Enhancing meteorological and climatological services and research through regional cooperation: The case of the IGAD countries

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Abstract

Most of the population of the countries in the IGAD (Inter Governmental Agency for Development) grouping of eastern Africa are engaged in rainfed agriculture and pastoralism. They are highly vulnerable to the consequences of climate change. The availability of good meteorological and climatological services plays a role as mitigating factor. Accordingly, good institutions are emerging in the region. On the other hand, science and technology have made significant developments during the last 30 years or so, and it is now possible to have seasonal forecasts that would allow end users to better cope with climate changes. For optimum results good coordination between researchers, operational agencies and end users is necessary. Focusing on Ethiopia, the paper proposes that government exert maximum effort in developing the rural population of Ethiopia (about 80% of the population) in order to minimize the consequences of underdevelopment, namely rapid population growth, migration to cities and towns, among others. It is also proposed that effectiveness of meteorological and climatological services be enhanced by complementary activities such as capacity building and enhancing coordination in the system consisting of researchers, forecasters, and end users.

1. Introduction

The countries of the IGAD (Inter Governmental Agency for Development), namely Eritrea, Ethiopia, Djibouti, Somalia, Kenya, Uganda, and Sudan (both South and North) are struggling to advance their economic development to improve the livelihoods of their populations. Most of the inhabitants of almost all of these countries are engaged in subsistence agriculture (mainly rainfed agriculture) and/or pastoral activities (as an example, in Ethiopia agriculture employs about 80% of the inhabitants who produce 54% of GDP and 90% of the exports of the country [1]). Modern industrial agriculture is also evolving, although not at a fast rate. These countries are frequently visited by severe droughts and are exposed to the threat of desertification. Further, global warming (provoked by human activities or otherwise) is likely going to lead to climate change whose nature can't be predicted accurately, which is posing additional challenges. They also suffer from population pressure and its consequences.

The above scenario points to the need of good meteorological and climatological services in the region. Further, during the last few decades, it has been recognized that there is a correlation between ENSO (El Niño/Southern Oscillation) and rainfall in southern Africa [2], [3], and elsewhere [4], and this recognition has led to the expectation that ENSO-based climate predictions will have significant applications in agricultural management. On the other hand,

good meteorological and climatological services are needed in the aviation industry and also for mitigating agroclimatic and environmental hazards. A close look at the ten thematic topics articulated by the organizers of the "Ethiopia 2050: Grand challenges & opportunities" conference shows that most of them are either directly or indirectly affected by meteorological, climatic, and related phenomena. Arguably, the rest may also be marginally affected in one way or another.

The paper attempts to justify the necessity of enhancing meteorological and climatic services and research for facing the challenges, and proposes measures to be taken to do it.

2. Background

2.1. The problem

Focusing on Ethiopia, one notes that agriculture employs 80% of the inhabitants and contributes 54% to the GDP. Most of those engaged in the agricultural sector are subsistence farmers, depending on rainfed agriculture and pastoralism. Quantifying may help in clarifying the situation. Accordingly, we define some sort of productivity index which we designate by P_a for those engaged in the agricultural sector, and by P_o for those engaged in the other sectors. P_a is defined here as the ratio of the GDP attributed to agriculture to the corresponding population, which comes out to be 0.675. P_o is defined likewise, and the corresponding value becomes 2.3. The challenge is to bring P_a upwards., at least to a comparable level as P_o.

This is an immense and complicated problem, but it is something that must be tackled. How should we approach this? The paper argues that during the last 30 years or so science and technology have advanced tremendously and that tools are now available, among other things, in the form of short term and seasonal forecasting, which could *assist* in facing the challenge. This is not a new idea and a lot has been done and is being done, but the efforts made must be enhanced, existing deficiencies must be bridged, and new developments must be adapted.

2.2. The nature of climate change

Although climate change involves variability of climate variables like, temperature, wind conditions, rainfall, and other parameters, the most important parameter in the region is rainfall. In most of the countries of the region, the rainy seasons are well known, and traditionally these have been designated as the big and small rainy seasons, separated by dry spells. The delineation is based on long-term mean of rainfall. Climate change is characterized by significant annual variations of the main rainfall indicators, like annual total, rainy season onset/cessation dates, distribution of rainfall within and outside of the rainy seasons, etc. As an example, the extent of year-to-year variability ranges from 20% to 80% of the mean in the Sahel savanna (13º-18ºN) of the West African Soudano-Sahel region [5].

The consequences of such large variations of the amount and distribution of rainfall complicates the traditional rainfed agriculture and cattle herding activities of the rural population, making life difficult. The farmers and herdsmen have very poor coping capacity and as things stand, negative

climate perturbances lead to degradation of the echo system of the environment, decimation of live-stoke herds, and famine to the population. As an example, as many as 250,000 people and about 12 million cattle are estimated to have perished during the 1968 – 73 Soudano Sahel drought [6].

2.3. Relevance of weather and climate services

Our everyday life and the sustainable development of societies are affected by the weather, climate, water resources and the natural environment. Weather, climate and water information and knowledge are used to influence decision making processes in many areas of human activities [7]. Some of the most prominent are given next.

Good meteorological and climatic services are highly needed in the farming sector, where most of the inhabitants of the region depend for their livelihoods. This is particularly imperative if climate change adaptation strategies are to work successfully [8].

Meteorological services are a requirement in the aviation industry which is growing in the region. Ethiopia has the best airline in Africa [9] offering world class air services. Kenya also has a good airline [10]. Given the rugged landscape, and the prevailing poor road network of most of the countries of the region, air transport is likely going to increase significantly in the future.

Statistics, during the time period 1980 – 2010, reveal that some 90% of natural disasters, 70% of casualties, and 75% of economic losses are caused by weather, climate, or water related hazards [11], [12]. Such hazards include droughts, floods, windstorms, tropical cyclones and storm surges, extreme temperatures, etc. (see for example [13] for two regions of Eritrea). These can be avoided or minimized through the use of early warning systems.

As the economy of the region grows it is expected that more activities will require good meteorological and climatic services.

2.4. Scope of the paper

The issue of developing an agrarian economy to become a sustainable and productive sector in the face of highly variable climate system is a challenge which can't be fixed by the provision of meteorological and climatological services alone; the fundamentals must be there. Here we focus only on the former.

Further, the focus here is on the possibility of adapting new systems and stressing the need to inject synergy into the various components of the system. To elaborate on this, it has been observed that recent research in sub-Saharan Africa in the nature of climate variations has been significant, but there have been obstacles in exploiting this to the benefit of end users [14].

3. Enhancing meteorological and climatic services and research

3.1. Basic concepts

Success in developing an agrarian community exposed to the consequences of climate variability "depends on the extent to which (i) the problem is understood, (ii) such knowledge is accessible to potential victims and policy makers, and (iii) society and vulnerable groups have the ability to put that understanding into practice" [14], [15].

Stated differently, the community of the scientists and technologists who produce the knowledge and systems, the community of operational agencies, the community of end users, and the respective decision makers, must act in conformity with the principle stated in the preceding paragraph. Further, it is necessary that the end users or victims must have options, or room of maneuvering, to face successfully the prevailing manifestations. This is fundamental.

3.2. State of meteorological and climatological services in the region

It can be stated that good institutions are emerging in the region. The Kenya Meteorological Department (KMD) offers weather, climate, and early waning services to a number of end users [12], [16] and the Department of Meteorology of the University of Nairobi has good programs in research and teaching/training [17]. To the best knowledge of the author, it is the only university department in the region.

The National Meteorological Agency of Ethiopia (NMAE) is responsible for the delivery of meteorological and climate services in Ethiopia, and there is a meteorological community under the umbrella of the Ethiopian Meteorological Society with its own scientific periodical. NMAE offers meteorological and climatological services to various end users in Ethiopia. Organizational and other relevant details are given in [18].

The Uganda National Meteorological Authority (UNMA) is responsible for meteorological and climatological services in Uganda. Pertinent information on the UNMA and the services it offers are given in [19]. There are indications for the modernization of UNMA [20].

The three meteorological agencies all use surface monitoring instruments of various types and each of them has at least one upper air facility. The regional office of the World Meteorological Organization (WMO) assists the countries of the region appropriately.

3.3. Developments in meteorological and climatological systems

Science and technology are developing fast and in the advanced countries, these developments are being exploited to improve meteorological and climatological services. As an example, The ECMWF (European Centre for Medium-Range Weather Forecasts), through the use of science and technology, has improved the reliability and spatial resolution of its weather forecasts significantly – current 6-day prediction is as accurate as 3-day prediction 30 years ago. The

corresponding spatial resolution is 20 times finer [21]. These improvements are expected to continue in the future.

On the other hand, the science of ocean – atmosphere coupling and its application to seasonal forecasting must be exploited as much as possible. Experts in agriculture explain that the planting period in rainfed agriculture is critical. Knowing the onset of rainy seasons in advance is an important information and seasonal forecasting may be used for optimizing yield (the variation in yield due to variations in planting date alone could be more than 50%) [2], [3].

Improvements in weather prediction have come through numerical weather prediction using suitable models. These are demanding in terms of data and computational power. The region has a variety of instruments in terms of surface data [12], [16], [18], [19]. Upper air data is obtained using radiosondes. In this case, an instrument carrying balloon ascends into the sky measuring temperature, humidity, and pressure, as a function of height, and transmits the information to a ground station (a system which also measures wind speed and direction is more properly called rawinsonde). The distribution of the global radiosonde station network is shown in Fig. 1.

Other types of upper air measuring systems are shown in Fig. 2. One of the new systems is the wind profiler system. This is best used for measuring wind. There are smaller units which can observe the boundary layer, and bigger ones for observing higher altitudes at tropospheric heights. One of the advantages of wind profilers is their high data gathering ability. Whereas radiosondes are normally launched 2 times per day, (the atmosphere is sampled twice a day), wind profilers can get a wind profile of the atmosphere in about 5 minutes, improving time resolution tremendously. Further, they can detect wind sheer (necessary for airports). The improvements wind profilers bring to weather and climate predictions is given in [23], [24].

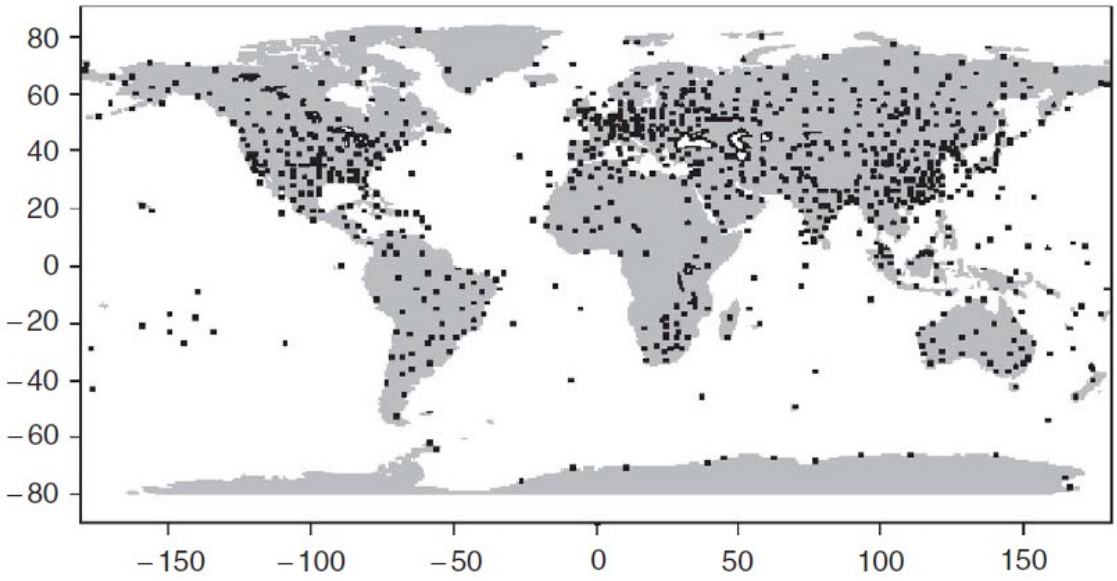

Fig. 1. Global radiosonde station network (adopted from [22]).

It is interesting, and indeed encouraging, to note that the Uganda modernization plan includes wind profilers (with possible site at Entebe airport) [20]. Satellite observation systems offer another option.

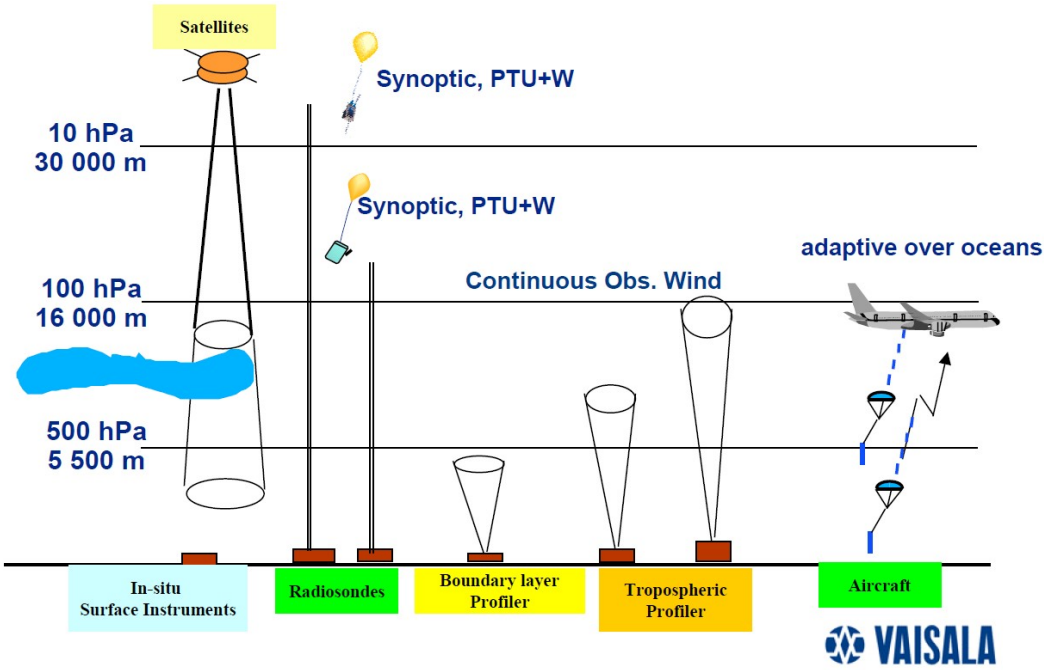

Fig. 2. Upper air monitoring systems (adapted from [24]).

It is to be noted that Ethiopia is acquiring its own satellite [25], while Kenya has already acquired one [26], and this is expected to increase the observational capacity of the region.

3.4. Discussion on the main points

It must be stressed that meteorological and climatological services help to mitigate the risks associated with varying climatic conditions. Forewarned is forearmed, and good meteorological forecasts save lives, and livelihoods. However, it has been observed that "very few people in the Sahel use the results of climate research, and few have access to seasonal forecasts, even though the vast majority seem willing to use such information" [14]. This indicates that the system consisting of researchers, operational agencies, the end users (mostly peasants and pastoralists), and the associated decision makers are lacking vital items. Lack of coordination may be the reason. Another possibility is that the end users may not receive the forecasts in good time, or are unable to act even if they get the forecast on time, because they don't have options. These must be addressed appropriately.

The role of the WMO Regional Office is critical, and must be enhanced. The European Union, with membership of 34 countries (in the weather and climate domain) has a number of meteorological and climatological programs, where ECMWF is one of them. By all indications they are benefiting by working together. As natural phenomena do not know political

boundaries, they are best studied through regional cooperation. A closer look at how this can be adapted in this region of Africa is useful.

As the economies of the IGAD countries develop, it is likely that the use of meteorological and climatological services will expand to more activities, similar to those currently existing in the northern hemisphere. The improved services will require more data inputs and expertise. Developing indigenous scientific and technological capacity to handle the required systems is a good investment for the future. Imported expertise and technology are not going to be sustainable unless they are mastered. The extent of indigenous capacity building depends, among other things, on the degree of cooperation with advanced institutions.

4. Conclusion and proposals

Meteorological and climatological services assist end users like farmers and pastoralists, as well as aviation and other organizations. Good institutions are emerging in the region that would permit further growth and improvement. Regional and international cooperation is necessary in dealing with natural phenomena which does not know political boundaries.

Focusing on Ethiopia, the following proposals are made.

1. Exert maximum effort to develop the rural population, mostly engaged in subsistence farming or pastoralism, in a manner that would substantially raise productivity resulting in better livelihood and sustainable living conditions.

   Justifications:

   Unless this is done, the country may face multi-pronged problems: exploding population, (unable to get descent living and life supporting facilities), resulting in mass migration to cities, among other things, which may also cause instability.

2. Improve meteorological and climatological services, and insure that end users get them on time, by the following complementary actions.
   (i) Develop high level research capacity in meteorology and related fields possibly by establishing a university department and associated research center(s).
   (ii) Improve communication between researchers, the operational agency, and end users to achieve optimal results.
   (iii) Exert maximum effort in building capacity in the user community to create more options, thereby enhancing their resilience to the consequences of climate variability.
   (iv) Advocate and pursue a policy of regional and international cooperation in the fields of meteorology and climatology.

Justifications:

Developing indigenous capacity insures sustainability and development, and synergy in all the activities insures good results. Good research results and meteorological and climatological services alone will not have impacts if the end users are not able to use them. Communication systems and an enabling situation for end users, mostly peasants and pastoralists at this point in time, is necessary.

References

[1] Central Statistical Authority, Ethiopia (2000). *Statistical abstract of Ethiopia*. Addis Ababa, Ethiopia.

[2] Cane, M.A., G. Eshel, and R.W. Buckland (994). Forecasting Zimbabwean maize yields using eastern equatorial Pacific sea-surface temperature. *Nature,* vol. 370, 204-205.

[3] Phillips, J.G., M.A. Cane, and C. Rosenzweig (1998): ENSO, seasonal rainfall patterns and simulated maize yield variability in Zimbabwe. *Agric. Forest Meteorol.*, vol. 90, 39-50, doi:10.1016/S0168-1923(97)00095-6.

[4] Yang S., Z. Li, J.-Y. Yu, X. Hu, W. Dong, and S. He (2018). El Niňo-southern oscillation and its impact in the change of climate. *Advances in El Niňo research*, DOI/10.1093/nsr/nwy046/4975301.

[5] Bello, N. J. (1996). An investigation of the characteristics of the onset and cessation of the rains in Nigeria. *Theor. Appl. Climatol*., vol. 54, 161-173.

[6] Borton J., and E. Clay (1986). The African food crisis of 1982 – 1986. *Disasters*, vol. 10, 258-272.

[7] WMO – Europe (2007). Strategic plan for the enhancement of meteorological and hydrological services in the region. *Publication of WMO*, 67p.

[8] Cooper, P. J. M., R. D. Stern, M. Noguer, and J. M. Gathenya (2013). Climate change

[9] Ethiopian Airlines (2016). Ethiopian fact sheet. *Publication of Ethiopia Airlines*, 6p.

[10] Kenya Airways (2017). KQ 2017 annual report and financial statements. *Publication of Kenya Airways*, 168p.
adaptation strategies in sub-Saharan Africa: foundations for the future. *http://dx.doi.org/10.5772/55133*

[11] IPCC (2013). Summary for policy makers. In *Climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change*, T. F. Stocker, D. Qin, G. K. Plattner et al., Eds., Cambridge University Press, Cambridge, UK.

[12] Shilenje, Z. W. and B. A. Ogwang (2015). The role of Kenya meteorological service in weather early warning in Kenya. *International journal of atmospheric sciences*, (http://dx.doi.org/10.1155/2015/302076).

[13] Woldesellasie Ogbazghi (2018). Agro-climatic and environmental hazards and mitigation measures for the Northern and Southern Red Sea zone administrations of Eritrea. *Journal of Eritrean studies*, vol. 8, 85-131.

[14] Tarhule, A., P. J. Lamb (2003). Climate research and seasonal forecasting for west Africans: perceptions, dissemination, and use?" *Bulletin of the American Meteorological Society*, vol. 84(4), 1741-1759, DOI. 10.1175/BAMS-84-12-1741
[15] Van Apeldoorn, J. G. (1981). *Perspectives on drought and famine in Nigeria*. George Allen and Unwin, 184p.
[16] Mukabana, J. R. (*). Role and operations of the KMD in service delivery for sustainable development. *KMD document*, Nairobi, Kenya.
[17] University of Nairobi (2016). Department of Meteorology: Annual report 2014-2015. http://meteorology.uonbi.ac.ke./
[18] Melesse Lema (2018). Climate data observation, climate monitoring and long range forecast methods in Ethiopia. Paper presented at WMO workshop, Pretoria, South Africa.
[19] Nkalubo, M. S. Z. (*). Service delivery by the Uganda Meteorological Services for sustainable development of the country. *Document of the UNMA*, Kampala, Uganda.
[20] MDA information systems (2013). A modernization plan for Uganda's meteorological services. MDA information systems, 186p.
[21] ECMWF (*). ECMWF strategy 2016 – 2015: The strength of a common goal. Publication of the ECMWF.
[22] Dabberdt, W. F., R. Shellhorn, H. Cole, A. Paukkunen, J. Hőrhammer, and V. Antikainen (2003). Radiosondes. *Elsevier Science*, 1900-1913.
[23] Benjamin, S. G., B. E. Schwartz, E. J. Szoke, and S. E. Koch (2004). The value of wind profiler data in U. S. weather forecasting. *Bulletin of the American Meteorological Society*, DOI:10.1175/BAMS-85-12-1871.
[24] Frederick, G. (2004). The value that wind profilers bring to weather forecasting. A publication of VAISALA, 36 p.
[25] Reuters (2019). Ethiopia is set to launch its first satellite into space – with China's help. https://qz.com/africa/1474369/china-to-help-launch-ethiopias-first-satellite-in-2019/ (accessed 30 August 2019)
[26] University of Nairobi (2018). Kenya's first satellite is now in Earth's orbit. https://www.technologyreview.com/f/611127/kenyas-first-satellite-is-now-in-earth-orbit/ (accessed 30 August 2019).

* No date.