ACCURATE DATA MONITORING
A NECESSITY FOR SOUND FOOD SECURITY INFORMATION

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1.0 Abstract

Tanzania Meteorological Agency (TMA) formerly the Directorate of Meteorology, goes on contributing highly in making reliable Food Security (FS) information. Contribution is in terms of monitoring weather elements such as rainfall, a parameter that in some observing stations records now go back as far as 100 years. Importance of the service currently goes on as food crop production to-date over most parts of the country depends on rain-fed small-scale agriculture.
The paper highlights an objective methodology in operation that monitors agrometeorological parameters. Products of the model enables quantification of crop yield on major food crops. Availability of such data has enabled standards reached of FS information in the country so far. Advance in technology, take for example the satellite science, has availed remote sensing as a tool that can quantify agrometeorological elements such as areal rainfall, changes in the greenness of the earth's surface. Such information improves a lot on the usual station data.
In dealing with data, occurrence of gaps cannot be avoided. The paper suggests a few simple and practical methodologies used to tackle this problem, thus bring improvement on the available time series important for analysis. Further more the paper sights limitations encountered during operations, taking the example of crop yield model that to-date needs for its fine tuning, seasonal crop cutting data. All in all, the meteorological science is in the frontline making FS information objectively.

2.0 BACKGROUND

Food Security Information making in the country took a scientific approach during the late 70's when drought situations became very frequent. Tanzania benefited from the implementation of the FAO stand to help developing countries make accurate information on expected food crop harvest needed to quantify the total national food basket at the end of a given period. Such statistic becomes important if food shortages occur.
In a very simplified format yield of growing crop was defined to be a function of total soil water used by a plant from planting to maturity. The soil water usage could be evaluated by accounting its availability through a given period where main source was rainfall. Even though yield of growing crops is mainly a function of parameters such as soil water usage, field management practices and fertilizer usage, nevertheless, on application to the local farmer's practice level in the country, rainfall is assumed as the major dependent variable, a theory that can be modeled easily. Using such approach an objective methodology was put in place where raw data was thus monitored agrometeorologically.

When the idea was implemented for the first time in the country, the rainfall observation network run by the Directorate of Meteorology by then, was used in addition a number of supplement stations were also established over important Agriculture areas. The majority of the observers are volunteers; a factor that has helped to sustain the data collection system so far. These *wananchi* need to be commended for their dedicated service over the past 30 years. A token of some sort is necessary to these observers given the current change in the trend of most operations becoming commercially oriented. The observers thus provide station rainfall and crop phenological information using 10-day pre-paid Post Cards.

3.0 FAO CROP YIELD MODEL

The theory was modeled first by FAO Agrometeorologist consultants, (Frere' *et al* 1979). The model was computerized later written as FAONDEX version 2.11 (Gommes 1993). These pioneer scientists produced a monitoring tool that enabled quantification of total soil water usage by a plant over a given period. When potential evapotranspiration through a plant has bee met by sufficient soil moisture supply, the evapotranspirating plants remain healthy and correspondingly better crop yield level would be reached. In fact they established a crop satisfaction index which was a function of soil water usage by the growing plant. The model has been found to work better over areas with soil water limiting farm conditions. Results show that indices below 50% depicted a failed crop while above 50 corresponds to better yields and thus the range between 90 to 100% corresponds to an excellent crop.
The model uses 10-day rainfall information together with the basic crop parameters such as planting date and its cycle length. Such information is keyed into a computer program that evaluates to what extent the plant soil water needs were met over a given period of growth. The index correlates highly with crop yield levels especially over semi arid areas.

4.0 Meteorological Data

Tanzania Meteorological Agency (TMA), formerly the DIRECTORATE OF METEOROLOGY up December 1999, has the Governments mandate to observe and archive meteorological elements in the country. On the aspect of Food Security Information, the Agency has a memorandum of understanding established through the parent ministries on provision of meteorological experts to the Food Security Department, generally resulting in exchange of data that flows smoothly. Nevertheless, amendments to the document are forth coming, as within the TMA now cost recovery is the goal for its services offered.

4.1 Rainfall:

Rainfall is the most popular meteorological element widely used in the country to describe the performance of the agriculture sector, the later called the backbone of the economy of the country. TMA currently runs a network of 21 active Synoptic stations, 12 Agrometeorological stations all managed by Meteorological officers linked by telephone to the headquarters. The next category is the voluntary observers numbering about 2000. The volunteer observers work in various institutions in the Ministry of Agriculture such as research stations and institutions and district offices. Other centers include Maji, Schools, Missions, Health centers, National Parks, Prisons and also some individual farmers. All these observers furnish TMA with raw data on a monthly-prepaid Post Card.
Tanzania covers a vast area with marked zonal characteristics where physically depicts coastal lowlands rising to about 500 meters from the sea level. Next in elevation are the low lying areas over the highland ranges (500-1500m) and then the spectacular isolated mountain areas that peak out to altitudes above 1500m. To monitor properly meteorological elements a dense network is necessary, WMO standard recommend an 8km grid, but operational costs become high in terms of maintaining **working** measuring instruments and training the high turnover volunteer observers needed to make accurate raw data. All in all, station rainfall has been recorded for more than 100 years in some areas.

4.2 Weather Forecast

Short and long-range weather forecast issued with a good lead-time (Gibberd *et al* 1997), can feed timely into Government Planning sector involved in areas such as disaster management. The science of meteorology has profited much from research circles that have established the existence of a significant link between changes in global weather systems and localized regional changes in their seasonal weather performances. One widely used area is the anomalies in Sea Surface Temperatures (SST) as that existing over the tropical east Pacific Ocean. A warm mode termed as *El Nino*, can be significant as early as during the months of May June July. Given such situation the impact to Tanzania will be a prediction of occurrences of high chances of above normal levels in the *vuli* and *masika* rainfall season that occur during October through December. This gives a lead-time between 2 to 3 months. Likewise, a *La Nina* phenomenon is the cold mode; it results in diminished *vuli* rainfall season, which was the case during the 1999.

TMA in corroboration with regional and international forecasting centers meet during forums to come out with a consensus outlook of the rainfall trends. It is the TMA's duty to scale down such statements to local level scales, a sure guiding gauge in the making of Food Security information. The 1999/2000 forecast update for March-June 2000, issued to the press during mid-February can be discussed on its usefulness so far.

4.3 Remote sensing data

Remote sensing technology has helped solve the problem of sparse data prominent with the existing station information, the existing satellite data covers even over remote areas. Such extended data is very useful and can be received in formats such as:

4.3.1 Rainfall estimates images are now available for localized areas where modeling show high skill using satellite observed parameters such as cold cloud duration.

4.3.2 Normalized Difference Vegetation Index (NDVI). Indicator of change in the greenness of the earth's surface. During a growing season such change if interpreted scientifically can help depict trend in status of vegetation.

Given knowledgeable analysis capability, such information can be input in the crop yield models used to estimate amount of food crop to be harvested as Production = Yield * Area planted to the particular Crop. Mostly done on major food crops like maize, beans and sorghum.

Operationally, not all data is available for the period of interest, gaps sometimes appears, and at times creates serious problems to quality of analysis especially if the information is not monitored at all. Also improving on the above quoted model, seasonal GIS information on inputs and yield data (got by crop cutting) is already over due. Some of our institutions that contribute in collecting basic FS Information need to change on their priorities such that use of objective methodologies is emphasized in raw data making otherwise some of Tanzania's basic data will need from now, another set of 30 years to establish norms.

5.0 Data Gaps in Meteorological elements

Data gaps at availing near real time analysis are mainly due to

5.1Postal problems:

- Delays to post filled cards,
- Broken communication system - e.g. non payment of bills

5.2 Station Requirements

- due to absence of the observer/working instrument, stationary.

5.3 Observer welfare

- Lack of motivation/supervision

5.4 Unsustainable operational budget at head offices

- budget to maintain links - internet
  -RS data reception
- budget to maintain hard/soft wares

6.0 Data gaps Mending

Gaps in Food Security Information in the country vary depending on the reference point one urges from. Meteorology science stands out as one of the leading sciences that have contributed a lot in availing sound objective methodologies to create needed raw data. Nevertheless, occasional gaps in the time series available occur. To this problem a few methods that can be applied to rectify are highlighted below.

6.1 Methods used in gap filling

Gaps in the time series of meteorological elements such as rainfall can be tackled using the following methods that can give accuracy befitting FS Information

6.1.1 Normal Ration Method (U.S. weather Bureau)

Use information from near by stations (e.g. 3 stations a, b & c) to that with missing value can be taken as follows:

$$P_x = \tfrac{1}{3}[(N_x/N_a)P_a + (N_x/N_b)P_b + (N_x/N_c)P_c]$$

P_x , N_x,: missing and normal value for station -x-
P_a , N_a,: actual value, normal for station -a-
P_b , N_b,: actual value, normal for station -b-
P_c , N_c,: actual value, normal for station -c-

6.1.2 Use of an Ida GIS Tool - sedi window

A computer program written by a consultant during mid-1990s for Regional Remote Sensing Project for the tasks of managing data collected from SADC countries (Hoefsloot 1996). A GIS referenced set of station rainfall file with missing values is first rationed against a cold cloud duration image with same geographical references. The resulting file is then converted to a raster image. As then the data has been extrapolated, missing values at specific points can be extracted in the sedi window. Detailed mathematics can be found in the reference manual quoted.

6.2 Crop Phenology

Description of state and stage of growing crops (phenology) in the fields at the end of a given period is necessary whenever an agrometeorological situation is given. From the observation network, rainfall data can be available timely, but crop status information usually is scant and delays to reach in time for analyses. A temporal way around this problem has been suggested and documented (Mboya 1997). Use of FAO Index products (IndxLast - the end of a given period water satisfaction index. A parameter that predicts the trend in the development of a crop using normal conditions from the time actual data has been received looks forward to maturity. If the timing is during late vegetative stage the estimate information is dependable.

6.3 Physical Assessment Missions

Surveys can be conducted to improve quality of information to particular targeted problem areas. Experts of different scientific fields can be able to gather at a short time interval important basic situational information needed to fill in the gaps for analyzing a situation of a specified period, thus improve a lot in the accuracy of an ad hock report

7. 0 Challenges

TMA undertakes to provide its services professionally, efficiently, accurately and timely. Lets continue working scientifically such that our institutions work with good data to be able to offer better analyses such that reliable FS information is provided.

As stated earlier, Agrometeorology urgently needs GIS referenced information on inputs used during growth and the ultimate yield of our food crops per season to update (tune) the operational model.

8.0 Reference

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