualization of model outputs). Except for connectivity concerns, which are now resolved, there have been no substantial changes in the level of access to products supplied by global and regional centres during the last two years. The EMI staff has been regularly participating among others the following trainings related to NWP and forecasting tools:

- ICPAC training prior to RCOF events (3 times a year)
- ACMAD - staff were seconded from EMI for 3-4 months period
- WMO Regional Office in Nairobi offers project-related short training sessions
- WMO SWFP Eastern Africa program in which EMI staff was trained for nowcasting products and impact based forecasting
- Severe weather training sessions provided by the UK Met Office

Summary and comments of Element 5.1
EMI accesses various forecast products from WMO's RSMC-Nairobi including (NWP) model outputs from ECMWF, DWD, Meteo-France and GFS. Access to products has not significantly changed in the last two years, however EMI staff regularly participates in NWP and forecasting training.

5.2. a) Models run internally (and sustainably), b) Data assimilation and verification performed, c) appropriateness of horizontal and vertical resolution.

The EMI currently runs the WRF model in their own ICT systems once a day with 10 days lead time. The model is configured to use the GFS model data for the boundary and initial data and the resolution of the model is 4 km. Currently there are no data assimilation practices at EMI, however, AWS network data was previously assimilated, but this has been discontinued due to technical issues with observation data management. In addition, the radio sounding data was once assimilated, this data is no longer available and cannot be used in assimilation. At the time of writing this report, the hardware for running the WRF model is approximately 7-8 years old and should be urgently renewed.

Through the SAREPTA project (2023-2027), EMI will receive capacity building training on model verification, among other things.

Summary and comments of Element 5.2
EMI runs the WRF model daily with a 10-day lead time, using GFS model data for boundary and initial data. Data assimilation is not currently implemented due to

[29] Regional Specialized Meteorological Centre (RSMC)

technical issues.

5.3. Probabilistic forecasts produced and, if so, based on ensemble predictions.

Generally, EMI does not issue forecasts or warnings based on probabilistic NWP. This is particularly true for short- and medium-term forecasts. However, for seasonal forecasting, probabilistic NWP is utilised alongside statistical methodologies which often link climate signals, such as sea surface temperatures (SSTs), to precipitation and temperature in a specific place. EMI has limited to no capacity for post-process NWP, including Ensemble Prediction System (EPS) products.

Summary score, recommendations, and comments for Element 5

EMI's maturity level for "Numerical model and forecasting tool application" is assessed as **Level three**: *"Prediction based mostly on model guidance from external and limited internal sources (without data assimilation) and remotely sensed products in the form of maps, figures and digital data and cover nowcasting, short and medium forecast time ranges."*

The entire value chain of deploying, verifying and assimilating weather forecasts requires development to ensure that the most benefit can be gained from available information. There are good elements and processes, but new technologies and automation would fill a gap and increase the effectiveness of the weather forecasting process.

Recommendations:

- Ensure maximum benefits through different on-going projects (such as Finnish and Norwegian funded ones), EMI is in the process of modernising NWP modelling and verification capabilities
- Ensure sustainability of human resources, organisational capacity, a lifecycle of IT hardware and regional collaboration
- Improvements in the observational capabilities at EMI will enhance the data assimilation procedures included in the NWP modelling, including radar data

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.

The EMI produces short, medium, and long-range forecasts. Except on Saturdays and Sundays, when only routine operations are performed, the short-range forecasting system is generated every weekday and often includes warnings. EMI does not have a 24/7 warning or alert service that operates all year-long. However, in extreme weather events, 24/7 services can be provided.

Ethiopia has a Multi Hazard Early Warning System (MHEWS) roadmap (see element 1.1) where different stakeholders including governmental ministries, UN agencies, foundations, regional knowledge-based institutions, NGOs, CSOs, and private sector work together in implementing the various EWSs in Ethiopia. This is done through leveraging of technologies and optimal use of disaster risk information, then mainstreaming of disaster risk plans. The following institutes are involved: EMI, Ethiopia Water, Sanitation and Hygiene (WASH), MoH, Nutrition, MoA, education, gender, emergency shelter and protection. The recent Ethiopia's MHEWS report (A Roadmap for Multi-Hazard, Impact-Based Early Warning and Early Action System 2023-2026) provides policies and guidelines for monitoring and forecasting systems for multiple hazards that occur simultaneously or cumulatively over time. There also exists a MHEWS warning for potential cascading impacts. This is provided in the working version MHEWS roadmap but as it is in its very initial stage, there needs to be a monitoring phase to ensure its implementation. EMI's monitoring and forecasting systems are designed such that they can handle scenarios where multiple hazards may occur simultaneously. Varied customised forecasts can then be generated, including the incorporation of multi-sector discussions and dialogues for effective early warning advisory services. This, however, requires strengthening because it is still in the early stages of development.

Currently there is no data available on the number of people per 100,000 covered by early warning information in Ethiopia. EMI's maximum lead time for warnings is one month for seasonal warnings, and one day for short range warnings.

Summary and comments of Element 6.1

EMI generates short, medium, and long-range forecasts, with the short-short-range system generated every weekday except on Saturday and Sunday. EMI does not have a 24/7 warning or alert service Ethiopia has MHEWS in place which involves different stakeholders. Maximum lead time is one month for seasonal and one day for short-range warnings.

6.2. Hydrometeorological hazards for which forecasting and warning capacity is available and whether feedback and lessons learned are included to improve warnings.

As provided in the MHEWS Roadmap, EMI provides warnings for drought/dry spell, flash flood and water dam related hazards. Warnings on forest fire, frost and landslide are provided in collaboration with relevant ministries including the MoWE and EPA. There exists a user feedback mechanism in place at EMI to verify warnings for hydrometeorological hazards. At least three times a year, feedback is collected from various levels of stakeholders in the NFCS during NCOF Sessions. EMI uses this feedback to improve their services accordingly.

EMI evaluates the performance of their services (e.g. seasonal forecast and the related impacts) together with different relevance stakeholders in the NFCS (EDRMC, MoWE, MOH, MoA, EPA). Flash Floods warnings are reviewed after the event.

EMI established a mechanism for co-design/co-production in 2018 after launching of NFCS. Through the NCOF platform, EMI with seven sectors engage in co-production of tailored climate services, based on NFCS. Feedback is also shared at these forums for service delivery improvement. Downscaled rainfall/temperature forecast, agro-meteorological, hydro-meteorological, and bio-meteorological advisories, forecast and Grass root level weather/climate services are outputs of these forums:

- Agro-meteorology (Customise the climate information for the benefit of crop and livestock production using various indexes, such as Moisture Index, WRSI, NDVI and the like)
- Hydro-Meteorology (Customise the climate information for the benefit of water resource management.)
- Bio-Meteorology (Customise the climate information for the benefit of human and Animal health)

The system in place is however not yet mature or comprehensive and thus needs some improvement.

Summary and comments of Element 6.2

EMI provides warnings for drought, flash flood, water dam hazards. Warnings on forest fire, frost, and landslide in collaboration with ministries. A user feedback mechanism verifies hydrometeorological hazards. Feedback is collected from stakeholders in the NFCS during NCOF Sessions.

6.3. Common alerting procedures in place based on impact-based services and scenarios taking hazard, exposure and vulnerability information into account and with registered alerting authorities.

EMI has recently implemented the Common Alerting Protocol (CAP)[30], and this has been active since 2022 for drought and flash floods. At present there are no Standard Operating Procedures (SOP) in place in Ethiopia with registered authorities and stakeholders. It is however stated in Ethiopia's MHEWS roadmap that the Federal government is responsible for developing SOP for federal, regional, and local agency actions in the immediate aftermath of a disaster to allow for more systematic disaster response. EMI is in the process of establishing a threshold for risk matrix for impact-based forecast (IBF) and warning. This is however not yet fully functional as the forecasters have not been trained on the principles, methods and application of IBF. In addition, the institute has no software tools and capacity to produce impact-based forecasts and warnings. EMI however has plans to produce impact-based forecasts in collaboration with relevant stakeholders.

Through the NFCS sectoral technical working group, EMI is able to access the impact information and thus able to use hazard, exposure and vulnerability information as an input into the development of relevant advisories. This can be well incorporated into EMI future IBFs; the recent roadmap for Multi-Hazard, Impact-Based Early Warning and Early

[30] WMO's Register of Alerting Authorities for Ethiopia

Action System in Ethiopia policy recommendation is fully operational. It should also be noted that all kinds of warnings produced by EMI are usually accompanied with hazard specific advisories. This is possible through the co-production process with key-stakeholders esp. for seasonal rains.

At present EMI does not use any hazard-specific impact models in their forecasting. However, Ethiopia's MoWE is working on flood-impact modelling in collaboration with EMI. The WRF/NWP on the other hand has been operational in EMI since 2009.

Summary and comments of Element 6.3

EMI implemented the Common Alerting Protocol in 2022 for drought and flash floods but lacks standard operating procedures (SOP). Despite limited software tools, EMI is working on a risk matrix for impact-based forecasts.

Summary score, recommendations, and comments for Element 6

EMI's maturity level for "Warning and Advisory Services" is assessed as **Level three**: *"Weather-related warning service with modest public reach and informal engagement with relevant institutions, including disaster management agencies".*

Many agencies and stakeholders are usually involved in different elements of the warning system and advisories for hydrometeorological hazards. In Ethiopia there are practical mechanisms in place for collaborations with relevant stakeholders and ministries for example MHEWS roadmap, NFCS mechanism for co-design and co-production, and the NCOF. EMI is therefore able to access the impact information relevant advisories. Because the systems in place are in their early phases, there is thus room for potential future developments and improvement.

Recommendations:

- Capabilities of the MHEWS roadmap should be assessed and improved
- Evaluate the operational and institutional capabilities for IBF at EMI, including training needs and capacity
- Enhance capabilities of the recently implemented the Common Alerting Protocol (CAP)
- Advocate for implementation of Standard Operating Procedures (SOP) for more systematic disaster response in the immediate aftermath of a disaster

Element 7: Contribution to Climate Services

7.1. Where relevant, contribution to climate services according to the established capacity for the provision of climate services.

In assessing the climate service capabilities in Ethiopia, several key aspects have been examined.

Governance: The National Framework for Climate Services (NFCS) is the national platform ensuring the coordination of climate services in Ethiopia and facilitates EMI's contributions to national adaptation planning. There exists an MoU with relevant ministries in the NFCS, with an agreed governance structure that is currently operational at federal government level. This however needs to be extended to grassroots level. The NCOF guidelines and platform established by EMI also provides a mechanism for co-design/co-production of climate services. These forums produce downscaled rainfall/temperature forecasts, agro/hydro/bio-meteorological advisories, and forecasts up to grass root level weather/climate services, which are summarized in Part 6.2.

Basic systems:
Observing networks: EMI's observation network covers only about 64% of what is required, as per Ethiopia's station masterplan study[31]. This will be improved with SOFF and additional 3 weather radar installations (in progress).
Data and data management system - EMI presently has limited capability to perform structured procedures regarding data quality management throughout the entire value chain including data ingestion, data quality control and assessment, storing, metadata management and data retrieval to ensure the reliability and accuracy of observations. Implementation of Ethiopia's GBON national Contribution plan through SOFF projects will be of great benefit.
Monitoring and forecasting systems - The current system performs optimally for production and delivery of climate information and services especially under the NFCS, but new processes and technologies should be adopted to increase the effectiveness of the weather forecasting process.

User interface: In Ethiopia there exists various mechanisms, tools and systems that allow climate services users and providers to interact, to ensure co-production and tailoring of services for decision support and feedback. Through the NCOF and NFCS platforms, there are various mechanisms including face-to-face and digital user interfaces platforms which enable information generation among institutions and users to interact with each other. But full representation of all actors particularly at the grassroots level is however lacking.

Provision and Application of Climate Services: EMI has decision support products and services available, but some are lacking high spatial resolution.

Monitoring and Evaluation of Socio-Economic Benefits: EMI currently lacks a structured mechanism for monitoring and evaluating the socio-economic benefits of climate services. Some pilot cases are in place, but not sufficient.

Capacity Development: Technical advisory services and training to address capacity development needs for climate service provision and use at EMI is available. There are national universities that provide BSc, MSc, and PhD in the field of meteorology. But short period skill capacity building is not in place nationally and often obtained through projects and regional collaborations.

[31] Ethiopia's Station Master plan2020-2030_Final.pdf

Data Rescue: EMI carried data rescue of 1.5-million-pages data in 2022/23. Phase two to continue 2023/24. On completion it will help for identification of weather and climate hazards of long period time series.

Summary score, recommendations, and comments for Element 7

EMI's maturity level for "*Contribution to Climate Services*" is assessed as **Level three:** "*Essential Capacity for Climate Services Provision".*

Recommendations:

- Improve the observations network, data collection, data management, monitoring, and forecasting systems through SOFF.
- Establish mechanisms to monitor or evaluate the socio-economic benefits of climate services.
- Ensure that all user interface platforms have full representation of all actors particularly on the grassroots level.
- Improve the decision support products and services with higher spatial resolution.

Element 8: Contribution to hydrology

8.1. Where relevant, standard products such as quantitative precipitation estimation and forecasts are produced on a routine basis according to the requirements of the hydrological community.

In Ethiopia, hydrological services are administratively separate from those offered by EMI. The Ministry of water and Energy (MoWE) is responsible for operational hydrological services including collection of hydrological data, hydrological forecasting, and water resource assessment activities. EMI cooperates closely with the MoWE at national level and at regional governments' level. EMI mainly provides meteorological observations relevant for hydrological services.

Summary and comments of Element 8.1
MoWE oversees operational hydrological services in Ethiopia while EMI provides meteorological observations in close collaboration with MoWE.

8.2. SOPs in place to formalise the relation between Met Service and Hydrology Agency, showing evidence that the whole value chain is addressed.

There exists SOPs between EMI and MoWE including those described in the NCOF guidelines, NFCS guidelines and Ethiopia's MHEWS Roadmap. The roadmap for example provides a matrix of the governance of early warning systems and the mandates of different ministries in Ethiopia and their supporting agencies. The NCOF guidelines provides further detail on steps to achieve and implement the principles stipulated in one of the NFCS guidelines pillars (user interface platform pillars) which is aimed at strengthening the NCOF through participatory and sustained dialogue to tailor, interpret, translate, and communicate EMI's seasonal forecasts in decision-oriented formats. The NCOF guidelines thus specify the roles and responsibility of the identified institutions. The EMI hydro-met team and the focal points from the water and energy sectors (MoWE) develop scenario-based recommendations for the water and energy sectors in an effort to foster climate service co-design and co-production. These activities are usually based on the seasonal forecast and intent to provide an impact outlook for the Water and Energy sectors. Some of the activities based on the NCOF guidelines are:

- Designing a scenario-based flood/drought forecast for the hot spot areas of the season based on the seasonal outlook.
- Designing to predict the possible impact of the predicted seasonal climate on the dam level depending on the seasonal outlook and current level of the dams.
- Designing to compute the water balance for each Dam which is more impacted during the season based on the climate information for selected analogue year.
- Design the water balance in the river system based on the selected analogue years which are more impacted during the seasons.
- Projecting the likely impact of the predicted seasons on the reservoirs management depending on the seasonal outlook and the current status of the Reservoir Water Level.
- Design to predict the impact of the seasons on the energy production, water supply and irrigation systems.
- Develop one composite map for drought/flood monitoring for the coming season.
- Design community based EWS for flood vulnerable areas.

As stipulated in the MHEWS Roadmap, the Ethiopia's Disaster Risk Management Commission (EDRMC) coordinates all disaster risk reduction activities including those related to operational hydrology.

Summary and comments of Element 8.2

In Ethiopia hydrology is administratively separate from the National Meteorological Services. EMI and MoWE have established SOPs, including those in the NCOF and NFCS guidelines, and Ethiopia's MHEWS Roadmap, to promote climate service co-design and co-production in Ethiopia.

8.3. Data sharing agreements (between local and national agencies, and across international borders as required) on hydrological data in place or under development.

Policies with regards to hydrological data fall under the mandate of the MoWE in Ethiopia.

8.4 Joint projects/initiatives with the hydrological community designed to build hydrometeorological cooperation.

Ethiopia has in place several initiatives for hydrometeorological collaboration including those described in the NFCS, NCOF and the MHEWS Roadmap. The most recent is the WB Flood Management Project which was recently launched in Ethiopia.

Summary score, recommendations, and comments for Element 8

EMI's maturity level for "*Contribution to Hydrology*" is assessed as **Level three:** "*There is a moderately well-functioning relationship between the meteorological, hydrological and water resources communities but considerable room for formalising the relationship and SOPs.*"

Recommendations:

- Develop further the existing structures to enhance capabilities of hydrometeorological cooperation in Ethiopia.

Element 9: Product dissemination and outreach

9.1. Channels used for user-centred communication and ability to support those channels (for example, does the NMHS operate its own television, video, or audio production facilities? Does it effectively use cutting-edge techniques?).

EMI employs a comprehensive set of communication channels to ensure effective dissemination of weather products and services. These channels are instrumental in delivering timely and accurate weather-related information to the public and other end-users. To reach a broad spectrum of users, EMI uses channels such as television, telegram, radio, e-mail, printed media, and internet including EMI website. From different social media channels EMI regularly communicates via Facebook (Meta), Twitter (X) and Instagram. In addition, EMI is planning to establish two new TV studios to improve their user-centred communication and outreach.

EMI also uses a specific mobile application, Ethiopian public weather app, which has been operational for 3 months. It is called Ethio Met and it gives daily weather information including generation of up-to 3-day weather forecasts in the cities that the user selects. The SAREPTA project by MET Norway has also considered improving EMI's website development and weather app within the capacity building project.

In addition to these channels, EMI also regularly provides information to people in person, as a service at their offices. Particularly farmers in the rural areas who sometimes require ad-hoc live weather information, visit EMI's regional offices for weather inquiries which they are provided face to face.

All the above communication channels are used in Ethiopia to disseminate warnings to the public and other end-users. EMI is also disseminating warnings at the local level in Ethiopia. This approach ensures that weather warnings are not only available nationally but are also tailored to the specific needs and challenges faced by communities in different regions of the country. To ensure this, EMI currently disseminates warnings in five local languages.

Summary and comments of Element 9.1

EMI uses various communication channels, including television, radio, email, and social media to disseminate weather information, including dissemination of weather warnings at the local level in different languages, ensuring they are tailored to the specific needs and challenges of different communities.

9.2. Education and awareness initiatives in place.

Regarding education and awareness initiatives, EMI is making efforts to implement awareness and has some initiatives in place; nevertheless, these activities could be more frequent, further explored and expanded. One of the awareness projects is the Early Warning Early Action in East Africa, a research project on procedures for quick decision making sponsored by the International Federation of Red Cross and Red Crescent Societies

(IFRC) in conjunction with Save the Children, Oxfam, WFP, and FAO. The program[32] outlines existing early warning and early actions systems and the importance of working closely with meteorological services to ensure weather forecasts are packaged in a way the practitioners can take action upon it. The weather forecasts provided by EMI have been used as a source for the multi-agency seasonal food security assessment, and the importance of product dissemination is highlighted throughout the research.

EMI is also working closely with higher education institutes, particularly with three different Ethiopian Universities. It is currently in plans to include climate and weather information as one subject in the curriculum in all Ethiopian Universities and High Schools. As the impact of such collaboration can be highly beneficial to the future climate change adaptation efforts in Ethiopia, there is space for EMI to further grow the collaboration with education institutes and expand the outreach to cover regional education and awareness initiatives.

Summary and comments of Element 9.2

EMI is making efforts to promote education and awareness initiatives in Ethiopia, including the Early Warning and Early Action project in East Africa, and collaborating with Ethiopian universities and high schools to incorporate climate and weather into their curricula.

9.3. Special measures in place to reach marginalised communities and indigenous people.

EMI has special measures in place to reach marginalised communities, including farmers and people living in rural areas. Particular attention has been paid to tailor different means of communication to better reach these communities, for example using channels such as radio or phone, that are more commonly used in daily life in rural areas.

To ensure that EMI stays up to date with the measures that it needs to have in place to reach these communities, its representatives regularly participate in local discussion groups, where information is shared and distributed on grass-root level. Needs analysis on service reachability are also conducted in these local communities through various surveys. Based on the outcome of these surveys, it ensures that its services are tailored so that all citizens will be able to reach, read and understand weather forecasting and early warning systems.

EMI also works closely with various local and international NGOs such as the Red Cross, CARE International, Oxfam, Christian Aid, who have strong local outreach and access to marginalised communities. It regularly exchanges information as part of the National Disaster Risk Management Commission of Ethiopia, the main federal agency for disaster prevention and response coordination, as well as with various ministries and local authorities.

Summary and comments of Element 9.3

[32] IFRC, 2014, Early Warning Early Action

EMI is dedicated to reaching marginalised communities by tailoring communication methods, participating in local discussion groups, and collaborating with NGOs and authorities to stay updated on required measures.

Summary score, recommendations, and comments for Element 9

EMI's maturity level for "Product Dissemination and Outreach" is assessed as **Level three:** *«a moderately effective communication and dissemination strategy and practices are in place, based only on in-house capabilities and supported by user-friendly websites."*

EMI uses various communication channels to disseminate weather information including taking into consideration marginalised communities and their need for tailored information in local languages. Despite the various communication channels, it's currently difficult to estimate the number of people reached in Ethiopia.

Recommendations:

- Conduct a study to assess the actual number of people receiving warnings by EMI including campaigns for increased weather warning information access.
- Development/expansion of communication techniques and platforms and adopt new technologies like its mobile app as demonstrated to ensure a large fraction of the population is reached.
- Promote the use of the weather app for early warning services.
- Actualise the plans incorporate climate and weather into Ethiopia's education curriculum through, awareness, and communication strategy, including collaboration with education institutes, civil society organisations and local authorities.
- Improving stakeholder and user engagements with EMI through grass-root workshops to enhance visibility of the institutes can yield multiple benefits.
- Extend partnerships and visibility through several media platforms and broadcasting companies to enhance EMI's capacity on the societal benefit of early warnings.

Element 10: Use and national value of products and services

10.1. Formalised platform to engage with users in order to co-design improved services.

As earlier mentioned, Ethiopia has a multi-sector consultative platform to foster regular cooperative dialogue i.e. the National Framework for Climate Services (NFCS). As initially indicated, the NFCS was set up to increase and formalise collaboration between various climate service institutions in Ethiopia. EMI is an active member of the platform and regularly engages in it, along with six ministerial sectors (MoA, MoWE, EDRMC, MoH, MoILL, EPA).

In addition to NFCS, EMI is a member of several other national committees composed of ministries, agencies and other stakeholders that coordinates Disaster Risk Reduction (DRR) activities at the national to sub-national levels. One of the most important one is the Ethiopian Disaster Risk Management Commission (EDRMC), established in 2015 and reporting directly to the Prime Minister[33]. EMI is a member of the committee and provides regular information and updates on extreme climate and weather, which is then cascaded to end users through the committee participants.

Other platforms that coordinate DRR activities in Ethiopia include the National Flood Task Force, activated when there's extreme rainfall and led by the Ministry of Water and Energy. This NDRMC led multi-sector task force issues flood alerts that are based on the forecasts of EMI. The alerts will form a basis of Flood Contingency Plan (FCP), which outlines the mitigation measures and resource mobilisation needed for the situation[34]. The alerts are regularly reviewed and updated based on EMI's forecasts.

EMI also regularly provides information to the Climate Change and Health Technical Working Group, which meets quarterly. It consists of various directorates and agencies of the ministry, relevant ministries and development partners and is chaired by the Ministry of Health. The Ethiopian Health National Adaptation Plan, outlines improving the early warning surveillance as their main objective to enhance health emergency risk management[35]. EMI directly contributes towards this goal and working group.

In December 2019 an Ethiopian Digital AgroClimate Advisory Platform (EDACaP) was launched, to increase farmers' resilience and capacity to adapt to growing challenges brought by changing climate, through digital agro-climate approaches. It combined regional and national engagement and improved seasonal climate predictions[36]. It is jointly chaired by the Ministry of Agriculture and EMI. During the rainy season, the participants meet as often as every ten days.

EMI also attends and provides climate and weather-related services in the UN-led DRM Technical Working Group. It is jointly chaired by the UNDRR and the EDRMC[37] and meets monthly.

Regarding tailored services, EMI has an established mechanism for the end-product co-design guidelines for seasonal National Climate Outlook Forum (NCOF). In terms of

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33 Ethiopian Voluntary National Report, 2022, The Midterm Review of the Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030

34 Government of Ethiopia, 2022, Ethiopia Flood Response Plan (Kiremt Season Floods)

35 Federal Ministry of Health, 2021, Ethiopian Health National Adaptation Plan

36 2019, Ethiopian Institute of Agricultural Research, Launch of the Ethiopian Digital AgroClimate Advisory Platform (EDACaP): Progress Report on EDACaP Development and Hosting: Info Note

37 UNDRR (2022),Policy Brief, Ethiopia: Risk-sensitive Budget Review, Public Investment Planning for Disaster Risk Reduction and Climate Change Adaptation.

aviation services, EMI has recently developed a web portal for online aviation services. The Corobor portal is in process. For aviation services EMI occasionally uses a cost-recovery mechanism, however this does not add up to a high amount.

Regarding studies on socioeconomic benefits (SEB) on climate adaptation, recent reports exist particularly in the field of smart agricultural practices,[38] and livelihood vulnerability during climate induced drought.[39] In 2021 World Food Programme (WFP) published a study on socio-economic impacts of floods in Ethiopia, however they were only observed as part of a "triple threat" of covid-19 and desert locusts.[40] More widely, the United Nations Economic Commission for Africa conducted a study in 2022 on Socioeconomic benefits of climate information services for disaster risk reduction in Africa.[41]

Hence, there is a gap of studies being conducted specifically with a focus on Socio economic benefits (SEB) of weather, climate and hydrometeorological services in Ethiopia. EMI has also not been consulted or participated in many of such studies in recent years.

Summary and comments of Element 10.1

Ethiopia's National Framework for Climate Services (NFCS) is a consultative platform to promote cooperation among climate service institutions. EMI is an active member of the platform and contributes to various committees, including the Ethiopian Disaster Risk Management Commission. An Ethiopian Digital AgroClimate Advisory Platform (EDACaP) was also launched to increase farmers' resilience. However, there is a gap in studies on socioeconomic benefits of weather, climate, and hydrometeorological services in Ethiopia.

10.2. Independent user satisfaction surveys are conducted, and the results used to inform service improvement.

EMI regularly conducts independent user satisfaction surveys and uses the results to inform service improvement. EMI has four KPI's in the EMI Strategic Plan; they are for customer satisfaction; for data, aviation, forecast and sectoral services. To ensure the implementation of this strategic goal, the Change Management Department at EMI is responsible for the user satisfaction surveys.

Regular surveys are conducted in every NCOF and baseline assessment surveys on climate services have been done as part of the NFCS. These are standard surveys, conducted by an independent consultant. Aviation customer satisfaction surveys are also conducted. Service Delivery assessment available in five languages.

EMI also regularly reviews and reports on the accuracy and timeliness of their services. This takes place seasonally, comparing previous findings and discussing them with

[38] Abonesh Tesfaye, Abebe Nigussie, Gebermedihin Ambaw, 202, Monitoring socioeconomic impacts of climate-smart agricultural practices at Doyogena and Basona Worena climate-smart landscapes, Ethiopia

[39] Tofu, Haile, 2023 Livelihood vulnerability and socio-economic determinants of households to climate change induced recurrent drought in Ethiopia

[40] Andualem Kassegn & Ebrahim Endris | (2021) Review on socio-economic impacts of 'Triple Threats' of COVID-19, desert locusts, and floods in East Africa: Evidence from Ethiopia, Cogent Social Sciences

[41] United Nations Economic Commission for Africa, 2022, Socioeconomic benefits of climate information services for disaster risk reduction in Africa: final report by the African Climate Policy Centre of the Economic Commission for Africa

stakeholders. Several case studies of verifications also exist, yet they are developed on ad hoc basis, rather than as a standard practice. Project-based surveys have also been conducted. This type of survey specifically targets project beneficiaries.

Summary and comments of Element 10.2

EMI conducts user satisfaction surveys to improve service. Baseline assessments on climate services and aviation customer satisfaction surveys are conducted. EMI also reviews and reports on service accuracy and timeliness, discussing findings with stakeholders.

10.3. Quality management processes that satisfy key user needs and support continuous improvement.

EMI has successfully implemented a Quality Management System (QMS) for its aviation services, achieving ISO 9001: 2015 certification. It has implemented QMS for international air navigation for the Bole International Airport and is in the process of implementing it for the other three international airports in Ethiopia. However, EMI has no QMS for the provision of meteorological, hydrological and climate warning services.

Looking ahead, EMI plans to implement QMS for the entirety of its forecast services. It estimates that it will be able to fully implement QMS for international air navigation by 2026. The timeline for implementation of QMS for early warning services, however, can take longer and will depend on annual budget allocations. Currently there is no clear plan, but internal discussions are ongoing at EMI, and rough estimations range from 5 to 10 years.

Summary and comments of Element 10.3

EMI has achieved ISO 9001: 2015 certification for its aviation services, including Bole International Airport and three Ethiopian airports. However, it lacks a QMS for meteorological, hydrological, and climate warning services. EMI plans to implement QMS for forecast services by 2026, and that of early warning services' timeline varying from 5 to 10 years.

Summary score, recommendations, and comments for Element 10

EMI's maturity level for "Use and National Value of Products and Services" is assessed as **Level three**: "*There is a moderately well-functioning relationship between the meteorological, hydrological and water resources communities but considerable room for formalising the relationship and SOPs.*"

The score for Element 10 was not obvious, and there were some discussions whether the final score should be 3 or 4. EMI has strong working relationships with various consultative platforms, providing information and services to a range of governmental institutes, international development partners, forums and working groups. The

established working relationship and data sharing takes place systematically, and EMI is also active in leading or co-chairing these initiatives.

Recommendations:

- EMI could expand its engagement with platforms focusing on vulnerable people or climate change-affected groups. One such example is the Working Group on Mainstreaming Gender in Disaster Risk Management, established in 2012 and working under the Disaster Risk Management Technical Working Group.[42]
- EMI could participate or conduct a study on SEB of weather, climate, and water hydrological services. There is a clear need for more evidence on this in Ethiopia, and the results could be significantly useful for EMI going forward.
- In terms of user satisfaction surveys, EMI has a clear process and appointed departments responsible for this area, however, to establish a continuous user engagement process that encompasses all service fields of EMI, facilitating customer feedback through various channels such as the website and mobile applications could also be explored.

Additionally, EMI has already taken significant steps in implementing QMS to enhance the provision of its meteorological and climate warning services, indicating its commitment to continuously improving and standardising its services to meet international quality standards and the needs of its users and stakeholders. However, expanding the implementation of QMS to cover all operational fields of EMI is essential to standardise and enhance the quality of services provided. This should be the top priority of EMI and clearly included in future strategies and work plans and taken into consideration in budget allocations.

[42] Government of Ethiopia, 2012, Gender Mainstreaming Working Group

Annexes

Annex 1 Consultations

To carry out the peer-review with EMI and stakeholders for this Country Hydromet Diagnostics (CHD) report, country information was obtained through:

1) A **questionnaire** on each element was developed based on the indicators provided in the CHD EW4All data inventory and review sheet for Ethiopia. The questionnaire was shared and filled up by the EMI-SOFF team based on consultation with different internal and external experts and stakeholders based on the review question.

2) The peer advisors conducted three **in-person consultation sessions** during the peer-peer review process:
    a) The first consultation session was held in Addis Ababa, Ethiopia on May 8-12, 2023, in conjunction with a SAREPTA project workshop. The SOFF session was mostly directed towards the SOFF GBON Gap Analysis during which some of the information acquired was relevant for the Country Hydromet Diagnostics report.

    EMI -SOFF experts: Melesse Lemma Tena, Kinfe Hailemariam, Lata Bekele, Henok Hailu, Singirogis Girmu, Abel Sisay
    Peer-reviewers: Kristine Gjesdal, Teferi Dejene

    b) EMI in collaboration with MET Norway organised a SOFF stakeholders meeting in Adama, Ethiopia on September 22-23, 2023. The stakeholder workshop brought together different government stakeholders and CSOs across the meteorological value chain in Ethiopia to facilitate dialogue and consultations that will maximise synergies between SOFF activities in EMI and other stakeholders. About 85 participants from different sectors in Ethiopia were present at the workshop. The meeting report[43] provides more information.

    Prior to the stakeholder meeting, The EMI management team scheduled a preliminary consultative meeting, where infrastructure and the human and institutional capacity needed to achieve GBON compliance were identified. The findings of the preliminary meeting were presented at the stakeholder meeting and were very useful towards SOFF GBON National Contribution Plan and CHD report. Feedback from the questionnaire was also provided during this meeting.

    EMI -SOFF experts: Melesse Lemma Tena, Kinfe Hailemariam, Abel Sisay
    Peer-reviewers: Elinah Khasandi Kuya, Kristine Gjesdal, Teferi Dejene Demissie.

    c) The third in person consultation session was held at the Norwegian Meteorological Institute in Oslo, Norway alongside the SAREPTA project workshop on October 4-11, 2023. Focus was put on verifying feedback from the CHD questionnaire which had been sent out to EMI and populating Ethiopia's CHD EW4All data inventory and review sheet.

    EMI -SOFF experts: Melesse Lemma Tena, Kinfe Hailemariam, Abel Sisay
    Peer-reviewers: Elinah Khasandi Kuya, Kristine Gjesdal, Hildegunn V. Dyngeseth Nygård, Visuri Marilla, Eerikäinen Matti

[43] Report of Consultative Meeting of Stakeholders on Systematic Observations Financing Facility in Adama, Ethiopia

3) Bi-weekly meetings were scheduled and held whenever possible with the SOFF team at EMI, peer-reviewers and the implementing entity (UNDP) to discuss the progress of SOFF reporting, including the CHD report.

   EMI -SOFF experts: Melesse Lemma Tena, Kinfe Hailemariam
   Peer-reviewers: Elinah Khasandi Kuya, Kristine Gjesdal, Hildegunn V. Dyngeseth Nygård
   Implementing entity (UNDP): Ababu Anage

4) Peer-advisors and designated SOFF staff at EMI have also been in email correspondence and chats regarding different issues and data sharing of additional information throughout the report writing.

Annex 2 Urgent needs reported

The recommendations outlined in each chapter pertaining to elements 1-10 are essential steps aimed at improving EMI services and advancing the department's maturity to a higher level.

The following recommendations have been assessed as the most promising in addressing the critical needs identified in this report:

1. To address the financial challenges, EMI should lobby for sustainable government funding to reduce dependency on development assistance. EMI should also re-evaluate cost-recovery funding arrangements with the ECAA and implement a risk management plan for capital projects.
2. EMI needs better documented training procedures, dedicated staff with expertise in climatology and research including regular recruitment of highly qualified staff. Gender balance among the staff should be promoted.
3. EMI should enhance their financial decision-making and resource allocation strategies to streamline projects in line with their strategic development plan and capacity.
4. Strengthen the relationships with the academia with formal agreements and arrangements for collaboration on key areas of science and advancement of weather and climate services in Ethiopia.
5. EMI needs urgent development to comply with GBON, including modernising surface observation data infrastructure, redesigning data management systems, improving ICT infrastructure and implementing Ethiopia's GBON National Contribution Plan to hence functional and sustainable observational infrastructure.
6. Assess MHEWS roadmap capabilities, including the operational and institutional capabilities for impact-based forecasting at EMI, improve Common Alerting Protocol, and SOP implementation for systematic disaster response.

Annex 3 Information supplied through WMO

- WMO Global GBON gap Analysis
- WMO Monitoring System Data
- WMO EW4All Rapid Assessment for Pillar-2
- WMO Hydrology Survey
- Data from Checklist for Climate Services Implementation

Annex 4 List of materials used

1. NMSA, 1996: Assessment of Drought in Ethiopia. Meteorological Research Report Series. PP69.
2. Ethiopia Meteorological Institute proclamation 201 of 1980
3. Proclamation No.1263-2021
4. National Framework for Climate Services - Ethiopia Coordination Guideline
5. A Roadmap for Multi-Hazard, Impact-Based Early Warning and Early Action System 2023-2030
6. Ethiopian Meteorological Institute 10 years plan in Eng
7. Finland's country strategy for Ethiopia 2021–2024
8. Institutional Support and Capacity Building for Weather and Climate Services
9. Ethiopia Flood Management Project
10. Build Resilience for Food and Nutrition Security (BREFONS)
11. Climate resilient water sanitation and hygiene (WASH) initiatives from 2013-2018
12. Final Evaluation of Satellite Index Insurance for Pastoralists in Ethiopia (SIIPE) Programme In Ethiopia (2019 – 2022)
13. Resurgence
14. ClimDev Special Fund
15. Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) programme
16. http://www.ethiomet.gov.et/
17. Promoting Autonomous Adaptation at the Community Level in Ethiopia
18. National Climate Outlook Forum (NCOF) Guide - Ethiopia
19. Private Public Partnership Proclamation.pdf
20. NMA Forecast Verification final draft.pdf
21. Verification Of Forecasts Given to Ciare Project Intervention Areas
22. Report of Consultative Meeting of Stakeholders on Systematic Observations Financing Facility
23. EMI's Data Policy-English
24. Regional Specialized Meteorological Centre (RSMC)
25. WMO's Register of Alerting Authorities for Ethiopia
26. Ethiopia's Station Master plan2020-2030 Final.pdf
27. IFRC, 2014, Early Warning Early Action
28. Ethiopian Voluntary National Report, 2022, The Midterm Review of the Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030
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37. Government of Ethiopia, 2012, Gender Mainstreaming Working Group

38. Report of Consultative Meeting of Stakeholders on Systematic Observations Financing Facility in Adama, Ethiopia