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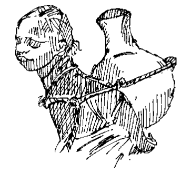
INTEGRATED DEVELOPMENT FOR WATER SUPPLY AND SANITATION



To upgrade the hydrometeorological network in Ethiopia

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THE EXISTING HYDROMETEorological network density of Ethiopia (about 832 meteorological and 507 hydrometric stations) does not satisfy the WMO's recommendations (2399-5428 meteorological and 674-1796 hydrometric stations). This problem is aggravated due to budgetary constraints and capacity limitations of the two responsible governmental organizations - The National Meteorological Services Agency (NMSA) and The Hydrological Studies Department (HSD). In this regard a rigorous strategy based on the country's socio-economic conditions is proposed. The proposed strategy for meteorological network is to establish stations in compounds of schools and churches or mosques with observers from these centers. Incentives being provided by the regional governments and the collected data being processed and verified by regional NMSA offices. If 50 per cent of the total number of schools and churches or mosques are fit and considered for station establishment, Ethiopia could have more than about 5,000 and 8,000 additional meteorological stations, respectively. For hydrological network, personnel for the various agricultural extension programs of the Ministry of Agriculture (MOA) could be utilized for supervision and/or observation. Senior students in engineering and related sciences could conduct Establishment of observation stations with incentives during their summer vacation. Principal recommendation concern integration of meteorological and hydrological network planning and analysis.

Introduction

The design of a specific network depends on specific network objectives, scientific considerations, and monetary constraints. Questions like for what purposes are the data to be used? What time scale is of principal interest? How accurate are the point measurements? How representative are they of the surrounding terrain? What economic factors are involved? are the major concern of hydrometeorological network design. In this paper a rigorous strategy is proposed which fully addresses some of these questions by considering Ethiopia's actual socio-economic conditions.

Ethiopia, with a total geographical area of 1.13 million $(km)^2$, has a highly rugged topography. According to NMSA (1996), Ethiopia's climate is characterized by high rainfall variability. It is therefore essential to assess rainfall with the associated weather systems in sufficiently rigorous fashion so as to evaluate its influence on the socioeconomic development activities of the country. Therefore in planning and design of the country's hydrometeorological network, rainfall is the most important parameter.

The country is divided into the following four regions based on rainfall types (Fig. 1):

- Region B: monomodal type 1; (ii) Region D: monomodal type 2;
- Region A: bimodal type 1; and
- Region C: bimodal type 2.

When the rainfall occurs in one continuous period of time in a year, this is termed as monomodal and when this occurs in two discontinuous periods in a year, this is termed as bimodal. Again, each of these are divided into type 1 or 2, based on the time of occurrence of the continuous period(s) or by the prominence of rainy periods. Even though the climatic features of the country are highly associated with the rainfall variability both in space and time, other meteorological parameters such as temperature, wind speed, humidity, potential evapotranspiration, etc. are also important.

The existing hydrometeorological network is operated by the two governmental agencies: NMSA for meteorological data and HSD for hydrological data. However, the tradition of data acquisition strategy by these two agencies will not enable the country to achieve the desired hydrometeorological network density within a short time frame due to capacity limitations.

In Ethiopia, the most significant difficulty in the realm of operational hydrology is the sheer lack of measurement stations. Four major reasons are responsible for this: (i) budgetary constraints, (ii) low level of know how of the society and the decision-maker on the importance of hydrometeorological data, (iii) few skilled manpower in the profession, and (iv) problem of accessibility due to the mountainous topography of the country.

The WMO (1970) recommendations with respect to the density of rainfall and flow measurement stations in *mountainous, flat, arid regions of temperate, Mediterranean and tropical zones* has been determined for Ethiopia and presented in Table 1. However, the existing total number of meteorological stations in Ethiopia is about 832 (WRC, 1987). Fig. 2 presents the status of the existing stream gauging stations in Ethiopia by basin.

One of the peculiarities of meteorological stations in Ethiopia is their location being limited in the towns and related sites. Accessibility is the major reason in this consideration. Several towns in Ethiopia were established by former local governors on fortified places from military strategy point of view. Therefore, the existing meteorological network of the country lacks sound consideration of the variability of the meteorological elements (mainly rainfall) to be measured.

Moreover, the existing hydrometric stations for stream gauging are mostly located at bridge sites due to problem of accessibility though bridge sites are not hydraulically very suitable sites. On top of this the nature of the streams in this country are mostly hilly catchments in which the variations of stream flow is significant within smaller reach of the streams. Moreover, The practice of groundwater observations based on network design principles is at an infant stage.

Proposed strategy

Primary and junior secondary schools can be used as one of the promising sites for meteorological stations. According to 1995/96 educational statistics by Central Statistics Authority (CSA), there are about 9704 primary schools and 1304 junior secondary schools in Ethiopia. If the average (50%) of the total number of these schools are fit and considered for station establishment from hydrometeorological characteristics and operational point of view, there could be more than 5,000 additional meteorological stations.

Instruments such as raingauges, wind vanes, thermometer can be supplied by NMSA (preferably locally manufactured in metal workshops). Regional governments and/or the respective development associations better be responsible for data acquisition through the respective regional education bureau. The school director can assign teachers or students for observation and supervise the data acquisition in the station located in his/her school compound. It is recommended that incentives be provided to the data observers by the respective regional governments. However, simple and standardized data sheets should be prepared by NMSA and distributed through the newly opened regional NMSA offices.

Data observed by the individual schools will be transmitted to regional NMSA branch offices. The collected data can be processed and verified based on the data from benchmark stations. Detailed yearbooks will then be published region-wise whereas summary yearbooks published at federal level.

Data acquisition in the schools will have three major purposes: firstly *for upgrading meteorological network density, secondly serving as a practical demonstration center in the schools for students learning science and geography subjects, and finally for awareness creation on the importance of hydrometeorological data in combating droughts and desertification in Ethiopia.*

Other promising sites are religious centers (churches and mosques). It is known that in most parts of Ethiopia every village has church and/or mosque. Therefore advantage can be gained from this condition in upgrading the existing meteorological network. According to the 1994 housing & population census report by CSA, more than 17,000-peasant association are available in Ethiopia. If the average (50%) of the total number are fit and considered for station establishment from hydrometeorological characteristics and operational point of view, there could be more than 8,000 additional meteorological stations. Observations could be made by server of the churches or mosques who are able to read and write with incentives provided by the regional governments. The data transmission, processing and verification will be conducted in a similar manner like that discussed for schools. However, there will obviously be duplication of stations when schools and religious centers are used jointly. Therefore, further research is necessary based on meteorological and operational characteristics of specific areas to come up with the appropriate meteorological network density.

If the above discussed strategy is positively considered and justified by further research, Ethiopia could not only meet the WMO recommendations for meteorological network density but also will have a denser network with minimum cost and within a shorter period of time. Some African countries like Zimbabwe have a very good experience of the proposed data acquisition strategy. For example, Zimbabwe with a total geographical area of about

Table 1. Hydrometeorological specificatins in Ethiopia by basin based on WMO(1970) recommendations

S.N	Name of basin	Area (km)^2			# meteorological stations			*Total*	# hydrometric stations			*Total*
		Mount.	Flat	Arid	Mount.	Flat	Arid		Mount.	Flat	Arid	
1	Blue Nile	142400	60800	-	570-1424	68-102	-	*638-1526*	143-475	25-61	-	*168-536*
2	Rift Valley Lakes	39009	13730	-	156-390	16-23	-	*172-413*	39-130	6-14	-	*45-144*
3	Awash	36601	73718	3377	147-366	82-123	1-3	*230-492*	37-122	30-74	1	*68-197*
4	Omo-Ghibe	43917	34296	-	176-440	39-58	-	*215-498*	44-147	14-35	-	*58-182*
5	Genale-Dawa	39230	105412	26400	157-393	118-176	3-18	*278-587*	40-131	43-106	2-6	*85-243*
6	Baro-Akobo	24566	49586	-	99-246	55-83	-	*154-329*	25-82	20-50	-	*45-132*
7	Wabi-Shebele	33605	152682	16400	135-336	170-255	2-11	*307-602*	34-112	61-153	1-4	*96-26*
8	Tekeze	54821	35180	-	220-549	39-59	-	*259-608*	55-183	14-36	-	*69-219*
9	Danakil	7741	27808	38460	31-78	31-47	4-26	*66-151*	8-26	12-28	2-8	*22-62*
10	Mereb-Gash	12643	11289	-	51-127	13-19	-	*64-146*	13-43	5-12	-	*18-55*
11	Ogaden	-	77121		-	15-74		*15-74*	-	no streams		
12	Aysha	-	2223		-	1-2		*1-2*	-	no streams		
Total number of stations required								**2399-5428**				**674-1796**

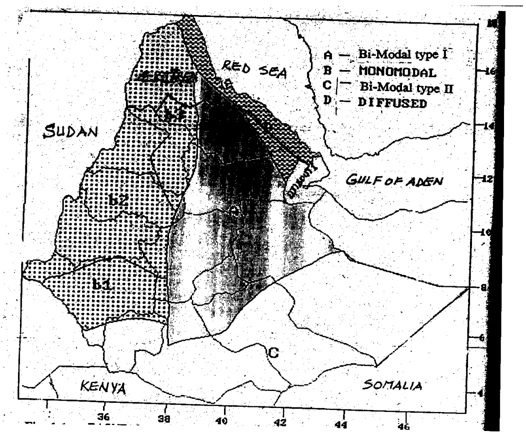

Figure 1. Rainfall Regimes of Ethiopia (NMSA, 1996)

400,000 (km)^2 has more than 1,100 meteorological stations which are operated by the official meteorological agency, schools, religious centers, commercial farms, etc. (DOMS, 1981).

The installation of instruments and demonstration of observation readings can be conducted by senior college students in engineering and related sciences during their three months summer vacation with incentives provided by the respective regional governments. All round assistance can be obtained from international and local NGOs and UN organizations.

Effort made by the HSD is satisfactory towards achieving the WMO's recommendations for hydrometric network density. However, small-scale water resources development projects also require information about the hydrological characteristics of smaller ungauged streams. Therefore the target should not only be in achieving the WMO recommendations in the case of stream gauging. Stream gauging stations can be established in sites identified by river basin master plan studies (or new sites if necessary), which can be selected by a hydrometeorological team in the respective regional governments. Personnel of the MOA for the various agricultural extension programs can be utilized in data acquisition.

Conclusion

Ethiopia's climate is characterized by high rainfall variability. It is known that rainfall is also affected by various topographical factors such as orography, continentality, topographic trend distance, aspect, slope, etc. (Abebe and Savenije, 1995). The effect of these topographical factors on hydrometeorological elements is significant for mountainous countries like Ethiopia. This makes the hydrometeorological network costly and operationally difficult.

The existing total number of meteorological stations in Ethiopia which are operated by NMSA are about 832. The corresponding WMO recommendation is in the range of 2399-5428. To achieve the lower, average, and upper limits of this range, NMSA should show considerable effort by increasing the existing number of stations by nearly 3, 5, and 7 times the existing number of stations, respectively. In fact these targets are far-reaching if NMSA follows its tradition of establishment of new stations. However, if the rigorous strategy proposed in this paper is implemented, Ethiopia can have more than about 5,000 and 8,000 additional stations in schools and churches or mosques, respectively. This will enable NMSA not only in achieving the WMO norms with least cost and shorter period of time but also will create a good opportunity for its staff to concentrate on data processing and analysis and prepare handbooks, yearbooks, nomograms, empirical relationships between the various hydrometeorological elements, etc. using the collected data.

The total number of stations according to the strategy proposed might seem very much in excess of the WMO recommendations. However, this dense network will be operated for about 5 to 10 years and several stations can be abandoned after the hydrometeorological characteristics of the country are well understood by research activities.

The other alternative to upgrade the meteorological network is by using remote sensing techniques such as ground radar and geostationary meteorological satellite

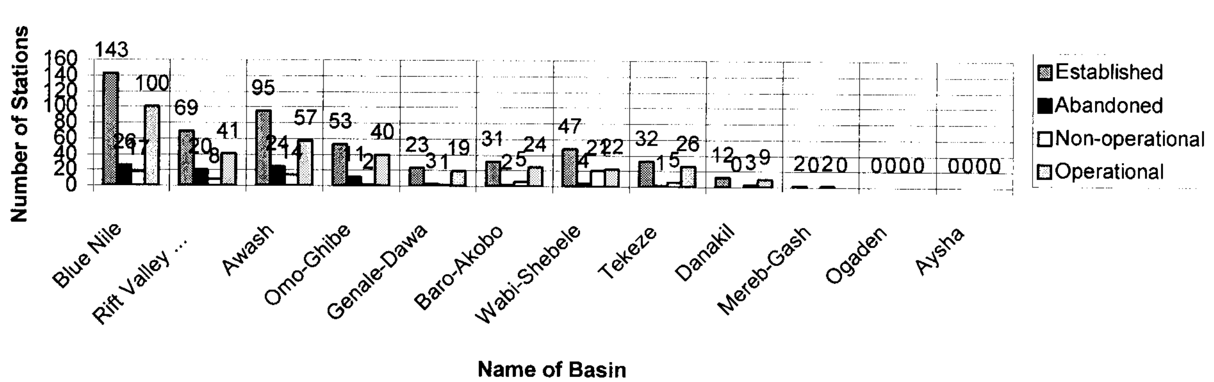

Figure 2. Status of stream gauging stations in Ethiopia by basin (after Kidane, 1997)

measurements. Since 1997/98 a joint USA-Japan satellite mission on Tropical Rainfall Measuring Mission (TRMM) at Goddard Distributed Active Archive Center (DAAC) is a break-through in the field of remote sensing for rainfall measurement. However, for poor countries like Ethiopia, the monetary constraint and capacity limitations will hamper the larger-scale use of this alternative. Therefore, the proposed strategy is still the most attractive alternative for Ethiopia.

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