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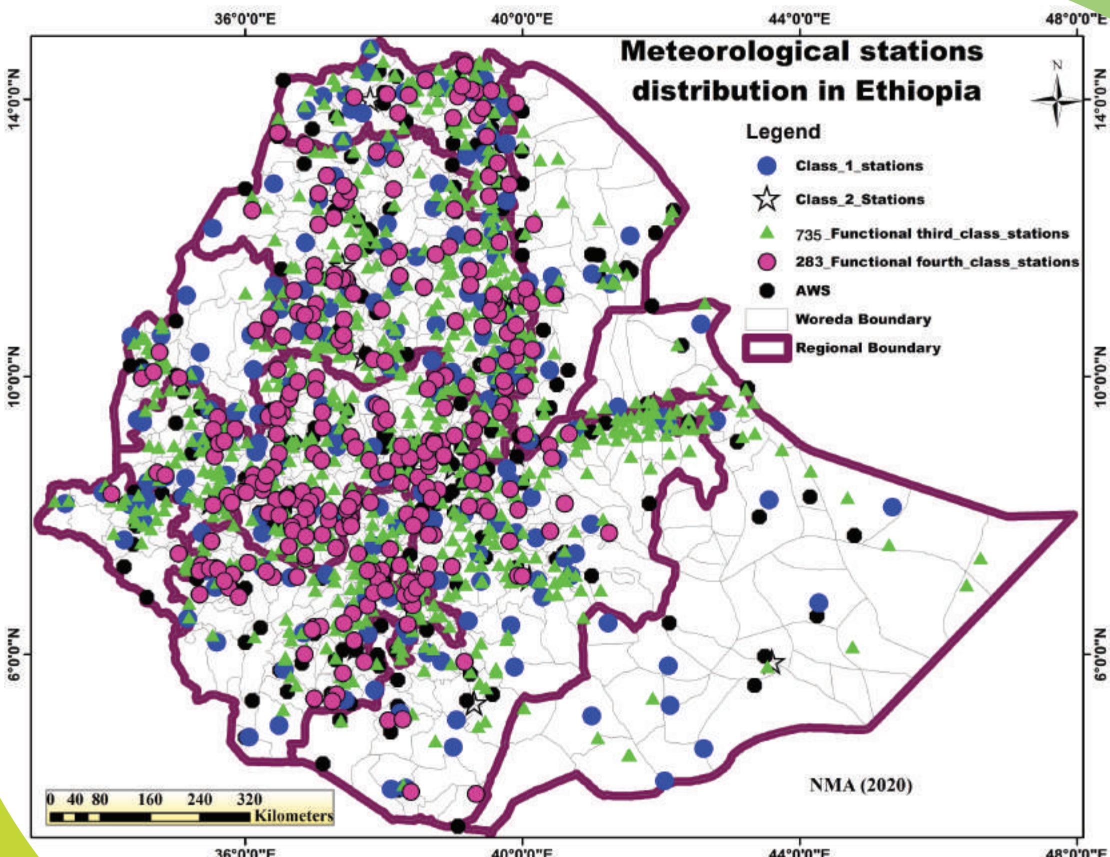
National Meteorological Agency

REVISED METEOROLOGICAL STATION NETWORK MASTER PLAN FOR 2021-2030



Addis Ababa, Ethiopia
August, 2020

Revised Meteorological Station Network Master Plan Preparation technical committee

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FORWORD

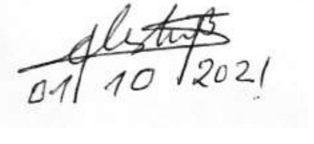
Meteorological observation has started in nineteenth century mainly by European missionaries with very limited stations. The importance of meteorological information's becomes realized by different sectors and thus, the National Meteorological Services Agency (NMSA) was established by Government Proclamation Number 201/1980, now renamed as; National Meteorological Agency (NMA) which was accountable for Water Resource commission during the establishement (Currently, NMA is reporting to the Ministry of Water Irrigation and Energy). One of the main objectives of the National Meteorological Agency is investigate and study weather and climate of Ethiopia by establishing Meteorological stations. National Meteorological Agency of Ethiopia is mandated to establish and rehabilitae different Meteorological stations across the whole regions which are operated manually and automatically. Moreover, the National Meteorlogical Agency has estabilished one thousand five thirty-nine (1539) different meteorological stations across the country. The distributions of meteorological stations are very crucial to provide representative, accurate and reliable weather and climate service for different sectors.

Hence, the National Meteorological Agency has made revision and expansion of the station network based on the master plan which was developed in 2015 and revised in 2020. The 2015's existing station network master plan needs to be updated and revised regarding the rapid need of meteorological services over many parts of the country including local levels. The fundamental aim of revising the station master paln network now is to modernize the services which are rendered by NMA. In light of the above, revising the past ten-year station master plan has been set for the need to improve the understanding of climate variability and climate predictions, and the way in which climate data and information is analyzed and provided to serve the needs of society. The revision of station master plan for the next ten years (2021-2030) will play a great role in improving of meteoorlogical station distribution over Ethiopia to assure and provide representative, accurate and reliable climate information's for various sectors. The revised station master plan network organized based on seven (7) chapters. The first chapter provides the general introduction and objectives of the station master plan; the second chapter evaluates the situation assessment of existing meteorological stations at NMA; the third chapter elaborates the station network master plan based on WMO standards and gives an insight of gap analysis; the fourh chapter depicts the newly revised master plan including the proposed station networks whereras chapter five discusses the implementation plan of the revised station network at NMA and chapter 6 and 7 provides annex and referenrce sections respectively. The revised station master plan network computed based on WMO standards and recquires a total need of two thousand five hundred eighty-nine (2589) rainfall recording stations across the country. From the total number of stations twenty-nine (29) stations are modern meteorological stations namely air pollution monitoring, lightening detection, weather radar and upper air stations to standardized the service of NMA across the country. The revised station master network covers both the existing station network and the future proposed stations based on geographic information and WMO guidelines. NMA is committed to facilitate and coordinate in the full implementation of the revised station master plan for a better meteorlogical service based on the newly developed document.

On behalf of government of Ethiopia, we would like to thank members of the technical committee and other NMA staffs for their help in finalizing this report within the limited time frame.

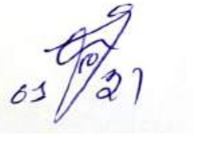
Dr. Eng. Seleshi Bekele

Minister
Ministry of Water, Irrigation and Energy



Fetene Teshome

Director General of National Meteorological Agency and PermanentRepresentative of Ethiopia with WMO



Abbreviations and Acronyms

AMDAR	Aircraft Meteorology Data Relay
ATIS	Automatic Terminal Information Service
AWOS	Automatic Weather Observing System
AWS	Automatic Weather Station
CRGE	Climate Resilience Green Economy
EMC	Electromagnetic Compatibility
FAO	Food and Agriculture Organization
GIS	Geographical Information System
GPRS	General Packet Radio Service
GTP	Growth and Transformation Plan
HSQL	Hyper Structured Query Language
LIDAR	Light Detection and Ranging
LST	Local Standard Time
NMA	National Meteorological Agency
NMSA	National Meteorological Service Agency
NWP	Numerical Weather Prediction
RADAR	Radio Detection and Ranging
RMSD	Regional Meteorological Service Directorates
SADIS	Satellite Distribution System
SAS	Small Airport System
SNNPR	Southern Nations Nationalities and Peoples Region
WMO	World Meteorological Organization

1 INTRODUCTION

There is a general consensus and an international recognition on the adverse effects of climate change, variability and extremes on poverty reduction and sustainable development. Accurate and reliable data on hydro-meteorological processes, and stronger capacity to analyze and model them, is a key to making more informed decisions on issues such as the number of hydropower plants, the design of individual plants, and the operation of the grid. Effective management of climate variability and change requires that sufficient availability of climate information be used effectively in planning and that climate risk be incorporated routinely into development decisions. In order to do this, the observational networks and spatial coverage, quality control, management and exchange of data as well as enhancement of the capacity to produce and deliver the full range of climate services in support of sustainable development is very crucial.

The strengthening of the meteorological station network is considered as the first major step to address the problem of the availability of weather and climate data. This needs formulation of plans and policy for network development, operation, maintaining of network functions, monitoring of network performances so as to identify and implement improvements in monitoring by undertaking review of network efficiency and effectiveness, which would be very important for improving station network management and the related operational tasks. Thus, this report addresses the review of the existing meteorological station network so as to develop a revised station network master plan that can be used by the Agency for the next ten years.

1.1. Objectives of the Revised Meteorological Master Plan

- Review of the existing master-plan of meteorological stations network and formulate a new revised meteorological stations network master plan that takes into account the huge demand of the economic and social development of the country.

- Enhance the quality of the data and information service provision by the Agency through a better and an effective spatial coverage of the meteorological stations network and bring about the use of weather and climate information at Woreda level to be realized.

- To meet the increased demands of climate change adaptation activities at various levels which need more processed climate data and information including community targeted services and advisory services.

- To have well defined identification of the number, type, geographic location, cost, timing, etc of the meteorological station network to be installed all over Ethiopia in the coming ten years.

1.2. Historical Background

The history of meteorological station establishment in Ethiopia started in 19th century where religious missionaries and European travelers were the major actors during this period. However, when we consider the starting of meteorological service in Ethiopia, it was for the purpose of the safety of flying of aircraft. The historical expansion of the meteorological station network over Ethiopia can be categorized in the following four major purposes, presented as follows. The establishment of meteorological station network for aviation purposes. The expansion of the network due to the need to get meteorological data for master plan studies of river catchments and for agricultural purposes. It was undertaken by different governmental organizations for their own purposes and which usually, lacked coordination, until the establishment of NMSA in 1980.

Centrally coordinated meteorological network expansion continued with the establishment of NMSA in 1980. Beside this, the need for drought monitoring over the country has been one major factor for the expansion of the meteorological station network during those times. The proposed ten-year station master plan network expansion is based on the previous station network master plan, where the major targets were data sparse areas in the country. Though the developed ten years of 2021-2030 station network master plan will be of great help for the agency to be used as an important input for establishing different type of stations throught the entire country.

1.3. Justification For Revising The Existing Station Master Plan

The National Meteorological Agency has been undertaking the expansion of the Meteorological Station Network based on the master plan developed in 2015

- The existing master plan of station network has not addressed the fast pace of automation that is being undertaken globally and the main focus of the old station network master plan has been largely on the conventional meteorological stations. Thus, we need a station network master plan of automatic weather stations.
- The existing station network master plan needs to be updated in line with the ten-year national development plan of the country. The old station network master plan has not taken into account the fast pace of the growth of the country's economy including airports expansion. The monitoring of the country's newly developing hydro-electric dams may need the design of additional station network on the said catchments.
- The existing station network master plan needs to be updated

regarding the rapid pace of urbanization taking place over many parts of the country. Moreover, the problem associated with air pollution in our country at nearby industrial area requires revising the station network master plan on air pollution monitoring stations.

- The existing station network master plan has not taken into account the various types of climate change adaptation activities needed by the national and international donors on the provision of agro-meteorological information at sub-district level, for weather index insurance may require the design of dense network of stations expansion.

- The existing master plan has not taken into account rank of Ethiopia in observation and monitoring service delivery reference to WMO criteria, hence station expansion network needs to be developed to put the country from basic to full climate service categories.

- The Agency is expected to run high resolution numerical weather prediction (NWP) models on cluster machines with in the next few years. If we become more optimistic on the application of initialization and assimilation of local data, then the master plan on upper air observation systems must be revised.

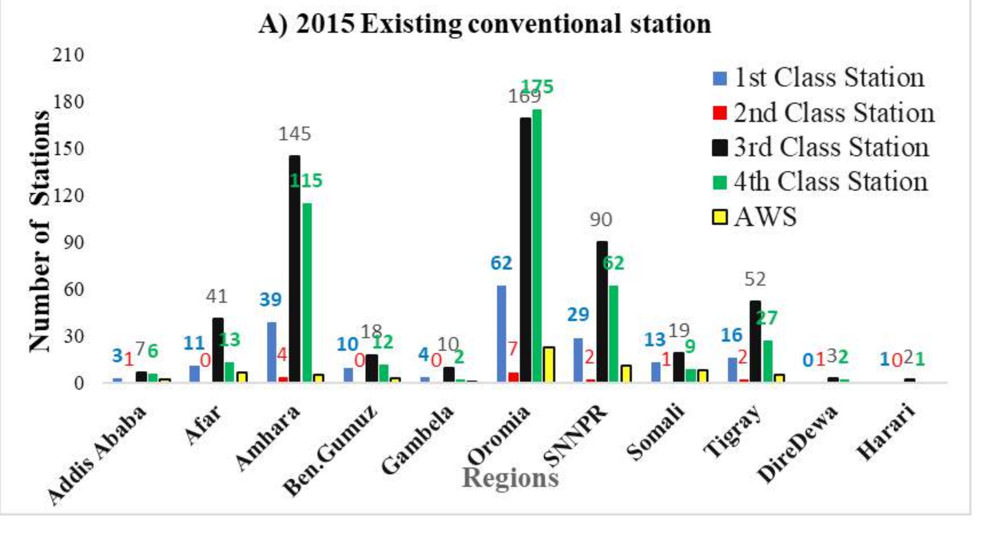
1.4. Assessment of the Benefits and Beneficiaries

The most important sectors that can benefit from meteorological station network expansion and improvement which includes Agriculture, water resources and the natural environment, human health, nutrition and poverty reduction, tourism-welfare, energy, transport and communication, urban settlement and sustainable development, financial services and economic development Moreover other sectors also include those involved in the protection of human health, nutrition and poverty reduction, Tourism is a rapidly growing economic sector and highly climate and weather sensitive accurate geographically specific meteorological information is essential for many tourist operations (mountains, coastal areas). Early warning of extreme events can be used by decision makers to make informed decisions to manage impacts and ensure public safety. The Energy sector is the other increasingly sector which is demanding the availability of weather and climate data for efficient services and also for operational and strategic planning in the sectors. In developed countries, Energy sector is the highest user of earth observation products and weather and climate products. Weather and climate data, information and advisories are crucial for attaining the major targets of the CRGE, and the ten-year development plan of Ethiopia.

2 SITUATION ASSESSMENT

2. SITUATION ASSESSMENT

National Meteorological Agency now has reached meteorological station network capacity of 1539 (table 1), which all are fully functional. Moreover, there are existing nonfunctional (11) and totally closed (4) first class station over the country, 47 non functional and 7 totally closed third class stations and 5 totally closed and 17 existing non-functional fourth-class stations are existed due to different reasons (Figure 11 and 12). Moreover, out of four upper air stations over the country 2 of them are non functional (full informations on nonfunctional and closed stations are available on the annex part). One radar station at Entoto is not working. Hence, non functional stations may require either a strategy of rehabilitation or else substitution with new automated weather stations. The following table shows the status of the network of the stations of different classes existing now in the country.



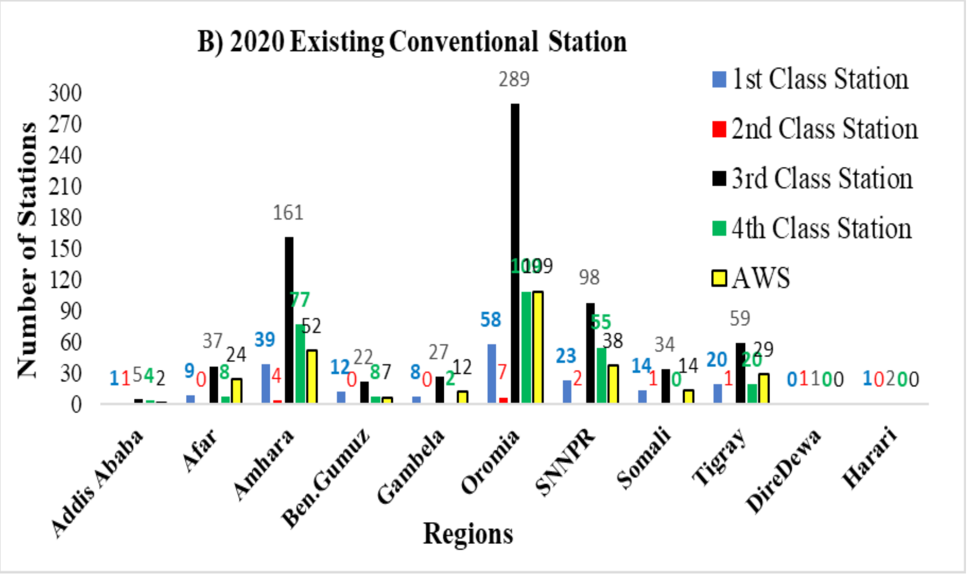


Figure 1 Existing Meteorological stations A) 2015 and B) 2020

Table 1. Existing Meteorological Statio

2015 Existing conventional station								2020 Existing Conventional Station					AWS	Upper air station	Radar	Air pollution	Airport Electronic stations		
No	Region	1st	2nd	3rd	4th	Sum	AWS	1st	2nd	3rd	4th	Sum					AWOS	Avimet	Conv
1	Addis Ababa	3	1	7	6	17	2	1	1	5	4	11	2	1	1(NF)	1	1	-	-
2	Afar	11	0	41	13	65	7	9	0	37	8	54	24	-	-	-	-	-	1
3	Amhara	39	4	145	115	303	5	39	4	161	77	281	52	-	1	-	2	1	1
4	Ben. Gumuz	10	0	18	12	40	3	12	0	22	8	42	7	-	-	-	-	1	1
5	Gambela	4	0	10	2	16	1	8	0	27	2	37	12	-	-	-	-	1	1
6	Oromia	62	7	169	175	413	23	58	7	289	109	463	108	1 (NF) Borena	-	1	-	2	2
7	SNNPR	29	2	90	62	183	11	22	1	81	46	150	37	-	-	-	-	-	2
8	Sidama							1	1	17	9	28	1			1		1	1
9	Somali	13	1	19	9	42	8	14	1	34	0	49	14	1 (Gode) NF	-	-	-	2	2
10	Tigray	16	2	52	27	97	5	20	1	59	20	100	29	1	-	-	1	2	1
11	DireDewa	0	1	3	2	6		0	1	1	0	2	1	-	-	-	1	-	-
12	Harari	1	0	2	1	4		1	0	2	0	3	1	-	-	-	-	-	-
Sum		188	18	556	424	1186	70	185	17	735	283	1220	286	2	1	3	5	10	12
Total existing functional meteorological stations = 1539																			
NF: non functional																			

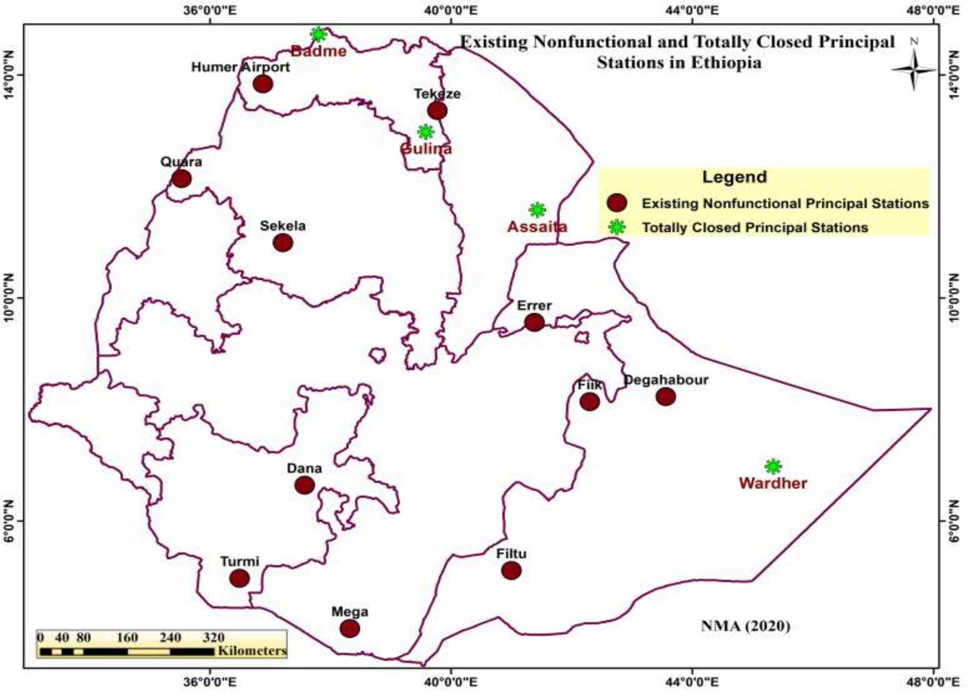


Figure 1. Existing nonfunctional and closed first class stations

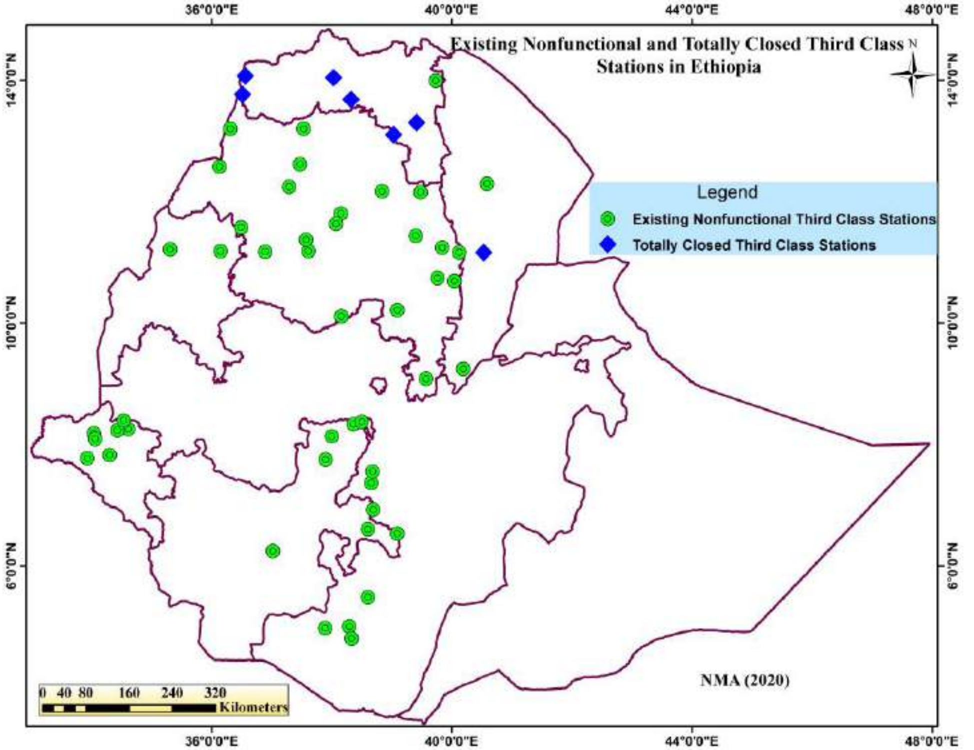


Figure 2. Existing nonfunctional and closed third class stations

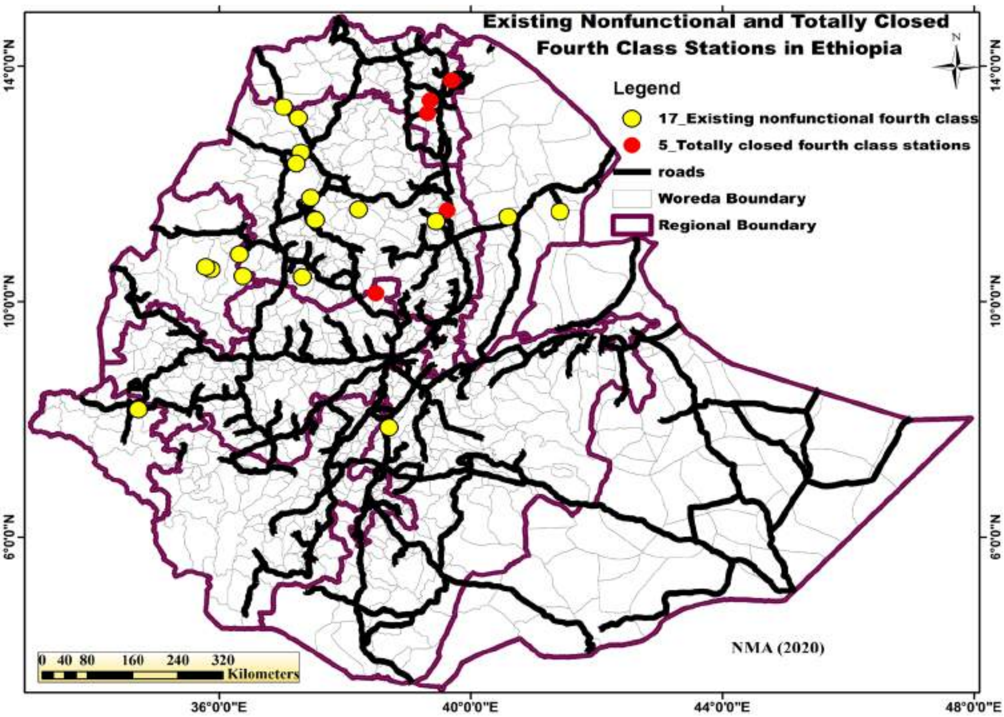


Figure 3. Existing nonfunctional and closed fourth class stations

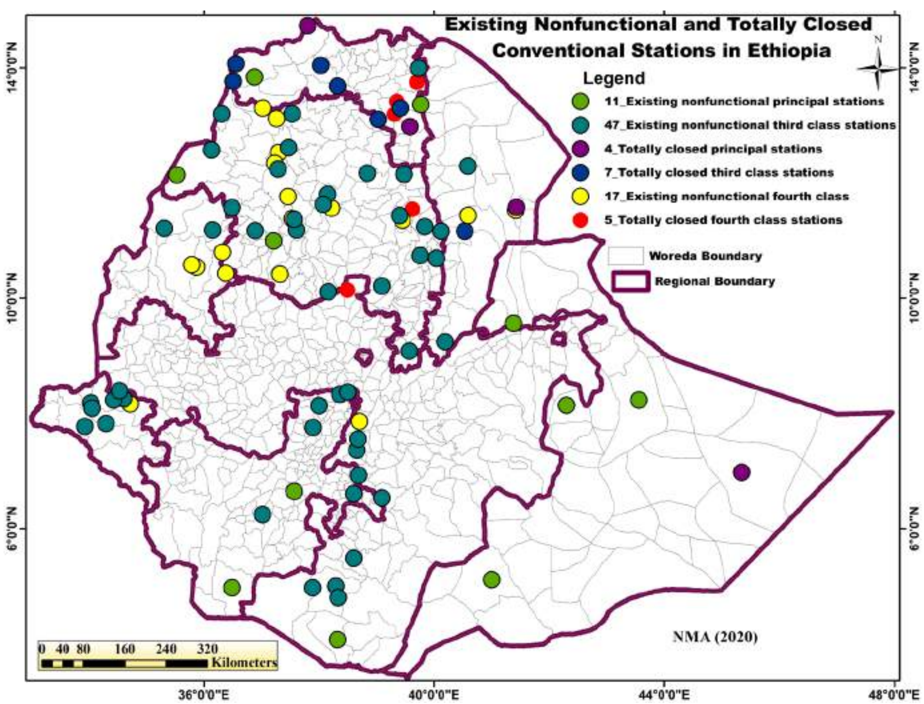


Figure 4. Existing nonfunctional and closed conventional stations

2.1. Precipitation (4th Class) Stations Network

Precipitation stations are the basic WMO station to record only rainfall total for 24 hours. Currently NMA operate 283 stations with installed standard rain gauge and measurement taken by part time observers, which are trained on-site, their distribution in regional state and over the country is seen on Table 1.

2.2. Ordinary Stations

The basic climatic parameters are Rainfall and Temperature. The major history of ordinary stations over the country is associated with the different water resources master plan studies undertaken by the Ethiopian Government. Moreover, the Ministry of Agriculture was also involved in the setting up of ordinary stations during the master plan study period. Some of the problems associated with the ordinary stations during the master plan study period were that of the problem of continuity and also the problem of distribution, as most stations are located along the roads. Later on, after the establishment of the NMA by proclamation, the expansion of the network was undertaken chiefly through government and non governemental budget.

2.3. Agro-Meteorological (Principal) Station Network

Indicative stations: - The history of rapid expansion of the indicative stations is greatly related with the extreme droughts and floods of the 1970s and the 1980s, and the major objective of the setup of these meteorological stations was related with the greater need for the strengthening of the monitoring and early warning of drought over the country. These stations are also called class I meteorological stations and moreover, they are also called agro-meteorological stations is also called principal. The indicative stations measure maximum and minimum temperature, rainfall, soil temperature at different depths, wet bulb and dry bulb temperature, sun shine duration and self-recording instruments which includes Thermograph (Temperature), Hygrograph (Relative humidity), actinography that measure solar radiation and self-recording that measures rainfall intensity. The representativeness of an observation for agricultural purpose such as evaporation need to be taken up to 100 meter (mesoscale) horizontal resolution (WMO, 2001, 2010e).

Since these stations can be used for the monitoring of crops water requirement by enabling the calculation of the reference evapo-transpiration, their importance for agricultural purposes is very important, and thus are usually also included in the agro-meteorological station network set up. The major problem associated with the indicative station network is the problem of some of the instruments not working and also the self-recording instruments the soil thermometers etc. The other problem is associated with the large area needed for these stations (100mts by 100 mts), which is becoming more and more difficult to maintain in the face of rapid urbanization and the lack of understanding by the local government officials in the role of these stations. These stations can be considered as very vital in making available data which can be used not only for agricultural purposes but also for projects involved in the water resources management sector. Thus, these stations also are very important for hydro-meteorological purposes as they are also equipped with self-recording instruments for measuring rainfall intensity of various duration. So NMA has 1507 diffferent class types station distribution over the country (Figure 5).

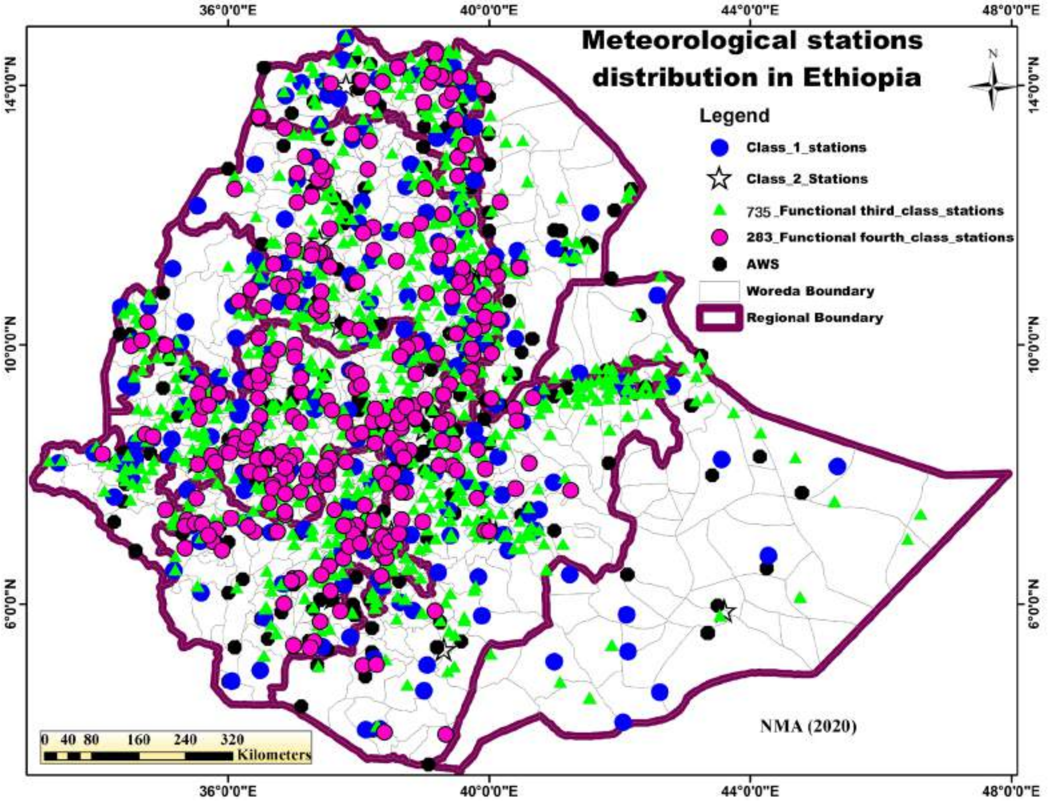


Figure 5. Existing functional manned Meteorological stations network at Woreda Level

2. 4. Meteorological Electronic Stations Network

The definition we used for the purpose of this master plan study, meteorological electronic stations are weather monitoring stations or data exchange stations that have features of electrical hardware and software. These stations mostly have electronic sensors, data communication and central data base system. In this study, we consider the station network study of automated weather stations (AWS, AWOS, DWS, AVIMET, etc.), Weather RADAR, Air Pollution Monitoring Station, Upper Air Observation Stations, Lightening Detection Station, Wind Profiler, Lidar, Satellite Receiving Stations (SADIS, EUMETCAST, GeonetCast etc). NMA experience of electronic station goes back to more than 30 years on satellite receiving stations and airport based automated stations such as digital wind system and automated weather observing system. NMA also had MR5 weather radar installed some 30 yrs ago at Entoto mountain of Addis Ababa, but never operational. With the current fast growth of the communication and electronic technology, meteorological electronic stations growth and expansion would be immense and have a potential for a total replacement of the conventional stations in short time period.

2.5. Automatic Weather Stations (AWS)

Since 2010, NMA stretched itself in expanding its automatic weather stations outside the airports. As of November 2020, NMA has 286 operational AWS all over Ethiopia (Figure 6). The 286 operational automatic weather stations measure air temperature, wind speed, wind direction, relative humidity, rainfall and global radiations. It takes measurement sample every minute and the statistics of 15-minute measurement are recorded. GPRS telemetry communication is used to send the data directly to a central station in real time based on the GPRS connection quality. The system also logs 6-month data at remote station, depending on the size of the variables colleacting. At the base station a gateway is used to collect the data and transmit to the database server. The base station uses HSQL open-source data base for data processing and exchange. Spatial data visualization and network-based data exchange is integrated into the current base station. AWS has advantages over the conventional in terms of high-resolution observation frequency, minimize human error, automatic digitization and transmission of the data, and remote monitoring of the stations. Running AWS has different challenges including, but not limited to the following: coverage and quality of GPRS network, data homogenization with log years' historical data from conventional stations, capacity to calibrate and maintain AWS, potential for multiple base station administration, short life time of sensors relative to the conventional instruments that ranges from 3 to 5 years, high frequency of preventive maintenance and calibration and, expensive running cost. Depending on the use and application different sensors could be mounting on AWS. For agricultural purposes, in addition to the six-element mentioned above, leaf wetness, sunshine hours, evaporation, soil moisture and soil temperature are the major sensors needed to be mounted. Synoptic AWS and AWS at airports need the addition of atmospheric pressure sensors. Airport AWS, sometimes called Automatic Weather Observing System (AWOS) and small airport system (SAS, AVIMET) need to have additional sensor for cloud and visibility observations. Thus, based on the application AWS station network study should consider the distribution of different categories such as airport, synoptic, agricultural, climatology and urban.

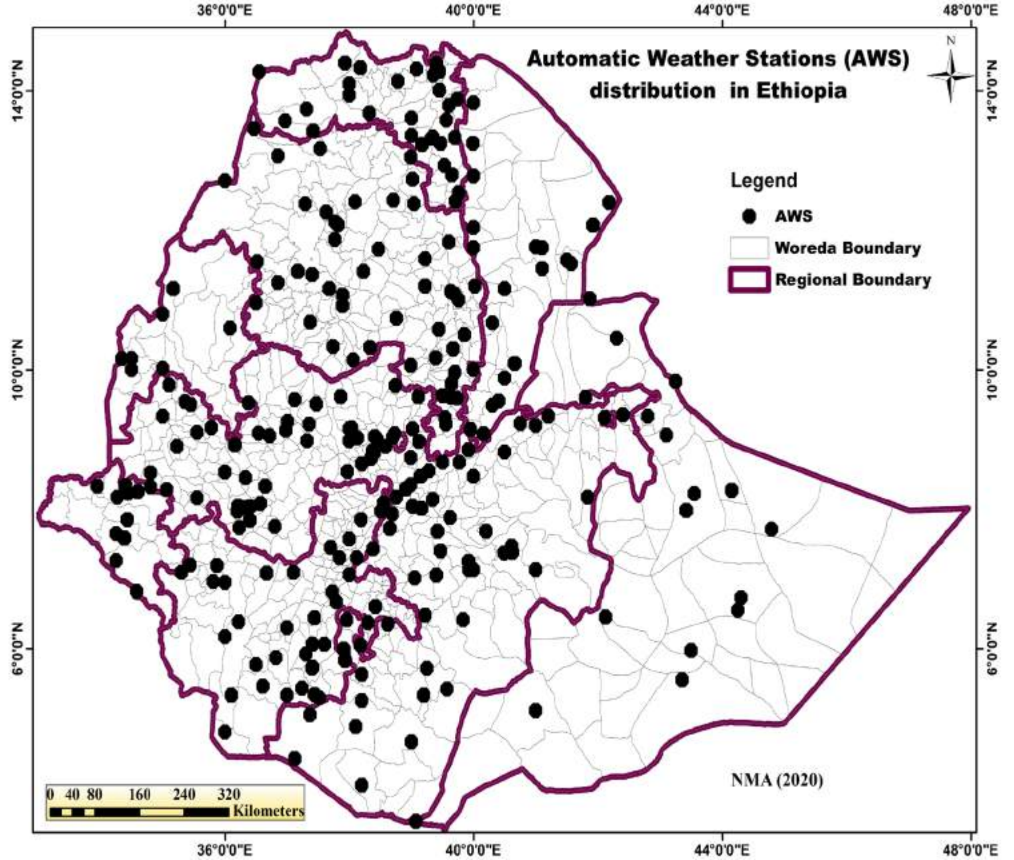


Figure 6. 287 AWS stations distribution

2.6. Weather Radar

Radar stands for Radio Detection and Ranging. Meteorological weather radar operates in frequency ranging from 3MHz to 300 GHz (X-Band: 8-12GHz, S-Band: 2-4GHz, C-band: 4-8GHz). Weather radars send directional pulses of microwave radiation, on the order of a microsecond long, using a cavity magnetron or klystron tube connected by a waveguide to a parabolic antenna. The wavelengths of 1–10 cm are approximately ten times the diameter of the droplets or ice particles of interest, because Rayleigh scattering occurs at these frequencies. This means that part of the energy of each pulse will bounce off these small particles, back in the direction of the radar station. Shorter wavelengths are useful for smaller particles, but the signal is more quickly attenuated. Thus 10 cm (S-band) radar is preferred but is more expensive than a 5 cm C-band system. 3 cm X-band radar is used only for short-range units, and 1 cm Ka-band weather radar is used only for research on small-particle phenomena such as drizzle and fog.

Some of the output of weather radar observations includes: plan position indicator, constant altitude plan position indicator, vertical composite, accumulations, echotops, vertical cross section, range height indicator. Radar integrated display with geospatial elements, animations, etc. Data from modern dual polarized weather radar includes precipitation rate, rain droplet motion, radial wind speed, precipitation type, precipitation size, convective cloud structure, etc. NMA, under the Tana Beles Integrated Water Resource Management Project has already installed C-Band weather radar around Shaura, west of Lake Tana. Because of the earth curvature and Ethiopian topography, a good radar range could be 150km to 200km radius. Selecting a weather radar site need considerations of obstruction free line of site, which normally is at the top of mountains. Radar site needs good access road, dependable three phase electric supply, wide and reliable communication system, and electromagnetic interference frees area, etc. In a country like Ethiopia, with rugged topography, finding a radar beam blockage free site would be challenging, if not impossible. Digital elevation-based models are used to make a beam lockage analysis at different radar elevation angle and for different ranges. Ideal Radar station network study should include a beam blockage analysis and site survey for the proposed locations of the radar installation, which needs a lot of resources for the site survey, software and training.

2.7. Upper Air Observation

Atmosphere is like a layer cake. We must examine all the layers before we can determine a complete picture. The lowest layer is important because it's where we live, but what happens at ground level is really a result of the integrated behavior at all the different levels. So, before we can put together a good forecast, we must figure out what is going on above the ground. There are two common methods of upper air observation. The simplest balloon is called a pilot balloon and is filled with gas. After being released, it's tracked with a telescope-like device called a theodolite. At equal intervals, such as once a minute, the balloon's position is noted in terms of its vertical and horizontal angles. These can be put into a formula to determine wind speed and direction. Other balloons carry a special instrument package called a radiosonde, which measures the pressure, temperature, and humidity at different heights. The balloon is tracked, often with radar, and the wind can be determined, just as it is with a pilot balloon. At the same time, the data is transmitted back to the tracking station at given intervals. The third method for upper air observation is AMDAR.

For example, every few mill bars of ascent, the switch goes on, and data is sent. The balloon's position is known, and its pressure given. The strength of the returning signal is proportional to the temperature and humidity. Above 19 miles, radar and rockets are used to determine weather conditions. The rocket drops an instrument package, and it's tracked by radar. National Meteorological Agency (NMA) is currently operating upper air observation stations at Addis Ababa head office, Negelle synoptic station and Mekelle. The system installed at Negelle is MW11 (pilot balloon station) and installed upper-air station at Addis Ababa is MW15 (radio sonde stations). The Addis Ababa station also have modern hydrogen generator, while hydrogen at Negelle is generated manually. From Negelle pilot balloon station only wind speed and wind direction data are collected, while from Addis Ababa's radio sonde station, atmospheric pressure, wind speed, wind direction, air temperature and relative humidity data are collected.

From Mekelle upper air station atmospheric pressure, wind speed, wind direction, air temperature and relative humidity data are collected. Pilot ballon is not working at Mekelle upper air stations. The main challenge in running a radiosonde upper air station is radiosonde and balloon are expensive. NMA cost million Birrs in a year just to run the Addis Ababa upper air station. Meteorological Elements recorded at upper air stations by Radiosonde at 2:00 LST in the Afternoon. Pressure, Wind speed and direction, Relative humidity, Temperature, Dew point temperature, Geopotential height, also, by theodolite in the morning: Angel (Elevation and Azimuth) and wind speed and direction.

2.8. Aeronautical Meteorological Stations

The existing structure of the airport aeronautical meteorological station network is basically the result of the demands of the international and the national aviation industry. Weather information is required by the pilot and/or air traffic control system during all phases of flight to make both strategic and tactical decisions impacting flight safety. The detection of wind shear event during or prior to the arrival and departure phases of a flight is an example of where weather information may directly impact flight safety.

Types of meteorological data for aviation purposes regarding airports used for the Jet age require high precision meteorological data and thus most international air lines do not allow their airplanes to land at airports which do not have the ultra-modern Automatic Weather Observation System. Thus, this great task of supporting the country's GTP in the aviation sector is the responsibility of the NMA, which requires great investment to realize the needs of the aviation sector regarding high precision meteorological data for flight safety. These require network expansion of the modern Automatic Weather Observation System, the digital wind system, the AVIS at the different airports of the country. A total of 23 airport stations are available in Ethiopia among these 4 stations are installed in international airport and available instrument types are depicted in (Figure 7 and 8)

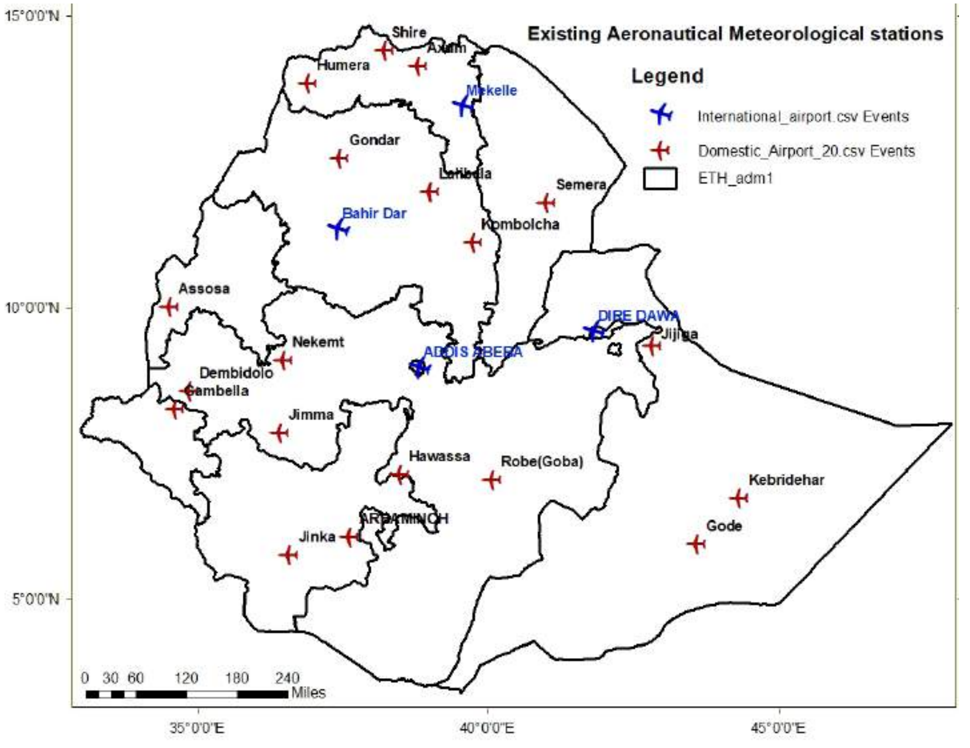


Figure 7. Existing Aeronautical Meteorological stations

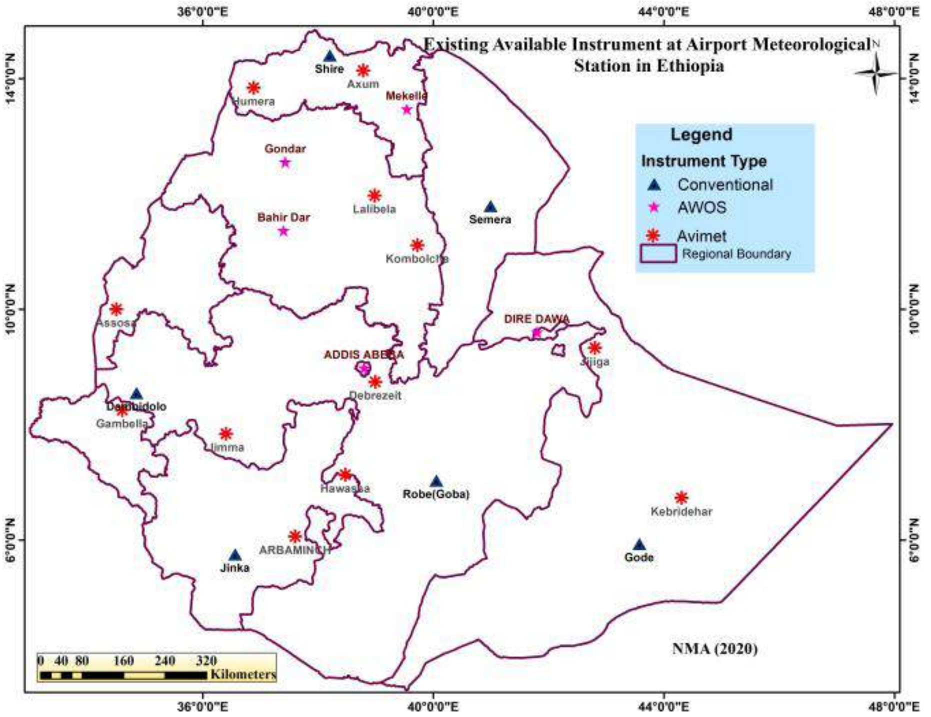


Figure 8. Existing available instrument at Aeronautical Meteorological stations

2.9. Meteorological Station Network distribution at Agro-Ecological Zones

In the agro-ecological analysis of meteorological station network, we have adopted the new Agroecological classification produced by Ministry of Agriculture.

2.9.1. Climate and Agro-Ecological Zones

Climatic elements such as precipitation, temperature, humidity, sunshine, wind, are affected by geographic location and altitude. Ethiopia, being near the equator and with an extensive altitude range, has a wide range of climatic features suitable for different agricultural production systems. Climatic heterogeneity is a general characteristic of the country. Temperature and rainfall are the most important climatic factors for agricultural production in Ethiopia. Altitude is a factor that determines the distribution of climatic factors and land suitability; this influences the crops to be grown, rate of crop growth, natural vegetation types and their species diversity. Taking the two extreme altitudes, temperatures range from the mean annual of 34.5° C in the Danakil depression, while minimum temperature fall below zero in the upper reaches of Mt. Ras Dashen (4,620 metres) with a mean of less than 0° C, where light snowfalls are recorded in most years.

Between these extremes are vast areas of plateau and marginal slopes where mean annual temperatures are between 10° and 20° C. According to FAO (1984 a) rainfall in Ethiopia is generally correlated with altitude. Middle and higher altitudes (above 1,500 meters) receive substantially greater falls than do the lowlands, except the lowlands in the west where rainfall is high. Generally, average annual rainfall of areas above 1,500 meters exceeds 900 mm. In the lowlands (below 1,500 meters) rainfall is erratic and averages below 600 mm (Table 2). There is strong inter-annual variability of rainfall all over the country. Despite variable rainfall which makes agricultural planning difficult, a substantial proportion of the country gets enough rain for rain fed crop production (FAO, 1984b).

Table 2. General Features of the Traditional Agro-ecological Zones

Traditional zone	General features					
	Altitude (m)	Rainfall (mm)	Soil type	Natural vegetation	Main plant species	Crops
High wurch (alpine)	> 3,700	> 1,400	Black, little disturbed	Afroalpine steppe meadow	Mountain grassland (Artemisia, Helichrysum, Lobelia)	None, Frost Limit
Wet wurch (Sub-alpine)	3,700-3,200	> 1,400	Black, highly degraded	Subalpine	Erica, Hypericum	Barley (2 Crops/Year)
Moist wurch (sub-alpine)	3,700-3,200	1,400-900	Black, degraded	Subalpine	Erica, Hypericum	Barley (1 Crop/Year)
Wet dega (high land)	3,200-2,300	>1,400	Dark brown clay	Afromontane forest bamboo	Juniperus, Hagenia, Podocarpus, Arundinaria	Barley, Wheat, Neug, Pulses (2 Crops/Year)
Wet woyna dega (mid altitude)	2,300-1,500	> 1,400	Widespread drainage		Acacia, Cordia, Ficus, Arundinaria	Tef, Maize, Enset (In West) Neug, Barley
Moist woyna dega (mid altitude)	2,300-1,500	1,400-900	Red brown drainage		Acacia, Cordia, Ficus	Maize, Sorghum, Tef, Enset, (Rare) Wheat, Neug, Finger, Millet, Barley
Dry woyna dega (mid altitude)	2,300-1,500	<900	Light brown to yellow	Savanna	Acacia	Wheat, Tef, Maize (Rare)
Wet kola (low land)	1,500-500	>1,400	Red clay, oxidized		Millettia, Cyathea, Albizia	Mango, Taro, Sugar, Maize, Coffee, Orange
Moist kola (low land)	1,500-500	1,400-900	Yellow silt		Acacia, Erythrina, Cordia, Ficus	Sorghum, Teff(Rare), Neug, Finger, Millet, Groundnuts
Dry kola (low land)	1,500-500	<900	Yellow sand		Acacia spp.	Sorghum (Rare), Teff
Bereha (low land deserts) Note in the earlier table this unit is over 500 m!	<500	<900	Yellow sand	Acacia-Commiphora bush land	Acacia, Commiphora	Only with Irrigation

In order to generate different agro-meteorological parameter, it is essential to establish not only agro-meteorological stations with common instruments, but need to consider other reference agro-meteorological stations, which consist of special instruments for measuring leaf wetness index and soil moisture as well as for measuring actual evapo-transpiration and values of crop evapo-transpiration. Therefore, based on the WMO guide (WMO, 1980), principal and ordinary agro-meteorological stations are defined as stations that provide detailed simultaneous meteorological and biological information that will be used in the application to modern farming for increasing food production (Table 2 and Figure 7).

Table 3. First class, Second class and AWS Meteorological station network in the different Agro-Ecology zones

No	AEZ31	Count	Major_agro	Area__Ha	%	Met Stations	AWS
1	A1	10	Hot arid lowland plains	12202265	10.8	6	7
2	A2	18	Warm arid lowland plains	22356361	19.8	15	23
3	A3	0	Tepid arid mid highlands	488143.37	0.4	0	0
4	H2	2	Warm humid lowlands	2592646.7	2.3	6	12
5	H3	2	Tepid humid mid highlands	3001629.6	2.7	11	11
6	H4	1	Cool humid mid highlands	926331.16	0.8	3	2
7	H5	0	Cold humid sub-afro-alpine to afro-alpine	62620.01	0.1	0	1
8	H6	0	Very cold humid sub-afro-alpine	50577.54	0	0	0
9	M1	1	Hot moist lowlands	672104.34	0.6	0	1
10	M2	14	Warm moist lowlands	17109776	15.1	31	20
11	M3	8	Tepid moist mid highlands	9101287.8	8.1	30	47
12	M4	2	Cool moist mid highlands	1963109.3	1.7	9	9
13	M5	0	Cold moist sub-afro-alpine to afro-alpine	78829.42	0.1	0	0
14	M6	0	Very cold moist sub-afro-alpine to afro-alpine	15246.1	0	0	0
15	PH1	0	Hot per-humid lowlands	13087.56	0	0	0
16	PH2	1	Warm per-humid lowlands	765389.51	0.7	1	0

No	AEZ31	Count	Major_agro	Area__Ha	%	Met Stations	AWS
17	PH3	0	Tepid per-humid mid highland	152280.91	0.1	1	2
18	SA1	0	Hot semi-arid lowlands	449789.29	0.4	1	2
19	SA2	3	Warm semi-arid lowlands	3114607.3	2.8	5	4
20	SA3	0	Tepid semi-arid mid highlands	218624.16	0.2	0	2
21	SH1	2	Hot sub-humid lowlands	1893409.9	1.7	7	9
22	SH2	7	Warm sub-humid lowlands	8046859.3	7.1	18	20
23	SH3	6	Tepid sub-humid mid highlands	7504025.3	6.6	25	44
24	SH4	0	Cool sub-humid mid highlands	589048.5	0.5	0	2
25	SH5	0	Cold sub-humid sub-afro-alpine to afro-alpine	68815.01	0.1	0	0
26	SH6	0	Very cold sub-humid sub-afro alpine to afro- alpine	34889.05	0	0	0
27	SM1	1	Hot sub-moist lowlands	637275.79	0.6	0	0
28	SM2	9	Warm sub-moist lowlands	10890128	9.6	6	16
29	SM3	5	Tepid sub-moist mid highlands	5850114.9	5.2	19	28
30	SM4	1	Cool sub-moist mid highlands	1314156.3	1.2	6	14
31	SM5	0	Cold sub-moist mid highlands	76818.84	0.1	0	0
32	SM6	0	Very cold sub-moist mid highlands	18021.27	0	0	0
33	WB	1	Water Body	870794.62	0.8	2	2

In this connection, therefore, with a view to protecting food and water availability from the harmful effects of climate related disasters, it is vital to expand the establishment of agro-Meteorological stations network. In view of this, the maximum principal stations and the new proposed stations to be established during the next ten years (2020-2029) master plan are indicated. 489 stations (First class, synoptic and AWS) are purely agro-meteorological stations. In this respect, it should be noted that all types of stations that are located at any river basin should be used as hydro-meteorological stations, taking in to consideration that each stations record rainfall for hydro meteorological analysis.

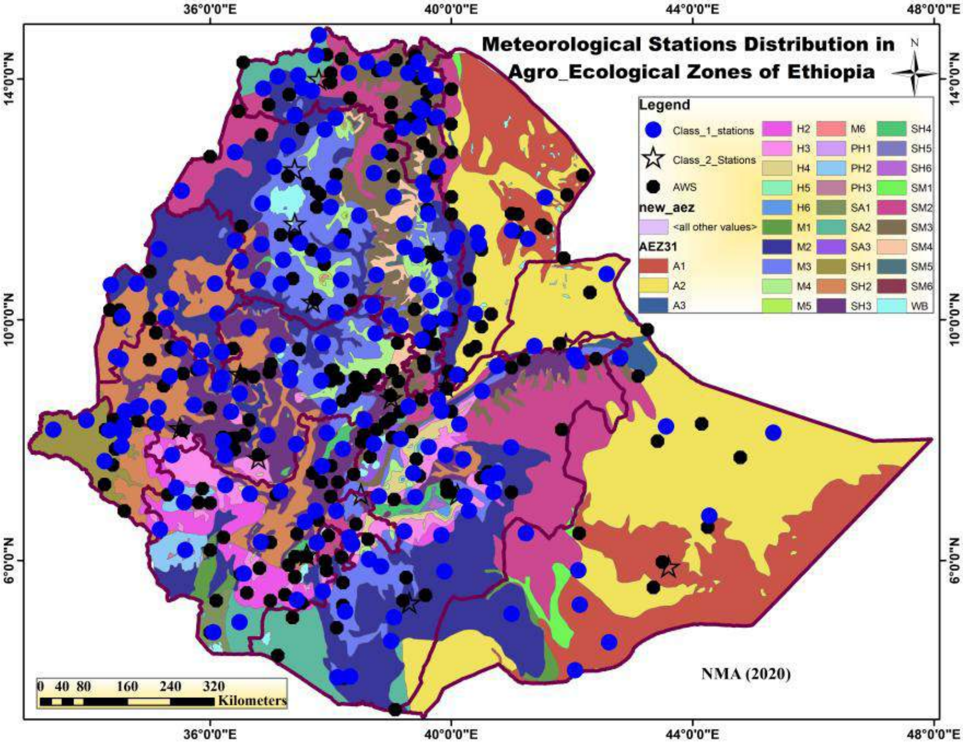


Figure 9. Meteorological station distributions at Agro-Ecology zone level

2.10.Hydro-Meteorological Stations

In order to provide effective hydro-meteorological information for various applications that include construction, agriculture, environmental degradation, flood hazards, e.t.c, it is vital to install rainfall-recording instruments with daily charts at all river basins appendix III (Figure 10). Therefore, the identified new rainfall intensity indexes that require daily charts are 22 principal stations. In the recent revised station master palne there are new proposed rainfall intensity recording stations that need to be established on flood prone Woreda's along the major river basins. The increasing demand for hydro meteorological information requires fully to satisfy their needs, however, the inefficient station distribution need to be changed so that we can be able provide hydro-meteorological information as plenty as possible as desired. In light of the above desire, the upgrading of stations network for hydro meteorological services should be an essential step towards the development of hydrometeorology to broaden service of NMA in more efficient ways.

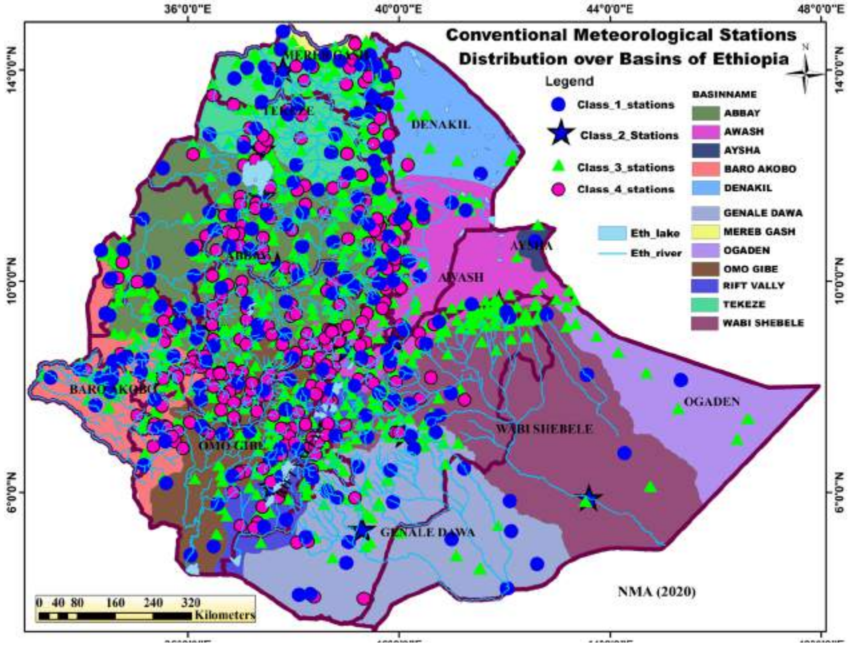


Figure 10. Hydro-met station distribution

3 STATION NETWORK MASTER PLAN

3.1. Methodology

The methodology on the design of the new meteorological station network is based on the use of three major considerations. These are:

i) The consideration of the WMO standard

ii) The consideration of the socio-economic factor

iii) The consideration of CV method to determine Hydro meteorological station distribution within the basins

In order to determine optimum number of radar numbers in Ethiopia radar coverage from special software analysis and electromagnetic compatability analysis (EMC) were performed (adopted from VAISALA, 2018).

To determine the need of lightening detecting stations over Ethiopia bandwidth coverage, threshold crossing rate and frequency analysis were considered (adopted from VAISALA, 2018).

The approach to the use of the WMO standard to be used for the expansion and strengthening of the Agency's meteorological station network is necessary, as the vision of the Agency is to become an institution providing world class standard services. Thus, minimum distances have been set based on the WMO standard for different classes of meteorological stations undertaking meteorological observation. The consideration of the socio-economic factor as one important component of the methodology is justified, since the ultimate mission of the Agency is providing services that target the socio economic development of the country. The two major points of departures considered here are: -

- Representativeness at the Woreda level considering that each Woreda is to have at least one precipitation station with the general target of getting one more third-class station, since the Woreda is the basic political entity, where availability of meteorological data input can be important for the socio-economic plans and programs of Woreda, including climate change adaptation activities.
- The consideration of "Agro-ecological representativeness" is justified since the overall target of the meteorological station network of the Agency is that each agro-ecological region in the country is adequately represented by at least one agro-meteorological stations in the meteorological station network as the agricultural sector is considered the base on which the country's industrialization will be affected.
- Representativeness at the basin level

To determine the optimum number based on the WMO standard adopted by the NMA for the development of the new station network master plan. Categorized here the three major topographical features of Arid, Plain and Mountainous areas. Arid areas whose elevation is below 500 masl. Plain areas whose elevation is between 500 and 1500masl. Mountainous areas whose elevation is above 1500 masl. The optimum number of the fourth class meteorological stations, the third class ordinary meteorological stations and the first class and second class meteorological stations is computed based on the adopted WMO standard.

3.2. The consideration of the WMO standard

The conceptual approach to design a climate-station network would be to install a large number of temporary stations and then compare the results from adjacent places. If the correlation between simultaneous measurements from adjacent stations proves to be too high' (i.e., an increase at one station is almost always accompanied by a similar increase at the other), or the difference between measured values is ‘too low’, one of the pair is redundant and should be removed, for economy. In this way, stations would be reduced to a number sufficient to sample all the various topo climates.

The difficulty with this procedure comes in deciding what correlation is ‘too high’. Stringer (1972) suggested that the spacing between adjacent climate stations A and C should be such that the error in interpolating climatic values for an intermediate place B is comparable with the instrumental error at any single station. (The interpolation error would be found by comparing the estimate with actual measurements at B.) Godske (1969) arbitrarily and tentatively proposed that satisfactory correlation coefficients are between 0.8–0.95 in 90 per cent of synoptic situations. Other writers have recommended a minimum coefficient of 0.7. Coefficients less than that would imply significantly different un-sampled topo-climates between the stations. The appropriate spacing depends on what climate element is being considered.

The following standard has been adopted after undertaking comprehensive review of the WMO literatures on standards regarding meteorological station network (Table 4). The importance of the following table is that a station master plan network must be based on international standards set by the World Meteorological Organization so that the representativeness of the data and information collected by the network can meet international standards. As the vision of the National Meteorological Agency is to reach world class standard, the implementation of the WMO standard would be the major point of departure for the development of the Agency’s New Master plan for the next ten years.

Table 4 Station Network Standard adopted by the National Meteorological Agency

Meteorological parameters	Inter station distance or coverage area wise			References
	Mountainous	Plain	Arid areas	
Rainfall	250 sq km	575 sq km	10000sq km	WMO No. 168
Self-recording rainfall	2500 sq km	5750 sqkm	100,000sq km	WMO No. 1185
Air Temperature	30 km	60 km		WMO No. 168
Wind	20 km	70 km		WMO No. 168
Sun shine duration	60 km	120 km		WMO No. 168
Radiation	50 km	80 km		WMO No. 168
Upper air Sounding Station	300 km			WMO No. 168
Radar	150-250 km			WMO No. 168
Synoptic Station	200 km			WMO No. 168

3.3. Topographic Analysis of Ethiopia

Since one major factor taken into consideration for the design of the meteorological station network is topography, GIS analysis has been undertaken based on the variation of altitude characteristics. Over the country. The following diagram (Figure 9) shows the GIS analysis of topographic characteristics based on elevation above sea level.

The computation of areas for different physiographic topographies over Ethiopia shows that more than 65% of the country is found up to an altitude of 1500 mts above sea level (Table 5). Thus, based on three major physiographic topographies, that is for the arid, lowlands and the high lands of the country, gap analysis was undertaken (Table 6).

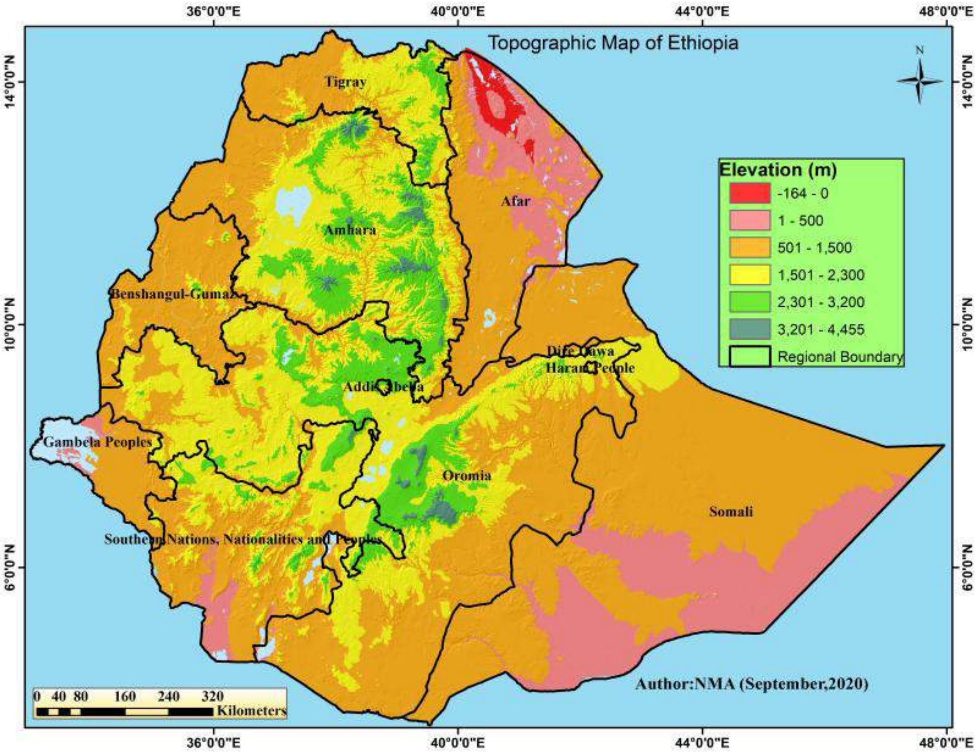


Figure 11. Topographic map of Ethiopia

Table 5. Computed areas for different physiographic topographies (On National basis)

Elevation(m)	Area_km2	Percent (%)
<500	150,594.6	13.293
500-1500	597943.52	52.782
>1500	384325.32	33.925
Total	**1,132,863.44**	**100**

Table 6. Computation of the number of stations as per the adopted WMO standard

Elevation (m)	Area km^2	(%)	4th Class	3rd Class	1stclass	Synoptic
<500 (Arid)	150594.6	13.3	150,000/10,000 = **15**	150,000/3600 = **42**	150,000/100,000 = **1.5 ~2**	150604/40000 =**4**
500.01- 1500 (Plain)	597943.5	52.8	597,975/575 = **1040**	597.975/3600 = **166**	597975.6/5750 = **104**	597975/40000 =**15**
>1500 (Mountainous)	384325.3	33.9	384281/250 = **1534**	384281/900 = **427**	384281.6/2500 = **154**	384281.6/40000 =**11**
Total Area	**1,132,861**		**2589**	**635**	**260**	**30**

3.4. Gap Analysis Based on the WMO Standard

The Gap analysis result shown in Table 7 and 8 in the next table indicates that the lowland areas of the country are still much less than the required standard when compared with the highlands regarding precipitation stations. Moreover, the gap analysis indicates that the future strategic direction of the meteorological station network expansion should focus on the following major areas:

i. Developing a program and a plan of action to solve the problem of the great gap in the precipitation station network over the country.

ii. Giving more consideration to the lowland parts of the country so that their network coverage is closer to the computed standard.

iii. Since the third class station network standard is fulfilled both at National level, but the major focus should be in identifying local areas where the gap in the third class station network coverage should be not fully covered and also considering the socio-economic demands, where it has been proposed that each Woreda (administrative district) should have a third class station for the development of climate change adaptation activities.

iv. The first-class station network for both classes is about 71% of the total. Thus, the rehabilitation, strengthening and the automation process would be the most important strategic step in the case of the first class stations

Table 7. Gap analysis of the existing meteorological station network for two major physiographic areas over the country

Physiographic Topographies	Precipitation stations (4th Class)			Ordinary Meteorological stations (3rd class)			Principal (First class) stations			Synoptic stations		
	Comp	Exist	%	Comp	Exist	%	Comp	Exist	%	Comp	Exist	%
Arid (<500 amsl)	15	3 (52)	20% (346.7%)	42	33 (49)	78.5% (116.6%)	2	15	750%	4	1	25%
Plain (501-1500 amsl)	1040	53 (262)	5.1% (25.2%)	166	153 (209)	92.2% (125.9%)	104	52	50%	15	4	26.7%
Highlands (>1500 amsl)	1534	227 (906)	14.8% (59.1%)	427	549 (679)	128.5% (159%)	154	118	76.6%	11	12	109%
Total	**2589**	**1220**	**47.1 %**	**635**	**937**	**147.6%**	**260**	**185**	**71%**	**30**	**17**	**56.7%**

Note: The need for the numbers in the bracket is, because for the gap analysis of precipitation measuring station network, we should not only consider the precipitation measuring stations but also the ordinary and the first class stations since they also measure rainfall, the same is true when we undertake analysis of the ordinary meteorological station network, since the first class stations since also measure temperature but synoptic, radar stations and upper air are computed using station coverage standards.

Table 8. Computed values of number of conventional Meteorological stations based on the adopted WMO methodology (computed on National basis)

Type of Stations	Existing	Computed values to meet the standard	Existing Station coverage (%)	Remark
Precipitation	283	1664	16.5%	2589-(635+260+30)) =1664
Third Class	735	635	115.7%	
First Class	185	260	71.2%	
Second Class	17	30	56.7%	
Total	**1220**	**2589**	**47.12%**	

Table 9. Existing and Computed Meteorological station based on Elevation over Ethiopia (at Woreda basis)

Oromia						Gambela					
Elevation (m)	Area km2	4th Class	3rd Class	1st Class	2nd Class	Elevation (m)	Area km2	4th Class	3rd Class	1st Class	2nd Class
<500	1401	0	0	0	0	<500	8877	1	2	0	0
500-1500	142434	248	40	25	4	500-1500	20712	36	6	4	1
>1500.01	179112	716	199	72	4	>1500.01	871	3	1	0	0
Total (compute)	322947	964	239	96	8	Total	30460	40	9	4	1
Existing		109	289	58	7	Existing		2	27	8	0
Proposed		260	0	38	1	Proposed		13	0	0	1
Somali						**Benishangulmz**					
Elevation (m)	Area km2	4th	3rd	1st	2nd Class	Elevation (m)	Area km2	4th	3rd	1st	2nd Class
<500	90284	9	25	1	2	<500	2	0	0	0	0
500-1500	214081	372	59	37	5	500-1500	46385	81	13	8	1
>1500.01	8174	33	9	3	0	>1500.01	3942	16	4	2	0
Total (Compute)	312539	414	94	42	8	Total	50329	96	17	10	1
Existing		0	34	11	1	Existing		8	22	12	0
Proposed		53	60	31	7	Proposed		20	0	0	1
SNNPR						**Addis Ababa**					
Elevation (m)	Area km2	4th	3rd	1st	2nd Class	Elevation (m)	Area km2	4th	3rd	1st	2nd Class
<500	8341	1	2	0	0	<500	0	0	0	0	0
500-1500	50997	89	14	5	1	500-1500	0	0	0	0	0
>1500.01	42438	176	54	19	1	>1500.01	539	2	1	0	0

Total (compute)	101,776	266	71	25	2	Total	539	2	1	0	0
Existing		46	81	19	1	Existing		4	5	1	1
Proposed		118	0	6	1	Proposed		10	0	0	0
Tigray						**Dire Dawa**					
Elevation (m)	Area km2	4th	3rd	1st	2nd Class	Elevation (m)	Area km2	4th	3rd	1st	2nd Class
<500	68	0	0	0	0	<500	0	0	0	0	0
500-1500	24387	42	7	4	0	500-1500	705.48	1	0	0	0
>1500.01	27806	111	31	10	1	>1500.01	349.08	1	0	0	0
Total (compute)	52261	154	38	14	1	Total	1054.56	3	1	0	0
Existing		20	59	18	1	Existing		0	1	0	1
Proposed		34	0	0	0	Proposed		3	0	0	0
Amhara						**Harari**					
Elevation(m)	Area km2	4th	3rd	1st	2nd Class	Elevation (m)	Area_km2	4th Class	3rd Class	1st Class	2nd Class
<500	30	0	0	0	0	<500	0	0	0	0	0
500-1500	42357	74	12	7	1	500-1500	91.76	0	0	0	0
>1500.01	112900	452	125	45	3	>1500.01	279.88	1	0	0	0
Total (compute)	155287	525	137	53	4	Total (compute)	371.64	1	0	0	0
Existing		77	161	37	4	Existing		0	2	1	0
Proposed		121	0	16	0	Proposed		1	0	0	0
Afar											
Elevation (m)	Area km2	4th	3rd	1st	2nd Class	Elevation (m)	Area km2	4th	3rd	1st	2nd Class
<500	40452	4	11	1	1	<500	0	0	0	0	0

500-1500	52758	92	15	9	1	500-1500	518	1	0	0	0
>1500.01	1362	5	2	1	0	>1500.01	6308	26	0	4	0
Total (compute)	94572	101	27	10	2	Total (compute)	6826	27	0	4	0
Existing		8	37	9	0	Existing		9	17	1	1
Proposed		32	0	1	2	Proposed		18	0	3	0

Table 10. Computed values of number of Meteorological stations based on the adopted methodology (Woreda basis)

Type of Stations	Existing	Computed values to meet the standard	Existing Station coverage (%)	Remark
Precipitation	283	1484	20.6%	2589-(795+280+30) = 1484
Third Class	735	795	92.5%	60 aditional station needed
First Class	185	280	66.07%	95 aditional station needed
Second Class	17	30	56.7	13 aditional station needed
Total	**1220**	**2589**	**47.9%**	

3.5. Gap Analysis Regarding Woreda Representativeness

The major focus for the assessment of socio-economic criteria regarding the meteorological station network mater plan is the assessment of meteorological station network master plan on Woreda basis. Thus, the major thrust of this analysis is not for the assessment of the Woredas (administrative districts) which do not have first class and ordinary stations meteorological stations (Table 11). The following Figure 12, 13, 14 and 15 shown us the distribution of existing first, third, second- and fourth-class station over the country.

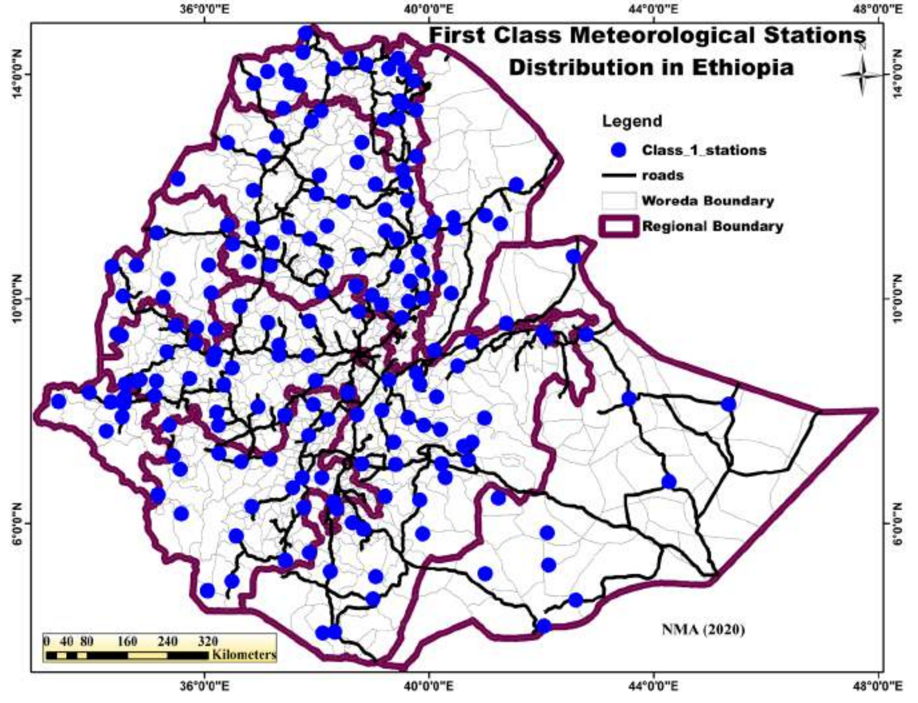


Figure 12. First class station distribution at Woreda level

Table 11. Woredas needed to 1st class stations as per the proposal

Region	No of Woredas
Oromia	38
Amhara	16
SNNPR	5
Tigray	-
Afar	1
Gambela	-
Somali	31
Benshangulgumuz	-
Sidama	4
Addis Ababa	-
Dire Dawa	-
Total	95

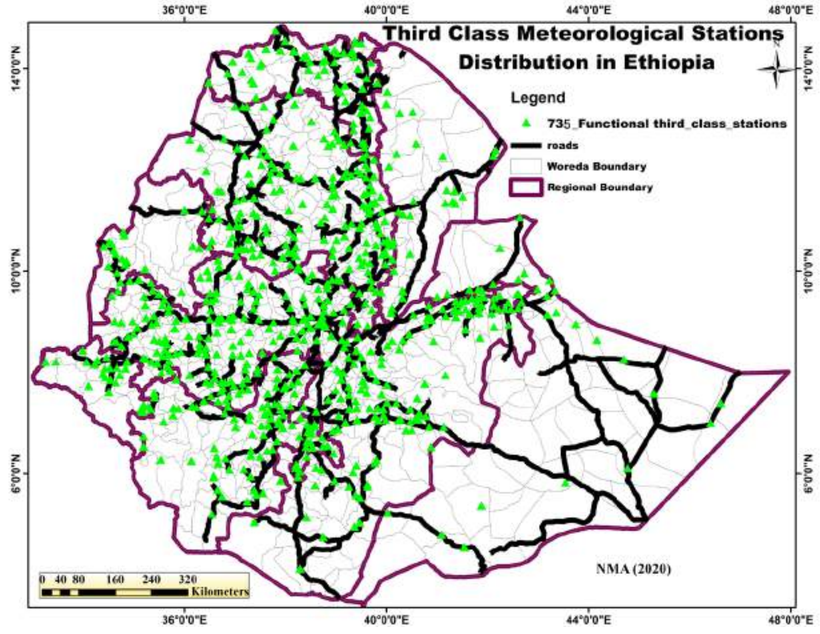


Figure 13. Third class meteorological station distribution at woreda level

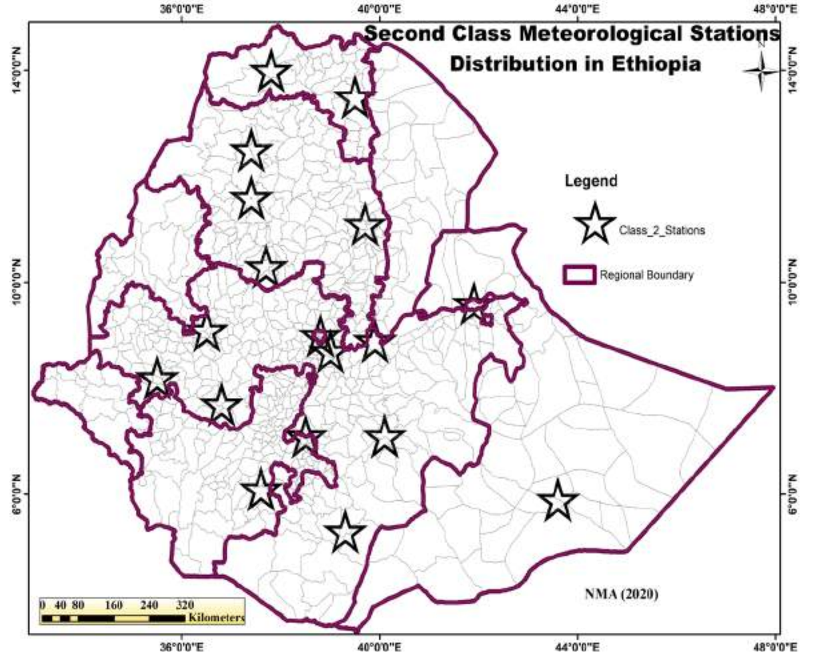


Figure 14. Second class meteorological station distribution at Woreda level

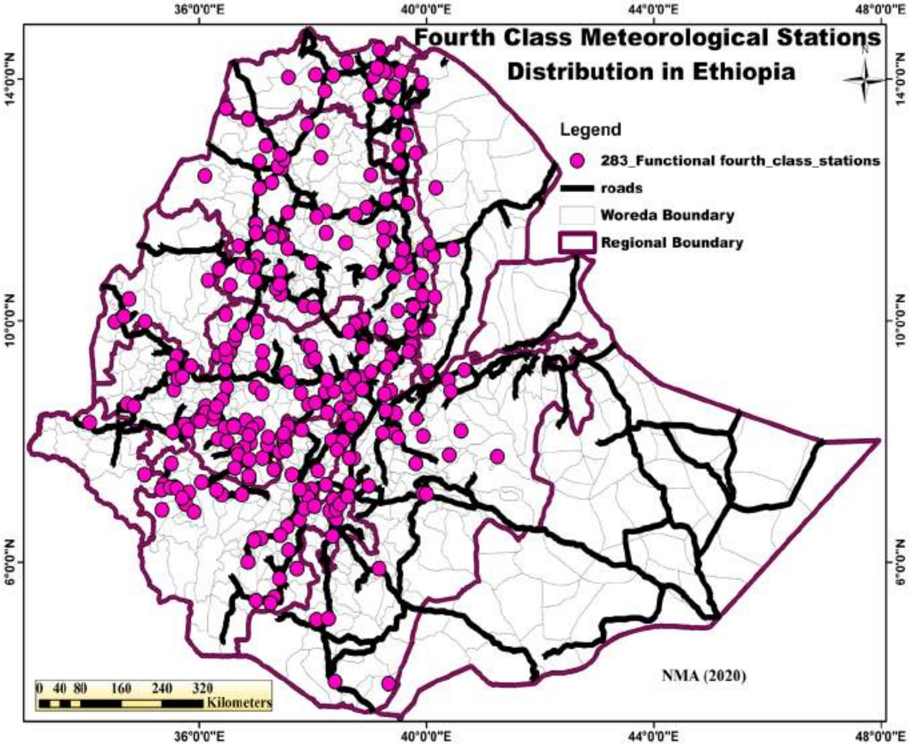


Figure 15. Fourth class station distribution level at woreda level

3.6. Hydro-Meteorological Stations Gap Analysis

Flood prone and potential risk areas over the country are: -

a. Abay: Bahirdar Zuria and Fogera

b. Awash: Dubti, Aysaita, Afambo, Mile, Gewane, Fursi, Dulecha, Fentale, Boset and Becho

c. Baro-Akobo: Jikao, Itang and Akobo

d. Omo-Gibe: Hamer-Bena, Selamgo, Baskato, Kemba, Boreda and Bako Gazer

e. Wabi Shebele : Gode, Denan, Kelafo, Ferfer and Mustahil

In order to determine the optimum number of hydro meteorological station (all class stations) to be installed over basins of Ethiopia the following method was adopted (Cv method): and 1220 Meteorological stations were used for the study (Table 12).

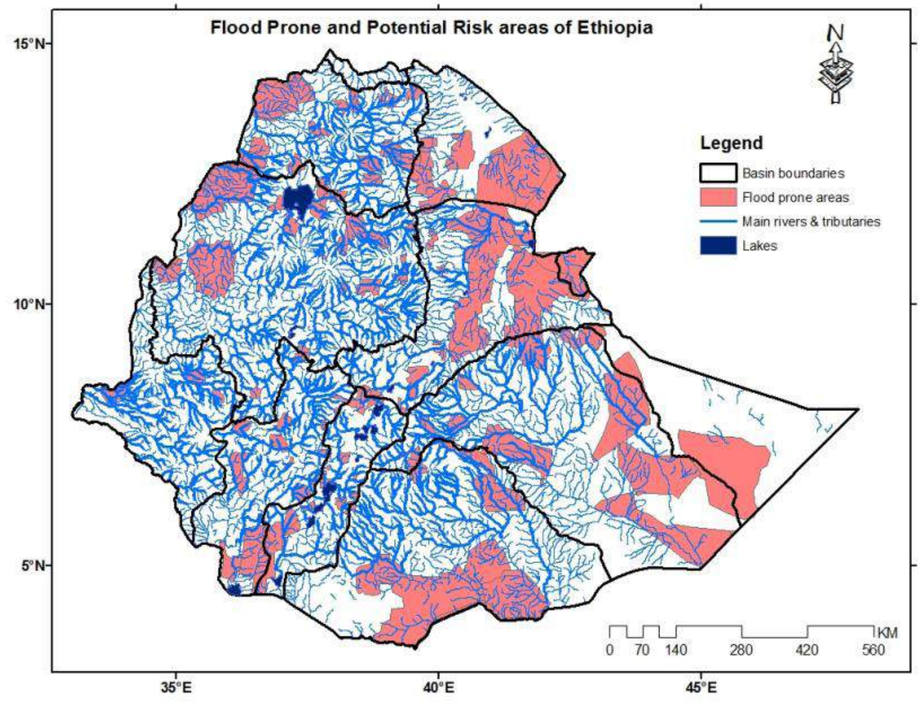


Figure 16. Map showing flood prone areas

To calculate coffeicient of variation, gridded rainfall data for the period 1981-2010 was used. More over, depending on the number of stations over the catchment 1to 5 desired degree of percentage error was employed.

$C_{v\ method}$: The problem of determining the optimum number of rain guages in various basins is of statistical nature and depends on spatial variation of rainfall. Thus, the coefficient of spatial variation of rainfall from the existing stations is utilized for determining the optimum number of rain gauges. If there are already some rain gauges in the catchment, the optimal number of stations that should exist to have an assigned percentage of error in the estimation of mean rainfall is obtained by statistical analysis as:

$N = (CV*100/P)^2$ where, N= Optimum number of rain gauge stations,

CV = Coefficient of variation of the rainfall, P = Desired degree of percentage error in the estimate of mean rainfall. Adopting the above formula, the table below is calculated (Table 12). The method above was cited in Senthilvelan (2016).

Table 12. Optimum, Existing and Additional meteorological stations (I-IV class)

Name of Basins	Optimum Rain gauge Stations	Existing Rain gauges	Additional required	Existing and Additional Rain gauges
Abbay	400	353	47	400
Awash	225	170	65	225
Aysha	4	2	2	4
Baro Akobo	134	118	16	134
Rift Valley	121	102	19	121
Danakil	64	37	27	64
Genale Dawa	121	77	44	121
Mereb Gash	25	19	6	25
Ogaden	16	10	6	16
Omo Gibe	144	126	18	144
Tekeze	144	116	27	144
Wabe Shebele	100	89	11	100
Total	**1498**	**1220**	**278**	**1498**

4 REVISED MASTER PLAN PROPOSAL

The revised station network master plan is developed for the different types of meteorological stations based existing station metadata information, WMO standard adopted, CV method, the result of the gap analysis, the socio-economic criteria and the overall technological development in the field of meteorological observation. Applying the above inputs, the following stations networks distributions are proposed over the country.

4.1. Meteorological Stations

a) **Principal stations:** The gap analysis of principal (first class) stations based on the World Meteorological stations requires 280 stations to be the minimum number for the country. However, the present number is 185 and 17(2nd class) total 202. Thus, it is proposed here that 95 more first class stations are proposed in this master plan.

b) **Synoptic Meteorological Stations:** Currently there are 17 Synoptic meteorological stations, and considering the average inter synoptic station distance of 200Kms, which is with in the context of the World Meteorological Organization standard, the total number of Synoptic meteorological stations is about 30. Thus here, 13 more synoptic stations are proposed here in this master plan.

c) **Agro-meteorological stations:** The need for increasing agricultural production greatly depends on the improvement in the management of the farming system and this is best handled through the use of specialized agro-meteorological stations which can provide more information regarding the soil moisture, leaf wetness and other related data. The major criteria used for the proposal of the specialized agro-meteorological stations are the agro-ecological characteristics of a given area. In Ethiopia there are 18 agro-ecological zones and when combined together with the soil characteristics there are 49 agro-ecological sub zones. Thus, the proposal here is to have 95 first class station to be applicable as specialized agro-meteorological stations.

d) **Precipitation stations:** The number of precipitation (4^{th} class) stations needed corresponding with the rugged topography of Ethiopia, according to the WMO standard has been calculated to be about 2589 inclusive of other conventional and synotic stations. Since the other classes of meteorological stations, which are the third class (795), the first class (280) and the synoptic meteorological stations (30) also measure rainfall; the effective deficiency in the number of precipitations monitoring stations would be about 1484 (2589-1081). Thus the proposal for the expansion of the fourth class station network in adding the 1484 4^{th} class station network for the next ten years is proposed to be undertaken by Volunteer observer institutions, where the instruments for the observation and the station establishment will be undertaken by the Agency but the Volunteer institution will be obliged to administer the observation, report the observed data to the NMA, but the institution can use the data, where a letter of agreement will be signed by the Agency and the Volunteer institution.

e) **Ordinary stations:** The major proposal of this master plan study regarding the ordinary (third class) stations are that every Woreda should have one third class station each. The major reason for this is that due to Global warming, the monitoring of temperature has increased gained more importance and thus climate change adaptation plans at Woreda level can become effective if Each Woreda can get a representative third class meteorological station. Thus, proposal for the next ten years is the establishment of new third class stations for the Woredas which did not have earlier any Meteorological stations. The number of 3^{rd} class stations needed corresponding with the rugged topography of Ethiopia, according to the WMO standard has been calculated to be about 795 and the present number is total 735. Thus here, 60 more 3rd class stations are proposed here in this master plan

4.2. Lightning detector stations network

A lightning detector is a device that detects lightning produced by thunderstorms. Ground-based lightening detectors calculate the direction and severity of lightning from current location using radio direction-finding techniques together with an analysis of the characteristic frequencies emitted by lightning. Ground-based systems use triangulation from multiple locations to determine distance. Both inter cloud (IC) and cloud to ground (CG) lightening detections has to be considered for effective meteorological application. Lightning detectors and weather radar are used together to detect storms. Lightning detectors indicate electrical activity, while weather radar indicates precipitation. Both phenomena are associated with thunderstorms and can help indicate storm strength.   The station density also determines the quality of detection in strength and location (Figure 17).

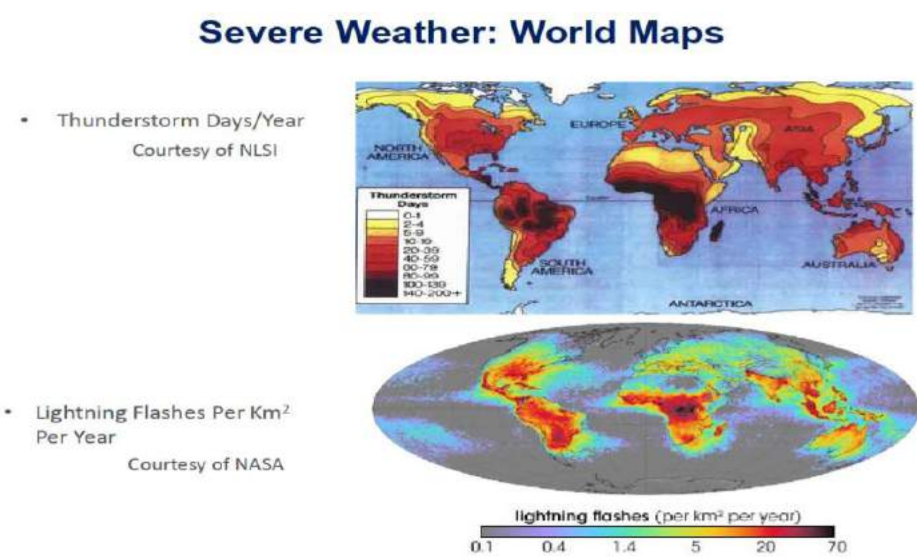


Figure 17. Severe Weather Map

Thunderstorms are mainly detected through the use of lightning counters. On the basis of the instructions provided to observers and issued by different Services, a certain number of lightning strokes per interval of time must be selected which can be used in combination with precipitation rates or wind speeds to define slight, moderate and heavy thunderstorms. Furthermore, Systems for locating thunderstorms based on the detection of the low-frequency electromagnetic radiation from lightning have been developed in recent years. These systems measure the time taken for the signal to arrive and/or the direction from which it comes. Also, some systems analyse the characteristics of each radio impulse to identify cloud-to-ground lightning strokes. In certain regions, a number of these units are installed to measure and locate these phenomena in an area of 50 to 100 km around the aerodrome (Figure 18).

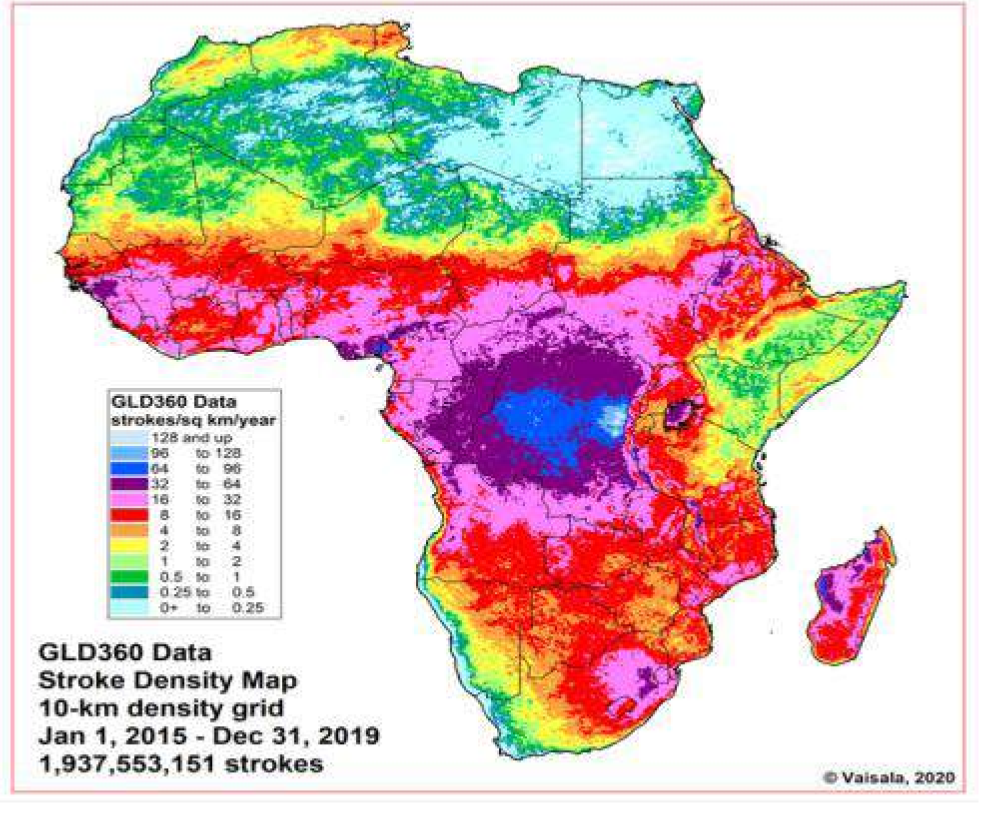


Figure 18. Stroke Density Map

Cloud-to-Ground Lightning Detection Efficiency: While the state of the atmosphere may be described well by physical variables or quantities, a number of meteorological phenomena are expressed in terms of discrete values.

Typical examples of such values are the detection of sunshine, precipitation or lightning and freezing precipitation. Detection Efficiency (DE) plots show the percentage of Cloud-to-Ground (CG) and In-Cloud (IC) strokes detected (Figure 19). The performance projections are modeled based on verified actual operating performance from the existing networks.

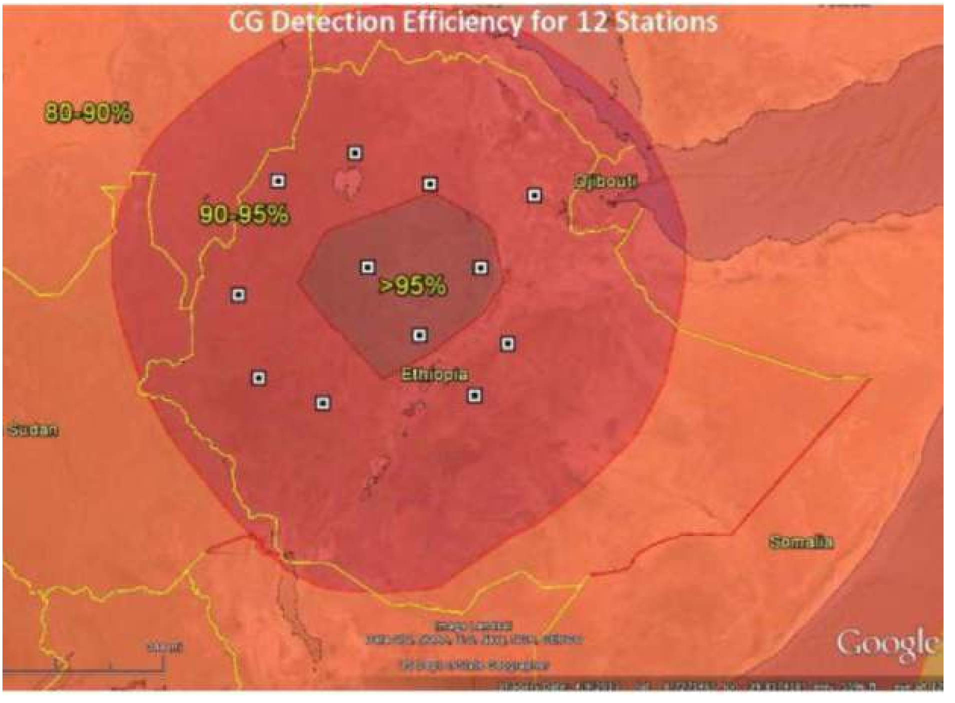


Figure 19. CG Detection Efficiency for 12 Stations (Source: Google Earth)

Intra-Cloud Lightning Detection Efficiency: Thunderstorms are mainly detected through the use of lightning counters (Figure 20). On the basis of the instructions provided to observers and issued by different Services, a certain number of lightning strokes per interval of time must be selected which can be used in combination with precipitation rates or wind speeds to define slight, moderate and heavy thunderstorms.

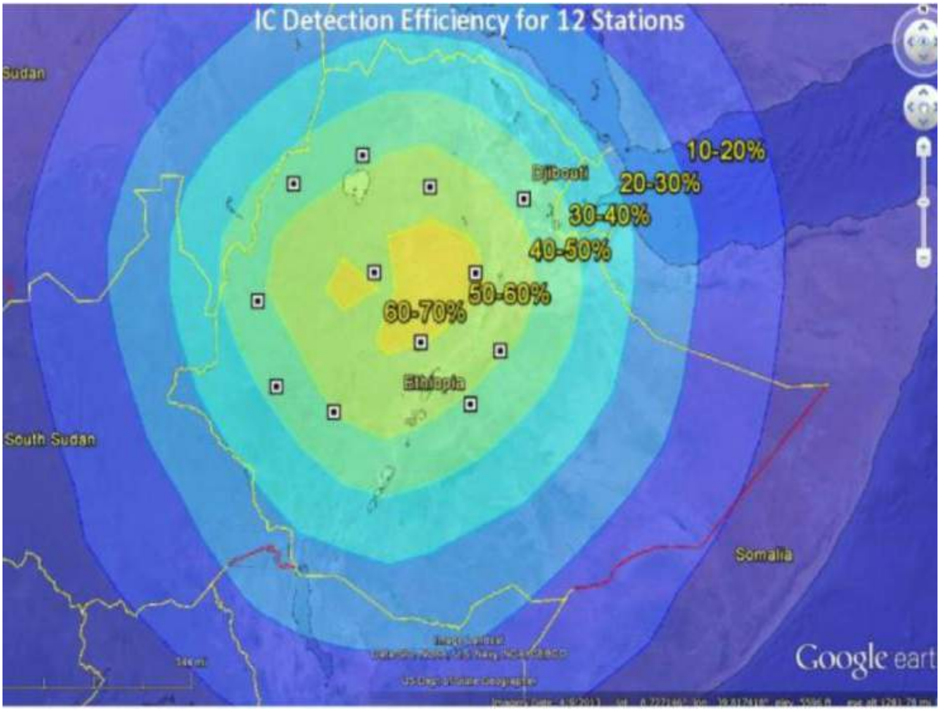


Figure 20. IC Detection Efficiency for 12 Stations (Source: Google Earth)

There are a number of key advantages to the Earth Networks Total Lightning System:

- ✓ The system is the most recently developed and most advanced lightning location technology available in the market today
- ✓ Comprehensive side-by-side comparisons with other available networks demonstrate definitively that Earth Networks Total Lightning System (ENTLS) detects significantly greater numbers of total lightning discharges and flashes due to its high efficiency detection of in-cloud (IC) lightning
- ✓ The detection frequency range is approximately 30 times greater: allowing for more complete total lightning detection (both IC and CG) over a wide geographic area

Pilot Network Location Accuracy: 12 Sensors: The time-of-arrival technique of locating lightning is in principle very accurate (Figure 21). The determination of the peak of the pulse can generally be made with an error of one or a few microseconds, which corresponds to a spatial error of the order of 1 km or less. Errors in travel times caused by differences in propagation paths also cause errors of the order of 1 μs.

For accuracy of more than 75% for IC and 98% CG lightening detection, a sensors location should be located 100km apart. Thus, 30-40 lightening detection stations are needed to cover Ethiopia with lightening detection station networks.

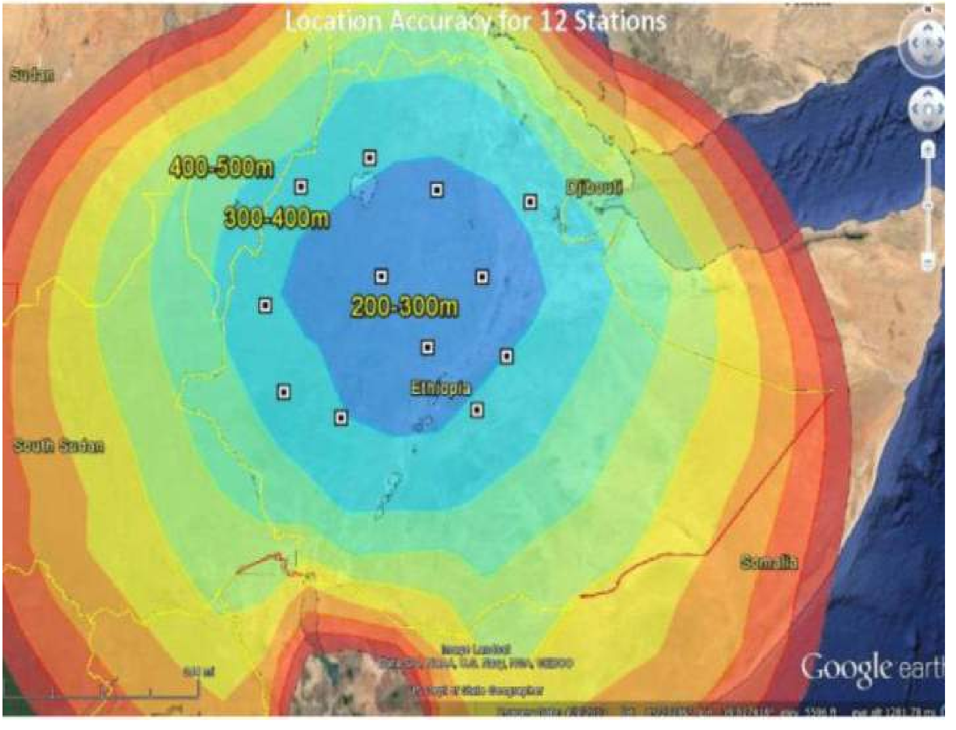


Figure 21. Location Accuracy

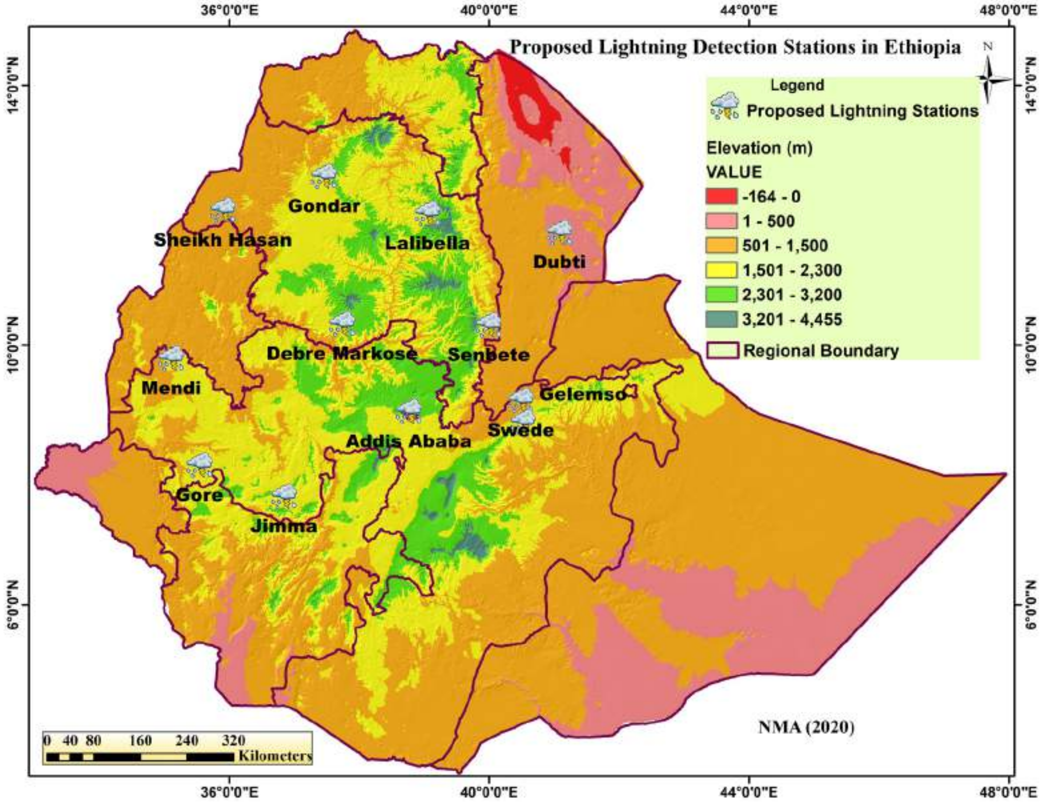


Figure 22. Proposed location of 12 lightening station network for Ethiopia

Some of the applications of lightening detection data in meteorology includes: Early warning on development thunderstorm, locating the storm, microburst prediction, storm identification (tracking), storm intensity quantification and tornado prediction. In Figure 22 Meteorological Station Network Revised Master Plan for lightening Stations.

4.3. Weather Radar

Radar, system or technique for detecting the position, movement, and nature of a remote object by means of radio waves reflected from its surface. Although most radar units use microwave frequencies, the principle of radar is not confined to any particular frequency range. There are some radar units that operate on frequencies well below 100 megahertz (megacycles) and others that operate in the infrared range and above. Moreover, the range of the object is determined by measuring the time it takes for the radar signal to reach the object and return. Radar involves the transmission of pulses of electromagnetic waves by means of a directional antenna; some of the pulses are reflected by objects that intercept them. The object's location with respect to the radar unit is determined from the direction in which the pulse was received. In most radar units the beam of pulses is continuously rotated at constant speed, or it is scanned (swung back and forth) over a sector, also at constant rate. The reflections are picked up by a receiver, processed electronically, and converted into visible form by means of a display screen.

The number of weather radar calculated for the country was adopted from the previous Ethio-Finland project and supported from Ethiopia government proposal. As shown in the Figure 23, NMA has 1 existing Radar station and planned to install 11 Radar stations in the next ten years.

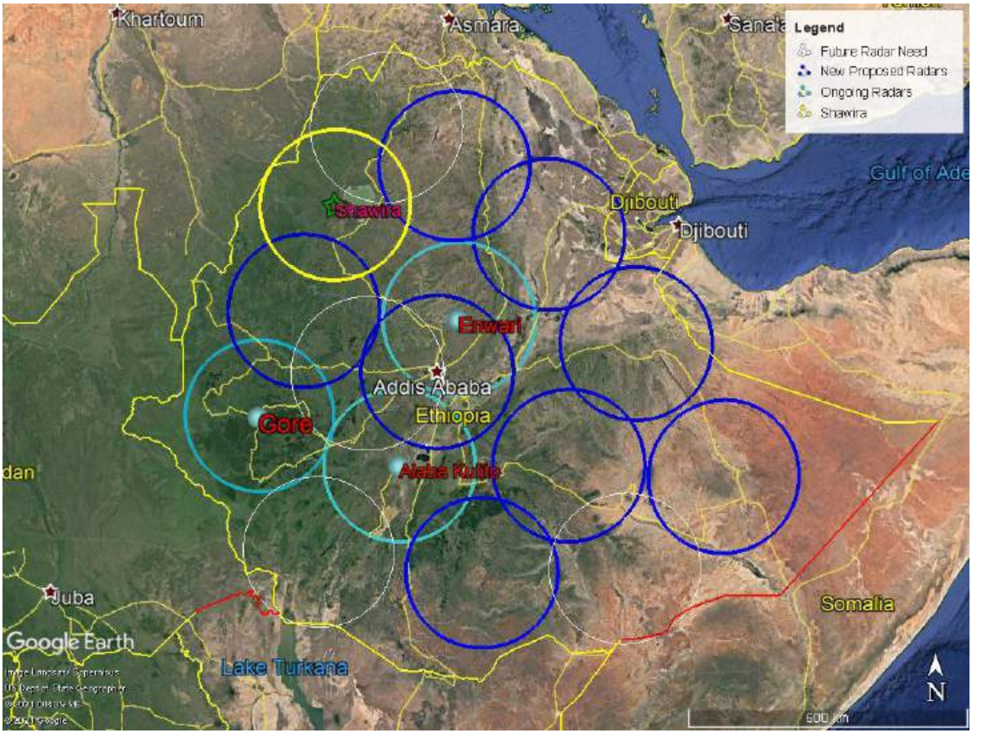


Figure 23. Proposed location of Radar station network for Ethiopia

4.4. Air pollution Monitoring Stations

Air pollution monitoring stations are divided in to two categories which consist of background air pollution stations and ambient air pollution measurement stations. The background air pollution measurement stations provide a base line against which to compare observations from other air pollution stations. Priority should be given to measurements of CO_2, turbidity and dry fall out. Ambient air pollution measurement stations are used to assess the concentration of ambient air pollutants in the troposphere. These include the monitoring of carbon monoxide, Tropospheric ozone, oxides of nitrogen, oxides of sulphur and particulate matter. The monitoring of ambient air requires high sensitivity and time resolution and hence requires high technological capacity. Thus, recently NMA has three air pollution monitoring station in major cities and revised meteorological station network master plan proposed 6 mobile or stationary air pollution monitoring station at national level (Table 13 and Figure 24).

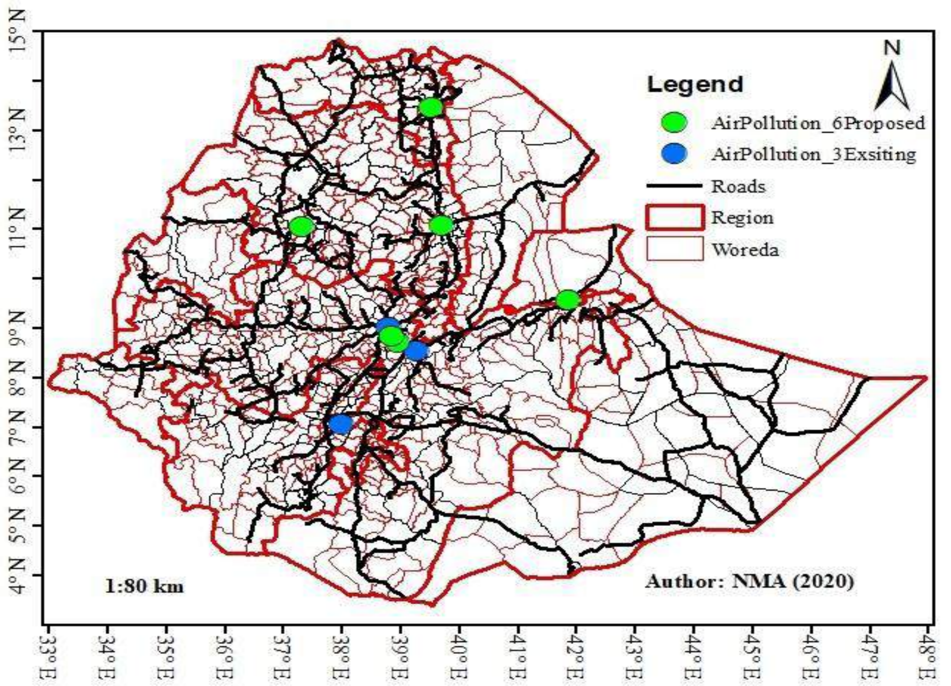


Figure 24. Existiong and proposed Air pollution monitoring station at national level

4.5. GIS Presentation of the Revised Meteorological Station Network Master Plan

Most manned surface stations whether they are categorized as an 3rd class meteorological employ standard rain gauges to measure rainfall amounts. It measuring daily temperature and precipitation, can provide low-cost data for nowcasting and forecast verification if data is reported on a timely basis. For example, for 3rd and 4th class meteorological stations, temperature and precipitation should be measured at least twice a day, once a day, respectively at fixed times that remain unchanged. The revised GIS work on the proposed meteorological station network is based on the analysis of spatial gaps between meteorological stations which is adopted from World Meteorological Organization standard (Table 13 and Figure 25 and 26). Moreover, identifying the Woredas which do not have 3rd and 4th class meteorological stations. However, the actual location will be determined when this master plan is downscaled to the Regional Meteorological Service Drectorates (RMSD).

Table 13. Revised master plan proposal for each class of meteorological Station

Type	Existing	Proposed to be completed before 2029	Total	Remark
4th class stations	283	690	964	* FTC based volunteer
3rd Class stations	735	60	795	Total station needed (795)
1st Class Station	185	-	185	95 Will be proposed by automated station (AWS)
2nd Class Station	17	13	30	
Aeronautical Station	23	6	29	
Upper air station	3	5	8	
Radar	1	11	12	
Air-Pollution Station	3	16	19	10 Air-pollution stations to be installed through Ethio-Filand project over Addis Ababa
Lightening detection& monitoring station	0	12	12	

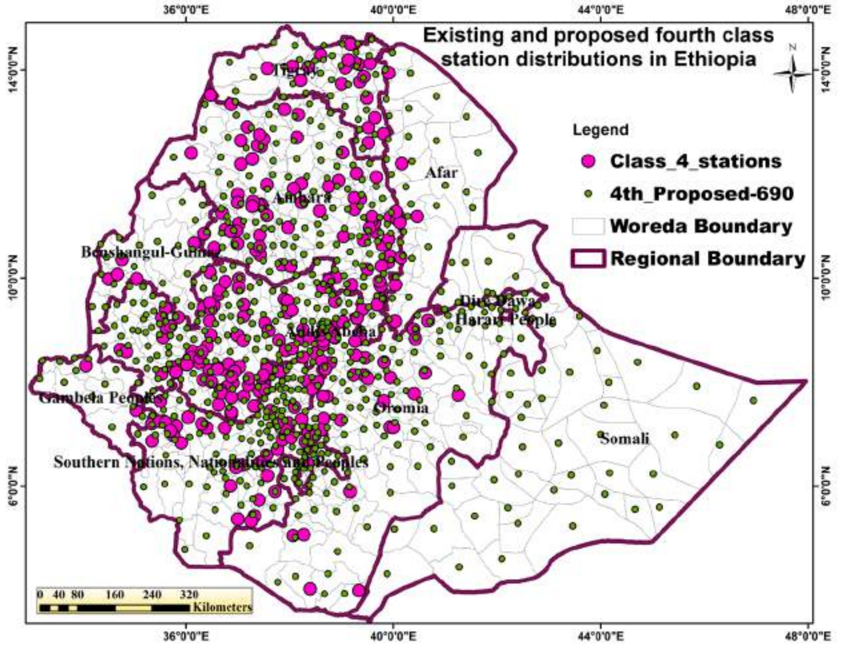


Figure 25. Meteorological Station Network revised master plan existing and proposal for fourth class stations at Woreda level.

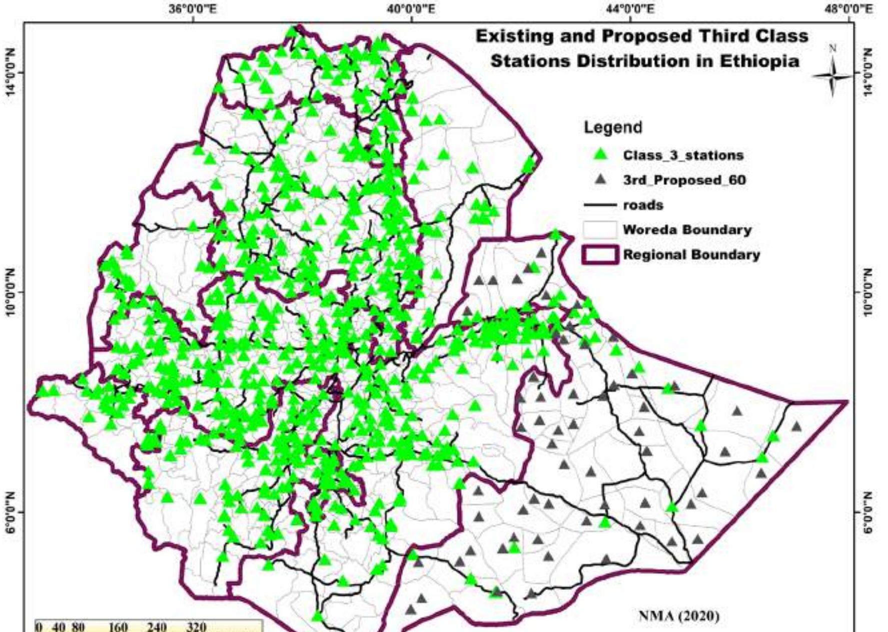


Figure 26. Meteorological Station Network Revised Master Plan Existing and Proposal for Third Class Stations at Woreda level

Internationally it is agreed that every second class station must make observations within three hours interval. However, only few second class stations report every three hours in Ethiopia. Based on WMO standard 13 second class Meteorological station network computed in the revised station master plan (Figure 27).

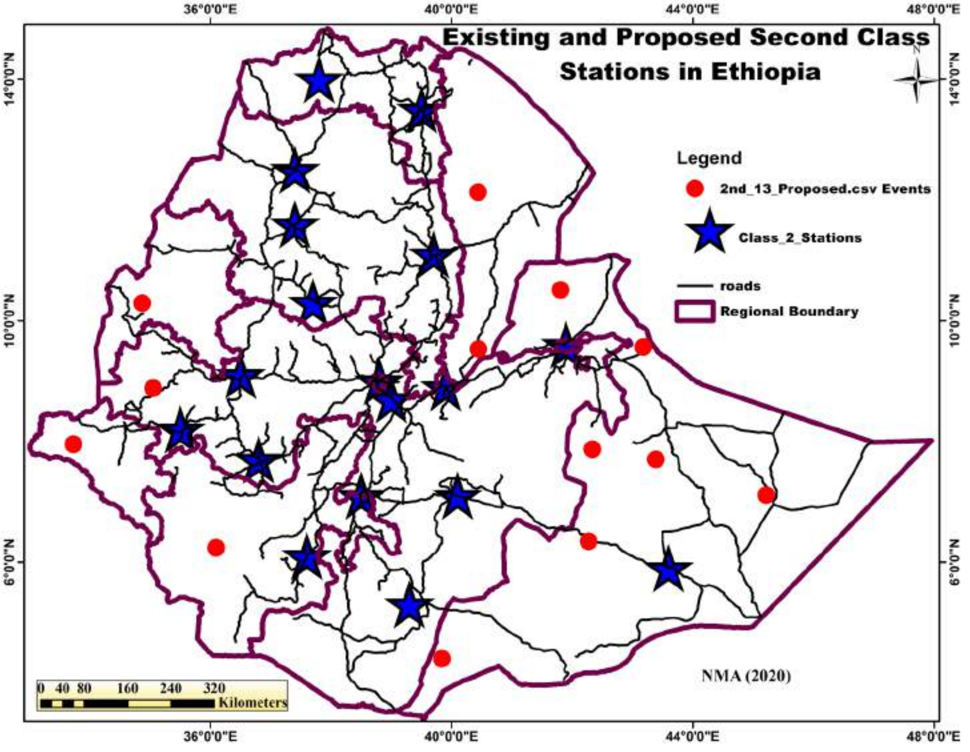


Figure 27. Station Network revised master plan existing and proposal for 2nd class stations

Table 14. Revised master plan proposal for Station Modernization

Type	Existing Stations	Existing 1st Class with AWS	Only AWS Existing	Proposed to be Modern ization	Proposed to be Completed before 2029	Total
1st Class Station	185	99	-	**86**	-	185
AWS	286	-	187	-	**85** (95 first class propose-10 overlay)	-
Total		99	187	**86**	**85**	457

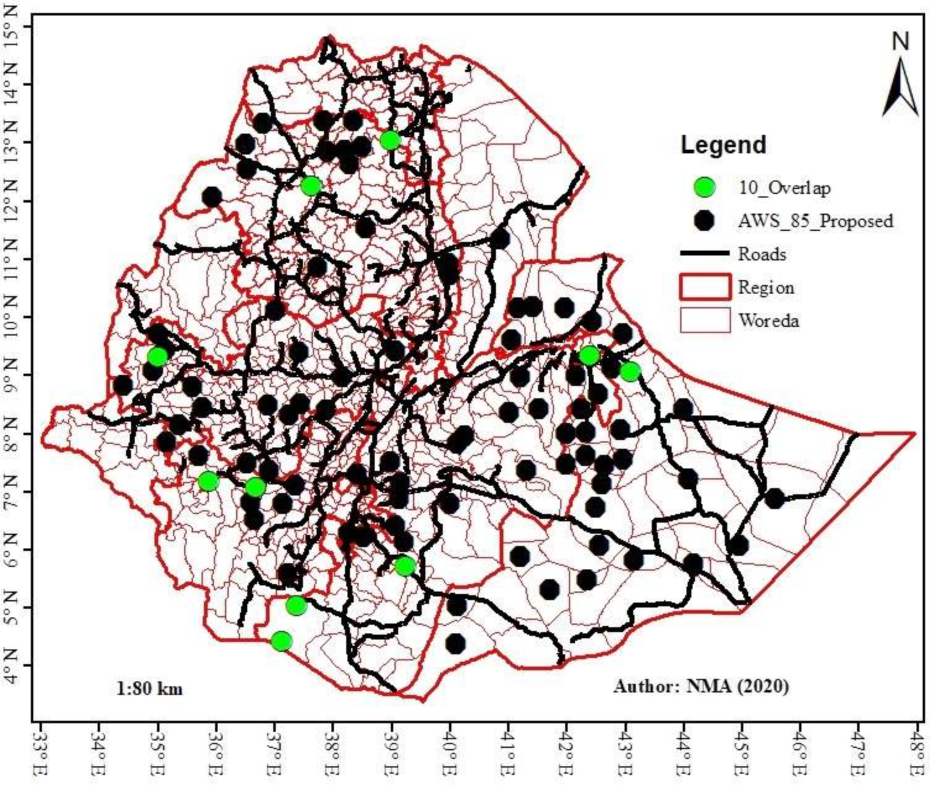


Figure 28. 85 AWS Proposed at national level

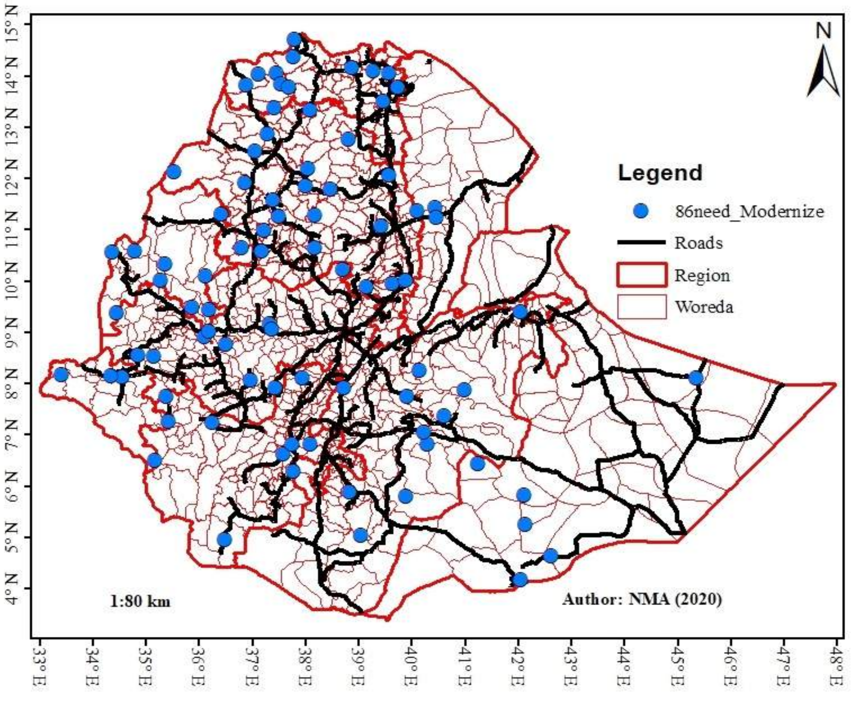


Figure 29. 86 1st class station without AWS and they need modernization at national level

Based on the analysis of spatial gaps between the 1st class meteorological stations need 95 stations and out of these 10 stations overlap with AWS. Moreover, identifying the Woredas only 86 first class stations which do not have Automated Meteorological stations. However, due to many constraints we will not propose conventional stations. Then, modernization is the perfable solution for these constraints and 86 AWS proposed at Woreda level (Table 14 and Figure 28 and 29).

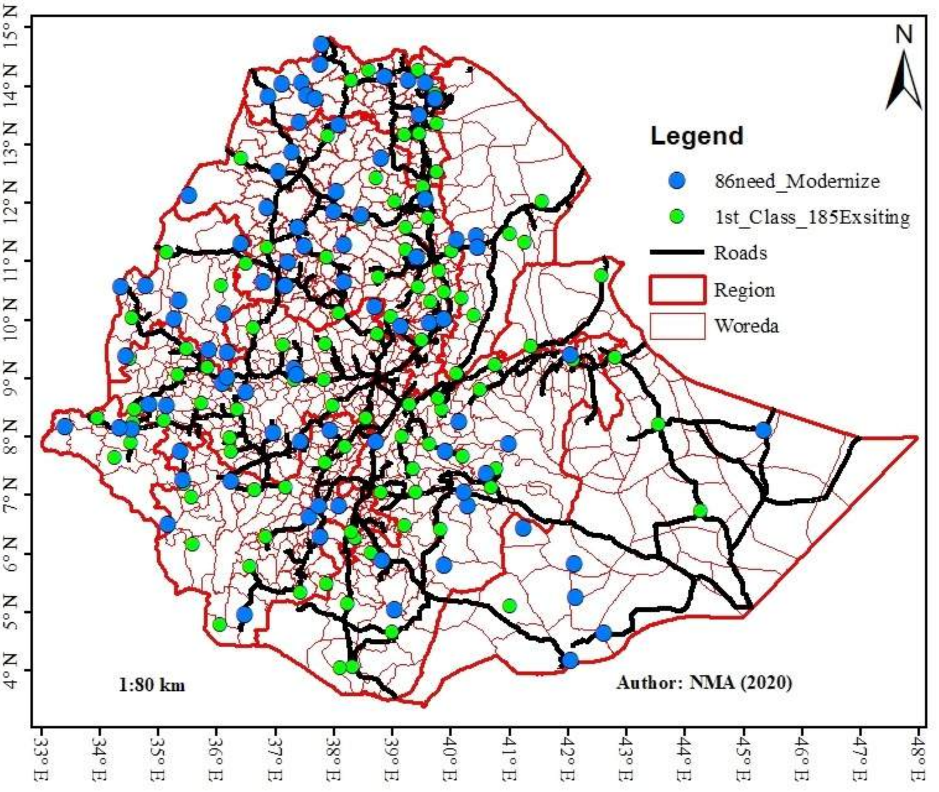


Figure 30. 1st class existing station and 86 stations need modernization at national level

Automatic Weather Stations (AWS): Hourly readings are taken, or alternatively, observations must be made at least 3 times daily, in addition to an hourly tabulation from autographic records. However, the progressive introduction of AWS has made it possible to substantially increase the temporal resolution of the climatic records, reaching 15-minute sampling. It is recommended to store these higher-resolution records in the climatological database.

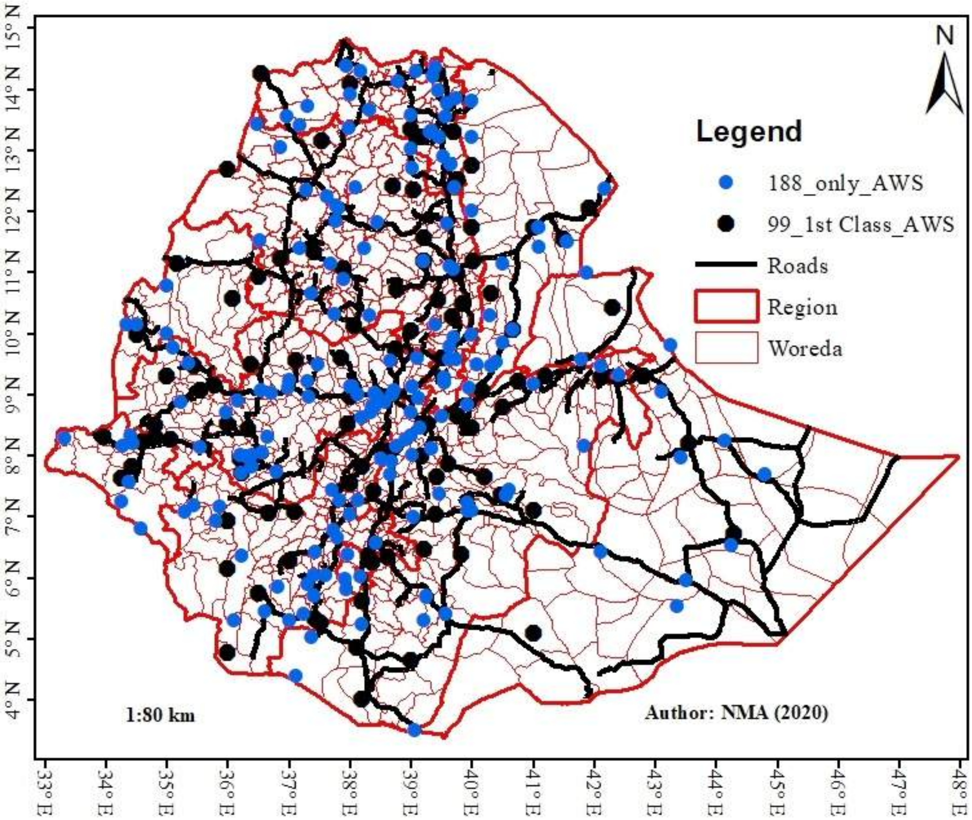


Figure 31. Existing 99 AWS with 1st class station and 188 AWS with out 1st class station

The data quality software should provide a list of suspected data, but final decisions on correction or updating of the digital file should rest on the competent climatological service personnel. However, given the increases in data available to NMA high resolution data from AWS and personnel restrictions, automatic quality checking may be the only option for some future data. Thus, NMA has 99 AWS with first class station on the same geographic location and 188 existions AWS at Woreda level (Figue 31 and 32).

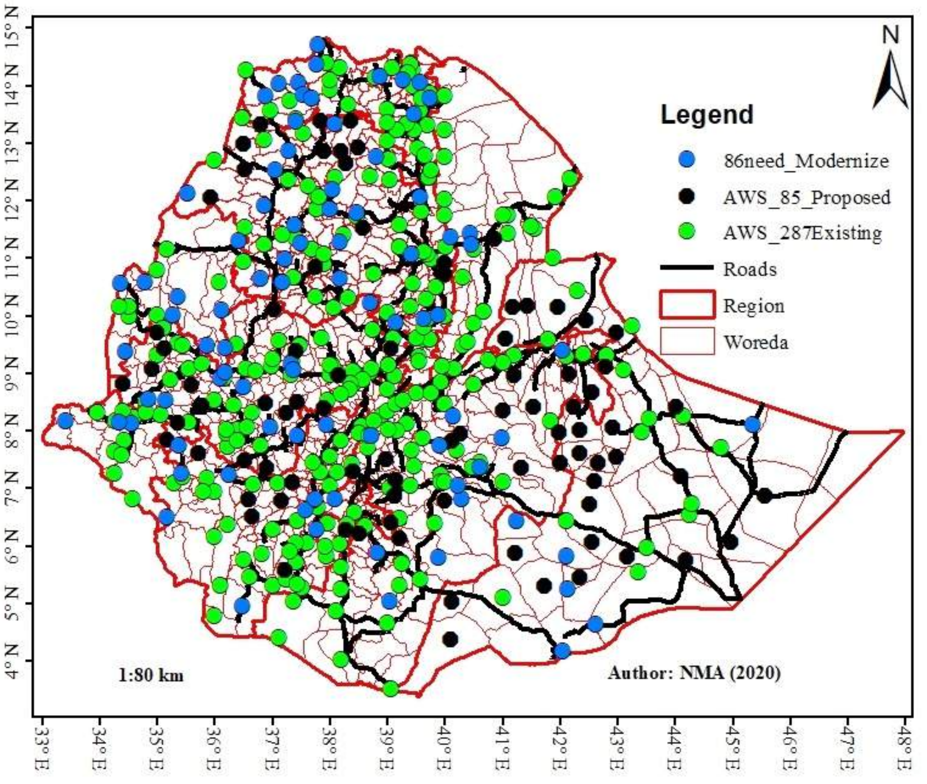


Figure 32. 86 stations need modernization, 85 Proposed and AWS existing at Woreda level

Aeronautical Meteorological Station: the need for representative measurements arises largely because:

A. One usually cannot measure atmospheric parameters at exactly those places where they affect the aircraft, i.e., at or over the runway; and

B. Even if one could, it would normally be impossible to carry out measurements on a sufficiently dense scale so as to obtain an accurate picture of atmospheric conditions over the whole runway or runway complex

As requirements for representative measurements depend to a considerable extent on types of aircraft and operations, close cooperation with operators will usually solve these problems. Frequently, it is the operators (i.e., pilots) who are the first to notice if measurements are not representative, and they should be encouraged to report such cases. While the question of representative measurements has a temporal as well as a spatial aspect, only the latter will be considered here, although the two are sometimes interconnected. For example, it has been shown that the degree of roughness of the terrain between the location of an anemometer and the runway may affect the optimum averaging period to be used for wind observations.

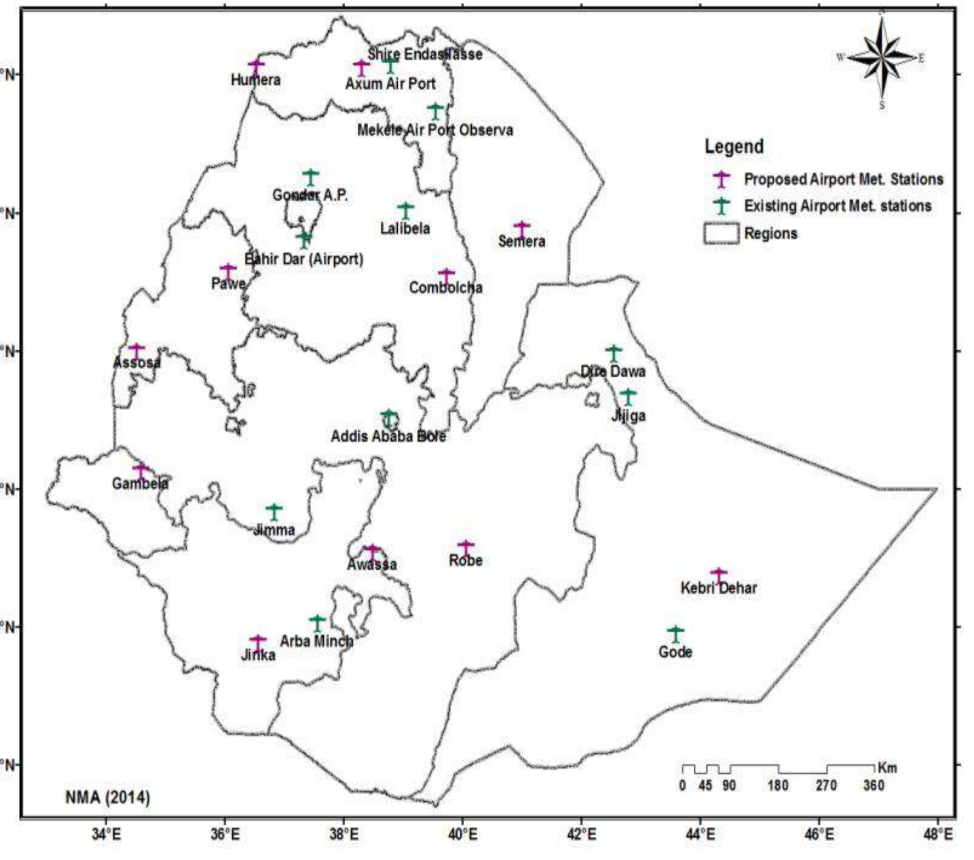


Figure 33. Existing and proposed Airport Met stations at national level

Spatial representativeness has a vertical and a horizontal aspect, and the two will be considered separately in the following paragraphs. The vertical aspect is partly connected with the need to provide measurements of conditions at a level or levels above the runway surface of particular relevance to aircraft landing or taking off (e.g., height of jet intake); in addition, there is the need to avoid effects of the ground and of obstacles which may influence the height at which measurements are being taken. As shown in Figure 6, the horizontal aspects are those which determine the number and location of instruments so as to provide satisfactory information on meteorological conditions for all operations at the airport, irrespective of its size or terrain configuration. Therefore, Aeronautical meteorological stations shall be established at aerodromes and other points of significance to international air navigation (Figure 33).

Upper_Air Meteorological Stations: National Meteorological Agency is presently functioning upper air observation stations at Addis Ababa head office, Mekele observatory and Negelle synoptic station. Based on WMO standard 5 more upper air stations are needed and the computed stations are proposed in this master plan.

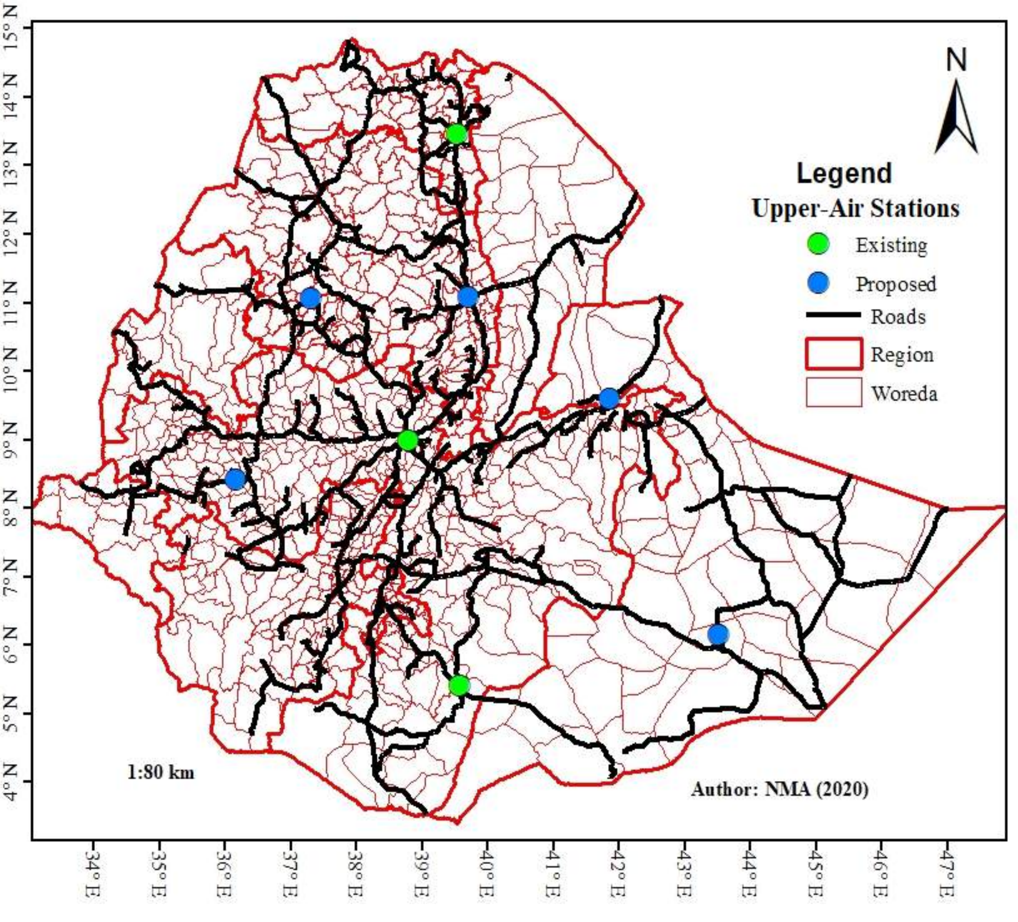


Figure 34. Existing and proposed Upper_Air stations at national level

5 IMPLEMENTATION PLAN

The schedule of the revised meteorological master plan implementation will work for the comming ten years (2020-2029) (Table 15).

Table 15. Schedule for the implementation of station master plan

Station type	Existing	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Proposed Station	Total Station	Remark
4th Class	283	77	77	77	77	77	77	77	77	74	-	690	973	Volunteers (FTC)
3rd Class	735	8	8	8	8	8	8	7	7	7	-	69	804	At Woreda
1st Class	185	-	-	-	-	-	-	-	-	-	-	-	185	
Synoptic	17	1	3	2	1	2	1	1	1	1	-	13	30	At Woreda
AWS	287	19	19	19	19	19	19	19	19	19	-	171	458	Automated
Aviation	23	1	-	1	-	1	1	-	1	1	-	6	29	As per airport Development plan
Air pollution monitoring	3	1	1		1	1		1		1	-	6	9	
Lightening	0	1	2	2	1	2	1	1	1	1	-	12	12	
Weather Radar	1	1	2	2	3	3	-	-	-	-	-	11	12	
Upper Air	3	1	-	1	-	1	-	1	1	-	-	5	8	

6 ANNEX

6.1. Annex I: List of Existing and Proposed Meteorological Stations

Existing 1st class stations

Abobo	Beltu	Errer	Kachise	Moyale	Sirinka
Abomsa	Billate	Fiche	Kamash	Mygaba	Tekeze
Adele	Bore	Filtu	Kebridehar	Myseberi	Teppi
Adet	Buie	Fugnido	Keffa Bonga	Mywoini	Tercha
Adigrat	Bullen	Gam_Airport	Ketema Nigus	Nazereth	Tisiska
Adwa	Bure	Gambella	Kibre Mengist	Nebelet	Tongo
Alem Teferi	Burji	Gashamo	Kofale	Nedjo	Turmi
Alemketema	Chagni	Gatira	Kombolcha	Nefasemewecha	Wachile
Alge	Cheffa	Gelemso	Konso	Nura Era	Wegel Tena
Aman	Chercher	Gidayna	Korarit	Omorate	Werabe
Ambamariam	Chewaka	Gimbi	Kulumsa	Pawe	Werielu
Ambo	Chira	Ginner	Kumruk	Quara (Gelego)	Wolaita Sodo
Amedework	Dama	Gnignang	Lalibella	Sahalu	Woliso
Ameya	Dana-1	Goben	Lare	Samere	Wombera
Arjo	Dangila	Gololcha	Lay_Birr	Sanja	Worka
Arsi Robe	Debark	Guhala	Limu Genet	Sawla	Yabelo
Assossa	Debidolo_ airport	Gundomeskel	Maichew	Sekela	Yasso
Atsbi	Debre Birhan	Hagere Mariam	Majete	Sekoru	Yetenora
Ayehu	Debre Tabor	Haragelle	Maji	Senkata	Zeway
Ayira	Debre Work	Haramaya	Mankush	Seru	Abala
Aykel	Dedebit	Harar	Masha	Shahura	Assaita
Aysha	Dedessa	Hossana	Medewolabo	Shambu	Awash areba
Badme	Degahabour	Humer Airport	Mega	Shebel	Chifra
Bahir dar (syn)	Dello Mena	Humera	Mehal-Meda	Sherkole	Dalifagi
Bahir Dar New	Dembidolo	Hunte	Meiso	Shiraro	Dubti
Bale chekata	Dilla	Ijaji	Mekaneselam	Shire	Elidar

Bare	Dima	Iliadura	Mekele Observa	Shola Gebeya	Gewane
Bati	Dolo oddo	Ime	Meraro	Showa robit	Gulina
Bedelle	Elkarre	Jarra	Metema	Simada	Mille
Begi	Emdibir	Jijiga	Mirab Abaya	Sinana	Semera
Belogiganfoye	Enewari	Jinka	Motta	Sirbaaby	

First Class stations need modernization

Adet	Chifra	Gnignang	Kibre Mengist	Nebelet	Simada
Adwa	Dana-1	Goben	Kombolcha	Nefasemewecha	Sinana
Alem Teferi	Debidolo_ airport	Gololcha	Korarit	Pawe	Sirbaaby
Arjo	Debre Tabor	Guhala	Kumruk	Quara (Gelego)	Teppi
Atsbi	Debre Work	Gulina	Lay_Birr	Sahalu	Tisiska
Ayehu	Dedebit	Gundomeskel	Limu Genet	Sanja	Tongo
Aykel	Dedessa	Haragelle	Masha	Sekela	Turmi
Badme	Dima	Haramaya	Medewolabo	Sekoru	Wolaita Sodo
Bahir dar (syn)	Dolo oddo	Humer Airport	Mekele Observatory	Senkata	Wombera
Bale chekata	Dubti	Ejaji	Mille	Shahura	Yasso
Bare	Elkarre	Iliadura	Mirab Abaya	Sherkole	Zeway
Belogiganfoye	Emdibir	Ime	Moyale	Shiraro	
Beltu	Enewari	Kamash	Mygaba	Shola Gebeya	
Billate	Gam_Airport	Keffa Bonga	Myseberi	Showa robit	

2nd Class Stations Existing and Proposed

Existing		**Proposed**
Addis Ababa Bole	Mekele	DaleWebera
Arba_Minch	Metehara	Tembaro
Awassa	Negelle	Amibara
Bahir dar (Airport)	Nekemte	Awra
Bale robe		Jore
Combolcha		Menge

Debre Zeit (AF)		Jigjiga
Debre_Markos		Degehabure
Dire_Dawa		Gunagado
Gode		Kebridehar
Gonder		Elkere
Gore		Fik
Jimma		Shinile

3rd Class Stations Existing

Abadi	Beleobereda	Diksis	Guguftu	Koyi	Seriel
Abasinajoger	Bengwa	Dilybza	Gulina	kuch	Seyo
Abaya	Bensadaye	Dimbong	Guliso	Kulish	Shamena
Abaye Ater	Berdimtu	Dimeka	Gumaide	Kulla	Shanto
Abebekeranso	Berhale	Dimma	Gumba	Kulmesk	Shashemen
Abiadi	Betnigus/ ywoinit	Dimma	Guna Abajama	Kulubi	Shebe
Abissa	Beto	Dimtu	Gunchire	Kumame	Sheno
Abol	Bichena	Dinsa	Gunde woin	Kumi	Sherkole
Abomiriga	Bidere	Dinsho	Gundil	Kuneba	Shindi
Abrhajira	Bidu	Dippa	Gunjo Mariam	Kuni	Shishinda
Adaar	Bilambilo	Dire gideb	Gununo	Kurfachale	Shobe
Adaba	Billate tena	Dire guda	Guroro	Kutaber	Shoga
Adadele	Bilumkun	Dire Shek Hussen	Gursum	Kuy	Shone
Adaytu	Bisidimo	Dodola	Guten	Lalo_kile	Siadebir
Adet	Bitata	DoyoAweso	Guyi	Lange	Sibo
Addis alem	Bitta Genet	Doyogena	Habe	Laske	Sibu sire
Addis kidam	Bizet	Dubluk	Hadero	Lefeisa	Sigmo
Addis zemen	Bodity	Dulshetalo	Hadew	Leku	Sikohumbi
AddisAlem	Bokoksa	Duna/ansho/	Hagereselam	Leman	Siltena
Adiarkay	Bombe	Durame	Hagereselam	Lemi	sireba
Adiawala	Bonaya	Durbete	Haik	Liben	Sirofta
Adidaeroo	Boneya	Dushi	Haisawita	Lokabaya (Hantate)	Sobeya
Adigala	Bonga	E/rebui	Hakimegara	Luguama	Sodere
Adigoshu	Boqolmayo	Ebentu	Halale	Lumamme	Sofomor
Adigudom	Boreda	Ebinat	Halelo	M/jebedu	Soka
Adihageray	Boreka	Effesson/Ataye/	Hamentile	Maihans	Somodo
Adikeyih	Borra/chelena	Ego	Hamusit	Maksegnit	Soretefasese
Adikilte	Borumeda	Ego	Hana	Manda	Soroqa

Adimehameday	BotarBacho	Eguganti	Hara	Mandura	Sululta
Adiremets	Boto	Ehud Gebeya	Harar	Mankusa	Supe
Aditsetser	Bule	Ehudit	Harato	Matchara	Talalak
Afambo	Bulki Mender	Ejere	Harbu	Mechara	Tedecha Bela
Afdem	Bure	Ejeresagoro	Haretishke	Megale	Teferibere
Afdera	Bure	Eliwuha	Haro	Megebit -28	Teferikela
Agalo	Burka	Embabo	Haro	Megue	Tefki
Agarfa	Busa	Enango	Harokelo	Mehoni	Tegdie(Kirakir)
Agaro	Butajira	Endabaguna	Harokemisse	Meka/derk abay	Tegni
Agbe	Chacha	Endegagne	Harqumbe	Mekaneyesus	Tejo
Agere genet	Chagel	Endifo	Harshin	Mekela	Telage
Ahuntegne	Chancho	Endris	Harsis	Meki	TelamoKentise
Aje	Chanchok	Endulu	Harwacha	Meko	Teltele
Akaki	Chandiba	Enfranz	Hasen Usuman	Melekoza	Terkodi
Akesta	Chanka	Enticho	Hawzen	Meliyou-Burka	Terta
Ako	Chefedonsa	Erebti	Hena	Melka Amanna	Teru
Alabakulito	Cheffa Robit	Esara	Hidi sokoke/ Hamus	Melka Odda	Ticho
Alaltu	Chelelektu	Estayish	Hidilola	Melkajilo	Tikur Inchini
Alamata	Chelenko	Ewa	Hirna 3RD	Melkasedi	Tilili
Alem Tena	Chenbe	Fadis	Hiwane	Mendi	Timuga
Aletawondo	Chencha	Fafen	Holota	Mendida	Tinshu_meti
Alga	Chenenek	Famatser	Homi	Merawi	Tita
Ali	Cheretti	Fasilides (Korie)	Homosha	Merhsenay	Tocha
Alibo	Chew Ber	Fatsi	Horo aleltu	Mersa	Togochale
Aliyu Amba	Chibo_V 7	Felege Berhan	Hurso	Merto Lemariam	Toyiba
Alle	Chicha chugi	Fenoteselam	Hurumu	Meskel Dirkina	Tsige
Amanual	Chiche	Feres Bet	Huruta	Mete Bila	Tulubolo
Amarokele	Chida	Fersmay	Huse	Metehar	Tulugulede
Amba 16	Chilla	Filiklik	Inchini	Meteka	Tume
Ambagiorgis	Chinakeson	Fincha	Indeto	Metema Yohannes	Uka
Amebo meda	Choche	Fiseha Genet	Intoto	Metu Hospital	Uke
Amed Ber	Chole	Fital	Itang	Midigalola	Ukuna
Ameyagindo	Chora	Fonko	Jaja	MizanTeferi	Vilage_11
Anbesamie	Chuko	FugoLeka	Jaju	Mojo	Vilage_13
Angacha	Combolcha	Fursi	Jama-Degolo	Molale	Wadera
Anger meti	Dabat	Galafi	Jangir	Morka	Waja
Angetu	Dader	Galasha	Jara	Morsito/ Misha/	Wajifo

Anno	Daerohafash	GarbaGuracha	Jarso	Mudula	Wama agalo
Arabi	Dalati	Gashena	Jeldu	Muger	Wanzaye
Ararty	Dalocha	Gassachere	Jeledasa	Mugi	War
Arata	Daramalo	Gato	Jiga	Mugulat	Water
Arbaya	Darba	Gazer	Jihur	Muklemi	Wayu
Arbegebeya	Daremu	Gebate	Jikawo	Multeta Diga	Wegedade
Arbegona	Darian	Gebre Chiristos	Jima horo	Nashe	Wejigra
Arbgebeya(Gaint)	Daroor	Gecha	K/Abokere	Natri	Welenchiti
Arda Tare	Dawe	Gechi	K_Gebya	Negadebaher	Welkite
Areka	Dawele	Gedamaitu	Kabie	Negele Singalo	Werajiru
Arekit	Dawunt/chet/	Gedeb	Kafta	Nolekaba	Werancha
Argoba(Gachine)	Debeko	Gedo	Kako	Nopa	Wetetabay
Aroresa	Debele	Gelaeso	Kaliti	Nunukmba	Wetete (TP)
Arsi Sire	Debele	Gelebeda	Kamba	Nyaa	Wodesemro
Artuma	Debena	Gelila	Karagora	Odabildgilu	wogdi
Asebe teferi	Debre Elias	Gelila	Karamile	Oddo Shakiso	Wogrie
Aseko	Debrekerb	Gena Bossa	Kawakoato/ Alicho/	Ogelcho	Wojed
Asgori	Debretsige	Genale Donta	Kebe	Omo_Nada	Woldia
Ashe	Debrezebit	Gera	Keberibaya	Onga	wolhe
Ashere(Angerb)	Debrezeit	Geramba-Dima	Kechema	Puchala	Worebabo
Assela	Debrezeit	Gerese	Kelala	Pukedi	Woreta
Assendabo	Debus atinbako	Gesera	Kemisse	Pukumo	Wuchale
Asteryo(konter)	Dedo	Gesha(Gecha)	Kemisse	Qoma fasiledes	Wukro
Atnago	Defo	Gesuba	Kercha	Qosh-mengel	Wulberg
Awash 7	Degaga	Gewada	Keresa	Quarit	Wushwush
Awash shelko	Degan	Gidami	Ketemnigus	Qunzila	Yadota
Awera GebYa	Degena	Gidole	Ketera Genet	R_Gebya	Yallo
Awura	Deilb	Gijet	Kewzeba	Rama	Yayaotana
Axum	Dejen	Gilgelbeles	Keyafer	Raya	Yayo (Dorani)
Ayele	Dekestifanos	Gimijabet	Kidamaja	Rebu Gebeya	Yebu
Ayer Tena	Delo Sebro	Ginager	Kiltu Kara	Rema	Yeduha
Azena	Dembecha	Ginchi	Kimoye	Rira	Yeha
Babile	Dembel	Girawa	Kirara	Robit	Yejube
Babo	Dembi	Gishe Rabel	Kiremu	Sagure	Yemello
Badeno	Demebel	Gizen	Koben	Saja (Saja School)	Yeri
Badme	Denegego	Goba	Kobo	Sanka	Yeshila
Baeker	Dengayber	Gobe	Kobor	Sankura	Yetemen
Bagie (Sentu)	Dengelber	Gobeyer	kocher	Sarmider	Yifag

Bako Tibe	Dengolat	Gog	Koka Dam	Sayint Adjibar	Yirbamuda
Bale Gardual	Dengoro	GogaKemise	Kokir Gedebano	Sebata	Yirgachefe
Bambasi	DeriGoma	Gohatson	Kokossa	Seka	Yirgalem
Bantu liban	Dertu Liben	Gojeb	Koladiba	Sekota	Yubdo
Baro_bonga	Dessie	Gombora	koloseri	Sekota Silassie	Zada
Becho	Detbahiri	Gorfo	Kombolcha	Seladingay	Zalanbesa
Bedesa	Dewe	Goro	kone	Selekleka	Zata
Bedessa	Dewero	Goromuti	Kone	Selka	Zbangedena
Behima	Dewhan	Gubeti	Kora	Selsa	Zegie
Beka	Dibate	Gublack	Korem	Semema	Zemero
Bele	Dichoto	Guder	Korojo	Senbetie	Zenbaba
Bele	Dido_ gordumo	Gudo Beret	Koshimando	serbo	Zigem
Belela	Diguatsion	Guguba	Kosober	Serdo	Zobil
Bokaso	Gassay	Gorgora	Kolfe Keranio	Mekanebrihan	Edaga Selus

3rd Class Stations Proposed

Chereti/Weyib	Dolo Odo	Gerbo	Kebridehar	Serer/Elkere
Chereti/Weyib	Dolobay	Gode	Kebridehar	Shekosh
Danot	East Imi	Goro Baqaqsa	Kelafo	Shilabo
Danot	East Imi	Gunagado	Lagahida	Shilabo
Debeweyin	Erer	Guradamole	Meyumuluka	Shinile
Degehabur	Ferfer	Gursum	Miesso	Shinile
Degehabur	Fik	Hamero	Moyale	Warder
Degehamedo	Filtu	Hareshen	Moyale	Warder
Dembel	Filtu	Hargele	Mustahil	West Imi
Denan	Gashamo	Hudet	Segeg	
Dihun	Gashamo	Jijiga	Selahad	
Dolo Odo	Geladin	Kebribeyah	Serer/Elkere	

4th Class Stations Existing

Abajara	Bido	Dinke	Hamusit/dera	Lote	Teji
Abdela	Bikilal	Dobi	Hana dikay	M_Lencha	Tenta
Abelti	Bilo Boshe	Dorebafena	Hardim	Maikinetal	Tikil dingay
Abisyina school	Bita Woshi	Dorobora	Haro	Maligawa	Toba

Abramo	Bofa	Dorze	Haro doyo	Marhuna	Toga
Abuna gindeberet	Boku	Doyotiro	Hashenge	Mayokote	Toke Irenso
Adigebru	Bologiorgis	Dugum	Hitsats	Mechare	Tora
Adigoshu	Boneya	Edaga Arbi	Homa	Med.Alem School	Tsigereda
Adilo	Bonosha	Ejere	Homa	Melaneha	Tuka
Adukuwa	Bontu	Ejersalele	Hombole	Mengash	Tula
Agalometi	Bulbul	Elike	Humbe	Menge	Urana
Albuco	Bulbula	Enjibara	Humbo Tebela	Menta wuha	Waâ€™ama
Amba 10	Burau	Erbore	Ifa biya	Meshenti	Wabirr
Ambuye	Burka	Ermich	Itaya	Meteso	WachaMaji
Amuru	Busa	Fagita	Jarmet	Mezezo	Wadeyesus
AnboWeha	Chara	Fendika	Jewha	ModyoGombora	Wankey
Andasa	Cheka	Fetra	JirenAbajifar	Morocho	Weranso
Andode	Cheleleki	Fide	Kara Kore	Mugechit	Woito
Aneded (Amber)	Chena	Figakobera	Kebado	Muja	Wojel
Anger shenkora	Chewbet	Finchwuha	Kelem	Muja	Woku
Ankober	Chila	Fofa	Kello	Muketuri	Wolalabaher
Aposto	Chimba	Gachino	Kemisse	NefesGebeya-2	Wolenkomi
Arba bordede	Chiroleva	Gedebye	Keranio	Nefesgebya-4	Wondo Genet
Arbe gebeya	Chitu	Gembe	Kerise	Rike	Work Amba
Arbgebeya (dera)	Chobi	Genetabo	Kersa	Rob gebeya	Wrhat
Arbuchulule	chokorsa (sombo)	Genetie	Kesem kebena	Robe High School	Wukromaray
Arfide	Dabo Ketema	Genji	Kessa	Robe Tiinic	Yambero
Arguba	Dadim	Genji	Kibet	Ruga	Yanfa
Asahara	Dame	Gerba	Kimbaba	sadafa	Yechereka
Asebot	Dana-2	Geregera	Kimir dingay	Sallega-22	Yekatit23 school
Asgede	Dansha	Gerhusirnay	Kokofe	Sassiga	Yeki
Asketema	Debaso	Getema	Kolashele	Sebader	Yekuassa
Askuna	Debre Sina	Getemate nakela	Kolme	Sebasebat (77)	Yembo
Awashme lkakunture	Debub	Gibe Farm	KoraMariam	Sedika	Yigem
Awassa Tabor	Dedessa river	Gimbi Bila	Koremesh	Segno Gebeya	Yina
Aynalem	Dega	Gimbichu	Koshe	Sero	Yirba Dubancho

Babu	Degem	Gishen	Kotobe TTC	Setema	Yismala
Bachuma	Delbo	Gobegob	Kotobe(luke)	Shedatura	Zenzelimma
Badesa	Delgi	Gobyie	Kotu	Shembekit	Zequala
Baro (Yaya-Hurum)	Deneba	Gore Stadium	Kumbi	Shewa Bench	Zigeh
Bechi	Derara	Goshmeda	Kura	Shinshicho	Zonga
Befolo gebreal	Deri(K / Gebeya)	Guba	Kureberet	Shukute	
Beleti	Dib bahir	Gubre	Kuyera	Suten	
Benben	Digdiga	GuraFerda (Biftu	Lewaye	Tebasit	
Benja	Dilalla	Gurenda Meta	Lilo Gurate	Teda	
Bera	Dilbi	Hamdidesa	LimuSeka	Teferiberhan	

4th Class Stations Proposed

Ababo	Bibugn	Dila Zuria	Gumay	Lare	Seden Sodo
Abala	Bidu	Dillo	Gumer	Lasta	Segeg
Abay Chomen	Bila Seyo	Dima	Guna	Lay Armacho	Seka Chekorsa
Abaya	Bilidigilu	Dinsho	Gunagado	Lay Gayint	Sekela
Abe Dongoro	Bilo Nopha	Dire	Gura Damole	Legambo	Sekoru
Abergele	Bio Jiganifado	Dire Dawa	Guradamole	Lege Hida	Sekota
Abeshege	Bita	Dire Dawa/ Town	Gurafereda	Legehida	Selahad
Abichuna Gne'a	Boh	Dita	Gursum	Leka Dulecha	Selamgo
Abobo	Boji Chekorsa	Doba	Gursum	Liben	Selti
Abuna G/ Beret	Boji Dirmeji	Dodola	Guto Gida	Liben Chukala	Semen Achefer
Ada'a	Boke	Dodota	Guzamn	Libo Kemkem	Semen Bench
Adaa'r	Bole	Dolo Odo	Habro	Lideta	Senan
Adaba	Boloso Bombe	Dolobay	Habru	Limu	Serer/Elkere

Adadle	Boloso sore	Dorani	Hadelela	Limu	Seru
Adama	Bona Zuria	Doya Gena	Hadero Tubito	Limu Bilbilo	Setema
Adami Tulu Jido Kombolcha	Boneya Boshe	Dubti	Hagere Mariam	Limu Kosa	Seweyna
Adda Berga	Bonke	Dugda	Halu	Limu Seka	Shalla
Addi Arekay	Bora	Dugda Dawa	Hambela Wamena	Loka Abaya	Shashemene Zuria
Addis Ketema	Bore	Dulecha	Hamer	Loma Bosa	Shashogo
Adola	Borecha	Dune	Hamero	Lome	Shay Bench
Adwa	Boreda	East Belesa	Harar	Lude Hitosa	Shebe Dino
Afambo	Boricha	East Esite	Harena Buluk	Maji	Shebe Sambo
Afdem	Boset	East Imi	Hareshen	Male	Shebel Bereta
Afder	Bugna	Ebenat	Hargele	Malga	Sheka
Afdera	Bule	Eferatana Gidem	Haro Limu	Malka Balo	Shekosh
Afele Kola	Bule Hora	Ejere	Haro Maya	Mana Sibu	Sherkole
Agalometi	Bulen	Elidar	Haru	Mandura	Shilabo
Agarfa	Bure	Enarj Enawga	Hawa Galan	Maokomo Special	Shinile
Ahferom	Bure	Enbise Sar Midir	Hawi Gudina	Mareka	Shirka
Akaki	Bure Mudaytu	Endamehoni	Hawzen	Mareko	Sibu Sire
Akaki - Kalit	Burji	Enderta	Hidabu Abote	Masha	Sigmo
Akobo	Bursa	Endiguagn	Hintalo Wejirat	Mecha	Simada
Alaba	Cheha	Enemay	Hitosa	Meda Welabu	Simurobi Gele'alo
Alaje	Cheliya	Enemorina Eaner	Homa	Medebay Zana	Sinana

Alamata	Chena	Ensaro	Homosha	Megale	Siraro
Albuko	Chencha	Erebti	Horo	Mehal Sayint	Sirba Abay
Ale	Chereti/ Weyib	Erer	Hudet	Mekdela	Sire
Aleltu	Cheta	Erob	Hulet Ej Enese	Meket	Siya Debirna Wayu
Alem Gena	Chifra	Esira	Hulla	Meko	Sodo
Aleta Wendo	Chilga	Ewa	Humbo	Melekoza	Sodo Daci
Alfa	Chinaksen	Ezha	Hurumu	Melka Soda	Sodo Zuria
Alge Sachi	Chire	Fagta Lakoma	Ibantu	Mena	Soro
Alicho Woriro	Chiro Zuria	Farta	Ifata	Mena	Sude
Alle	Chole	Fedis	Ilu	Menge	Sululta
Amaro	Chora	Fentale	Inkolo Wabe	Mengesh	Surma
Ambasel	Chora	Ferfer	Itang	Menit Goldiye	Tach Armacho
Ambo Zuria	Chuko	Fik	Jabi Tehnan	Menit Shasha	Tach Gayint
Ameya	Chwaka	Filtu	Jama	Menjiwo	Tahtay Adiyabo
Amibara	Dabat	Fogera	Janamora	Menz GeraMidir	Tahtay Koraro
Amigna	Dabo Hana	Gaji	Jarso	Menz Keya Gabriel	Tahtay Maychew
Amuru	Dale	Gambela Zuria	Jarso	Menz Lalo Midir	Takusa
Ana Sora	Dale Sadi	Gambella Wild Life	Jarte Jardega	Menz Mama Midir	Tanqua Abergele

Analemmo	Dale Wabera	Ganta Afeshum	Jawi	Merahbete	Tarema Ber
Anchar	Dalfagi	Gasera	Jeju	Mereb Leke	Telalak
Anderacha	Dalocha	Gashamo	Jeldu	Merti	Teltele
Aneded	Dalul	Gawo Kebe	Jibat	Mesela	Tembaro
Anfilo	Damot Gale	Gaz Gibla	Jida	Meskan	Tena
Angolelana Tera	Damot Pulasa	Gechi	Jijiga	Meta	Tenta
Anigacha	Damot Sore	Gedeb Asasa	Jikawo	Meta Robi	Teru
Ankasha	Damot Weydie	Geladin	Jille Timuga	Metema	Thehulederie
Ankober	Dangila	Gelana	Jimma Arjo	Metu Zuria	Tikur Enchini
Antsokiya	Dangura	Gelila	Jimma Genete	Meyu	Tiro Afeta
Arada	Daniboya	Gembora	Jimma Horo	Meyumuluka	Tiyo
Arba Minch Zuria	Dano	Gemechis	Jimma Rare	Michakel	Tocha
Arbe Gonna	Danot	Gena Bosa	Jore	Mida Kegn	Toke Kutaye
Arero	Dara	Gera	Kacha Bira	Midega Tola	Tole
Argoba	Daramalo	Gerar Jarso	Kafta Humera	Mierab Azenet Berbere	Tsegede
Argoba Special Woreda	Darimu	Gerbo	Kalu	Mierab Badawacho	Tsegede
Aroresa	Daro Lebu	Gesha (Deka)	Kamashi	Mieso	Tselemt
Arsi Negele	Dasenech	Geta	Kebena	Miesso	Tselemti

Artuma Fursi	Dawe Kachen	Getawa	Kebribeyah	Mile	Tulo
Aseko	Dawo	Gewane	Kebridehar	Mimo Weremo	Tulo
Asgede Tsimbila	Dawunt	Geze Gofa	Kediada Gambela	Minjar Shenkora	Ubadebretsehay
Assagirt	Debark	Gibe	Kelafo	Mirab Abaya	Uraga
Assosa	Debay Telatgen	Gida Ayana	Kelela	Mirab Armacho	Wadera
Atsbi Wenberta	Debeweyin	Gidami	Kelete Awelallo	Misha	Wadla
Awabel	Debre Elias	Gidan	Kemba	Misrak Azenet Berbere	Waliso
Aware	Debre Libanos	Gimbi	Kembibit	Misrak Badawacho	Walmara
Awasa	Debresina	Gimbichu	Kercha	Miyo	Wama Hagalo
Awasa Zuria	Debub Achefer	Gimbo	Kersa	Mojan Wedera	Wantawo
Awash Fentale	Debub Bench	Ginde Beret	Kersa	Moretna Jiru	Wara Jarso
Aw-bare	Decha	Ginir	Kersana Malima	Moyale	Warder
Awra	Deder	Girawa	Kewet	Moyale	Wayu Tuka
Ayida	Dedesa	Girja (Harenfema)	Kiltu Kara	Muhur Na Aklil	Wegde
Ayira	Dedo	Gishe Rabel	Kindo Dida	Mulo	Wegera
Ayisha	Dega	Gnangatom	Kindo Koysha	Munessa	Welkait
Aysaita	Dega Damot	Goba	Kiremu	Mustahil	Wemberma
Babile	Degehabur	Goba Koricha	Kirkos	Naeder Adet	Wenago
Babile	Degehamedo	Gobu Seyo	Kobo	Nefas Silk	Wenbera
Babo	Degeluna Tijo	Gode	Kochere	Nejo	Wenchi
Badele Zuria	Degem	Godere	Kochere Gedeb	Nenesebo	Were Ilu
Bahir Dar	Degua Temben	Gog	Kofele	Nole Kaba	Werei Leke

Bahir Dar Zuria	Dehana	Golo Oda	Kokir Gedbano	Nono	West Belesa
Bako Gazer	Dehas	Gololcha Arsi	Kokosa	Nunu Kumba	West Esite
Bako Tibe	Dejen	Gololcha Bale	Kola Temben	Odo Shakiso	West Imi
Bambasi	Delanta	Goma	Kolfe - Keran	Ofa	Wilbareg
Banja	Dembecha	Goncha Siso Enese	Kombolcha	Ofla	Wondo-Genet
Bare	Dembel	Gonder Zuria	Kondaltiti	Omo Nada	Wonosho
Basketo	Dembia	Gonje	Koneba	Pawe Special	Worebabu
Baso Liben	Denan	Gorche	Konso	Quara	Wuchale
Basona Worena	Dendi	Goro	Konta	Quarit	Yabelo
Bati	Denibu Gofa	Goro	Kore	Raya Azebo	Yalo
Becho	Dera	Goro Baqaqsa	Kucha	Rayitu	Yama Logi Welel
Becho	Dera	Goro Dola	Kuni	Robe	Yaso
Bedeno	Derashe	Goro Gutu	Kurfa Chele	Saba Boru	Yaya Gulele
Begi	Dessie Zuria	Guagusa Shikudad	Kurmuk	Saesie Tsaedaemba	Yayu
Bele Gesgar	Dewa Cheffa	Guangua	Kurri	Saharti Samre	Yeka
Bena Tsemay	Dewa Harewa	Guba	Kutaber	Sahla	Yeki
Bensa	Dewe	Guba Lafto	Kuyu	Sale Nono	Yem
Berahile	Dibat	Gudetu Kondole	Laelay Adiyabo	Sankura	Yilmana Densa
Berbere	Didu	Guduru	Laelay Maychew	Sasiga	Yirgachefe
Bereh	Diga	Gulele	Lagahida	Sayilem	Yubdo
Berehet	Diguna Fango	Gulina	Lalo Asabi	Sayint	Zala
Bero	Dihun	Guliso	Lalo Kile	Sayo	Ziquala
Beyeda	Diksis	Gulomekeda	Lanfero	Sayo Nole	Ziway Dugda

Automated Weather Stations Existing

Abala	Bakuba/ Hana	Dolomena	Harar	Mankush	Seru
Abergele	Bati	Dubit	Harkello	Mareko	Setema
Abobo	Bedele	Dulecha	Hawzen	Mecha	Shahura
Abomsa	Begi	Ejaji	Hintalo	Mega	Shambu
Abyadi	Berhale	Ejere	Hosana	Mehalmeda	Shay Bench
Adar	Birkot	Elidar	Huleteju Enese	Mehoni	Shebel
Addis Ababa	Bora	Elo Gorati	Humbo	Meiso	Shebele Berta
Addis Abba (OBS)	Bore	Endabaguna	Humera	Mekaneselam	Shekosh
Addiszemen	Borecha	Endrqan	Hunte	Mekele	Sheno
Adigrat	Boset	Entoto	Huruta	Melka_Werer	Sheraro
Afambo	Bui	Erebite	IIlu	Mena	Sherekole
Agarfa	Bullen	Erer	Immi	Mendi	Shewa Robit
Agayo	Bure	Eriambul	Inkolo Wabe	Merab Armacho	Shire E/S
Ahferom	Burji	Fiche	Itang	Meraro	Shola Gebeya
Alabaqulito	Burka	Filtu	Jabitenan	Meseret/ Tigray	Sibu Sire
Alaje	Chagni	FinchWuha	Jara	Metehara	Simada
Alamata	Chefa	Fiq	Jeldu	Mettema	Sirinka
Alem Tena	Chefe Donsa	Fogera	Jijiga	Miyo	Soro
Alemketema	Chena	Fugnido	Jikawa	Modjo	Sululta
Alemteferi	chercher	Gambella	Jimarare	Mortena Juru	Tach Armacho
Aleta wendo	Chifra	Gatira	Jimma	Mosobo/ Tigray	Tarmaber
Algea	Chifra2	Gatse	Jinka	Motta	Teferi Ber
Aman	Chira	Gelalu	Kachise	Moyale	Teji
Amaro	Combolcha	Gelemso	Kafta Humera	Mugulat	Tekeze H/ power

Ambamariam	Dallifage	Gento/ Kangati	Kebribeyah	Nazeret	Teltele
Ambo	Dama	Gerese	KebriDehar	Nedjo	Tercha
Amdework	Dangla	Gewada	Kemashe	Negelle	Tesede
Ameya	Dansha	Gewane	Kilinch/Cencha	Nekemte	Tole
Amibara	DawaChefe	Gewane/ Hundufo	Kobo	Nifasmewcha	Tsitsika
Angolelana Tera	Debark	Ghinch	Kochore	Nura_Era	Tulubolo
Ankober	Debel/Buri	Gidayana	Kofele	Ogolcho	wachille
ArbaMinch	Debre Markos	Gimbi	Kokadam	Omorate	Wadera
Areka	Debre_Zeit	Ginir	Kombolch/ Harar	Pimoli/ Gambela	Wadera
Argoba	Debrebrhan	Gode	Konso	Pokong/ Gambela	Wantaw
Arguba Tango	Decha	Gog	Kore	Qemogerbi/ Ziway	Wegeltena
Arjo	Degehabur	Gohala	Kucha	Qushmangul/ Assosa	Welaita Sodo
Arsi Robe	Dembidolo	Gololcha	Kulumsa	Robe-Bale	Welkait
Asbe	Denan	Gonjekolela	Laelay Adiabo	Sabure	Werabe
Assaita	Denbiya	Gore	Lalibela	Samire	Wereilu
Assosa	Dessie	Gozamin	Lare	Sawula	Werka/ Nesebo
Aura	Desta Abjata	Gubaseyo	Libukemkem	Sebata	Werqa/ chewaqa
Awaro	Diffo	Gudayya Bila	Limu	SebetaHawsa	Woliso
Awash Arba	Dilla	Guduru	Maichew	Segen/ Gumide	Wukuro
Awassa	Dillo	Gulo Mekeda	Majete	Sekota	Yabello
Axum	Dima	Gursum	Maji	Selga 23/ Assosa	Yayagulele

Ayisha	Dinkity	Hadellela	Makoy	Semera	Yeki
Ayra	Dire Dawa	Hagere Mariam	Maligento	Senafa	Yetnora
BahirDar	Dizma	Hagere Mariam	Manda	Serkem	

Automated Weather Stations Proposed

Adadle	Chereti	Fedis	Hamero	Meyumuluka	Shekash
AdiArkay	Chilga	Fik	Hargele	Mile	Shilado
Afdem	Chire	GawoKeba	Hudet	Moyale (Somali)	Shinile
Afelekola	Chora	Gdooda	Janamoro	Munesa	TachiGayit
Amigna	Dedo	GedebAsasa	Jida	Nole Kaba	Tsegede
Amuru	DegeHamedo	GenaBasa	Kelafo	Nono	Tselemt
Argoba	Dembel	Gerbo	Konta	Omonada	Warder
Aware	Dendi	Gesha-Deka	Legehida	Quara	Wegera
Awbere	DewaHarewa	Gidami	Limuseka	Sahle	Wenago
Babile	Dihun	Girja	LomaBasa	SaleNono	West Imi
Babile	Dodola	Goba	Manasibu	Segeg	
Babo	Dorani	Goro	Meisso	Selahad	
BeleGesgar	East Imi	GoroBekeksa	Melekoza	Sewena	
Bigugn	EastBelesa	Guduro	Mesela	Shalla	
Boke	Erer	Halu	Metema	Shebe	

Totally Closed and Existing non functional conventional Stations

Existing nonfunctional third class

No	Name	Lon	Lat	Regions	No	Name	Lon	Lat	Regions
1	Adame	39.84	11.24	Amhara	25	Langano	38.68	7.55	Oromia
2	Ayna Bugina	38.84	12.17	Amhara	26	Lerra	37.9	7.75	SNNPR
3	Bora	40.04	10.69	Amhara	27	Melka Soda	38.6	5.48	Oromia
4	Mekoyie	39.76	10.74	Amhara	28	Weteraresa	38.69	6.92	SIDAMA
5	Meragna	39.09	10.21	Amhara	29	Zala	37.02	6.24	SNNPR
6	Tekulesh	39.48	12.15	Amhara	30	Abay sheleko	38.16	10.11	Amhara
7	Teleyayegn	39.4	11.43	Amhara	31	Almahal	35.31	11.21	BenGumuz
8	Derra	39.73	13.99	Tigray	32	Bambudi	36.89	11.17	BenGumuz
9	Bazil	34.04	8.18	Gambela	33	Gassay	38.15	11.8	Amhara
10	Gam_Unversity	34.61	8.25	Gambela	34	Geregera	37.61	11.18	Amhara
11	Jor	33.93	7.77	Gambela	35	Gonder town	37.47	12.61	Amhara
12	Pimole	34.43	8.23	Gambela	36	Gorgora	37.29	12.24	Amhara
13	Puldeng	34.06	8.09	Gambela	37	Jawe	36.49	11.57	Amhara
14	Ruchi P.L.C	34.3	7.82	Gambela	38	Mambuk	36.15	11.18	BenGumuz
15	Solen	34.53	8.39	Gambela	39	Masero	36.31	13.2	Amhara

16	Acheber	38.36	8.33	Oromia	40	Mekanebrihan	38.07	11.63	Amhara
17	Agena	38	8.13	SNNPR	41	Shinfa	36.13	12.57	Amhara
18	Aliweya	37.89	4.97	Oromia	42	Tisabay	37.57	11.37	Amhara
19	Arsinegele	38.66	7.36	Oromia	43	Zarema	37.53	13.2	Amhara
20	Burssa	38.6	6.6	SIDAMA	44	Andedo	40.19	9.24	Afar
21	Chiri	39.09	6.53	SIDAMA	45	Awaramelka	39.57	9.08	Afar
22	Dawa	38.29	5	Oromia	46	Kassagita	40.12	11.16	Afar
23	Didahara	38.33	4.8	Oromia	47	Kori	40.59	12.29	Afar
24	Fato	38.5	8.37	SNNPR					

Third class totally closed stations

No	Name	Regions	Closing
1	Dimma	Tigray	2017
2	Finaruwa	Tigray	2018
3	Maikadra	Tigray	2014
4	Banat	Tigray	2018
5	Edaga Hibret	Tigray	2013
6	Aragure	Tigray	2018
7	Adar	Afar	

Existing non-functional Fourth-class stations

No	Station	Regional
1	Kundi	Amhara
2	Jawe	Gambela
3	Adamitulu	Oromia
4	Addis alem	Amhara
5	Anjene	Amhara
6	Aymba	Amhara
7	Baruda	BenGumuz
8	Chewahit	Amhara
9	Filwuha	Amhara
10	Gengel	Amhara
11	Gesengessa	BenGumuz
12	Jumera	Amhara
13	Korata	Amhara
14	Licha	Amhara
15	Washera	Amhara
16	Dobi	Afar
17	Logia	Afar

Totally closed Fouth class

Station	long	lat	Regional
Serekula	38.49	10.14	Amhara
Wurgesa	39.62	11.54	Amhara
Agulae	39.35	13.41	Tigray
Haik Meshal	39.70	13.75	Tigray
Maykeyah	39.31	13.19	Tigray

Existing nonfunctional principal stations

Name	Lon	Lat	Region
Filtu	41	5.11	Somali
Tekeze	39.77	13.36	Tigray
Humera	36.88	13.84	Tigray
Dana	37.57	6.64	SNNPR
Mega	38.32	4.07	Oromia
Turmi	36.49	4.97	SNNPR
Degahabour	43.56	8.23	Somali
Errer	41.38	9.56	Somali
Fiik	42.3	8.14	Somali
Quara	35.53	12.14	Amhara
Sekela	37.21	10.99	Amhara

Totally closed principal stations

No.	station	Closing date (MMMYYY)	Lat	Lon	Regional state
1	Badme	2018	14.73	37.8	Tigray
2	Wardher	2017	6.97526	45.34	Somali
3	Assaita	Jul-19	11.57806	41.43	Afar
4	Gulina	2009	12.98	39.58	Afar

6.2. Annex II: Types of Meteorological stations and observations

1. Type of Stations: Surface stations: There are 5 types of stations

   a. Principal stations (class I)

   b. Ordinary stations (class III)

   c. Synoptic Stations (class II)

   d. Precipitation stations (class IV)

Meteorological elements recorded by Class IV stations

No.	Element	Unit	Time of observation	Remark
1	Rainfall	Millimeters	09 LST	

Class III stations record the following elements

No.	Element	Unit	Time of observation	Remark
1	Rainfall	millimeters	09 LST	
2	Maximum Temperature	ºC	18 LST	
3	Minimum Temperature	ºC	09 LST	

Class I stations record the following elements

No.	Element	Unit	Time of observation	Remark
1	Rainfall	millimeters	09 LST	
2	Maximum Temperature	ºC	18 LST	
3	Minimum Temperature	ºC	09 LST	
4	Dry Bulb Temperature	ºC	06, 09,12,15,18 LST	
5	Wet bulb Temperature	ºC	06, 09,12,15,18 LST	
6	Relative Humidity	%	06, 09,12,15,18 LST	Read from table
7	Sun shine duration	Hours	18 LST	
8	Wind run at 2 meters	M/s or knots	06, 09,12,15,18 LST	

9	Wind speed and Direction at 10 meters	M/s and degree	06, 09,12,15,18 LST	
10	Cloud Amount	Oktas	06, 09,12,15,18 LST	
11	Soil temperature at 10, 20, 30, 50 and 100 centimeters depth	ºC	06, 09,12,15,18 LST	
12	Pan Evaporation	millimeters	06, 09,12,15,18 LST	
13	Pitche Evaporation	millimeters	06, 09,12,15,18 LST	

Class II (Synoptic) stations record the following elements

No.	Element	Unit	Time of observation	Remark
1	Rainfall	millimeters	09 LST	
2	Maximum Temperature	ºC	18 LST	
3	Minimum Temperature	ºC	09 LST	
4	Dry Bulb Temperature	ºC	00,03,06, 09,12,15,18,21 LST	
5	Wet bulb Temperature	ºC	00,03,06,09,12,15,18,21 LST	
6	Dew point Temperature	ºC	00,03,06,09,12,15,18,21 LST	Read from table
7	Grass minimum temperature	ºC	00,03,06,09,12,15,18,21 LST	
8	Relative Humidity	%	03,06, 09,12,15,18,21 LST	Read from table
9	Vapour pressure	mb (hPa)	03,06, 09,12,15,18,21 LST	“
10	Sun shine duration	Hours	18 LST	
11	Wind run at 2 meters	M/s or knots	00,03,06, 09,12,15,18,21 LST	
12	Wind speed and Direction at 10 meters	M/s and degree	00,03,06,09,12,15,18,21 LST	

No.	Element	Unit	Time of observation	Remark
13	Cloud Amount	Oktas	00,03,06,09,12,15,18,21 LST	
14	Soil temperature at 10, 20, 30, 50 and 100 centimeters depth	°C	00,03,06,09,12,15,18,21 LST	
15	Pan Evaporation	millimeters	00,03,06,09,12, 15,18,21 LST	
16	Pitche Evaporation	millimeters	00,03,06,09,12, 15,18,21 LST	
17	Station level pressure	mb(hPa)	00,03,06,09,12, 15,18,21 LST	
18	QNH (Sea level pressure)	mb(hPa)	00,03,06,09,12,15,18,21 LST	
19	Weather Present weather Past weather	In 100 and 10 weather symbols respectively	00,03,06,09,12,15,18,21 LST	
20	Cloud Low cloud amount Type of low cloud Type of medium cloud Type of high cloud	Oktas type	00,03,06,09,12,15,18,21 LST	Type of cloud can be identified by looking at pre-prepared cloud atlas. Meteorologically there are 10 cloud genera's
21	Height of low cloud	Kmts	00,03,06,09,12, 15,18,21 LST	
22	Horizontal visibility	Kmts	00,03,06,09,12,15,18,21 LST	Using codes

6.2. Annex II: WMO Class 1 station lay out (WMO No. 8)

III–10 GUIDE TO THE GLOBAL OBSERVING SYSTEM

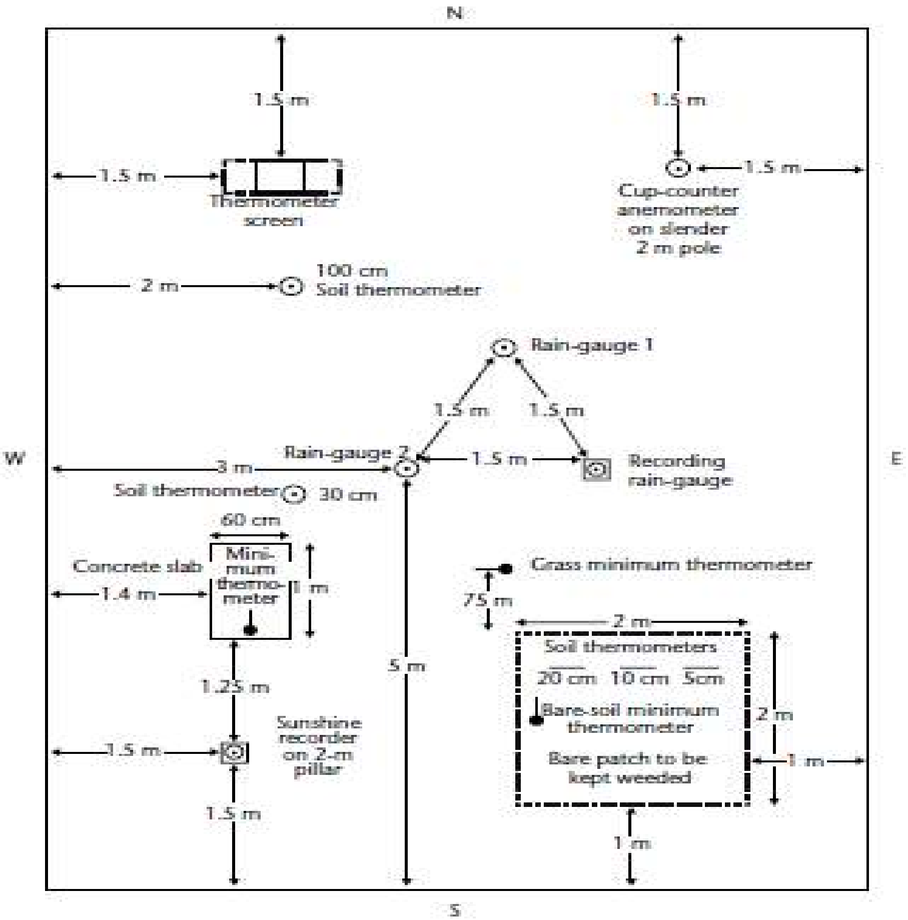


Figure III.1. Layout of an observing station in the northern hemisphere showing minimum distances between installations

Source: *The Observer's Handbook*, Meteorological Office, United Kingdom, 1982

6.3. Annex III Synoptic Observations

Surface synoptic observations recorded at a manned synoptic land station shall consist of observations of the following meteorological elements: (*a*) Present weather; (*b*) Past weather; (*c*) Wind direction and speed; (*d*) Cloud amount; (*e*) Type of cloud; (*f*) Height of cloud base; (*g*) Visibility; (*h*) Air temperature; (*i*) Humidity; (*j*) Atmospheric pressure; Together with such of the following meteorological elements as are determined by regional association resolutions: (*k*) Pressure tendency; (*l*) Characteristic of pressure tendency; Extreme temperature; (*n*) Amount of precipitation; (*o*) State of ground; (*p*) Direction of cloud movement; (*q*) Special phenomena.

A surface synoptic observation at an automatic land station shall consist of observations of the following meteorological elements: (a) Atmospheric pressure; (b) Wind direction and speed; (c) Air temperature; (d) Humidity; (e) Precipitation, yes or no (at least in tropical areas);

Together with the following meteorological elements which should be included if possible:

(f) Amount of precipitation; (g) Intensity of precipitation; (h) Visibility; (i) Optical extinction profile (height of cloud base); (j) Special phenomena.

Frequency and timing of observations: At synoptic land stations the frequency of surface synoptic observations should be made and reported eight times per day at the main and intermediate standard times in extra tropical areas and four times per day at the main standard times in the tropics. At a (manned or automatic) land station, surface synoptic observations shall be made and reported at least at the main standard times.

6.4. Annex IV: Agro-meteorological Stations

An agricultural meteorological station is a station that provides data on the relationship between the weather and the life of plants/crops/ as well as animals.

Principal agricultural Meteorological Station is a station that provides detailed simultaneous meteorological and biological information and where research in agricultural meteorology is carried out. Ordinary agricultural meteorological stations: A station that generates and provides routine and simultaneous meteorological and biological information, which would be used for research that relates the local climate with the phenological observations.

Auxiliary agro met station: A station that provides meteorological and biological information and other parameters like soil, temperature, soil moisture, PET, etc. in the lowest layer of the atmosphere. The biological information may include phenology, onset and spread of plant diseases, etc.

Agro-meteorological stations for specific purposes: An agro meteorological station set–up temporarily or permanently established for the observation of one or several elements for specified phenomena. Manned agro-meteorological stations with common instruments record: rainfall, maximum & minimum temperature, relative humidity, sunshine hour duration and wind run/speed, soil temperature at different depths, evaporation, phenological observations at (100X100) m^2. Specialized Reference agro-meteorological stations consist of special automatic sensors for measuring leaf wetness and soil moisture additionally. The specialized Reference Agro-met stations are based on GPRS telemetry, and measure the various parameters every 15 minutes and send the data to the central Server. They can be used to alert some weather shocks that can lead to the outbreak of plant diseases, soil health and moisture status. Reference Agro-meteorological Stations equipped with Lysimeter: - Agro-meteorological stations equipped with Lysi-meter are used to assess crop water requirement for specific crops at the different agro-ecological zones. Lysimeter measures evapotranspiration for the particular crop and soil moisture. Even though, the major function of Lysimeter is to measure actual evapo-transpiration and values of crop evapo–transpiration, it depends upon the type of crop and agro-climatic characteristics. Since soil moisture is an important element, consider the five thermal zones of the country and install five Lysi-meters in the five thermal zones, which are taken as references.

6.5. Annex VI: Requirement of Meteorological Instruments at Aerodromes

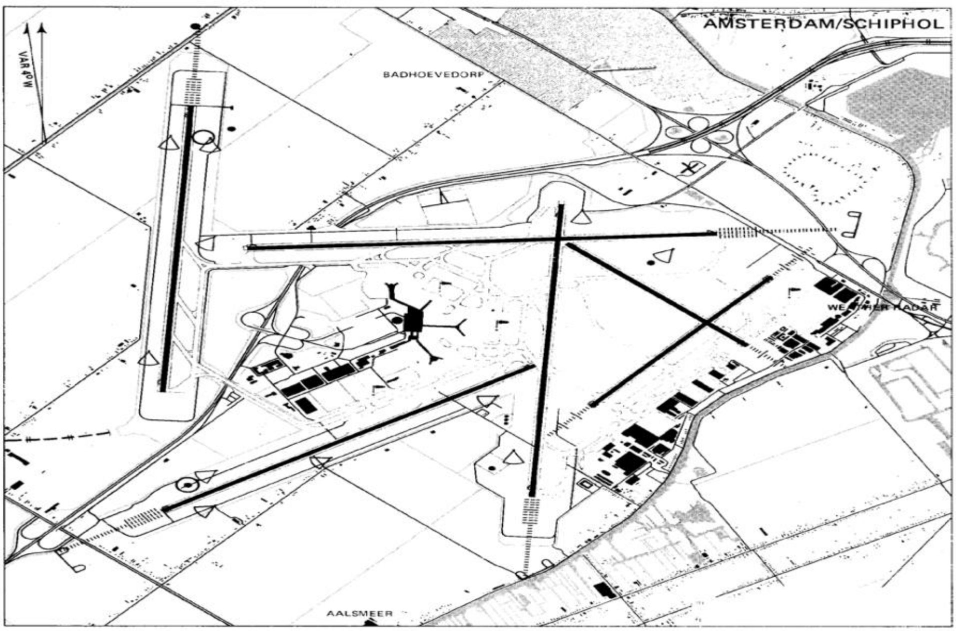
The sitting of meteorological instruments at aerodromes requires close coordination between the meteorological, ATS and aerodrome authorities as well as operators. The most important practical steps to be taken in choosing appropriate locations may be summarized as follows:

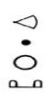
Step 1: Ascertain the geometry of the relevant obstacle limitation surfaces at the aerodrome, particularly the transitional and inner transitional surfaces. Particular aerodromes could comprise parallel and crossing runways which complicate the geometry. Assess the type of aircraft operations at the aerodrome (e.g. visual flight rules (VFR) or instrument flight rules (IFR) traffic) and frequency of use of runways (e.g. preferred landing directions), which runways are equipped with instrument landing system (ILS), possible noise abatement take-off directions, etc. Check aerodrome master plan for possible plans for expansion of the aerodrome runways, taxiways, buildings, etc. Check location and height of existing essential navigation aids such as glide path antenna, localizer, etc.

Step 2: Prepare meteorological survey of the aerodrome based upon climatological statistics of the aerodrome itself or nearby observing stations. The assistance of pilots and air traffic control officers familiar with the aerodrome will be essential in this regard. In preparing the survey, account should be taken of the topography of the aerodrome and surrounding land, preferably by on-site inspection by an aviation meteorologist. Location and effect of swamp areas, hills, coastline, slope of runways, local industrial pollution, etc., and their possible effect on the operationally significant points around the aerodrome, e.g. touchdown zone, take-off areas, etc., should be considered.

Step 3: Decide on the location of the instruments that would provide representative measurements as required by Annex 3 and, at the same time, allows for adequate exposure. Observe obstacle limitation surfaces in choosing sites as shown in Figure A2-2. In particular, anemometer masts normally should be sited outside runway strips and should not infringe the transitional slope. Where it is necessary to locate them within the strip, the mast should be frangible, lighted and the site should only be as close to the runway as is absolutely essential. Unless there are exceptional local circumstances, anemometer masts should not infringe the OFZ. If the latter is necessary, then the mast must be frangible, lighted and preferably shielded by an existing essential navigation aid. Take into account also the accessibility of the sites, the availability of power, telephone and other lines without undue costs or interference with aerodrome use. Consideration should also be given to installing the minimum number of instruments necessary to provide representative values. This is cost-effective and ensures a minimum number of obstacles on the aerodrome

Typical layout plan of meteorological instruments at an Aerodrome:
Runway visual range observation site





The proper location of meteorological instruments, or of the sensors connected with the instruments,1 presents many more difficulties at aerodromes than at synoptic meteorological stations. While in both cases the purpose of the instruments is to obtain as accurate information as possible on certain meteorological parameters, at the synoptic meteorological stations the only requirement in respect of location is adequate instrument exposure. At aerodromes, there is a range of requirements and conditions in addition to adequate instrument exposure which the instrument location must satisfy, and in particular these include the following:

a. a representative measurement for the aerodrome as a whole, and for take-off and landing operations in particular;

b. Compliance with obstacle restriction provisions;

c. Location, in certain operational areas, requiring frangibility of instrument support construction; and

d. Suitability of location in respect of terrain conditions, power supply and communication facilities.

This appendix deals with the location of the main types of meteorological instruments and instrument systems in use at aerodromes, i.e. those for the measurement of surface wind, runway visual range (RVR), height of cloud base, temperature and pressure. The information is relatively general because aerodromes vary greatly in respect of the types of operations for which they are used, and the types of terrain, aspects which may considerably affect the location of instruments.

The Aerodrome Environment: Before dealing with the location of instruments at aerodromes, there is a need for a brief description of the aerodrome environment in general. It is an environment of great complexity and size, covering at times large areas with runways attaining lengths of 4 km. The runway complex may be near built-up areas with public, administrative or technical functions. The difficulties that such a large and complex area as an aerodrome can create for the provision of timely and representative meteorological measurements are often considerable:

A. The size of the runway complex, which frequently cannot be adequately covered by a single instrument or sensor; difficulty of access to certain parts of the aerodrome, which may prevent the location of instruments at the most suitable sites or access for maintenance purposes;

B. The obstacle restriction regulations, which may have similar effects;

C. The size of buildings or of other constructions (towers, masts, etc.) which may prevent adequate instrument exposure;

D. The effects of aircraft movement and exhausts (particularly during taxiing and turning operations), and of large car parks and their associated emissions.

To overcome these difficulties, the meteorological authority must maintain close contact with the authority responsible for the aerodrome and its master plan. This involves daily contact, as well as long-range planning; because the setting up of instrument sites and the laying of cables and other connected activities must not interfere with other aerodrome systems, disturb the normal functioning of the aerodrome or become unduly expensive. Close cooperation with operators whose requirements often determine instrument location is also necessary. Finally, the local air traffic services (ATS) authority is also concerned with these difficulties as its units often use duplicate indicators and may have requirements of its own for the location of the relevant sensors.

In addition to close cooperation with aerodrome and ATS authorities and with operators, the effective determination of the most appropriate location of instruments requires a detailed on-site analysis by a meteorologist. The analysis could involve field trials, particularly in circumstances where the topography and/or prevailing weather are complex, while in more straightforward cases a simple on-site inspection may be sufficient. In the case of new aerodromes, it is usual to establish an observing station, or at least a minimum set of instruments, before the aerodrome is built in order to obtain information on meteorological conditions likely to affect operations at the aerodrome.

Obstacle Restrictions: In the choice of sites for instruments at aerodromes, account must be taken first and foremost of obstacle restrictions at the aerodrome. The meteorological instruments that are listed as objects which may constitute "obstacles" are anemometers, ceilometers and transmissometers/forward-scatter meters (for details see the Airport Services Manual). Specifications governing the restriction of obstacles at aerodromes are given in Annex 14, Volume I, Chapters 4 and 9. The objective of these specifications is to define the airspace at the aerodromes so as to ensure that it is free from obstacles thereby permitting the intended aeroplane operations to be conducted safely. This is achieved by establishing a series of obstacle limitation surfaces that define the limits to which objects may project into the airspace.

Aerodromes intended for use by international civil aviation are classified according to a reference code. This code provides a simple method for interrelating the numerous specifications concerning the characteristics of aerodromes, so as to provide a series of aerodrome facilities that are suitable for the aeroplanes that are intended to operate at the aerodrome. The width of the runways, the runway strips and the slope of the obstacle limitation surfaces, etc., varies according to the aerodrome reference code. The more important obstacle limitation surfaces, from the standpoint of the siting of meteorological instruments, are the transitional surfaces which limit obstacle height along the side of the runway. The recommended runway width, strip width and slope of the transitional surfaces which is derived from provisions given in Annex 14, Volume I. It may be seen that all runways should be protected by a transitional surface that begins at the edge of the runway strip and slopes upwards and outwards away from the runway. The width of the strip and the slope of the transitional surface depend on the runway reference code number. A precision approach runway is protected by a second "inner" transitional surface and the airspace over the runway between the two inner surfaces is referred to as the obstacle free zone (OFZ).

A cross-section of the transitional surfaces recommended for a precision approach runway of reference code number 3 or 4 as stated in ICAO document. The positions closest to the runway at which various meteorological instruments may be located without infringing the transitional surfaces are also indicated in Figure A2-2. Unless there are exceptional local circumstances, no meteorological instruments should infringe the OFZ. Where this is unavoidable, in order to ensure representative observations, the sensor support must be frangible, lighted and preferably shielded by an existing essential navigation aid. In addition to taking account of the distance from runway centre lines, in siting meteorological instruments, care must always be exercised to ensure that the instruments do not present an obstacle to aircraft using taxiways.

Adequate Instrument Exposure: In some cases, instruments may need to be protected against non-atmospheric influences, for example, from jet aircraft exhausts. This applies particularly to wind and temperature instruments, which should not be affected by exhausts from moving or parked aircraft but should be moved to more suitable sites. The adequate exposure of wind sensors often presents the most crucial and difficult problem in respect of instrument location at aerodromes. Some details in this respect are given below under "Representative Measurements". As far as temperature and dew point measurements are concerned, exposure problems may occur at some aerodromes, particularly those with high temperatures and little wind. Experiments have shown that in those cases, temperatures measured over grass or in an area surrounded by vegetation may be considerably different from those experienced over the runway surface. Where those differences are found to exceed 1°C, arrangements need to be made to shift the site of the temperature measurement to one that is better exposed, or use distant reading thermometers. The latter solution is now employed at an increasing number of aerodromes.

Aeronautical observations should consist of the following meteorological elements: (a) Surface wind direction and speed; (b) Visibility; (c) Runway visual range, when applicable; (d) Present weather; (e) Cloud amount, type and height of base; (f) Air temperature; (g) Dew point temperature; (h) Atmosphere pressure (QNH and/or QFE); (i) Supplementary information: Present Weather /Recent Weather /, Wind Shear, State of the sea, State of the Runway

Meteorological and Communication equipment systems at aerodrome

- Conventional Meteorological Station
- Automatic Weather Observing system/AWOS/
- Small Airport Systems
- Low Level Wind Shear Alert System/LLWAS/
- Terminal Doppler Weather Radar /TDWR/
- Satellite Distribution Information Systems/SADIS /
- Terrestrial Aeronautical Fixed Telecommunication Net work
- Aeronautical Meteorological Message Handling System/AMHS/
- Satellite Image and NWP, OPMET receiving systems
- Aircraft Meteorological Data Relay/AMDAR/ receiving system
- Wide and Local Area Network /WAN-LAN/

Aeronautical Meteorology Service Provision (Products and Services at Aerodromes)

- Aerodrome reports (METAR, SPECI)
- Aerodrome Forecasts (Terminal Aerodrome Forecast, Trend Forecast, Forecasts for take-off, Forecasts of en-route conditions)
- SIGMET Information, Tropical Cyclone and Volcanic Ash Advisory Information, AIRMET Information, Aerodrome Warnings and Wind Shear Warnings and Alerts
- Briefing, consultation and display, Flight documentation
- Automated pre-flight information systems
- Information for aircraft in flight
- Air Reports-AIREP

Annex VI: List of Airports in Ethiopia

City served		Region	ICAO	IATA	Airport name
Public airports					
1.	Adaba	Oromia	HAAD		Adaba Airport
2.	Addis Ababa	Addis Ababa	HAAB	ADD	Bole International Airport (Addis Ababa Bole Int'l)
3.	Arba Minch (Arba Mintch)	SNNPR	HAAM	AMH	Arba Minch Airport
4.	Asella (Asela)	Oromia		ALK	Asella Airport
5.	Asosa (Assosa)	Benishangul Gumuz	HASO	ASO	Asosa Airport
6.	Awasa (Awassa)	SNNPR	HALA	AWA	Awasa Airport
7.	Axum (Aksum)	Tigray	HAAX	AXU	Axum Airport
8.	Bahir Dar (Bahar Dar)	Amhara	HABD	BJR	Bahir Dar Airport
9.	Beica (Bega)	Oromia	HABE	BEI	Beica Airport
10.	Bulchi (Bulki)	SNNPR	HABU	BCY	Bulchi Airport
11.	Combolcha (Kombolcha) / Dessie	Amhara	HADC	DSE	Combolcha Airport
12.	Dansha (Dansha Bota)	Tigray[1]	HADA		Dansha Airport
13.	Debre Marqos	Amhara	HADM	DBM	Debre Marqos Airport
14.	Debre Tabor	Amhara	HADT	DBT	Debre Tabor Airport
15.	Dembidolo	Oromia	HADD	DEM	Dembidolo Airport
16.	Dire Dawa	Dire Dawa	HADR	DIR	Aba Tenna Dejazmach Yilma International Airport (Dire Dawa Int'l)
17.	Dodola	Oromia	HADO		Dodola Airport
18.	Fincha (Finicha'a)	Oromia	HAFN	FNH	Fincha Airport
19.	Gambela (Gambella)	Gambela	HAGM	GMB	Gambela Airport
	Ghinnir (Ginir)	Oromia	HAGH	GNN	Ghinnir Airport
20.	Goba / Robe	Oromia	HAGB	GOB	Robe Airport

City served		Region	ICAO	IATA	Airport name
21.	Gode	Somali	HAGO	GDE	Gode Airport
22.	Gondar (Gonder)	Amhara	HAGN	GDQ	Gondar Airport
23.	Gore	Oromia	HAGR	GOR	Gore Airport
24.	Humera (Himera, Himora)	Tigray	HAHU	HUE	Humera Airport
25.	Imi	Somali	HAIM		Imi Airport
26.	Jijiga	Somali	HAJJ	JIJ	Jijiga Airport(Garaad Wiil-Waal Airport)
27.	Jimma	Oromia	HAJM	JIM	Aba Segud Airport (Jimma Airport)
28.	Jinka (formerly Baco)	SNNPR	HABC	BCO	Baco Airport (Jinka Airport)
29.	Kabri Dar (Kebri Dahar)	Somali	HAKD	ABK	Kabri Dar Airport
30.	Kelafo	Somali	HAKL	LFO	Kelafo Airport
31.	Lalibela	Amhara	HALL	LLI	Lalibela Airport
32.	Maji	SNNPR	HAMJ		Tume Airport
33.	Makale(Mekele, Mek'ele)	Tigray	HAMK	MQX	Alula Aba Nega Airport (Makale Airport)
34.	Masslo	Oromia[2]	HAML	MZX	Masslo Airport
35.	Mekane Selam	Amhara	HAMA	MKS	Mekane Selam Airport
36.	Mendi	Oromia	HAMN	NDM	Mendi Airport
37.	Metema (Metemma)	Amhara	HAMM	ETE	Metema Airport
38.	Mizan Teferi	SNNPR	HAMT	MTF	Mizan Teferi Airport
39.	Nejo	Oromia	HANJ	NEJ	Nejjo Airport
40.	Nekemte	Oromia	HANK	NEK	Nekemte Airport
41.	Shakiso	Oromia	HASK	SKR	Shakiso Airport
42.	Shilavo	Somali		HIL	Shilavo Airport
43.	Shire	Tigray		SHC	Shire Airport
44.	Sodo	SNNPR	HASD	SXU	Sodo Airport
45.	Tippi (Tepi)	SNNPR	HATP	TIE	Tippi Airport
46.	Wacca	SNNPR	HAWC	WAC	Wacca Airport
47.	Military airports				
48.	Addis Ababa	Addis Ababa	HAAL		Lideta Army Airport
49.	Debre Zeyit	Oromia	HAHM	QHR	Harar Meda Airport
50.	Neghelle(Negele Boran)	Oromia	HANG	EGL	Neghelle Airport

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