Tanzania Meteorological Authority (TMA) Agrometeorological Database

Contents

1. Background

The Tanzania Meteorological Authority (TMA) Agrometeorological database provides a holistic tool that enables generation, analysis and pulling together of agrometeorological information from several different sources. The data sources include satellite data for different agrometeorological parameters, ground stations, and field reports. The platform was developed incorporating guidance and preferences obtained from a user requirements analysis undertaken with the technical experts at TMA and Food and Agriculture Organization (FAO) of the United Nations. This assisted the determination of the types of data stored and analysis necessary for specific information and products generation. Data can be entered manually, imported from Excel sheets, and automatically downloaded from satellite data sources. Further, data can be received and archived from manually operated stations into the database. Therefore, the database archives data and performs agrometeorological analysis on the archived data.

Agrometeorological products include information such as start of season, rainfall amounts, drought conditions, crop conditions, vegetation conditions, soil moisture, and crop yields. Due to availability of archival data (remotely sensed and in-situ observations), the database allows time series analysis of agrometeorological attributes. The agrometeorological database is designed to suit the needs of agricultural stakeholders (farmers, livestock keepers, fishers, extension officers, policy makers and decision makers), downloading and processing remote sense satellite data for soil moisture, rainfall estimates and vegetation indices from global data sources, generate tailor-made agrometeorological products and information, agrometeorological weather indices and downscaled agrometeorological products.

In addition to temporal analysis, the platform also allows spatial analysis of agrometeorological variables. The database allows visualization of maps and interactive retrieval of information at scales such as region and district in Tanzania. This allows comparison in space and time of the state of agrometeorological features. For each segment, a user can also plot graphics such as time series and comparison, for example, of a given dekad with same period in different years or with the long term mean. Therefore, the database has a user interface to display information analysed and generate downscaled agrometeorological products that meet user needs. This manual, therefore, provides the user with an overview of functions and products embedded in the database platform. Importantly, the manual also shows how users are given different privileges of accessing information at the discretion of TMA.

The TMA Agrometeorological Database was commissioned by TMA, FAO, United States Department of Agriculture (USDA) and Washington State University – International Development (WSUI-ID). TMA and MoA provided the station data, yield data and agrometeorological data reporting forms that were used to guide the customization of the database to their needs. TMA, MoA and FAO further provided guidance during the development of the database, with ongoing interactions and discussions. The Agrometeorological Database was developed by Tamuka Magadzire in consultation with Blessing Siwela. This manual was written by Tamuka Magadzire

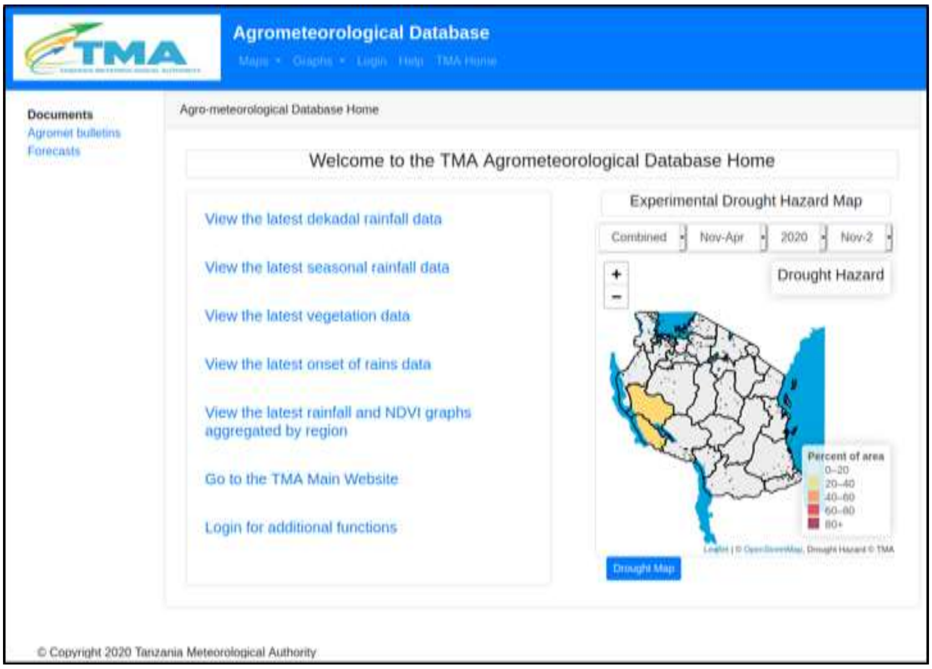
and Terence Mushore, with contributions from TMA, Ministry of Agriculture and FAO. Oversight of the development of the database during the duration of this project was provided by TMA and FAO.

2. Public access to the database

The Agromet Database can be accessed by all users from the following web address:

http://agromet.meteo.go.tz/

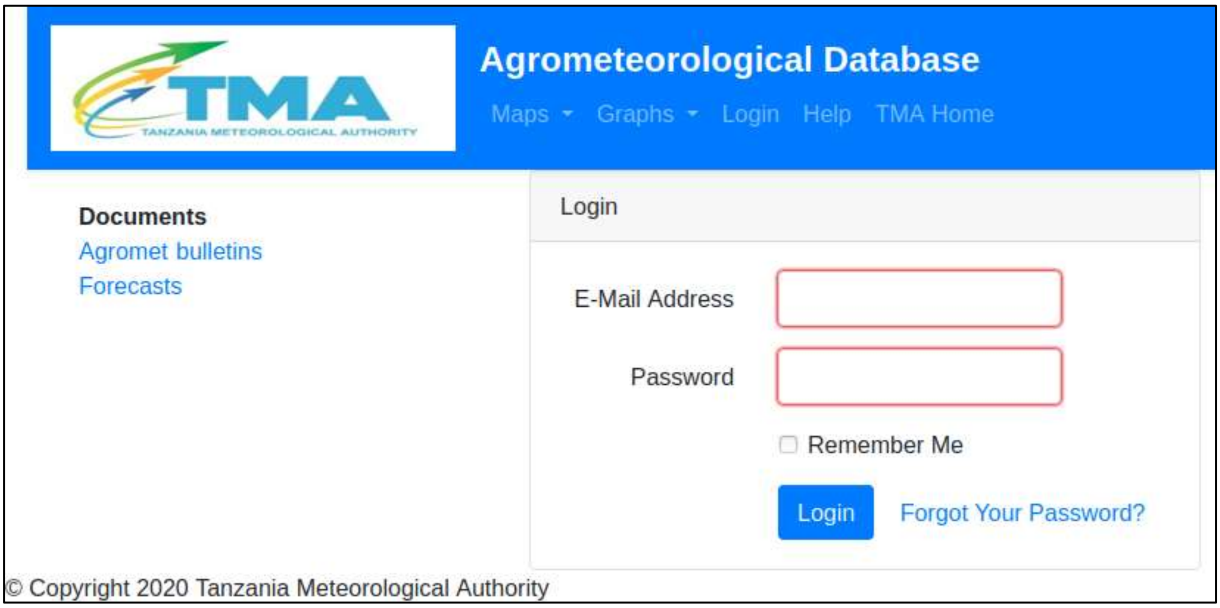
Public users such as researchers outside TMA can access the database without entering any login credentials. Public users are however limited only to visualization of publicly available graphs and maps, forecasts, and agrometeorological bulletins. In this case, the users land on a page with links to latest available data for various agrometeorological parameters, as well as a thumbnail of the latest experimental Drought Hazard Map showing the season-to-date drought conditions, as estimated by a frequency-based approach. Authorized users can access additional functions such as crop modelling and entering and viewing of station data.



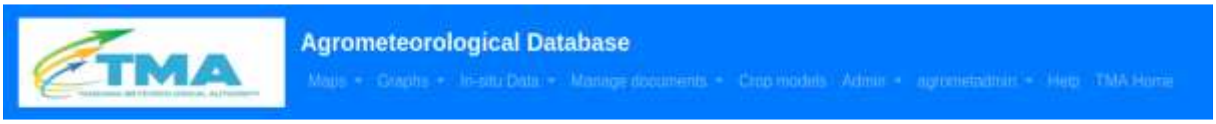
On the Drought Hazard Map, users have options to display drought information as a function of Normalized Difference Vegetation Index (NDVI), CHIRPS rainfall or the two combined (see illustration below). As the user hovers the cursor over a region, a value indicating percentage of drought affected area is shown under the "Drought Hazard" tab on the top right of the visualization section. The drought hazard map is explained in more detail in section 4.7.

3. Controlled access to the database

Access to additional functions of the database beyond visualization of maps and displaying of graphs requires logging-in with a username and password. The username and password are assigned by the administrator. The platform also provides privileges which differ between administrators and other users of the database. Access control allows TMA to specify who amongst their staff and stakeholders has the permissions to access and add data, to view station data, to upload bulletins and forecasts, and to model crop yields as well as to make necessary edits on the database. In order to access more data and functions, the user clicks on “Login” on the main menu bar and enters the registered credentials.

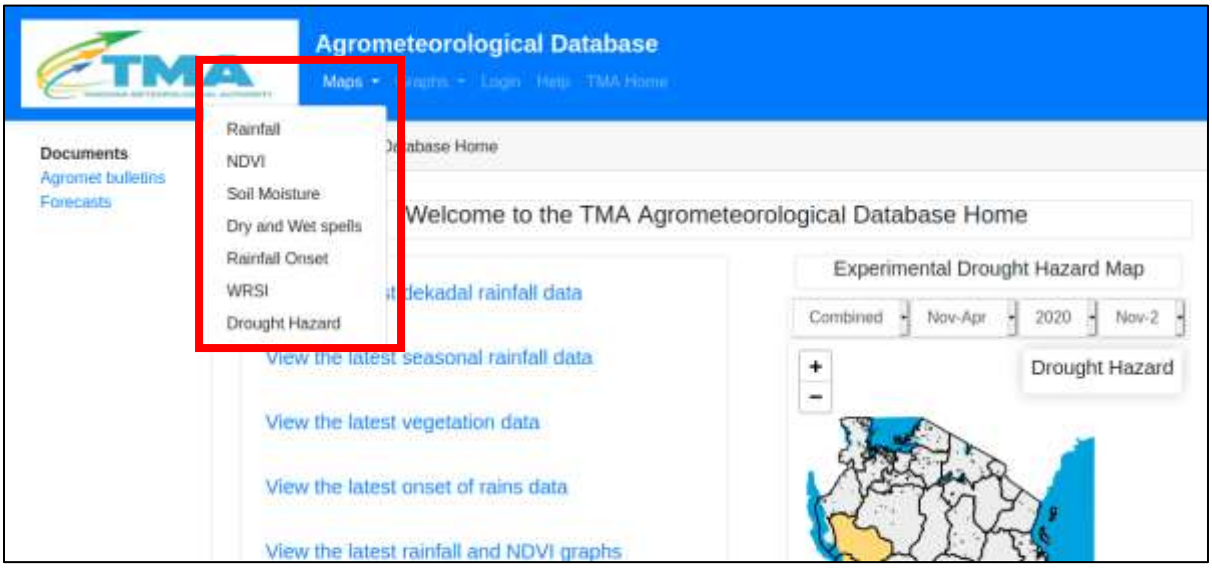


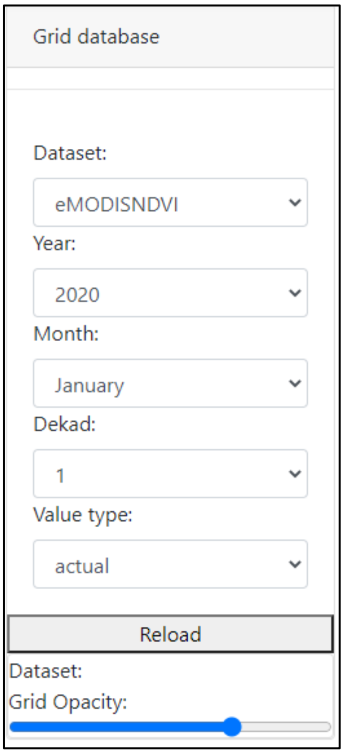
The database provides authorized users with access to functions which include data entry, plotting of graphs, maps of agro-meteorological attributes as well as crop models and document management. Upon signing in, the menu is expanded to display additional functions that the user will have access to. Clicking on menu items with a downward pointing arrow reveals sub-menus with more functions



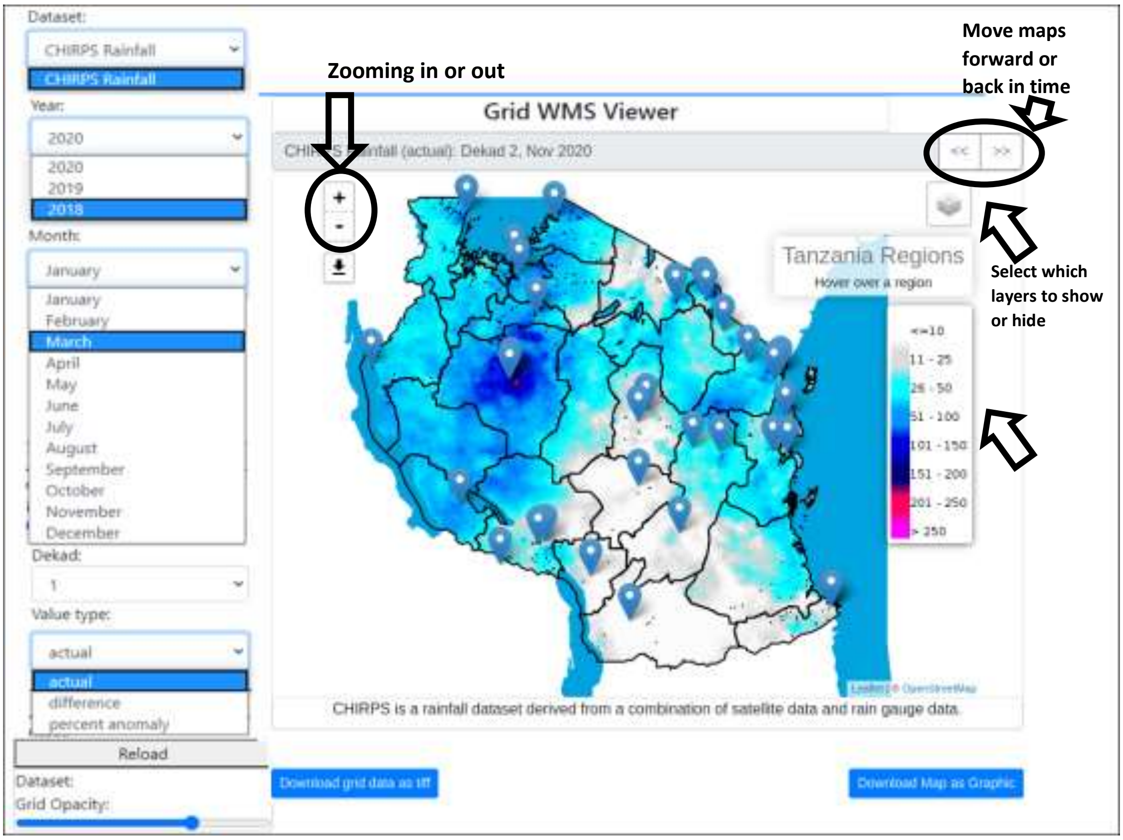
4. Mapping of agro-meteorological variables in the online database

Under the Maps function there is a list of variables that can be mapped at user specified periods. The list appears when the “Maps” button on the far left of the menu is clicked, which allows selection of data for mapping. The variables currently accessible are rainfall, NDVI, soil moisture, dry and wet spell, rainfall onset and WRSI. Once a variable is selected the values are automatically mapped and visualized in the Grid WMS Viewer as shown below.

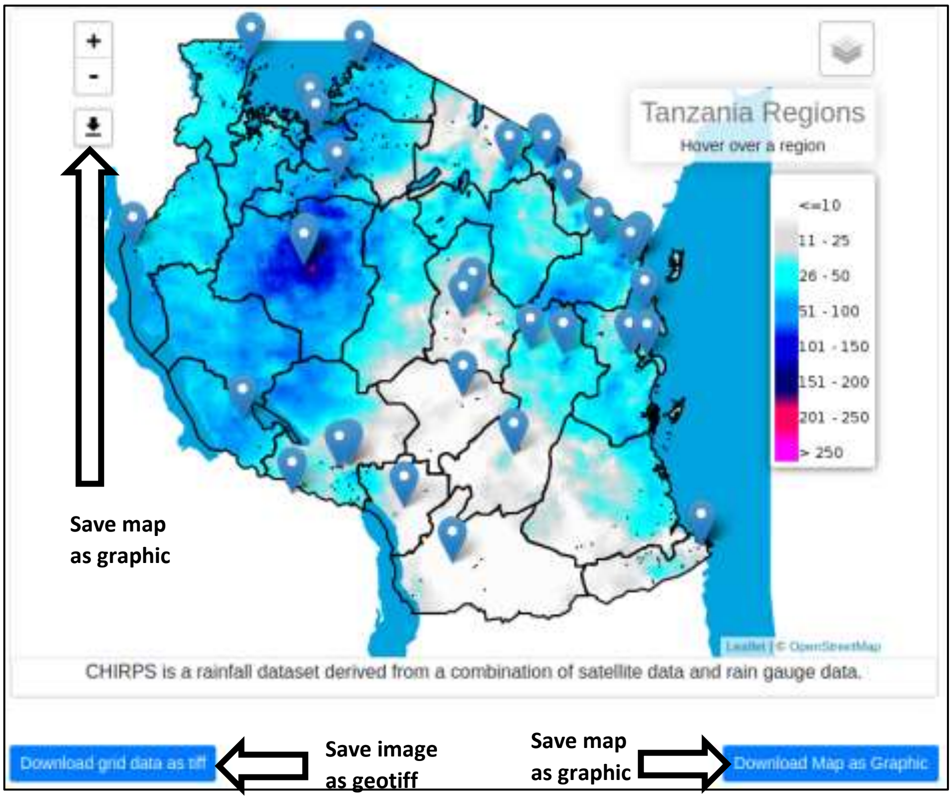




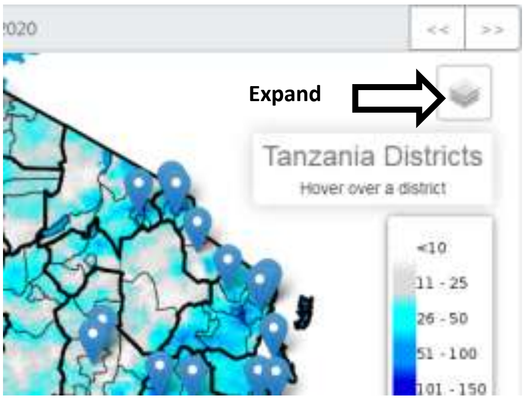
On the left of the viewer is a taskbar with additional options on visualization of the data.These options differ according to the agrometeorological parameter being viewed, but include selection of dataset to be visualized, the year, month and dekad to be considered as well as the value type with options accessed by clicking a drop down arrow on the right of the attribute. Once the parameters have been selected, the user can click the Reload button to update the map to show the selected parameters. Opacity can be adjusted by sliding to the left or the right the bar found at the bottom of this taskbar. Reducing opacity enables the user to view the underlying features and thereby provides context to the area on the map.

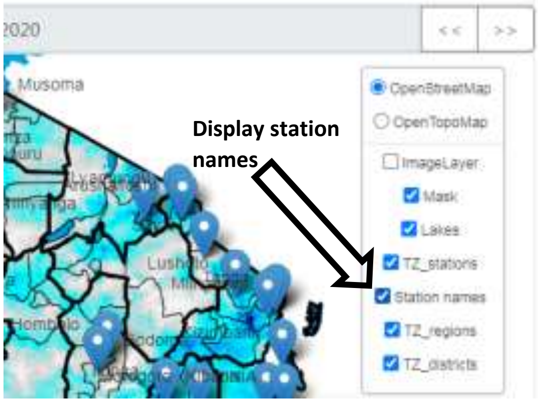


After making change/s to the display option they can only be effected in the Grid Viewer after clicking the "Reload" button.



The map that is being viewed can be saved as a png graphic by clicking on the downloaded buttons on the top left or the bottom right. The raster data can also be saved as a georeferenced geotiff that can be used in a GIS package for further analysis, by clicking on the button on the bottom left.

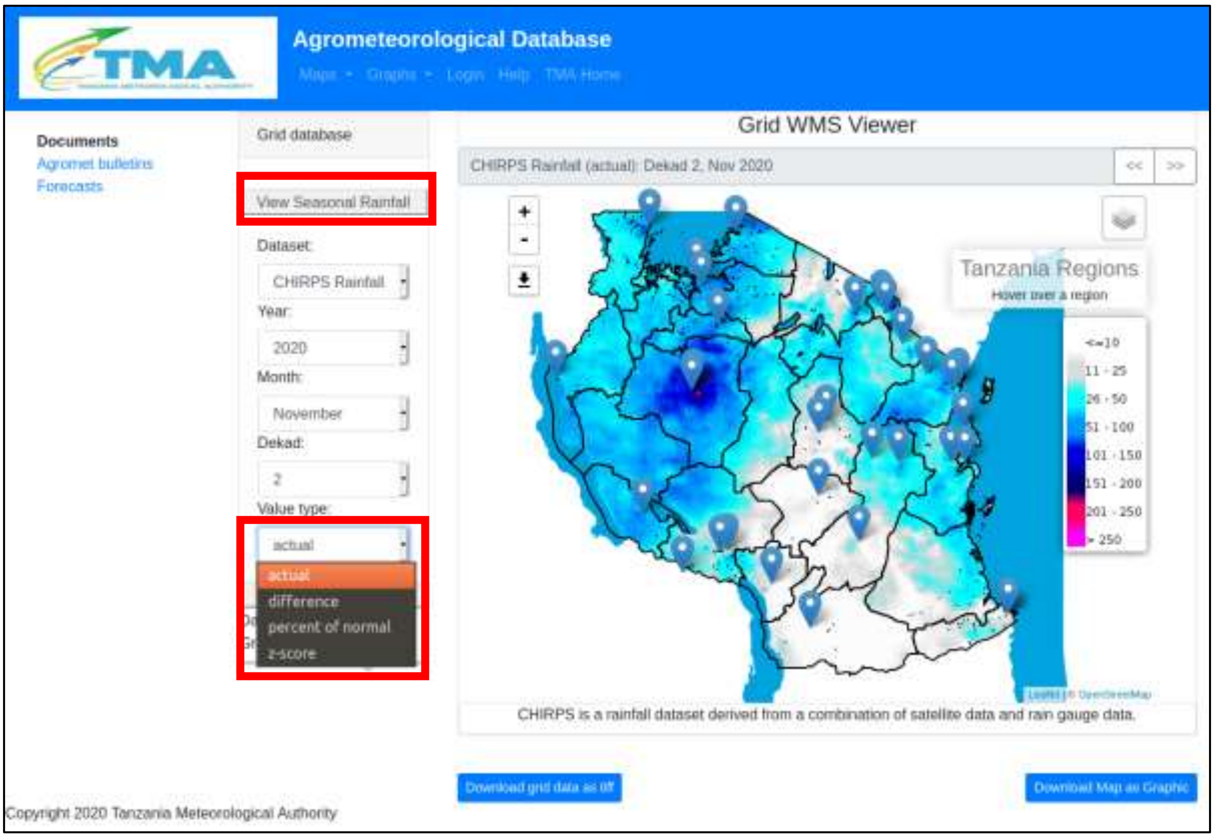




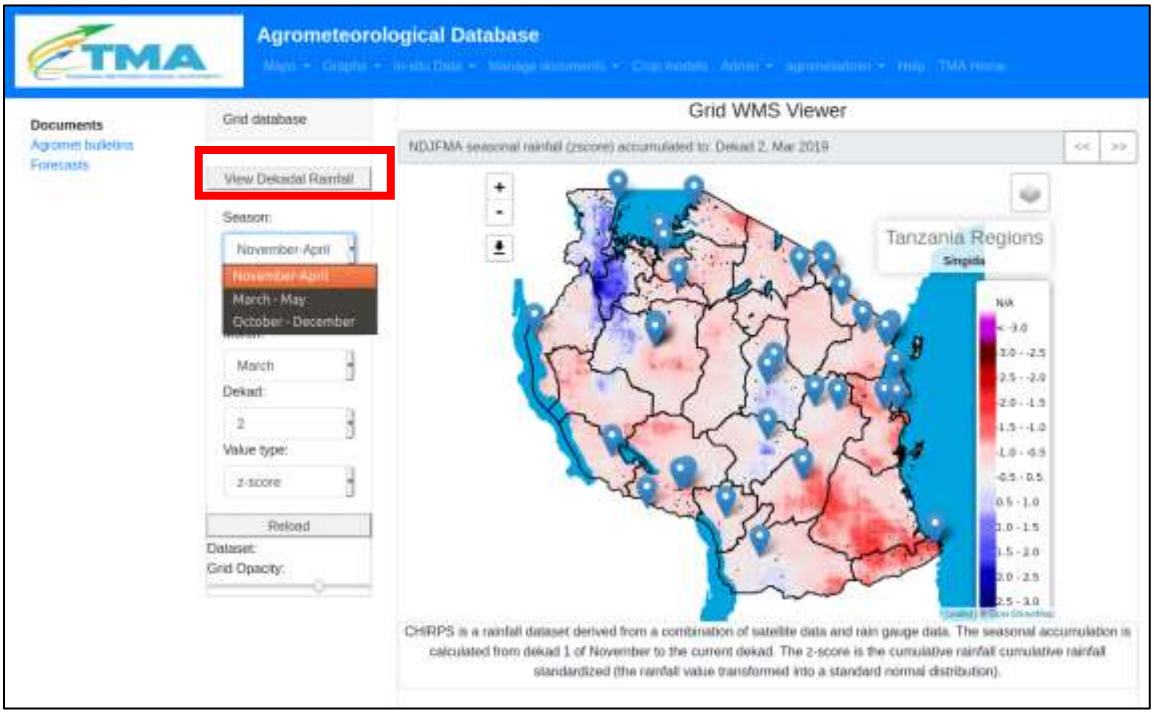
Station names can be displayed by hovering over the layer control widget on the top right of the map to expand it, then clicking on station names.

4.1 Visualization of a rainfall map

The Agromet Database has a combination of dekadal CHIRPS and CHIRPS Prelim rainfall data for mapping, with further options of selecting a specific year, month and dekad to view. Dekadal CHIRPS rainfall totals, percent of average, difference from average and z-score are calculated and updated on a dekadal time-step, from 1981 to present. In the Viewer, actual (rainfall totals), difference from average or percent of average can be chosen as mode of presentation. Pressing the “Reload” button will apply all the selected preferences for displaying the data.



Additionally, the user can choose the “View seasonal rainfall” option, which allows season-to-date rainfall totals to be displayed for any date from the start of the selected season to date. The seasonal data can be also be displayed as totals, difference from average, percent of average and z-score. Users can select from one of 3 seasons: November-to-April, March-to-May and October-to-December.

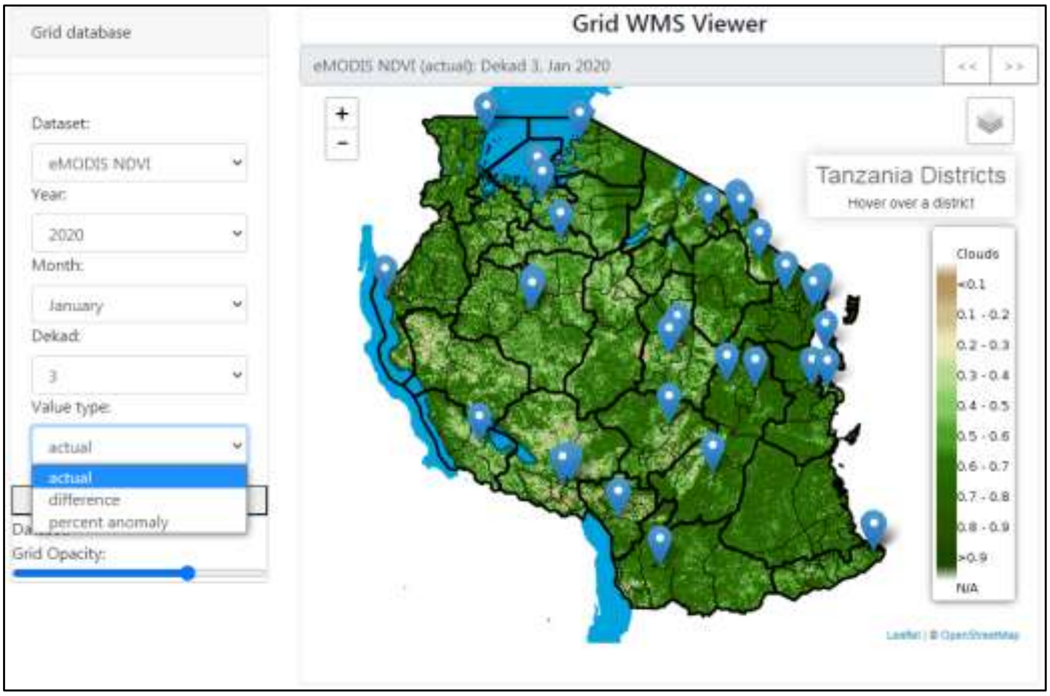


Seasonal accumulation of rainfall for NDJFMA season from 1 November 2018 to 2 March 2019, expressed as z-score

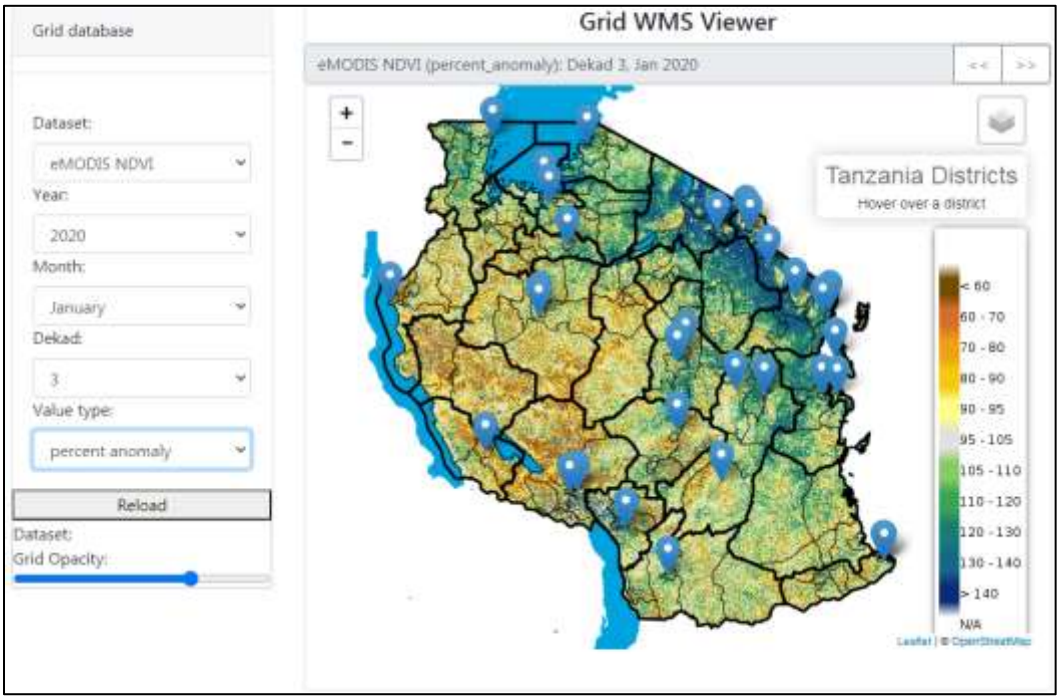
From the seasonal rainfall option, users can choose to return to dekadal data by clicking the “View Dekadal Rainfall” button.

4.2 Visualization of NDVI map

The user can select Dekadal NDVI (based on eMODIS NDVI), percent of median, and difference from median. The NDVI map can be presented for a given year, month and dekad according to user preferences, which can be selected from the panel on the left side of the screen. NDVI data is available from 2003 to present



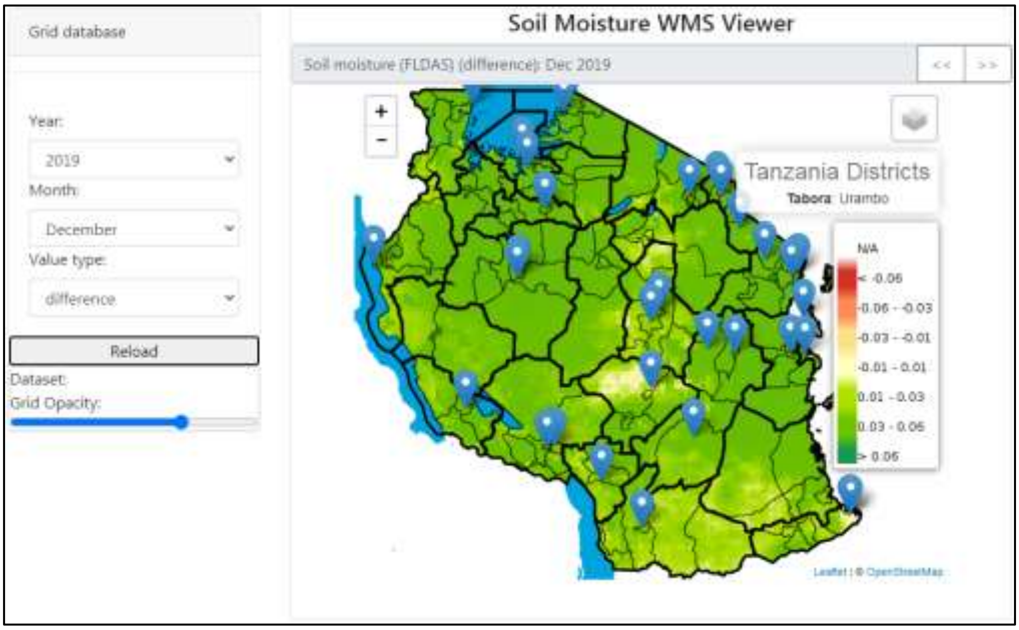
Dekadal NDVI for Dekad 3 of January 2020



Dekadal Percent of median NDVI for Dekad 3 of January 2020

4.3 Soil moisture mapping

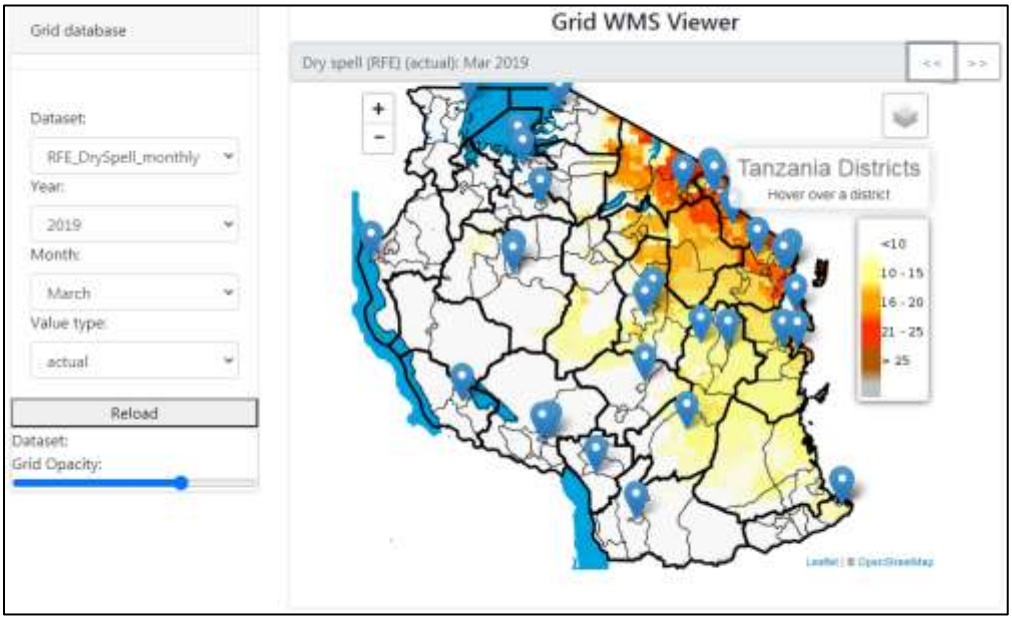
Monthly soil moisture in the top 100 cm of the soil profile, obtained from the FEWS NET Land Data Assimilation System (FLDAS) Noah Land Surface Model is available for visualization in the Agromet Database for the period 1982 to present. Soil moisture values can be presented as actual, or difference from average, depending on user selection



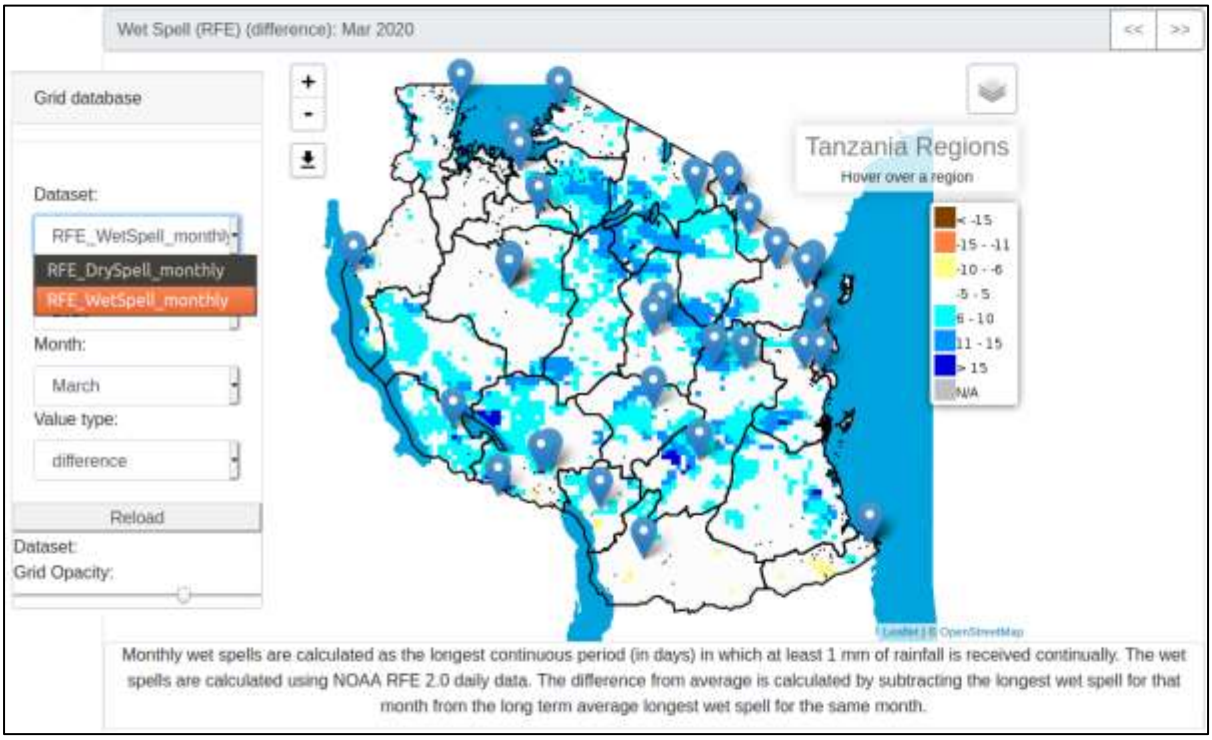
Monthly soil moisture anomaly (difference from average) for December 2019

4.4 Wet and dry spells mapping

The Agromet Database shows the highest number of continuous dry days (dry spell) or continuous rain days (wet spell) in a month. The data is available for the period 2001 to present. A rain day was defined in 2 different ways as either (i) at least 1 mm of rainfall or (ii) at least 5 mm of rainfall. The same threshold options were used to define a dry day: (i) less than 1 mm of rainfall or (ii) less than 5 mm of rainfall) with the user choosing from a drop down list. Therefore maps for Length (in days) of dry spells and wet spells for two different definitions of dry/wet day, based on these definitions for rain and dry day can be visualized on the platform. The data are currently available at monthly temporal resolution. The Wet and Dry spell values can be displayed as "actual" or "difference" (difference from normal)



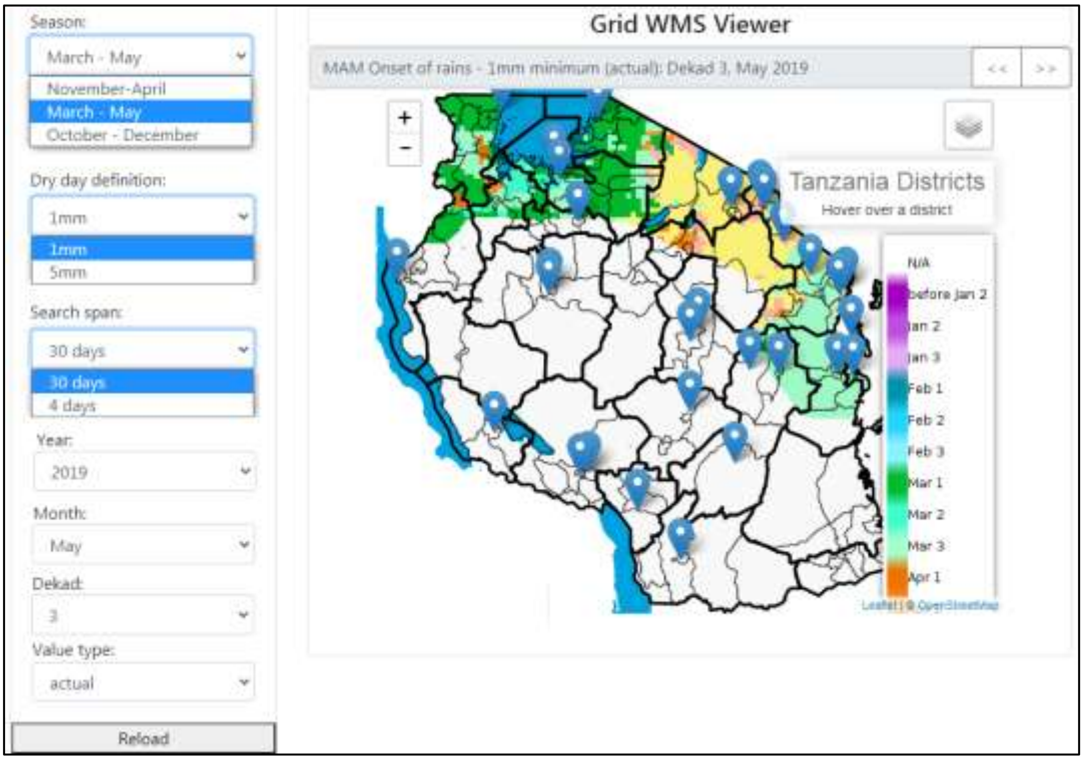
Maximum dry spell length for March 2019



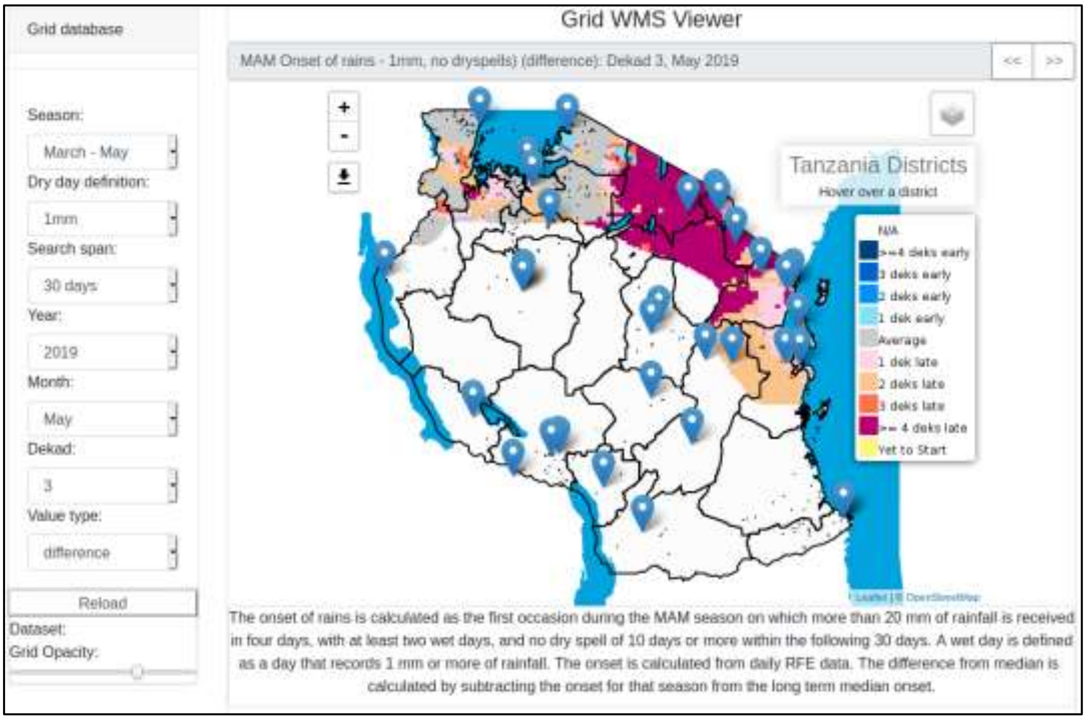
Maximum wet spell anomaly (difference from average) for March 2020

4.5 Mapping of rainfall onset

Rainfall onset was defined as the first day of which at least 25 mm of rainfall was received over a 4 day period with at least 2 rainy days. A rainy day was defined by 2 different options as stated above. In order to separate onsets from false starts, an additional optional condition was applied: after receiving 25 mm over a four day period, there should be no dry spell of 10 days or more over the ensuing 30 day period. Users therefore have the option of selecting onset as defined by any of these four conditions. Selectable parameters include, the season, dry day definition, year and value type (actual or difference from average) with options for each as indicated below. Data is available for the period 2001 to present.



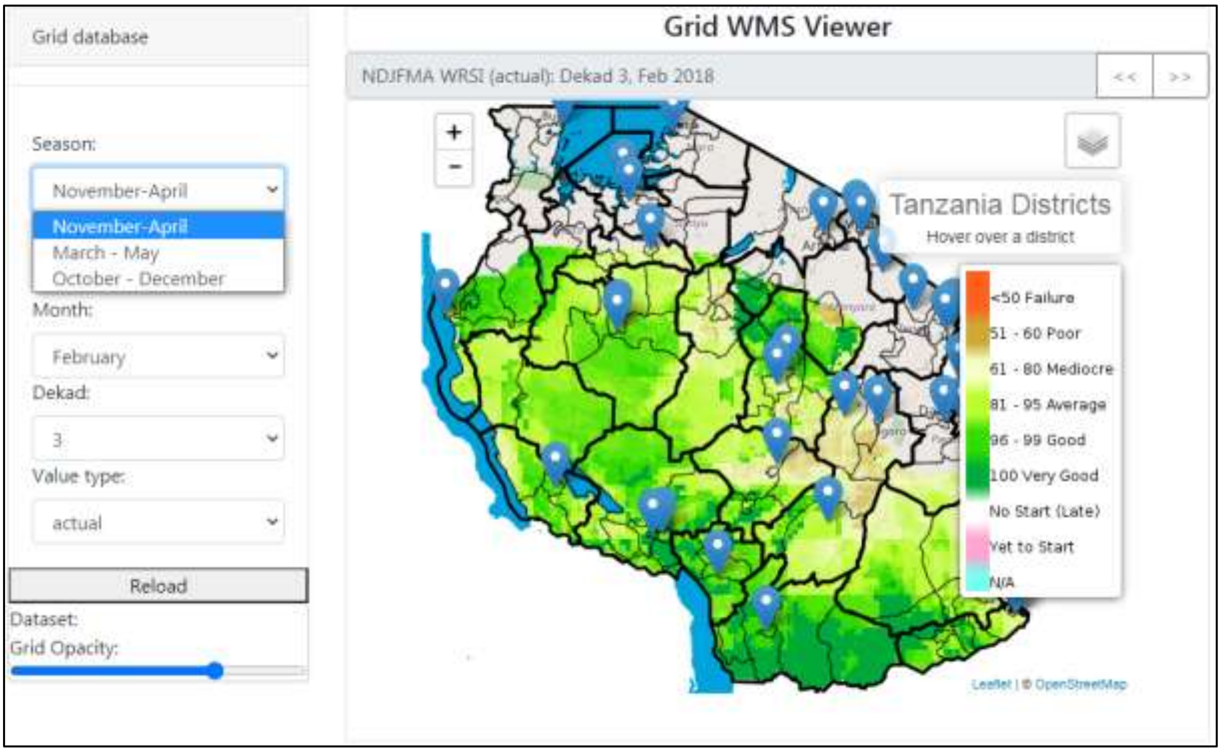
MAM Onset of rains as of Dekad 3 of May 2019



MAM Onset of rains anomaly (difference from median) as of Dekad 3 of May 2019

4.6 Crop condition mapping using WRSI

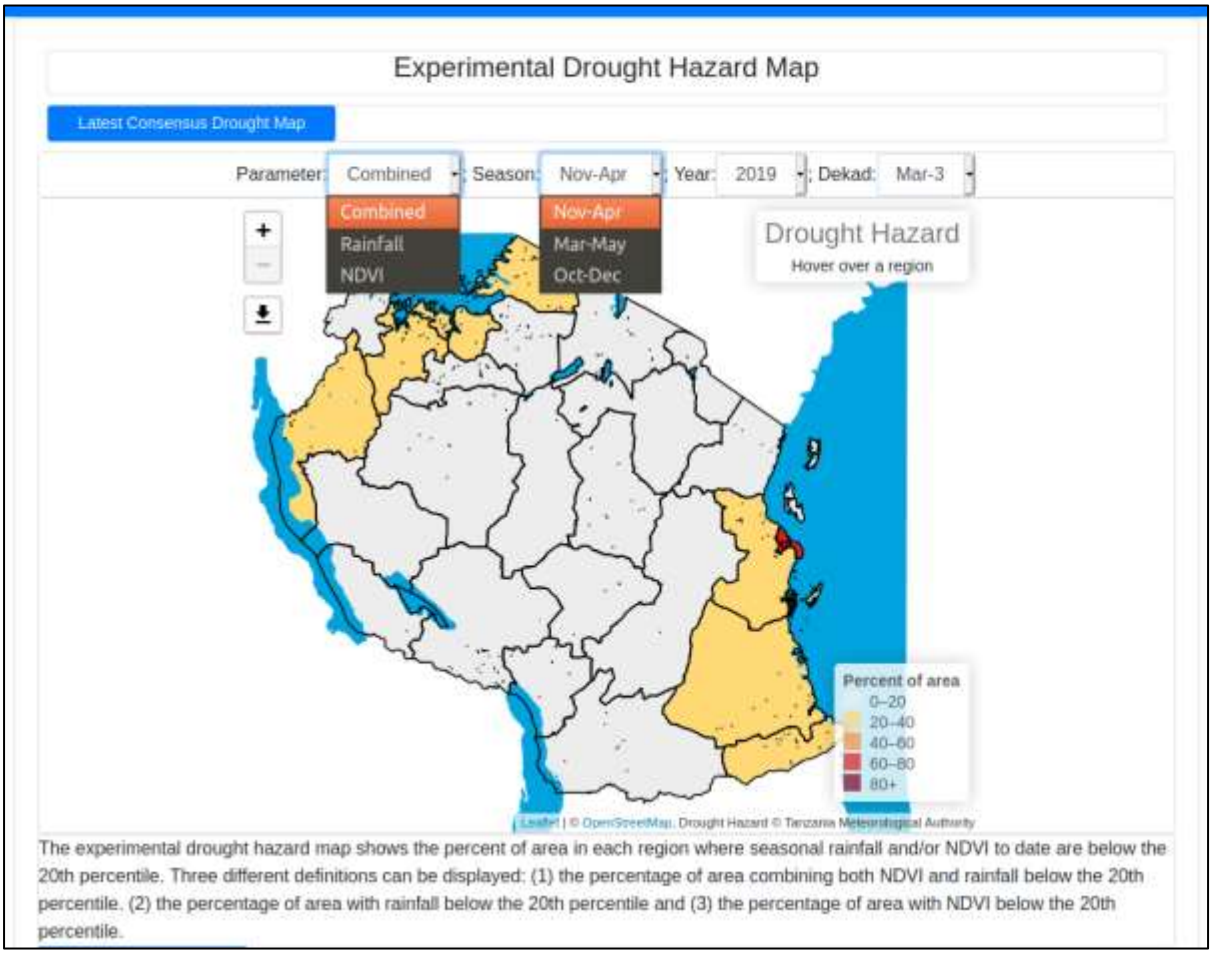
The platform also includes multi-dekadal monitoring of crop condition based on water requirement satisfaction index (WRSI). This compares the disparity between water available to the crop, (modelled using rainfall and evapotranspiration), and crop water requirements per phenological stage. This can be mapped using actual values or as an anomaly. The WRSI grids are available for the period 1981 to present.



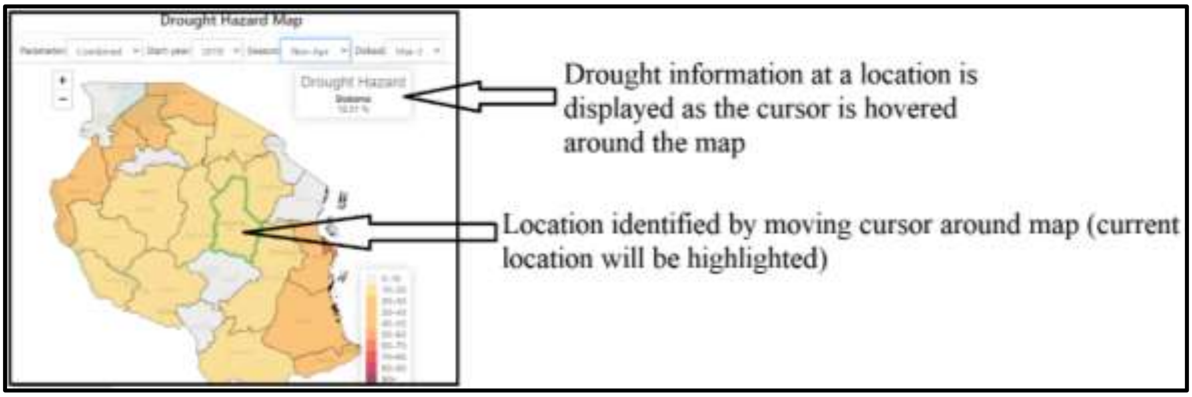
WRSI for the NDJFMA season for Dekad 3 of February 2018

4.7 Drought mapping

Drought severity is estimated using a frequency analysis approach.. In this definition, drought is defined as those areas in which the agrometeorological parameter under analysis is within the 20th percentile of the historical record. The US Drought Monitor uses a similar approach utilizing the 20th percentile as a preliminary indicator of drought, although they confirm the drought conditions using ground observations of impacts and user interpretation and intervention before delineating the drought conditions. In the Agromet Database, preliminary drought conditions can be mapped using NDVI, Rainfall or a combination of the two based on user preferences. The maps displayed show the percentage of each region that has experienced cumulative rainfall or NDVI (from the start of the season) under the 20th percentile. Three sub-seasons are considered, namely November to April (Msimu), March to May (Masika) and October to December (Vuli). The user can analyse the drought extent for a dekad of interest (see illustration below). For a given spatial demarcation (region or district) the legend presents the percentage of the total area recording at least a moderate drought. Experimental drought hazard maps are available from 2001 to present. In addition to the experimental drought hazard map automatically generated, users can also view a consensus, expert-analysed drought map by clicking on the "Latest Consensus Drought Map button at the top left of the interface. This links to a pdf map document that will have been generated and posted by TMA after analysis of the drought indicators and impacts. The process for uploading the consensus drought map is described in chapter 9.

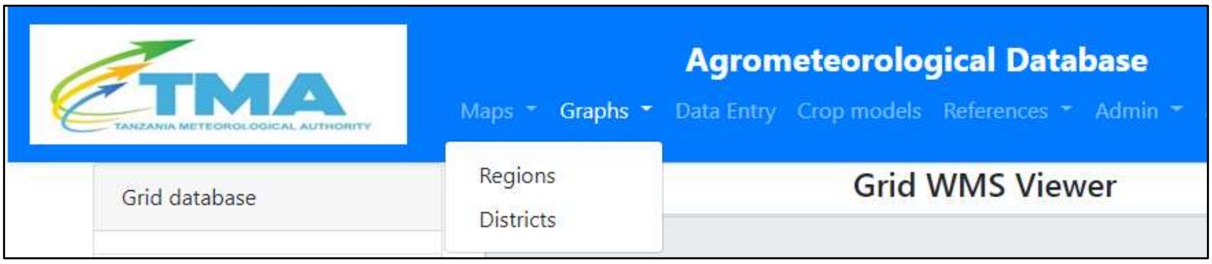


The percentage of the region/district experiencing at least a moderate drought can also be read by moving the cursor over as illustrated below. The values will change as the cursor is moved to different locations around the map.

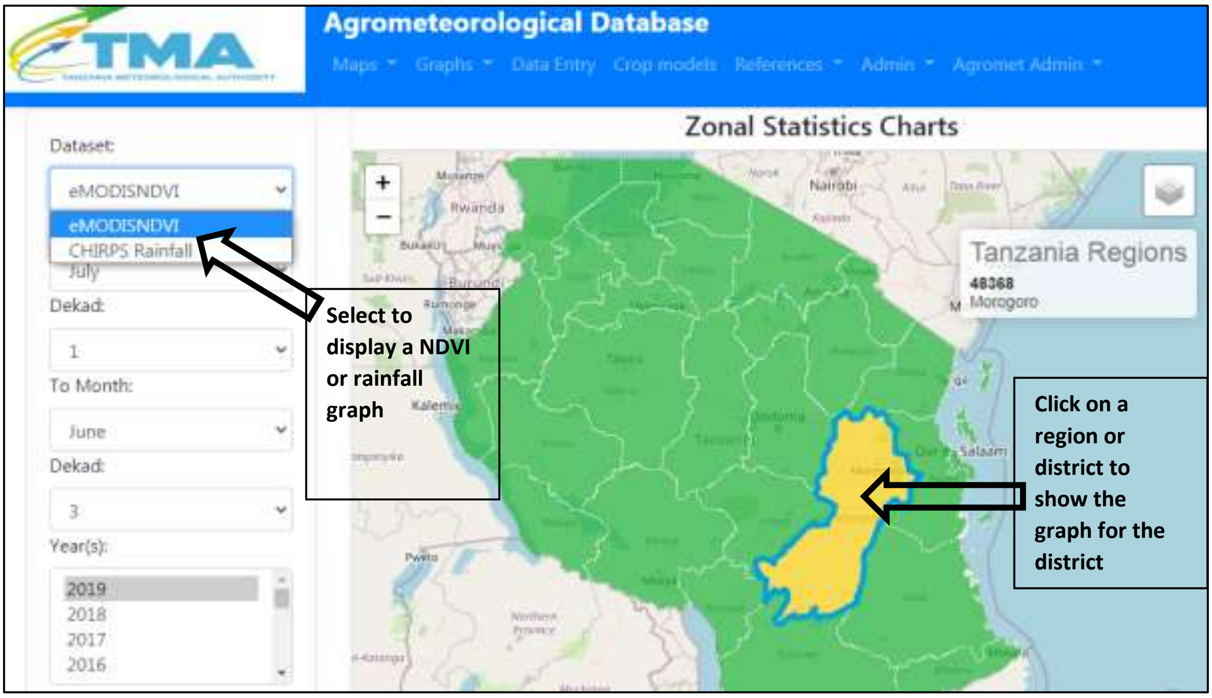


5. Time series Graphs

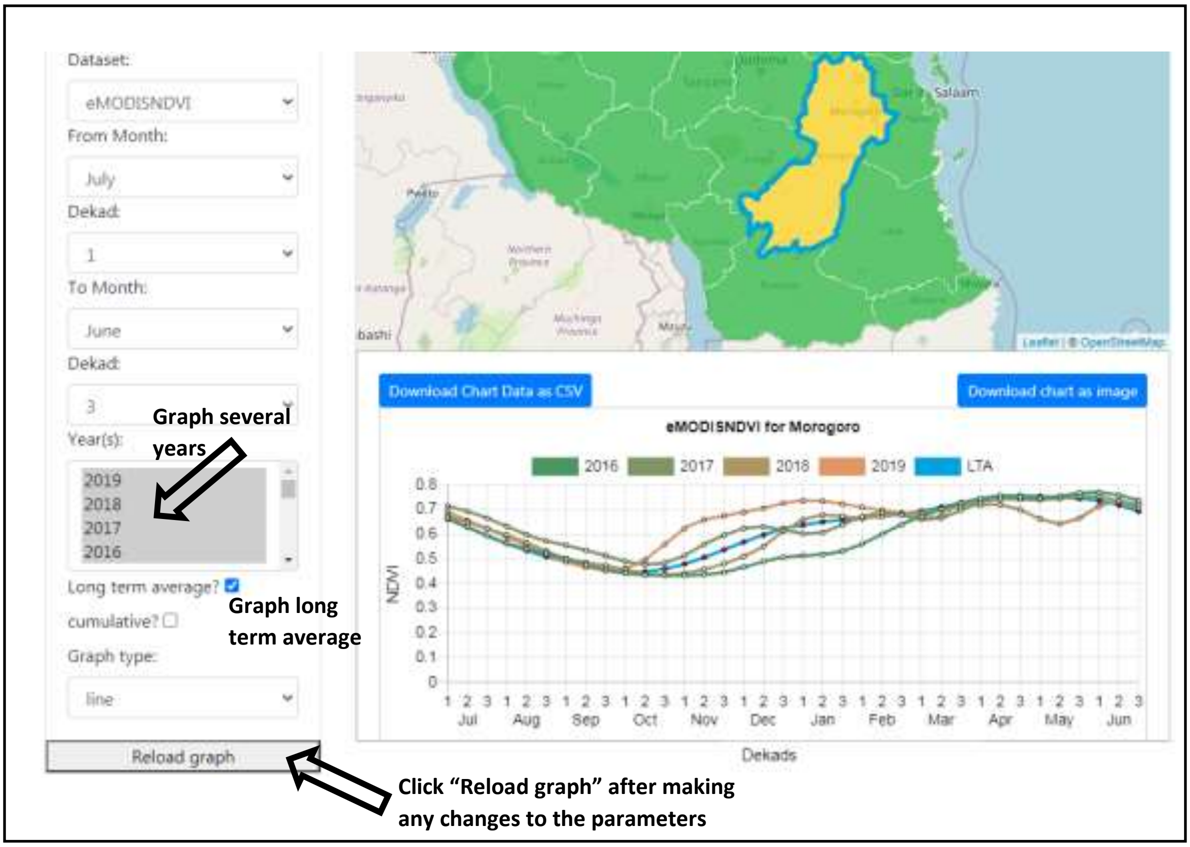
Graphing is possible with regions, districts and station data, showing the progression in the value of a specified parameter over the course of a season. Users can display several selected years including the current year to allow for comparison, as well as show the long term mean. Currently, the facility provides options to plot per region as well as per district spatial scales. These options appear upon clicking of a drop down menu on the “Graphs” menu item as shown below.



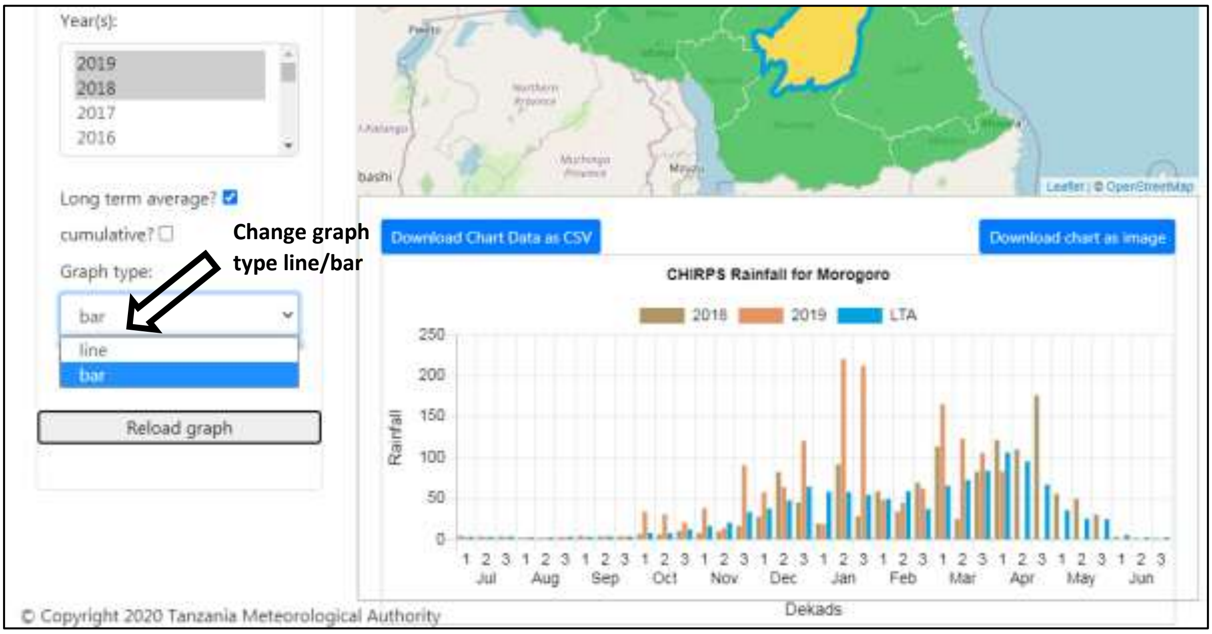
After selecting the spatial demarcation at which to derive the plots, a “Zonal Statistics Chart” Viewer appears for interactive selection of location whose data to plot graph/s from (as shown below). The dataset section on the left of the “Zonal Statistics Chart” Viewer allows selection of agrometeorological parameter from a list which includes rainfall and NDVI. Only one agrometeorological variable can be selected for graph plotting at a time.



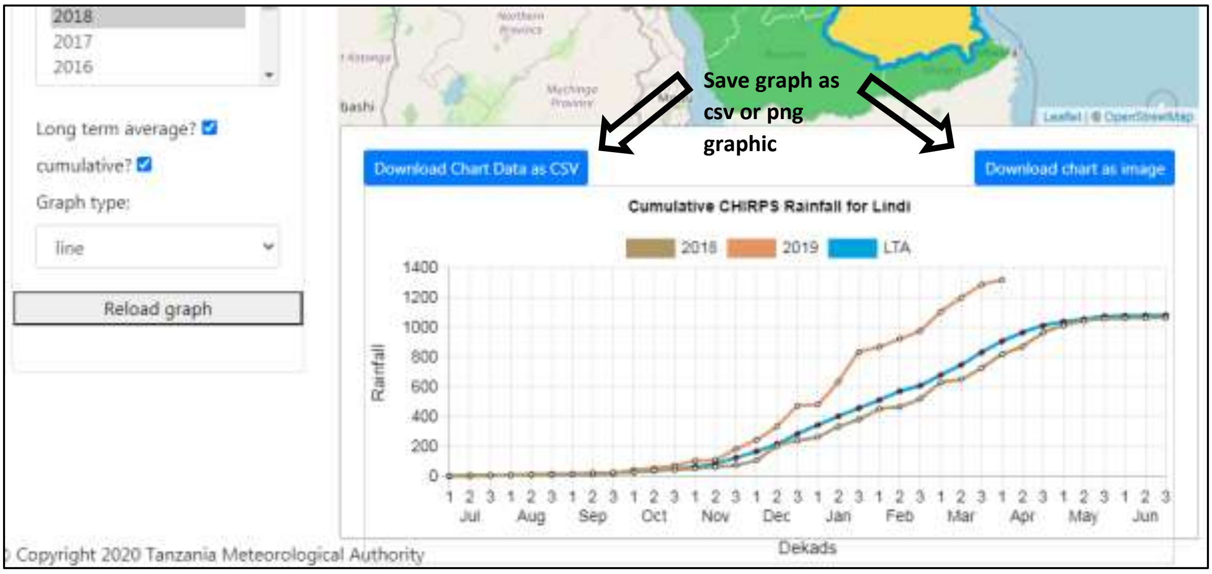
For a given variable it is possible to plot graphs for different years at once by selected all the years to be considered from a list as shown below. Note that for periods that cross years (e.g. July 2019 to June 2020), the “year” referred to is the year that time period of interest starts (so “2019” for example refers to the 2019/2020 season). The graph will appear on a window below the “Zonal Statistics Charts” Viewer immediately after clicking the “Reload graph” button once all desired data options are selected. The facility provides options of saving the plotted graph as image and the data used as CSV. The user also chooses whether to plot long term averages along with the current data, and can choose whether to plot the values as dekadal or cumulative values.



Data can also be displayed as bar graphs by selecting the "graph type". Reload the graph after making any changes,

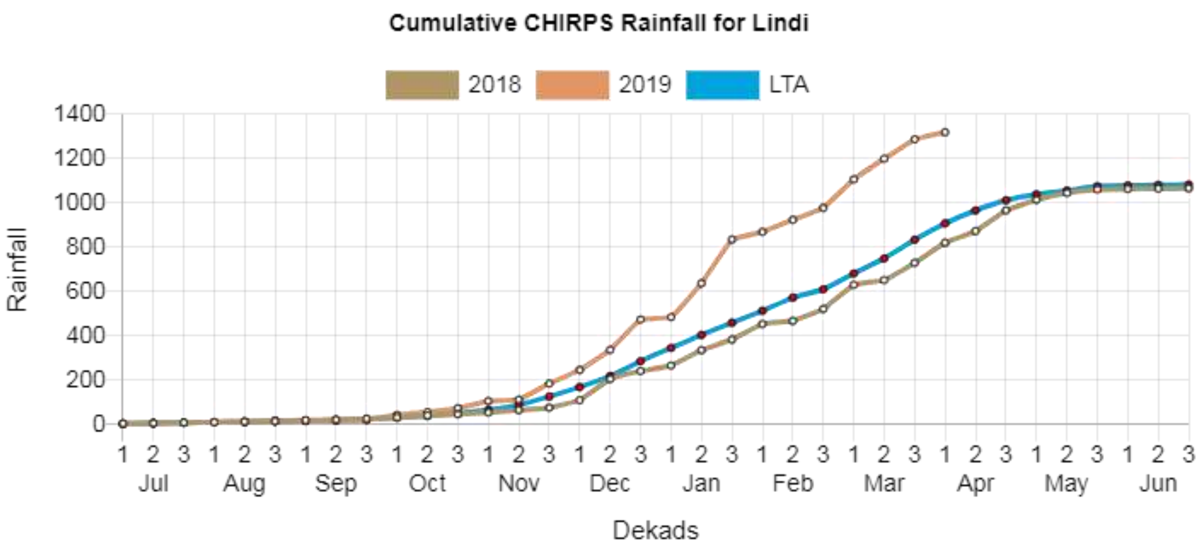


Graphs can be displayed as cumulative graphs by clicking the “cumulative” option on the right. The graph below shows the plot for Lindi, with well above average rainfall for the 2019/2020 season.



The graphs can be saved as either CSV or a graphic, using the buttons above the chart. Both files are saved according to the download settings on the user’s browser, typically in the download folder, unless this has been changed by the user.

The graphic is saved as a png file, with the filename root “ChartImage*.png”. An example that was saved for Lindi is shown below.



The csv file is saved with all the data used to produce the graph. It can be opened in Excel or other spreadsheet program. The filename for the csv file will contain the Region or District name, and the data type. For the example shown above, the filename is *Lindi_cumulative_CHIRPS Rainfall_chart-data.csv*. The csv data will appear like the one shown below when opened in Excel:

	A	B	C	D	E	F	G	H	I	J
1	Lindi	1-Jul	2-Jul	3-Jul	1-Aug	2-Aug	3-Aug	1-Sep	2-Sep	3-Se
2	2018	3.110066	5.543744	8.028222	9.980715	11.85136	15.19614	18.00282	20.93791	25.197
3	2019	2.44873	4.789276	7.176858	9.518815	11.35513	14.0936	16.04892	18.28692	21.458
4	LTA	2.726765	5.021589	7.594628	9.763924	11.73732	14.40696	16.41413	18.8182	22.199

6. Viewing Forecasts and Agromet Bulletins

Internet users can view agrometeorological bulletins and forecasts in pdf format directly from the Agromet Database interface, using links in the top-left corner of the screen.

Clicking on the Agromet bulletins link reveals three types of agromet bulletins.

Clicking on any of the links to the bulletins will take the user to the latest version of that bulletin, which will be displayed in the browser. The user can click the download icon to download the report for offline viewing

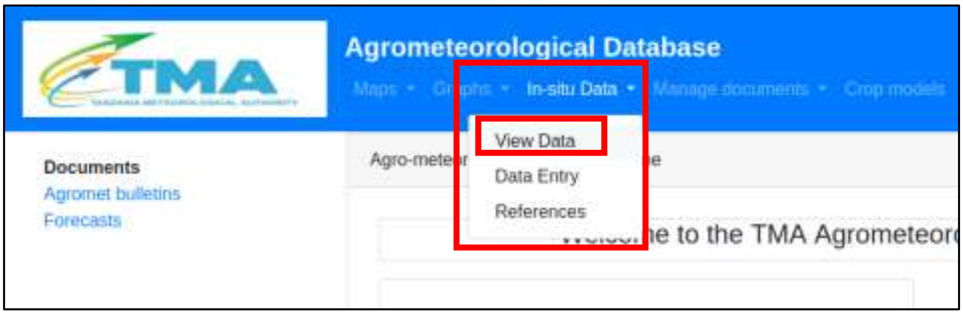
There are five different forecast documents available for viewing from the Agromet Database.

Clicking on any of the links to the forecasts will take the user to the latest version of that forecast, which will be displayed in the browser. The user can click the download icon to download the forecast for offline viewing

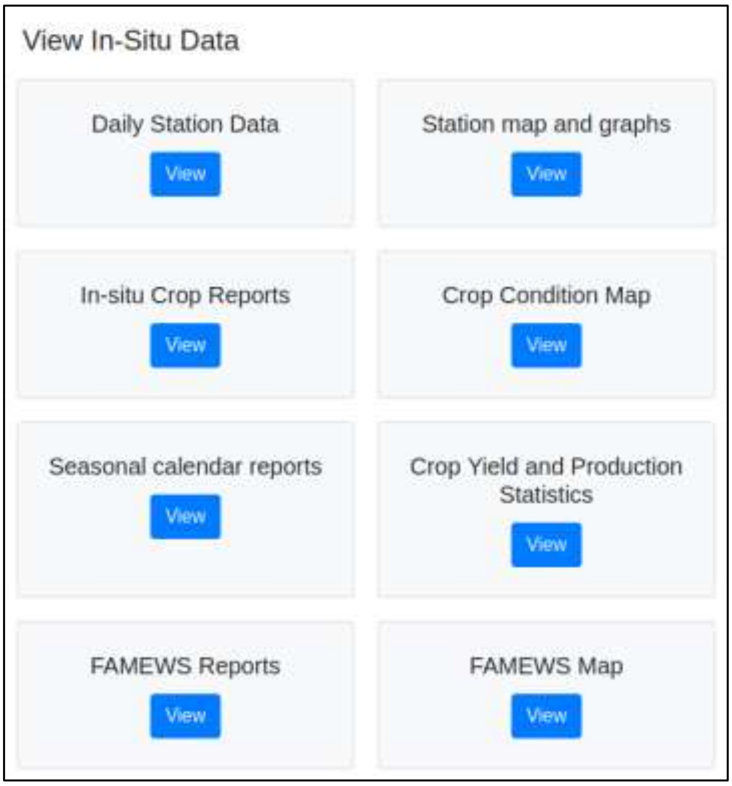
7. Viewing in-situ data

The View Data entry menu item is available to users logged in as viewers, editors or administrators. There are two types of data available, namely meteorological data and agricultural data. The meteorological data is viewable by users with meteorology viewing roles, while the agriculture data is viewable by users agriculture viewing roles. Roles are assigned by the administrator as described in section 12 of this manual.

The View Data menu is accessed under the *In-situ Data > View Data* menu.

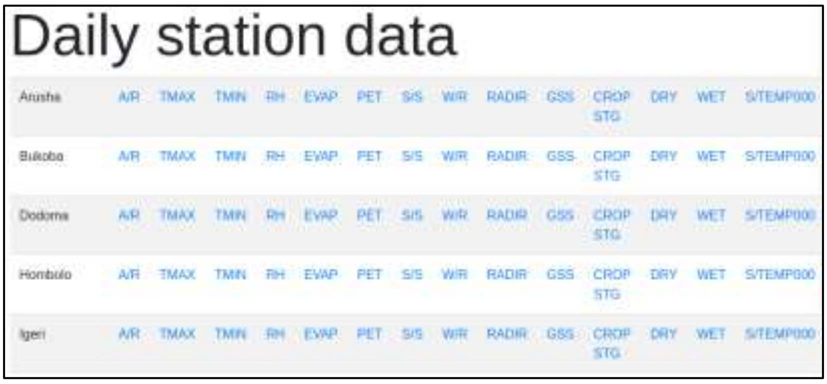


This show a menu of 8 different buttons that the user can use to view data, depending on their administrator-assigned roles.



7.1 Daily station data

Selecting the daily station data button will present the user with a list of all the different agrometeorological stations and station data parameters available in the database. Each parameter abbreviation is clickable.



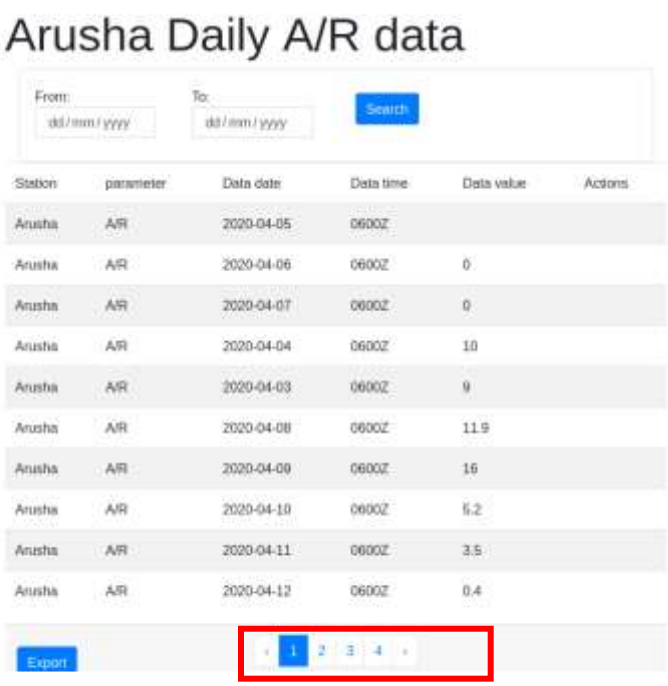
Daily station data

Arusha	A/R	TMAX	TMIN	RH	EVAP	PET	S/S	W/R	RADIR	GSS	CROP STG	DRY	WET	S/TEMP000
Bukoba	A/R	TMAX	TMIN	RH	EVAP	PET	S/S	W/R	RADIR	GSS	CROP STG	DRY	WET	S/TEMP000
Dodoma	A/R	TMAX	TMIN	RH	EVAP	PET	S/S	W/R	RADIR	GSS	CROP STG	DRY	WET	S/TEMP000
Hombolo	A/R	TMAX	TMIN	RH	EVAP	PET	S/S	W/R	RADIR	GSS	CROP STG	DRY	WET	S/TEMP000
Igeri	A/R	TMAX	TMIN	RH	EVAP	PET	S/S	W/R	RADIR	GSS	CROP STG	DRY	WET	S/TEMP000

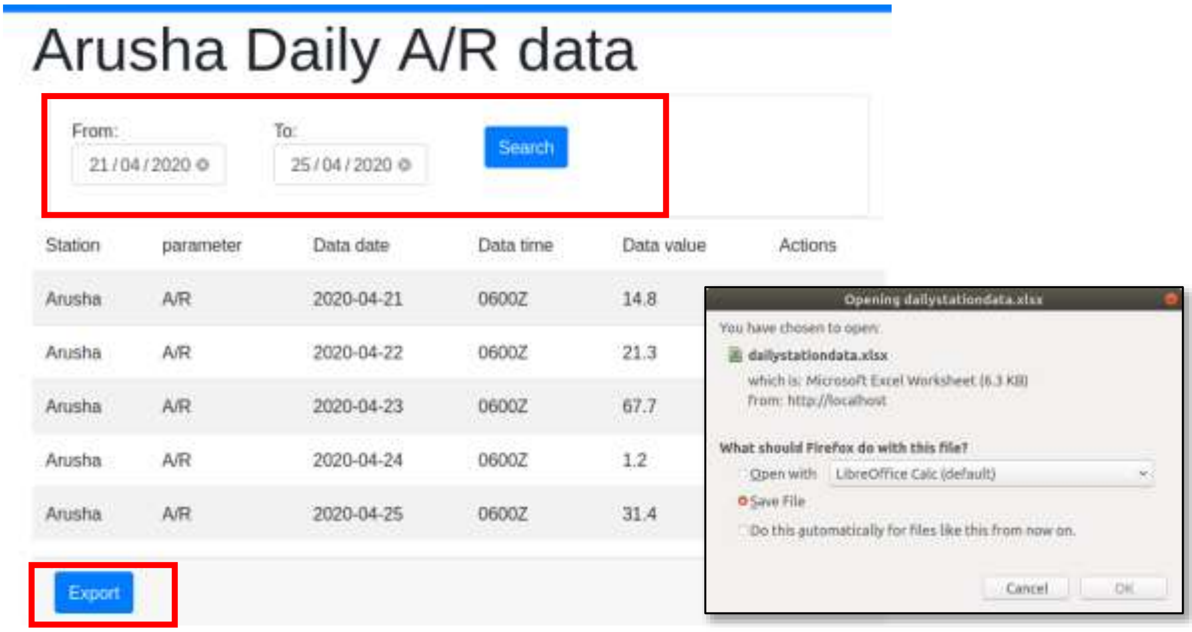
The full list of station data parameters available in the database by default, and their acronyms are as follows:

Parameter name	Parameter abbreviation
Observed rainfall	A/R
Maximum temperature	TMAX
Minimum temperature	TMIN
Relative humidity	RH
Evaporation	EVAP
Potential evapotranspiration	PET
Sunshine (hours)	S/S
Wind run	W/R
Solar radiation	RADIR
Grass minimum temperature	GSS
Crop stage	CROP STG
Dry bulb temperature	DRY
Wet bulb temperature	WET
Soil temperature (Surface)	S/TEMP000
Soil temperature from 5cm to 100cm depth	S/TEMP005 to S/TEMP100
Soil moisture (Surface)	S/M 000
Soil moisture from 5cm to 100cm depth	S/M 005 to S/TM 100

Clicking on a specific parameter for a particular station will show all the data available for that parameter and station. Only 10 records are shown on each page. The page buttons at the bottom of the page can be used to navigate between the different records.



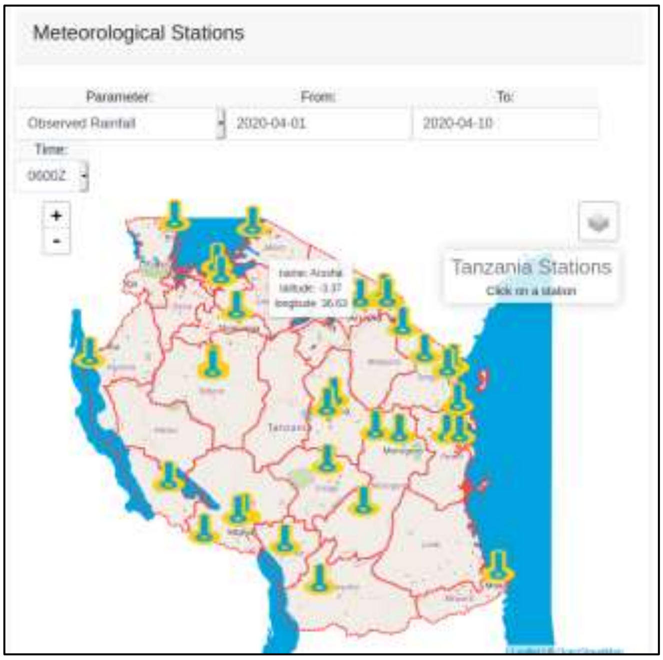
Using the search facility at the top of the page, the user can filter out data for a specific range of dates.



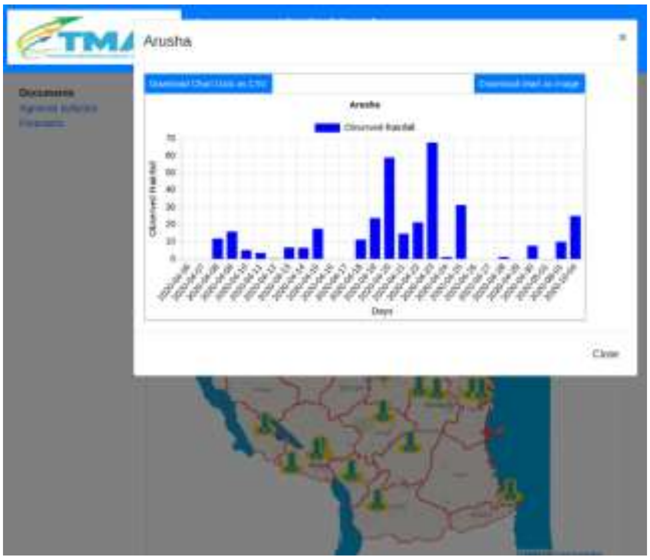
Users can also export data into Excel format using the Export button at the bottom of the page. The dates to be exported need to be specified and visible in the Search section before clicking the “Export” button. The Export feature allows for sharing of selected data with researchers and other collaborators.

7.2 Station map and graphs

In addition to viewing data in a tabular format, Users can opt to view the locations of the stations on a map as well as graph the available data. Hover over a station to show the name and coordinates of the station.

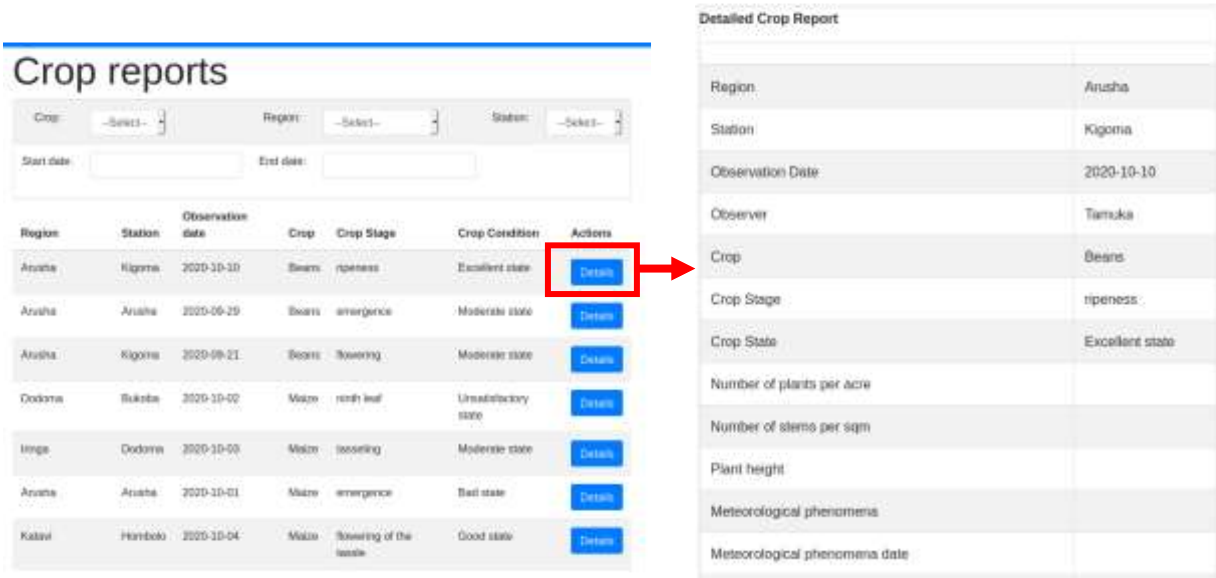


After specifying the parameter of interest, the dates to view, and the time of observation, the user can click on any of the stations to view the graph for the specified period and parameter. The available data for will be displayed as a pop-up graph in front of the map. The graph can be downloaded as a graphic or a csv file by clicking the blue buttons above the graph. Click the Close button on the graph, or anywhere outside the graph, to return to the main stations window.

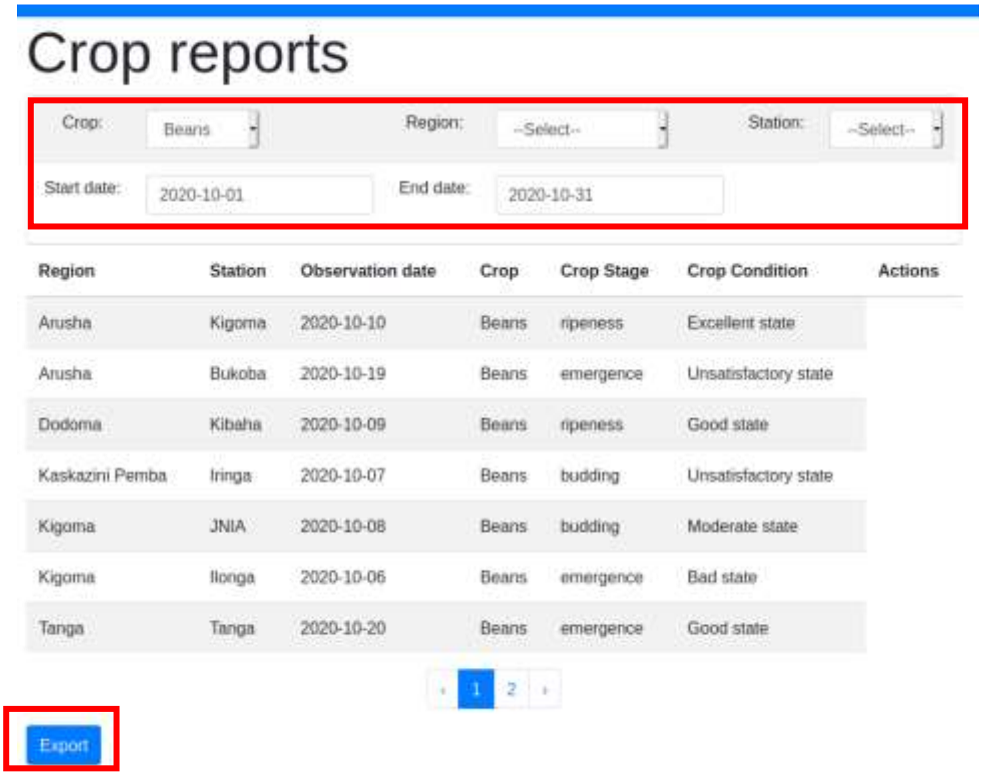


7.3 In-situ crop reports

All available data for in situ crop reports can be viewed by clicking on the In-situ crop reports menu. The full crop report including additional details can be viewed by clicking on the “Details” button to the right of each record.



The user can opt to view data only for selected crops, regions, stations and/or dates using the search panel.



Crop reports

Crop: Beans | Region: --Select-- | Station: --Select--

Start date: 2020-10-01 | End date: 2020-10-31

Region	Station	Observation date	Crop	Crop Stage	Crop Condition	Actions
Arusha	Kigoma	2020-10-10	Beans	ripeness	Excellent state	
Arusha	Bukoba	2020-10-19	Beans	emergence	Unsatisfactory state	
Dodoma	Kibaha	2020-10-09	Beans	ripeness	Good state	
Kaskazini Pemba	Iringa	2020-10-07	Beans	budding	Unsatisfactory state	
Kigoma	JNIA	2020-10-08	Beans	budding	Moderate state	
Kigoma	Ilonga	2020-10-06	Beans	emergence	Bad state	
Tanga	Tanga	2020-10-20	Beans	emergence	Good state	

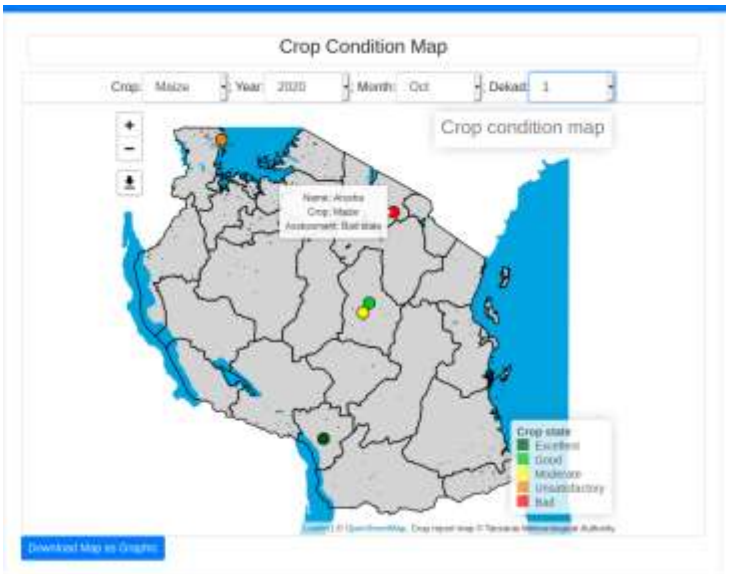
‹ 1 2 ›

Export

The selected data can be exported into Excel format using the button at the bottom of the page.

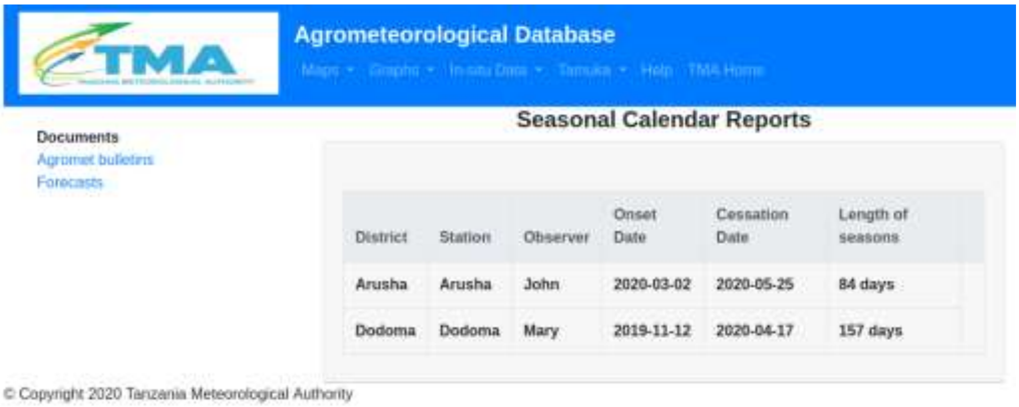
7.4 Crop condition map

All available crop condition data can be mapped using the Crop condition map button. Use the search tools at the top of the map page to specify the date and crop to map. Only one dekad at a time can be mapped. Hover over the station to show the details of the crop type and crop state.



7.5 Seasonal calendar reports

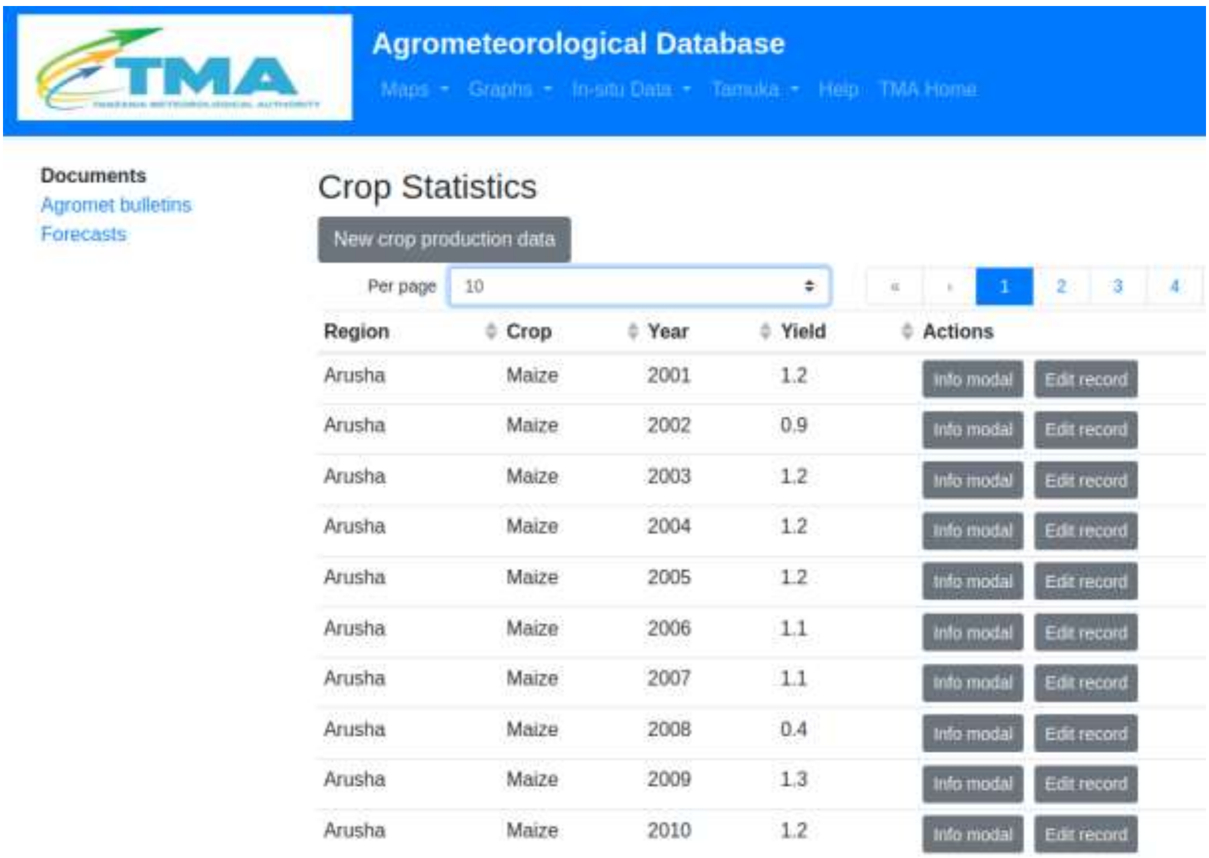
The seasonal calendar reports give the date of onset and cessation of rainfall as recorded by observers at different stations.



District	Station	Observer	Onset Date	Cessation Date	Length of seasons
Arusha	Arusha	John	2020-03-02	2020-05-25	84 days
Dodoma	Dodoma	Mary	2019-11-12	2020-04-17	157 days

7.6 Crop yield and production statistics

The crop yield statistics data can be viewed in tabular format as shown below. Use the page buttons on the top right to navigate different records.



Region	Crop	Year	Yield	Actions
Arusha	Maize	2001	1.2	Info modal Edit record
Arusha	Maize	2002	0.9	Info modal Edit record
Arusha	Maize	2003	1.2	Info modal Edit record
Arusha	Maize	2004	1.2	Info modal Edit record
Arusha	Maize	2005	1.2	Info modal Edit record
Arusha	Maize	2006	1.1	Info modal Edit record
Arusha	Maize	2007	1.1	Info modal Edit record
Arusha	Maize	2008	0.4	Info modal Edit record
Arusha	Maize	2009	1.3	Info modal Edit record
Arusha	Maize	2010	1.2	Info modal Edit record

7.7 FAMEWS Reports

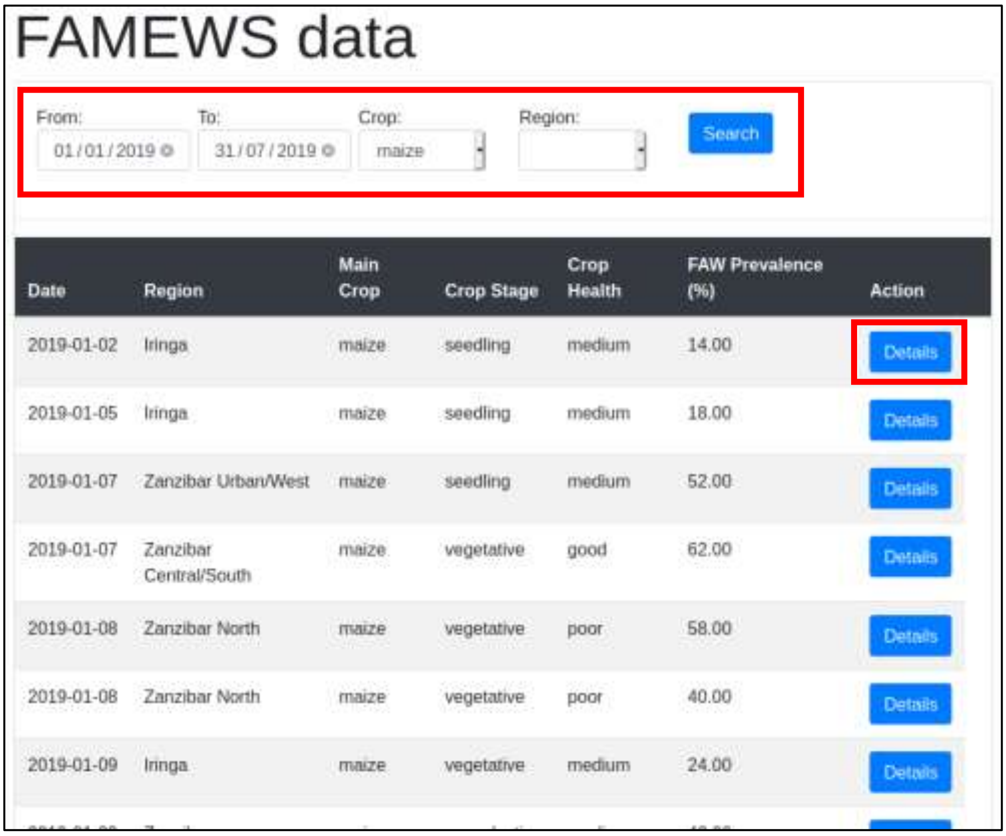
FAMEWS is an FAO-supported global resource that facilitates the sharing of data collected on the prevalence of Fall Armyworm (FAW). The data is collected by volunteers using a smartphone app, and the data is sent to a centralized server.

FAO has kindly offered to supply period updates on FAMEWS data over Tanzania, as new data becomes available.

In addition to data on FAW prevalence, the FAMEWS data also provides data on crop condition and crop stage, which is important for crop monitoring.

The FAMEWS data can be viewed by clicking on the FAMEWS Reports button accessible on the main View Data interface.

The following data will be shown on a table: Date, Region, Main Crop, Crop Stage, Crop Health and FAW Prevalence. The search function to be used to display data for a specific period, crop and region.



The selected data can be exported to Excel format by clicking the “Export” button at the bottom of the page.

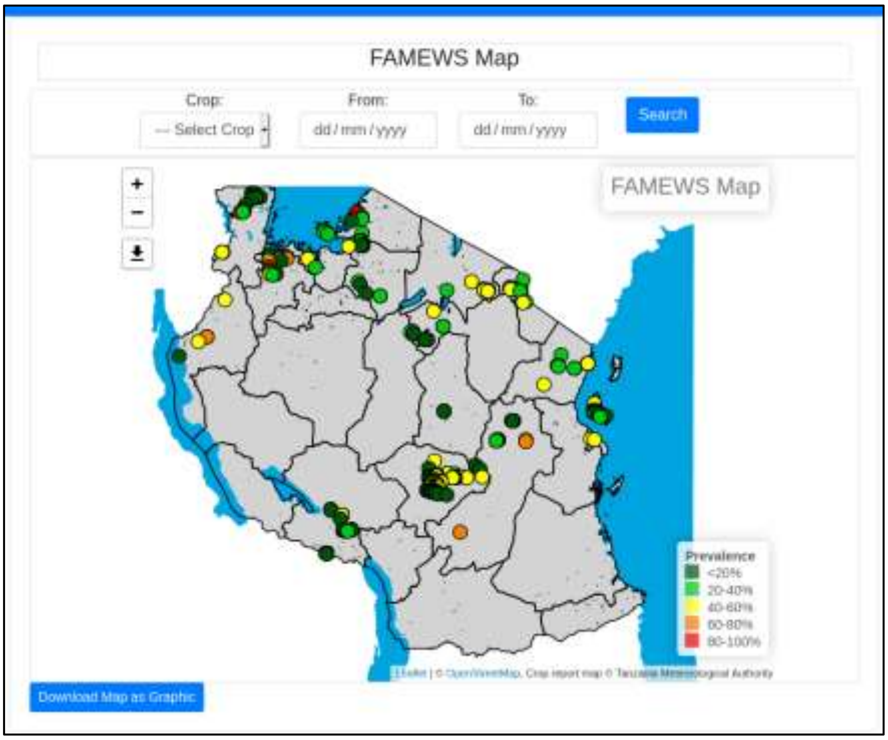
Additional details can be viewed by clicking the “Details” button on the right of each data entry.

Detailed FAMEWS Report

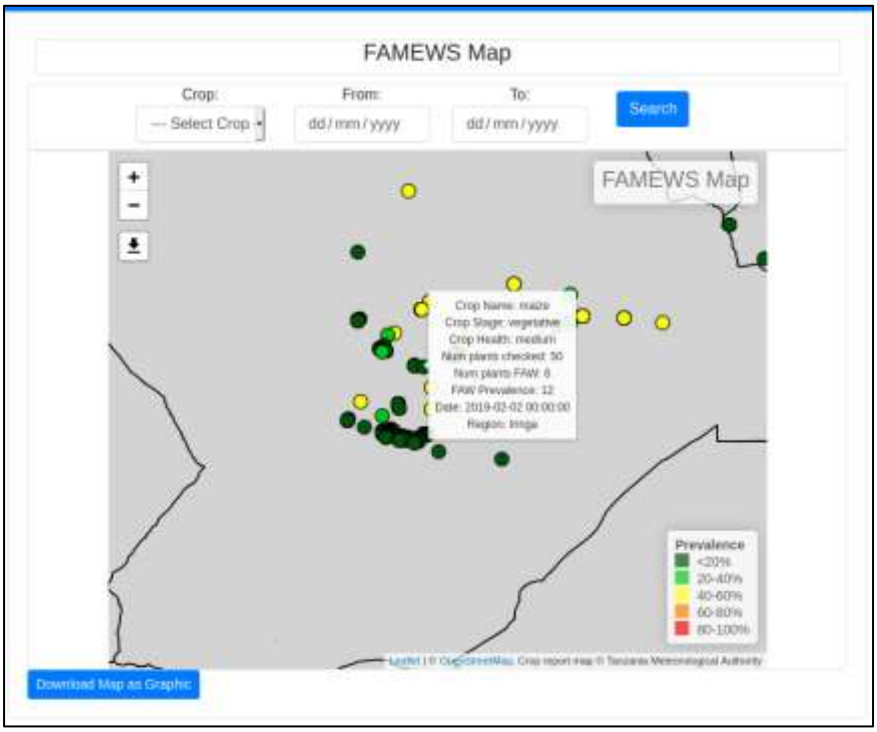
Parameter	Value
Date	2019-01-02
Crop Field Size Unit	acre
Location Name	sadani
Crop Variety	614
Crop Planting Date	11/11/2018 10:00:00 PM
Latitude	-7.9175
Longitude	35.53333
Main Crop	maize
Irrigation	rainFed
Fertilizer	yes
Crop Stage	seedling
Crop Health	medium
Crop System	seasonal
Crop Rotation	unknown

7.8 FAMEWS map

In addition to viewing the FAMEWS data in tabular format, the FAMEWS data can also be displayed as a map, by clicking on the "FAMEWS Map" button. This will present a map as shown below. The map shows FAMEWS observation locations, and is colour-coded such that lower FAW prevalence is dark green and high prevalence is orange and red.



Users can zoom in and out of the map as appropriate. Hovering over the observation point will show additional details.

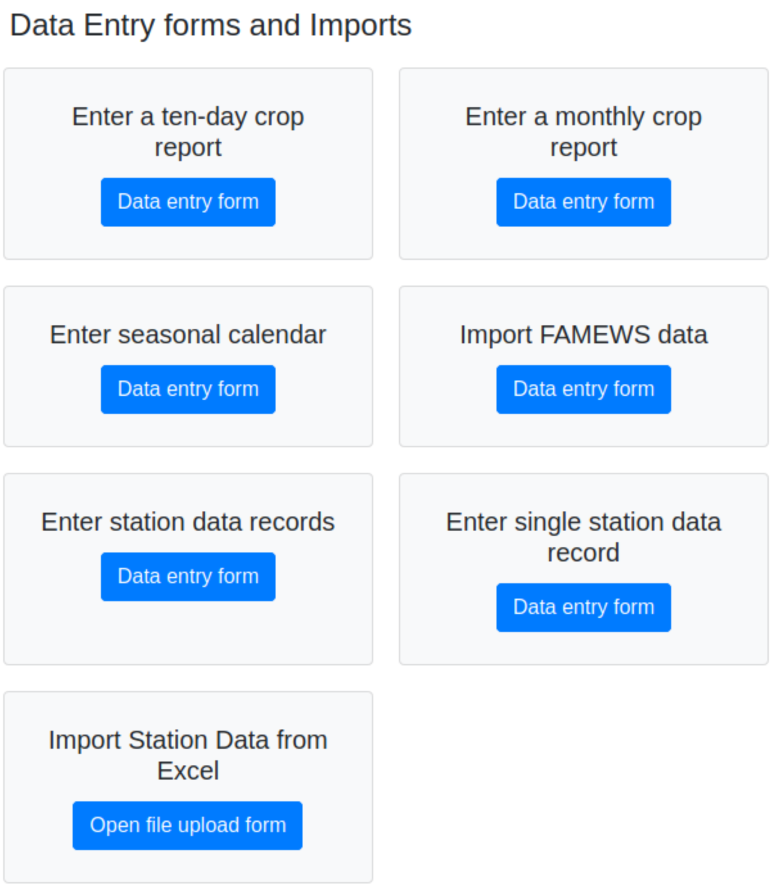


The FAMEWS Map can be filtered using the search function to select points to display only for selected crops or date range.

8. Data entry

The Data entry menu item is only available to users logged in as editors or administrators. It facilitates the entry of station data for meteorological and agrometeorological stations. It should be noted that although the AgrometDB allows the handling of station data, at present it is not intended as a comprehensive climate data management system (CDMS), due to the short time frame in which the database was developed. Its main function is to handle data already collated, quality-controlled and managed by existing processes and CDMS, with the main aim of facilitating agrometeorological analyses.

Upon clicking on “In-situ data > Data entry” on the main menu, the following options for entering data will appear as shown below.



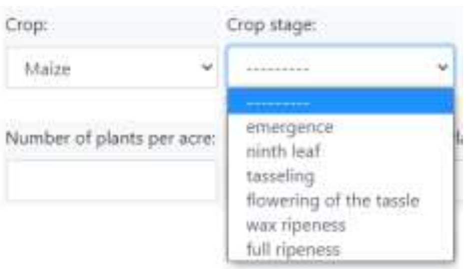
Clicking on each of the options will provide a platform for entering the data. The first four options allow manual entry of crop observation data and meteorological station data, while the fifth option, “Import Monthly Station Data” option allows uploading of station data saved in Excel format.

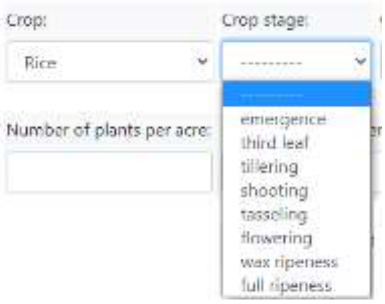
8.1 Ten-day crop report

The Ten-day crop report allows crop data observed at agrometeorological stations to be recorded into the database. As the database is available online, the observers can enter the data directly from the station if internet access is available, or the data can be sent to TMA HQ, and then entered by an authorized user.

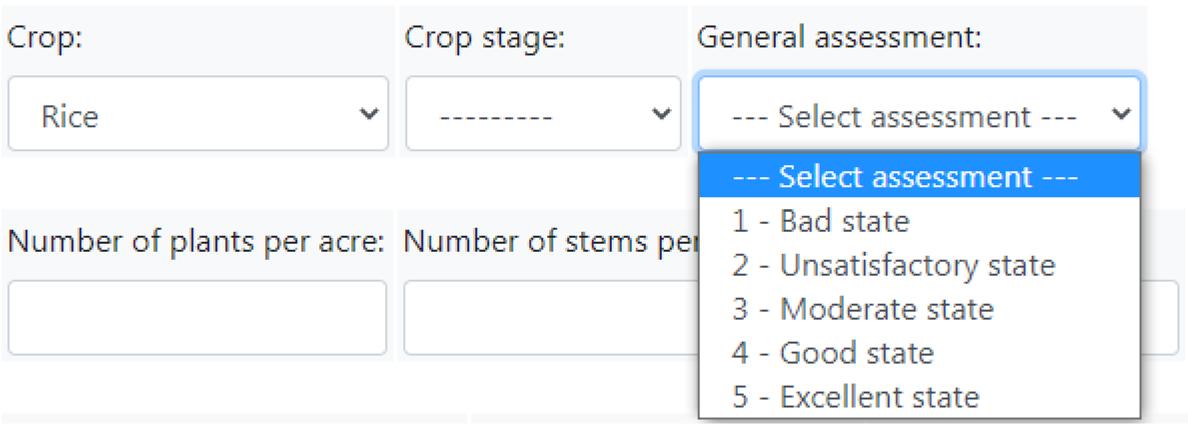
The first section of the form specifies the district, and the station that the data is relevant for, the name of the observer, and the date the observations were made.

The second part of the form deals with the crop type, the crop stage, and the crop condition. The crop stages presented are dependent on the crop type selected. For example, if the user specifies the crop being observed as Maize, the crop stages presented will be different than if the user selects Rice, as shown in the illustrations below





The general assessment refers to the state of the crop. The user has 5 options to choose from, as described below:

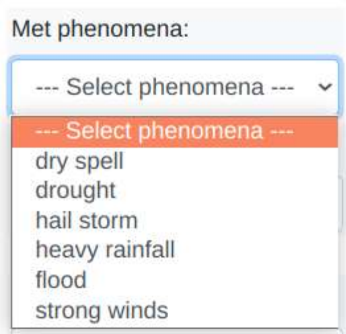


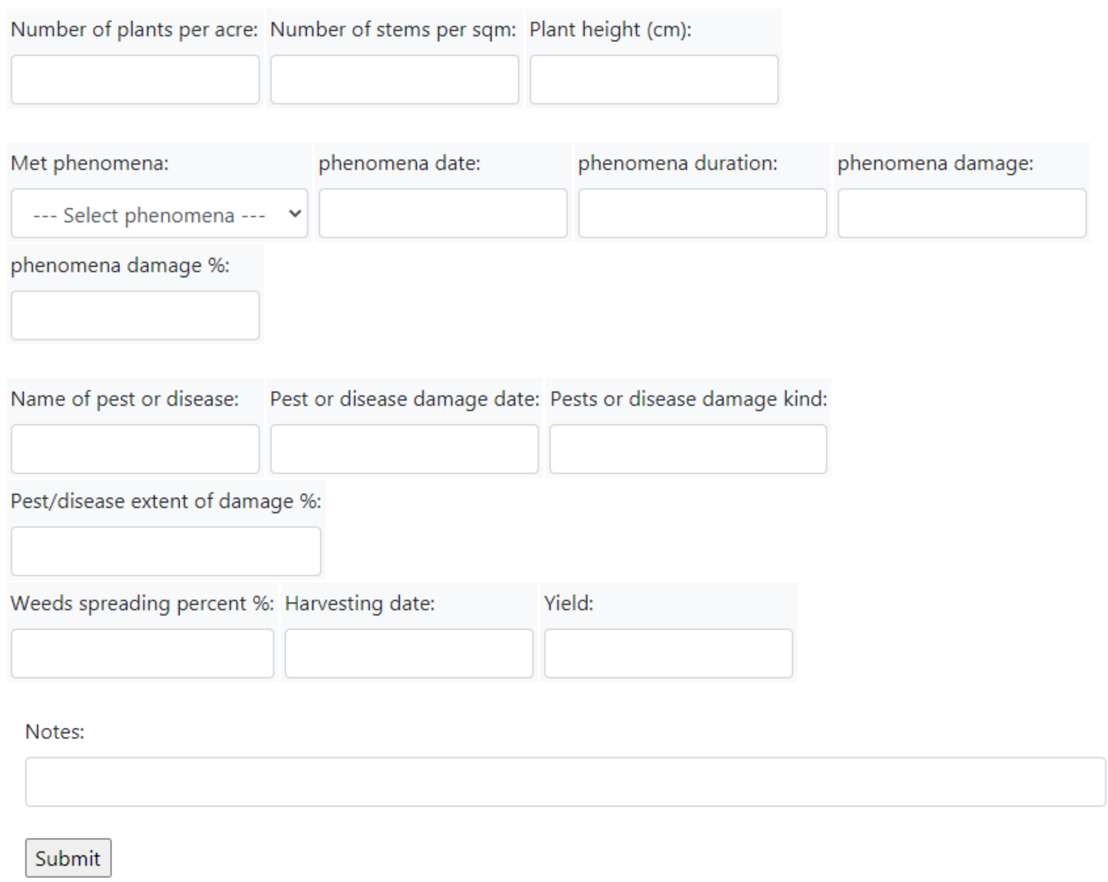
The full explanation for what each state means are presented in the table below:

Degrees of assessment	General State of the plants in field	Description of the state of the crop
1	Bad state	Plants are weak and in bad condition. A plant suffer from a very bad meteorological conditions, or are damages from adverse meteorological phenomena, pests or diseases. A very poor crop yield to be expected.
2	Unsatisfactory state	Plant density in the field is not sufficient due to unfavorable meteorological conditions or any other adverse factors. There is considerable amount of weeds. A yield below the normal expected.
3	Moderate state	Condition of the plants, density of the sowing area, amount of weeds, damages from adverse meteorological phenomena, pests or diseases, are as usual, and therefore a normal crop yield is to be expected.
4	Good state	Some plants are not very healthy or strong; there are some weeds; small damages from adverse meteorological phenomena, pests or diseases. However, the expected yield from such crops is still above the average for the area
5	Excellent state	The plants are strong, healthy, well rooted and developed. All parts of the plants and especially reproductive ones are in excellent condition. There are no weeds. It is typical for years with very good meteorological conditions, and a yield much higher than in normal years is to be expected.

The remainder of the form allows for entry of information on the plant population and height, details about meteorological phenomena that have adversely affected crop conditions, pests and disease incidence, weeds, harvesting, and yield estimate.

The options for meteorological phenomenon are dry spell, drought, hail storm, flood and strong winds.

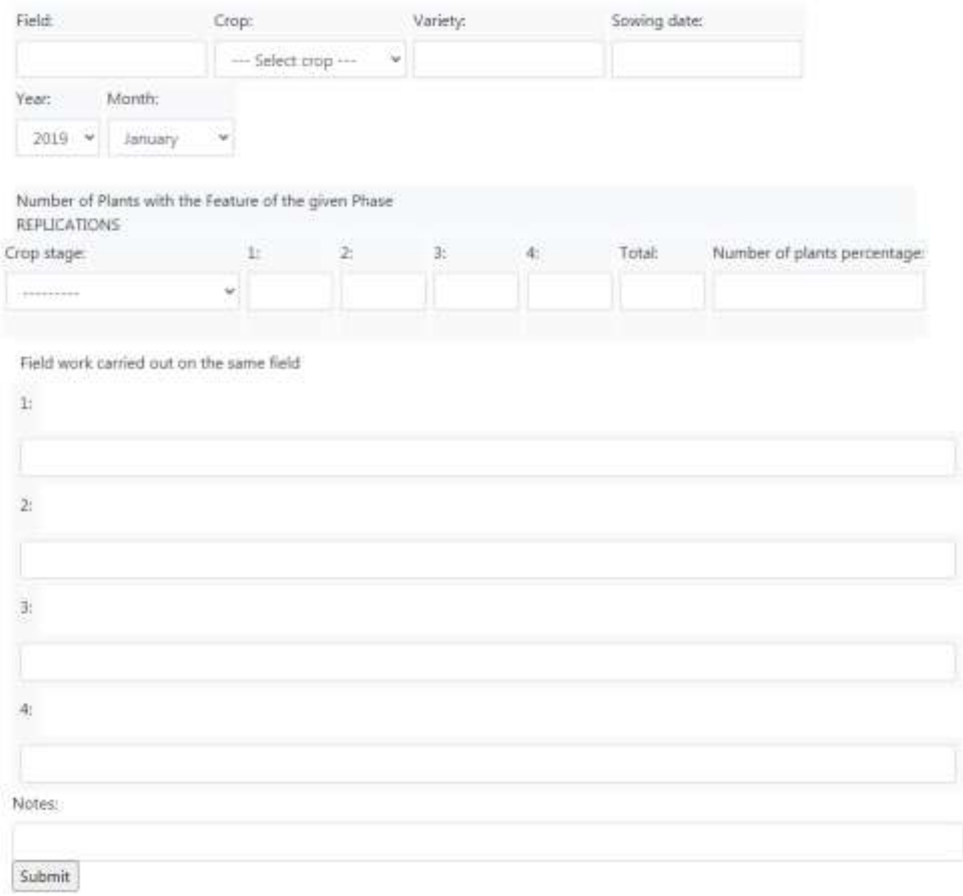




The user should click the “Submit” button after filling in all the details.

8.2 Monthly crop report

The monthly crop report is ideally entered once a month. The difference with the ten-daily crop report includes information on the name of the field where the observations are taking place, the crop variety (in addition to crop type), the sowing date, a breakdown of the percentage of crops at different stages of phenology, and the field work being carried out in the field.



8.3 Seasonal Calendar

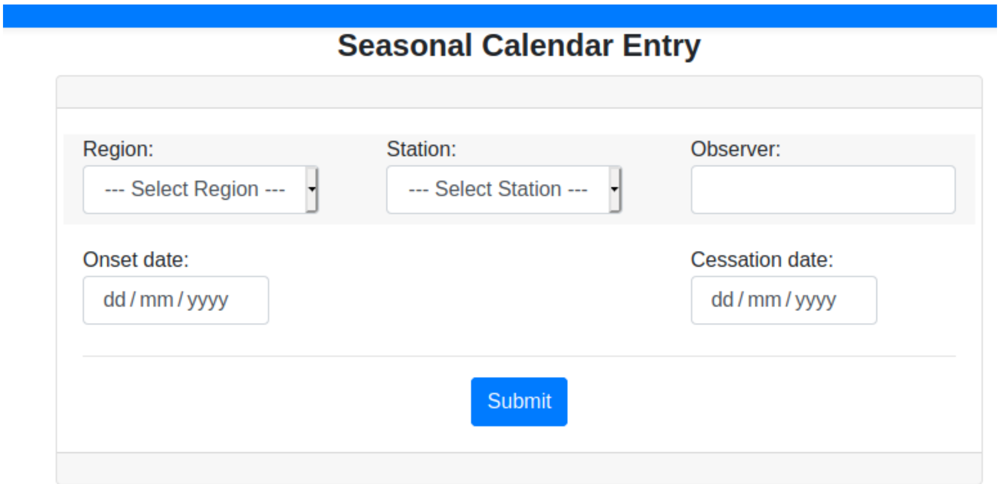
After clicking on the Enter Seasonal Calendar button, the user is presented with a screen showing all the available data, as well as an “Add Entry” button.

Seasonal Calendar Reports

Add Entry

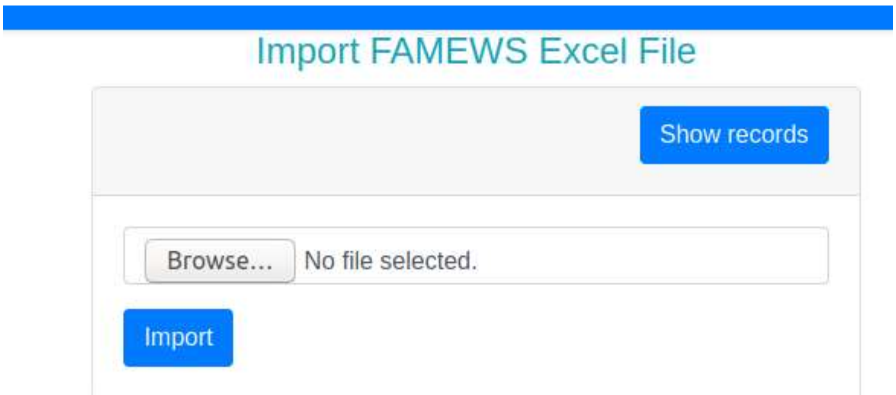
District	Station	Observer	Onset Date	Cessation Date	Length of seasons
Arusha	Arusha	John	2020-03-02	2020-05-25	84 days
Dodoma	Dodoma	Mary	2019-11-12	2020-04-17	157 days

Click on the Add Entry button to start adding new data: The data that needs to be entered is data the names of the region and the station where data is being observed, the onset of rains date, and the cessation of rains date. The length of season is then calculated automatically by subtracting the cessation data from the onset date.



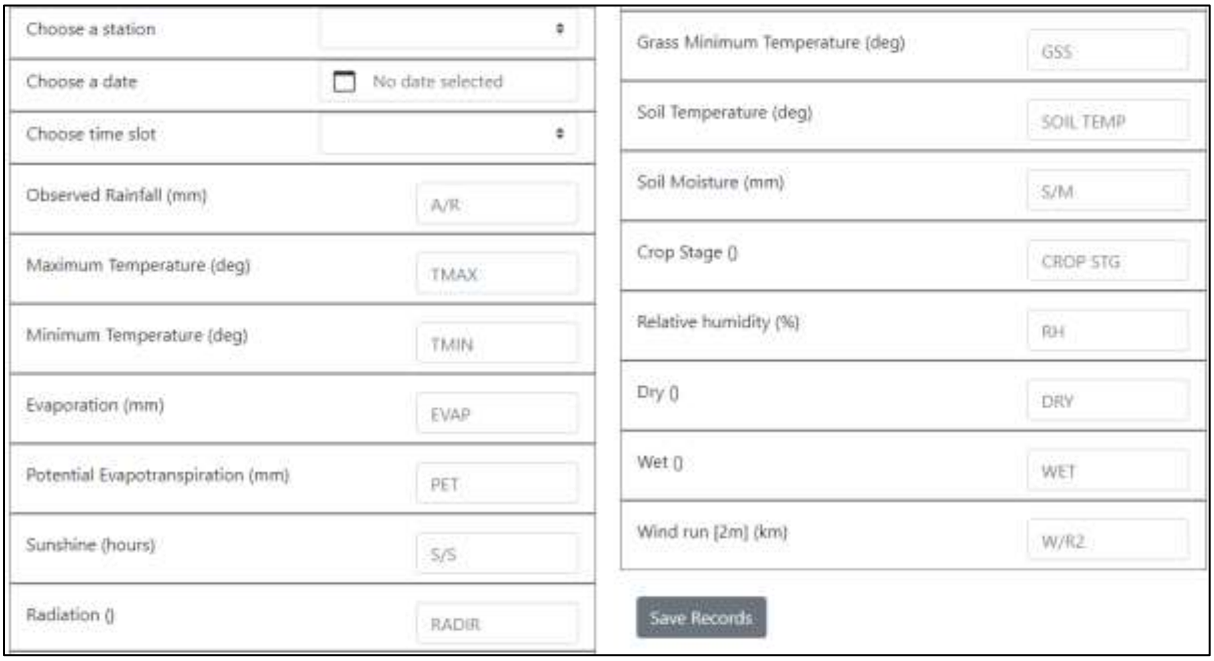
8.4 Import FAMEWS data

FAMEWS data is sent to TMA from FAO as an Excel file in a pre-determined format. The data can be imported by clicking the “Import FAMEWS data” on the main data entry interface, then clicking the Browse button on the following screen to select the FAMEWS Excel file, and clicking the “Import” button once the file has been selected.



8.5 Manual entry of station data records for all parameters

For agrometeorological stations where multiple agrometeorological parameters are observed, the user can manually enter the value of each parameter that was observed. Parameters that were not observed can be left blank. After a user selects a station, date and time, any observations already recorded in the database will be shown on the screen, in order to show the user that there are already values in the system. Missing values should be left blank. After data entry is complete, the user should click “Save Records”.



8.6 Single station data record entry

For instances where the user only wants to enter data for a single parameter, the single data record entry can also be used. This simplifies the interface, and allows the user to focus on that one parameter of interest.

For example, clicking on “Enter single station record” will give the form below

8.7 Importing data from Excel

In cases where the monthly data has already been entered into Excel, the data can be imported directly into the database using the import facility. The data has to be in a specific format for the import to work properly. The following format is required, based on a sample provided by TMA. The following should be adhered to:

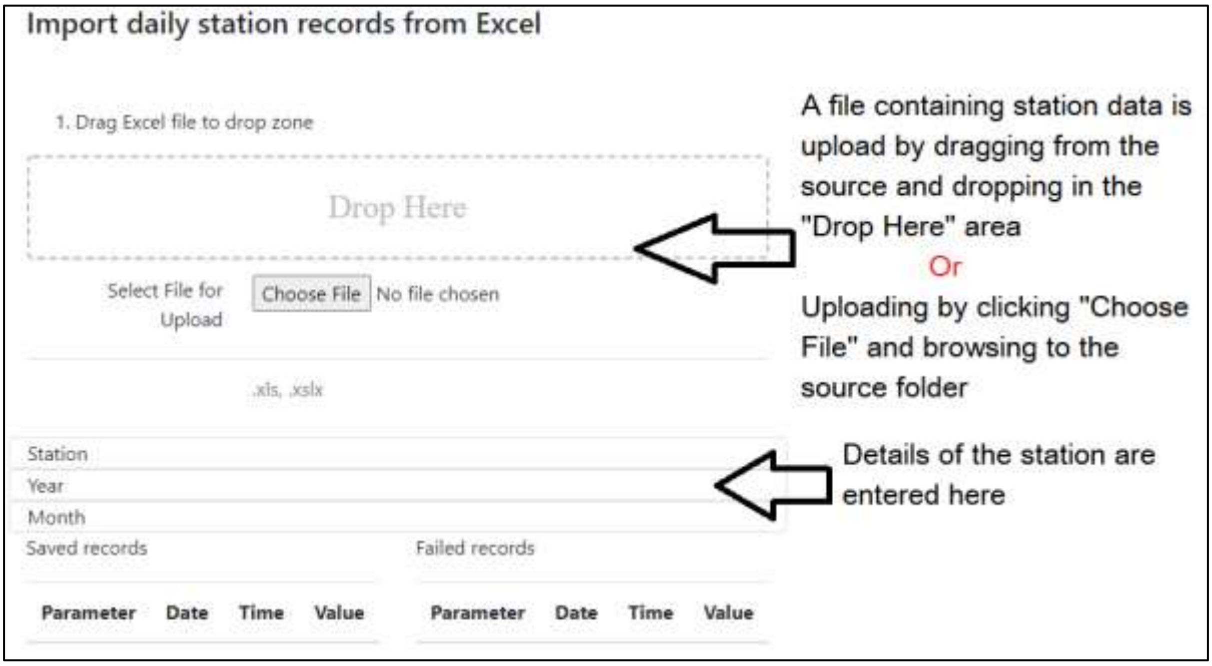
- Cell B1: Station name

- Cell B3: Data type (Daily)
- Cell D3: Month/Year
- Cell B4: Time (0600Z)
- Cell O4: Time (1200Z)
- Row 5: Parameter headings, in the order shown below
- Cell A5 to A36: dates from 1 to 31
- Missing values should be denoted by xx

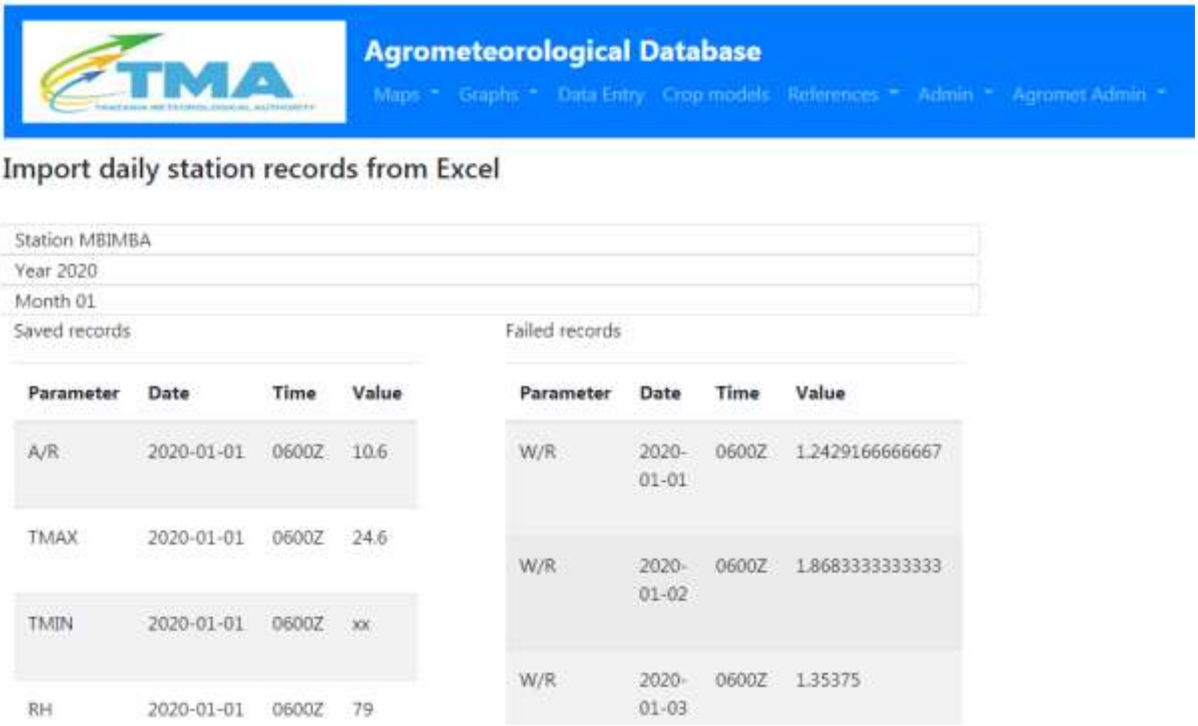
Failure to adhere to this format can result in import failure.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	**Station name**	**ILONGA**																
2																		
3	**Data type:**	**Daily**		**Month/Year: JANUARY-2015**														
4		**0600Z**													**1200Z**			
5	**DATE**	A/R	TMAX	TMIN	RH	EVAP	S/S	W/R	RADIR	GSS	SOIL TEM	S/M	CROP STG		DRY	WET	RH	SOIL TEMP
6	1	10.1	29.5	xx	91	3.3	2.2	2.9	xx	xx	20.6				23.9	19.9	71	22.3
7	2	30.7	26.6	xx	89	3.7	6.2	2.7	XX	XX	22.6				20.4	17.2	76	23.7
8	3	12.4	29.1	xx	91	4	6	1	XX	XX	22.7				23.7	18.5	64	24
9	4	25.4	21.3	xx	97	0.9	4.5	1.8	XX	XX	22.8				24.2	17.9	57	23.7
10	5	38.4	23.3	xx	85	3.4	6.4	2.8	XX	XX	21.9				23.4	16	50	22.5
11	6	2.6	27.2	xx	97	4.8	6.8	2.2	xx	xx	22				22.3	20.1	82	22.2
12	7	4.4	22	xx	82	5.7	2.5	1.5	XX	XX	20.1				21.9	16.2	61	23.2
13	8	0.8	28.7	xx	85	2.6	1.1	0.4	xx	xx	22.4				21.2	16.4	66	23.4
14	9	13.6	28.1	xx	98	2.9	6.5	2.6	xx	xx	21.8				21.2	18.2	77	23.9

Once the Excel data is confirmed to be in the correct format, the data should be imported as shown below



After importing, the user is given an overview of which data were successfully imported, and which records failed to import.



Agrometeorological Database

Maps Graphs Data Entry Crop models References Admin Agromet Admin

Import daily station records from Excel

Station MBIMBA

Year 2020

Month 01

Saved records

Parameter	Date	Time	Value
A/R	2020-01-01	0600Z	10.6
TMAX	2020-01-01	0600Z	24.6
TMIN	2020-01-01	0600Z	xx
RH	2020-01-01	0600Z	79

Failed records

Parameter	Date	Time	Value
W/R	2020-01-01	0600Z	1.2429166666667
W/R	2020-01-02	0600Z	1.8683333333333
W/R	2020-01-03	0600Z	1.35375

9. Managing documents

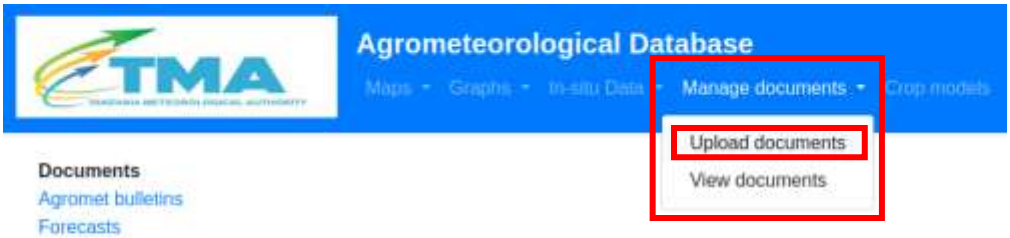
The TMA Agromet Database can handle Agromet Bulletins and Forecast documents (in pdf format) that web users can read directly from the website. The management of these documents is done from the Documents Management module. Authorized users can upload and delete documents, as well as list all the documents available in the system.

There are two different user roles for managing documents:

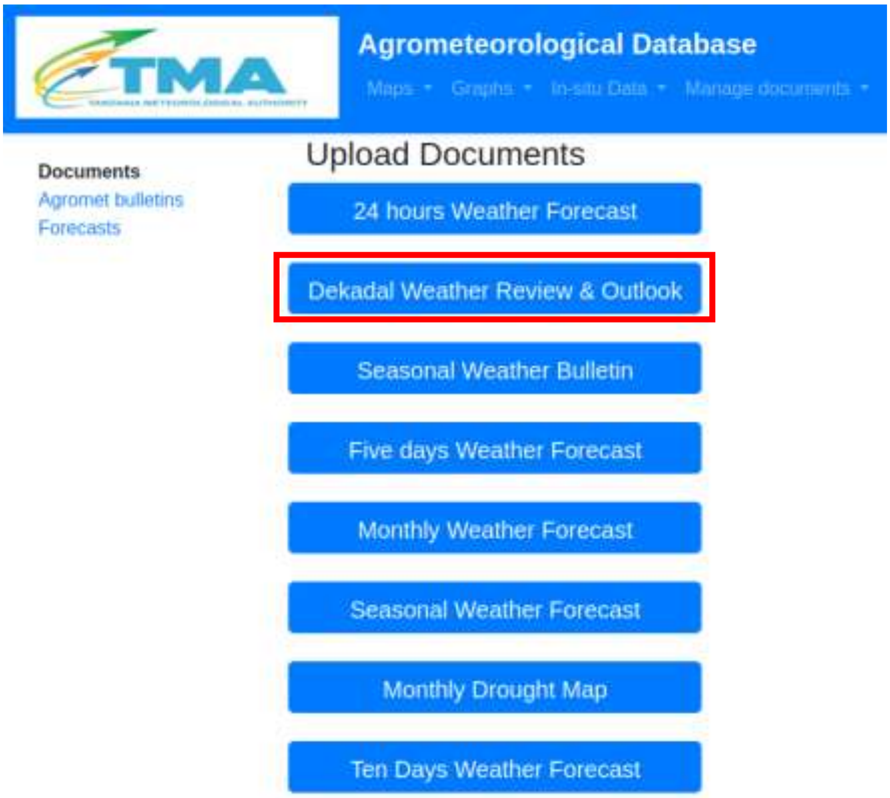
1. Agromet authors, who can upload, list and delete agromet bulletins
2. Forecast authors, who can upload, list and delete forecast documents.

9.1 Uploading documents

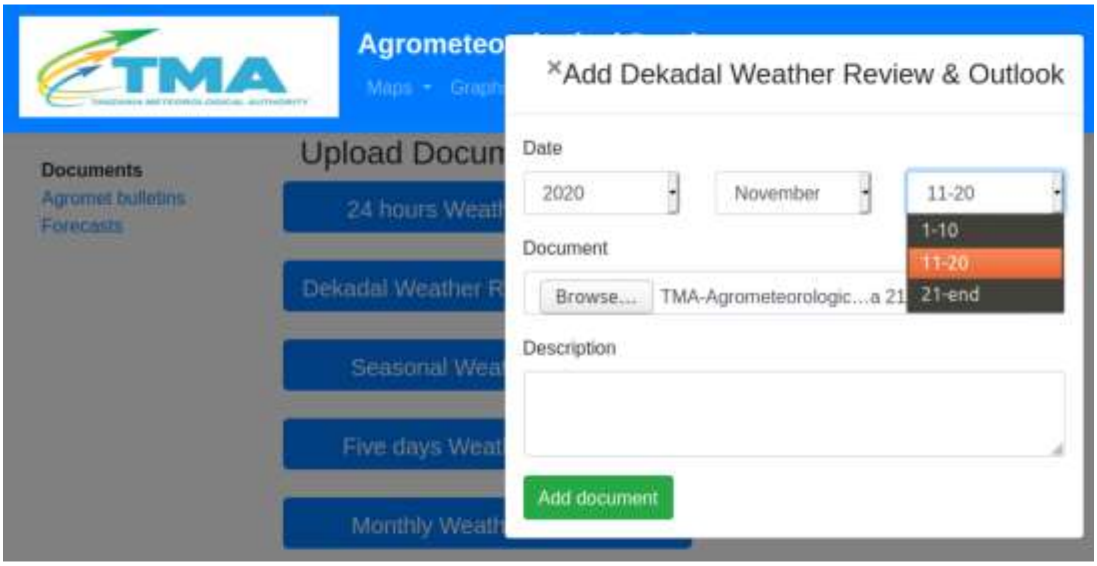
To upload a document, click the *Manage documents* menu, then click the *Upload documents* sub-menu item.



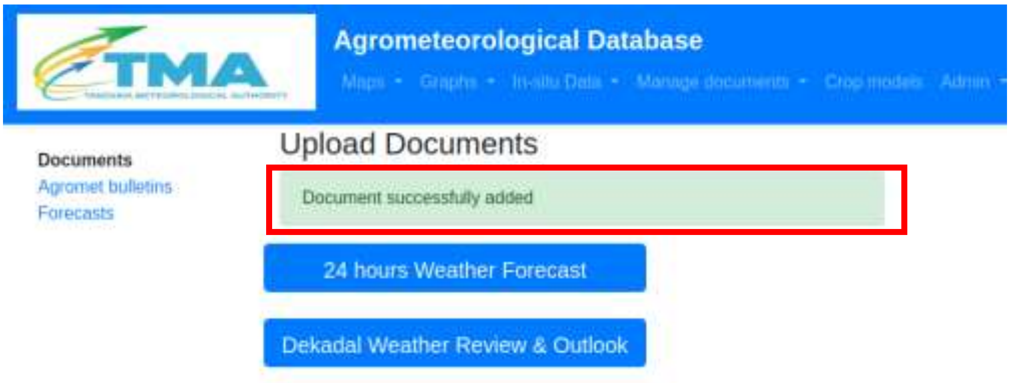
Select the type of document to be uploaded. For this example, a Dekadal weather review and outlook will be uploaded, by clicking on the *Dekadal weather review and outlook* button.



In the screen that pops up, specify the date that for which the document being uploaded is valid. Then click the Browse button and select the file to upload. A description of the document can optionally be added in the "Description" section if required. Then click the "Add document" button.

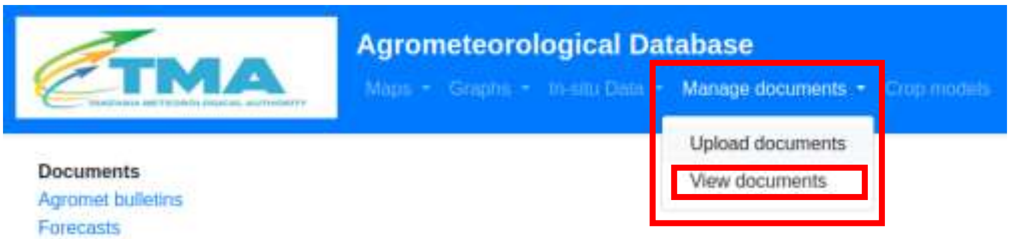


When the document has been successfully uploaded into the system, a message confirming success is displayed.



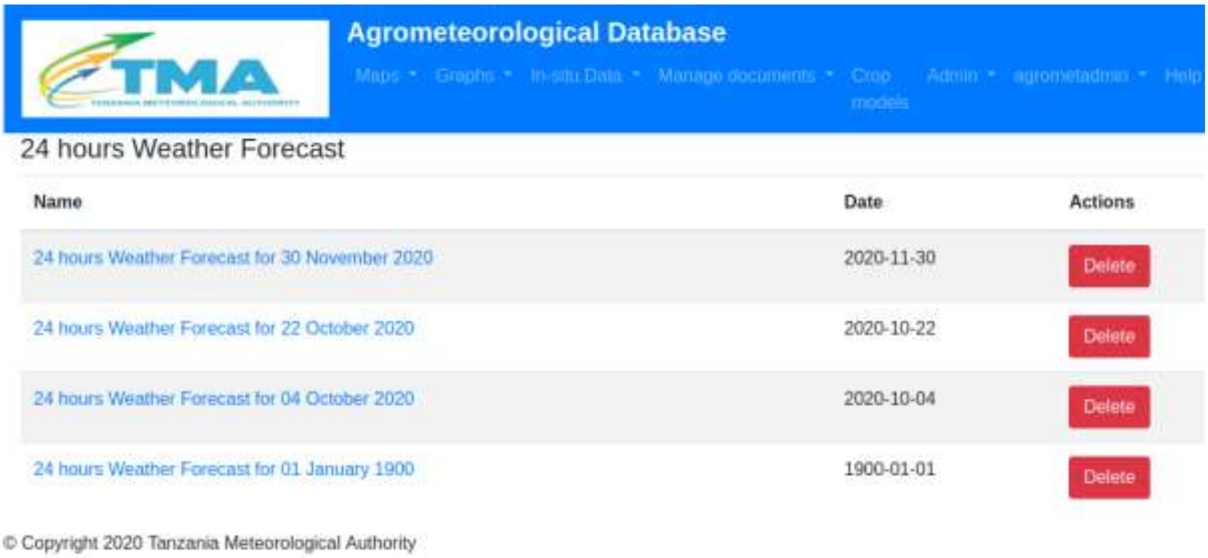
9.2 Viewing available documents

To view available documents, click the *Manage documents* menu, then click the *View documents* sub-menu item



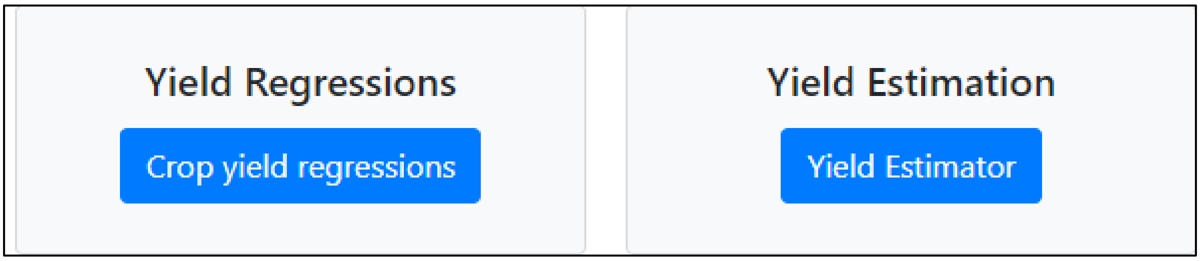
Select the type of documents to be viewed. For this example, the 24-hour weather forecasts will be viewed by clicking on the *24-hour weather forecasts* button.

A list of all the available documents of the specified type will be displayed in a table. Click on the name of the document to view the document, or click on the “Delete” button next to the name of the document in order to delete the document from the system.



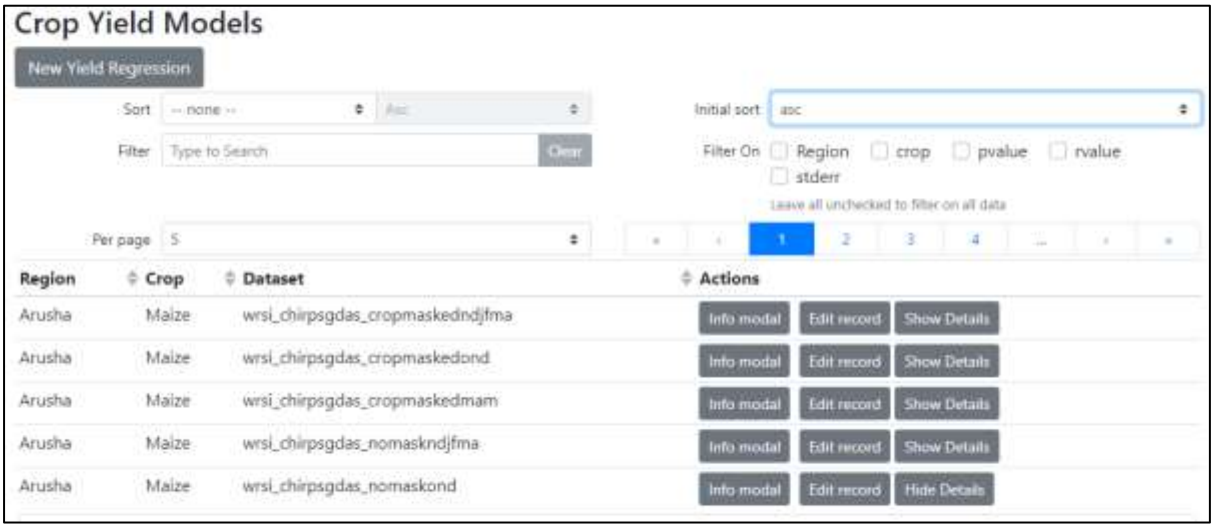
10. Crop yield modelling

The “Crop modelling” tab links the user with crop “Yield Regression” and “Yield Estimation” functions. Yield modelling is based on a set of regression equations per location and per crop type. The yield models that are in the database upon delivery of the database were developed using linear regression between crop yields and WRSI for the 2001 to 2010 period.



10.1 Crop yield regressions

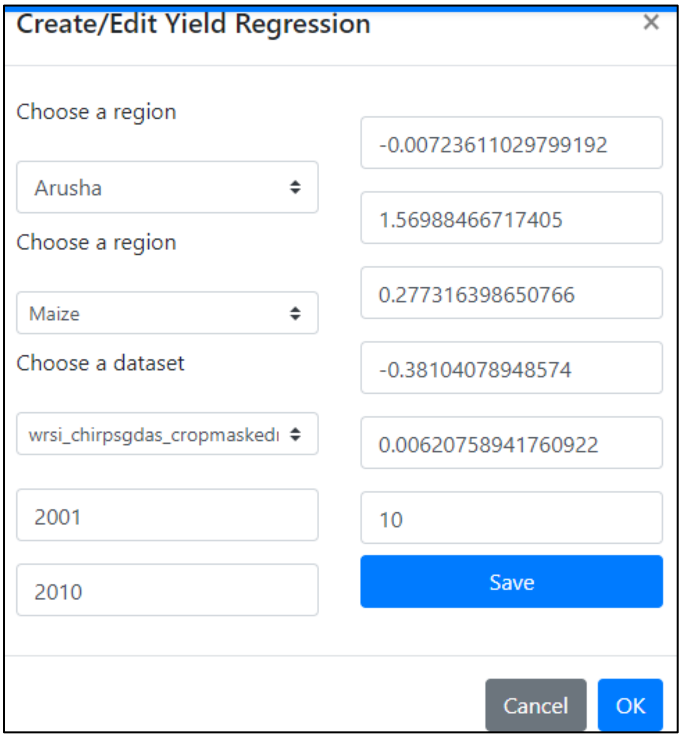
Clicking on Crop yield regressions takes the user to a window which shows details of regression equations including intercept and slope, correlation coefficient, data period considered, crop and region (see illustration below), and allows new yield regression models to be entered based on analysis that has been done externally.



Clicking on the “show details” button will provide yield regression statistics for the location and given crop. A statistically significant model will typically have p-value lower than 0.05. However, equations with higher p-values can still be instructive in providing guidance on potential yield outcomes.

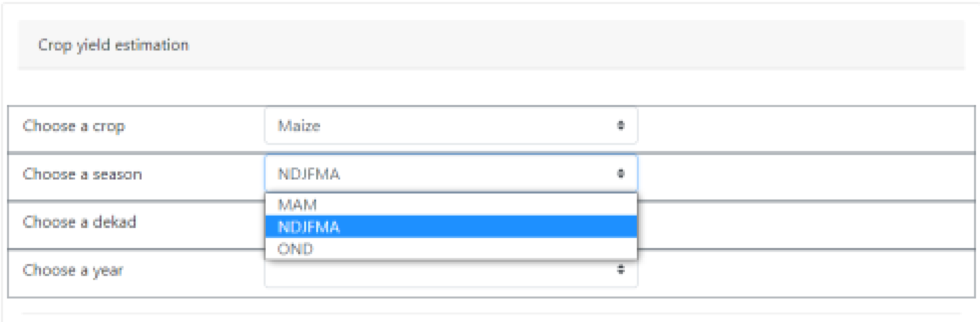
- crop_id: 8
- region_code: 48362
- grid_type: 24
- start_year: 2001
- end_year: 2010
- slope: 0.0409277538203548
- intercept: -2.19553481734203
- pvalue: 0.444703006654328
- rvalue: 0.273382104215111
- stderr: 0.0509137693838501
- numobsused: 10
- region: { "id": 16, "region_name": "Kigoma", "region_code": 48362, "created_at": null, "updated_at": null, "region_level": 1, "parent_code": null }
- crop: { "id": 8, "crop_name": "Maize", "crop_code": null, "crop_fao_code": null, "crop_description": null }
- dataset: { "id": 24, "gridtype_name": "wrsi_chirpsgdas_nomaskndjfma", "gridtype_content": "WRSI NDJFM no mask", "gridtype_purpose": "Crop monitoring", "gridtype_abstract": null, "theme_id": 1, "gridtype_keywords": "WRSI, NDJFMA, unmasked", "gridtype_timeseries": 1, "gridtype_lolimit": null, "gridtype_uplimit": null, "gridtype_status": null, "gridtype_citation": null, "gridtype_credit": null, "gridtype_source": 2, "gridtype_altsource": 3, "projection": 4326, "gridtype_language": null, "gridtype_cons": null, "gridtype_comments": null }
- _showDetails: true

Clicking on the “Edit record” allows making changes such as selecting another crop type as well as saving changes for incorporation in regression equation for yield modelling of the selected crop type. It is not advised to change the statistics on the right hand side as these should be calculated automatically in the model development.



10.2 Estimating yield

Yield can be calculated using regression equations that have already been entered in the database. The system allows yields to be projected for the current year, once the predictor parameter (e.g. WRSI) has been calculated and is available in the database. Based on this approach, is advised to estimate yields after at least 75% of the season has elapsed, or when the crop is late in the flowering stage. Yields for previous years can also be calculated using the same approach, although in this case, agrometeorological parameters such as WRSI, calculated at the end of the season, can be used. The yield estimation module can be accessed by clicking the “Yield estimator” button. Available yield estimation models are for maize, based on WRSI, although users can develop other models in the manner described above. The user needs to select the crop, season (MAM, NDJFMA or OND), as well as the dekad and year at which the user is calculating a yield estimate. The user can calculate a yield estimate at any dekad during the season for which data is available, assuming that the calculation of the parameter at that dekad is representative of the seasonal crop performance. This assumption is valid for parameters that integrate seasonal performance, such as WRSI, or cumulative NDVI over a specific period, as may be determined by empirical analysis. The database comes with a regression analysis that has been undertaken for maize only, but users can perform analysis for other crops using techniques described in section 7.1.



When the user has selected the crop type, year, season and dekad, yields are computed automatically based on regression equations, and results are displayed at the bottom of the parameterization section as below. Note that yield estimates calculated from models with high P-values should be treated with caution, as this means the model is not statistically robust. P-values with a value greater than 0.1 are coloured orange to warn the user to treat the resultant yield estimate cautiously. In the example below, Arusha has a yield estimate of 1.03 tons/ha. However with a P-value of 0.28, this estimate should be treated cautiously. Further analysis to develop a more robust model is advisable in such a scenario. Such further analysis can be done by calibrating the WRSI models, or trying other parameters such as NDVI.

Crop yield estimation

Choose a crop	Maize
Choose a season	NDJFMA
Choose a dekad	Mar-3
Choose a year	2020

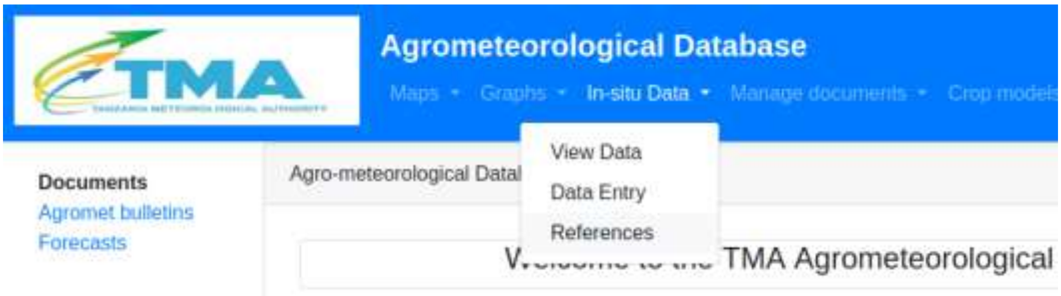
Region:

Crop: Maize

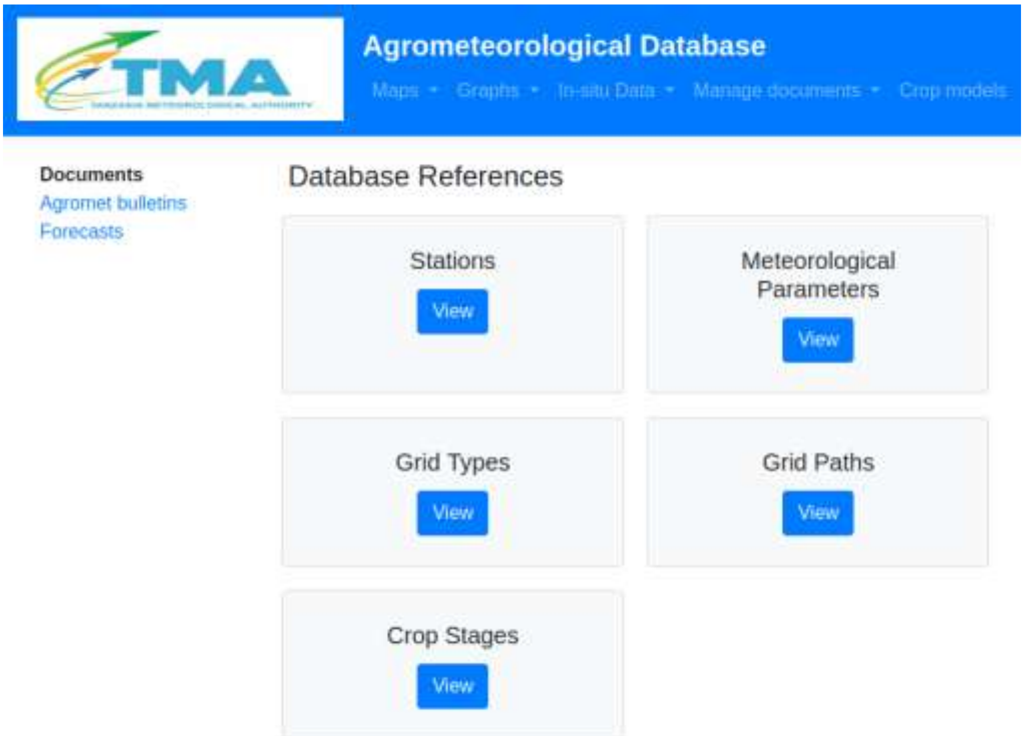
Region	Crop	Slope	Intercept	P-value	Year	X	Estimate
Arusha	Maize	-0.0072	1.5699	0.2773	2020	75	1.03
Dodoma	Maize	-0.0123	1.8341	0.4965	2020	99.93	0.61
Iringa	Maize	0.0302	-1.2518	0.3892	2020	99.83	1.76
Kigoma	Maize	0.0715	-5.3262	0.5954	2020	99.39	1.78
Lindi	Maize	-0.0498	5.7422	0.3572	2020	99.93	0.77

11. Reference functions

A number of reference functions can be accessed through the In-situ data > Reference button on the menu bar.



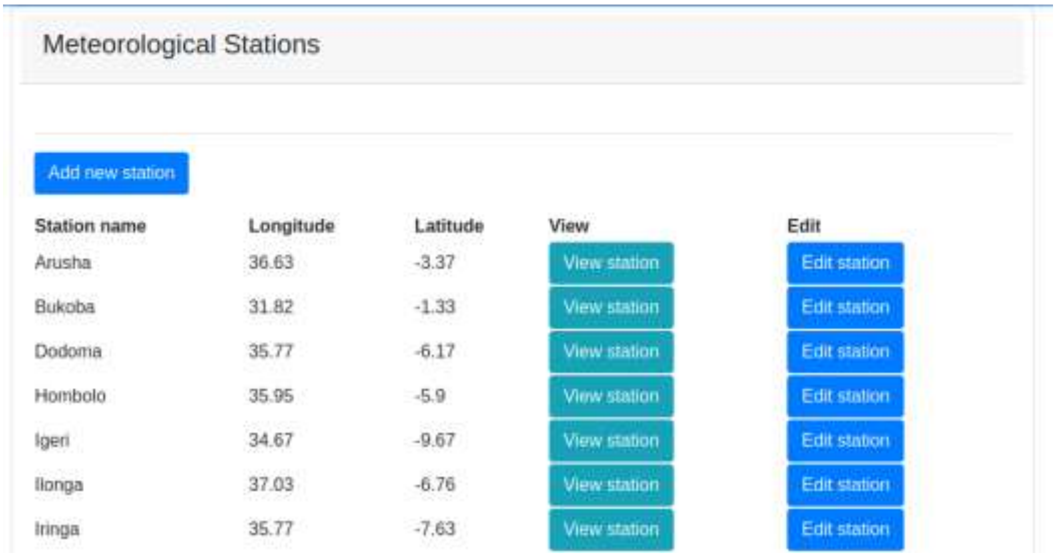
The reference functions include those for Stations, Meteorological Parameters, Crop Stages, Grid Types, and Grid Paths.



Each of the references are described in the following section.

11.1 Stations

Clicking on the Stations View button presents a list of all the stations available in the database. The list shows the station name, latitude and longitude, as well as buttons for viewing the station or editing the station



Meteorological Stations

Add new station

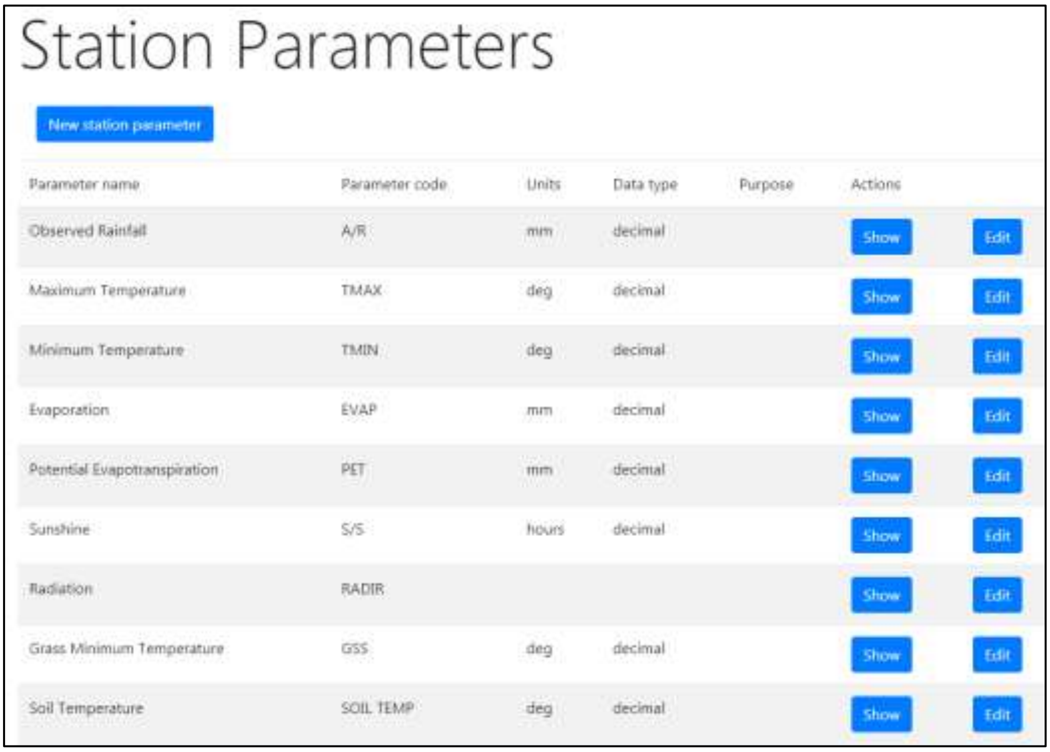
Station name	Longitude	Latitude	View	Edit
Arusha	36.63	-3.37	View station	Edit station
Bukoba	31.82	-1.33	View station	Edit station
Dodoma	35.77	-6.17	View station	Edit station
Hombolo	35.95	-5.9	View station	Edit station
Igeri	34.67	-9.67	View station	Edit station
Ilonga	37.03	-6.76	View station	Edit station
Iringa	35.77	-7.63	View station	Edit station

In this section of the stations management interface, the user can edit the station information such as name of the station, latitude, longitude, altitude, type of station, and the region the station is located in. A station is edited by clicking the "Edit station" button in front of the station's name.

Users can also add new stations to the database by clicking the "Add new station" button, and then specifying all the station's characteristics.

11.2 Meteorological Parameters

The station parameters menu item allows the user to display and edit available meteorological parameters, as well as specify new meteorological parameters:



Station Parameters

New station parameter

Parameter name	Parameter code	Units	Data type	Purpose	Actions	
Observed Rainfall	A/R	mm	decimal		Show	Edit
Maximum Temperature	TMAX	deg	decimal		Show	Edit
Minimum Temperature	TMIN	deg	decimal		Show	Edit
Evaporation	EVAP	mm	decimal		Show	Edit
Potential Evapotranspiration	PET	mm	decimal		Show	Edit
Sunshine	S/S	hours	decimal		Show	Edit
Radiation	RADIR				Show	Edit
Grass Minimum Temperature	GSS	deg	decimal		Show	Edit
Soil Temperature	SOIL TEMP	deg	decimal		Show	Edit

The system shows the name, code, units, minimum and maximum permissible values, priority and data type of each meteorological parameter. Click the “Edit” button to change any of these values. The minimum and maximum values permit some quality control during data entry, as any values entered that are outside the minimum and maximum values will be rejected by the database.

The priority determines the order in which the station parameters are displayed when viewing data. The higher priority items are displayed first

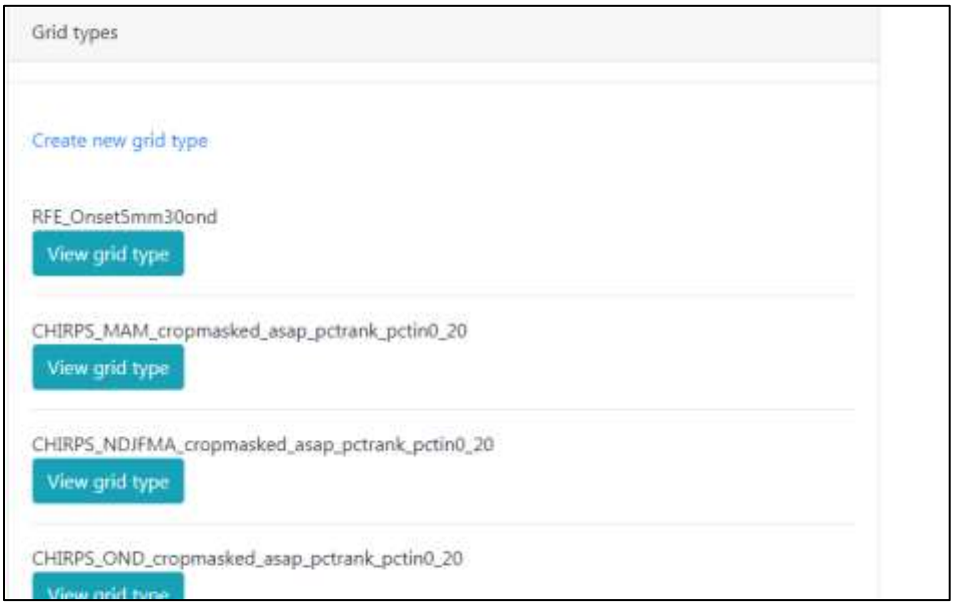
Click on “New Station Parameter” to specify a new station parameter:

Click “Submit” when all the details of the new parameter have been added.

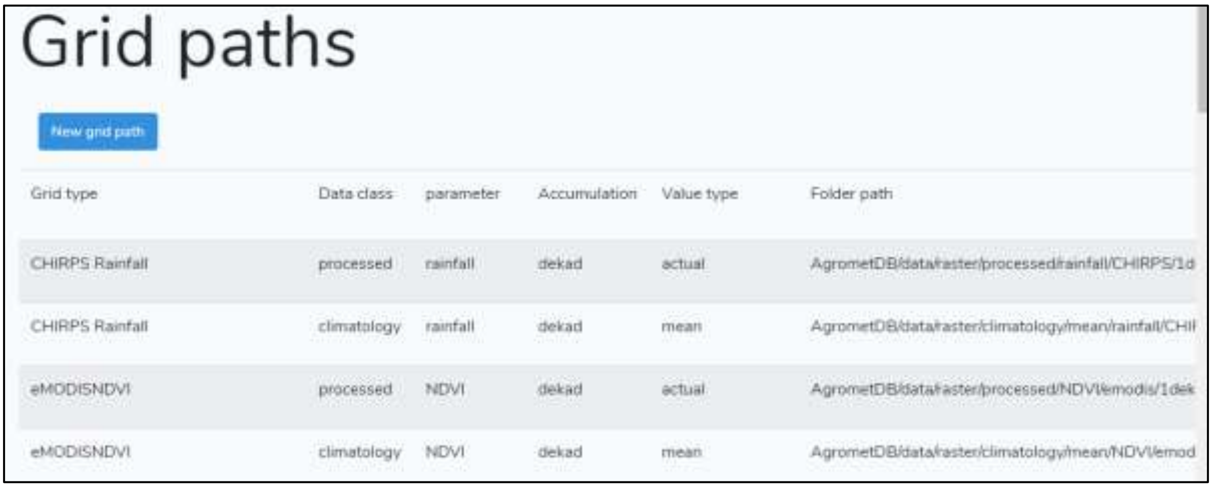
11.3 Grid Type and Path

The Grid Types and Grid Paths menu items allow the user to view the settings that are used for managing the display of gridded agrometeorological datasets. New grid types and grid paths can be added when new gridded datasets have been incorporated into the database. Typically users are not expected to use these particular functions unless a new gridded dataset is being incorporated to the database, for which additional configuration is required on the operating system.

The grid types views is shown below



The grid Paths view is shown below.



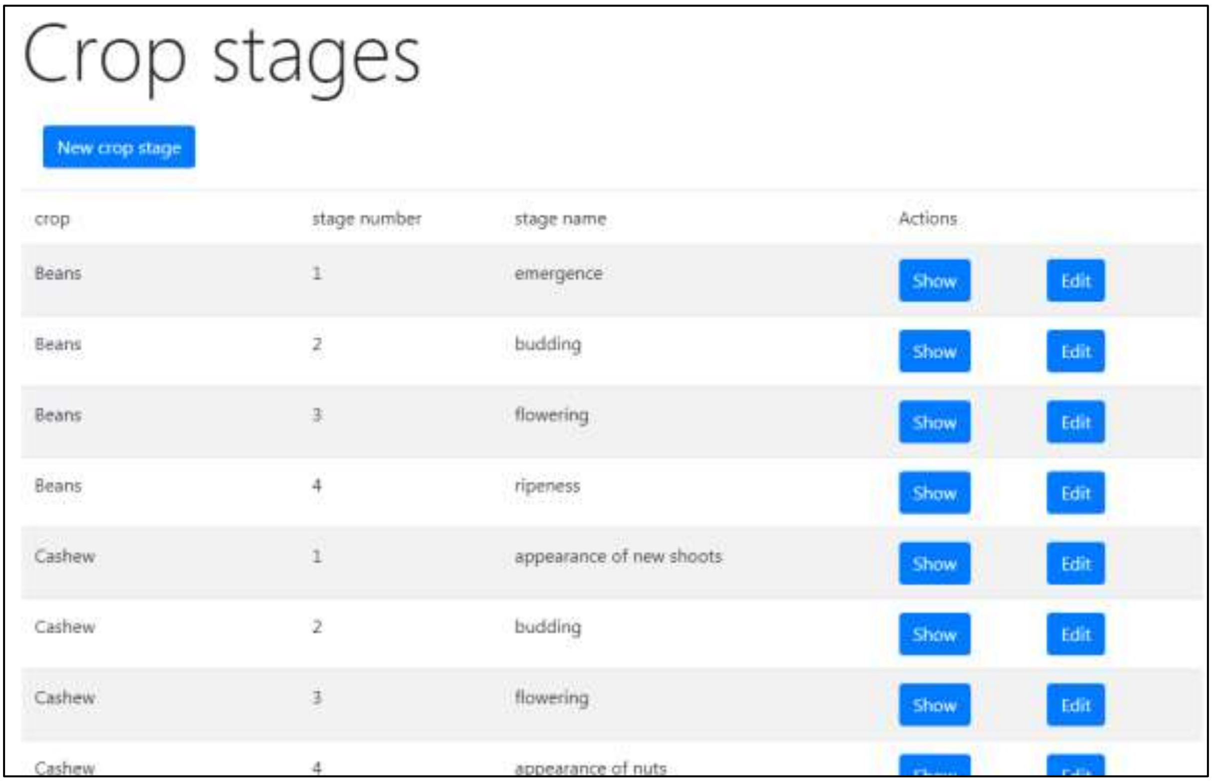
Grid paths

New grid path

Grid type	Data class	parameter	Accumulation	Value type	Folder path
CHIRPS Rainfall	processed	rainfall	dekad	actual	AgrometDB/data/raster/processed/rainfall/CHIRPS/1d
CHIRPS Rainfall	climatology	rainfall	dekad	mean	AgrometDB/data/raster/climatology/mean/rainfall/CHII
eMODISNDVI	processed	NDVI	dekad	actual	AgrometDB/data/raster/processed/NDVI/emodis/1dek
eMODISNDVI	climatology	NDVI	dekad	mean	AgrometDB/data/raster/climatology/mean/NDVI/emod

11.4 Crop stages

The name and number (chronologically, from first to last) of each phenological stage for each crop in the database is displayed when the user clicks the “Crop stages” sub-menu. Click edit to edit any of these values. New crop stages can also be added.



Crop stages

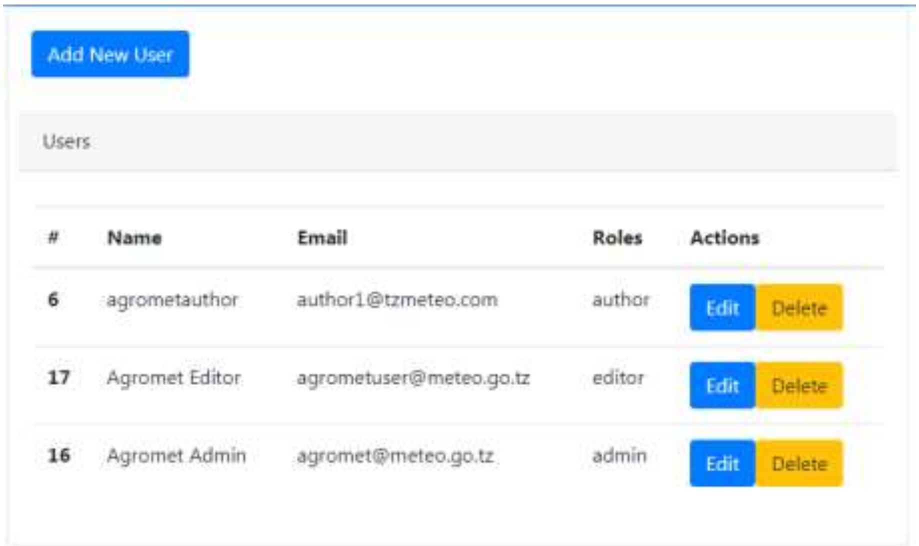
New crop stage

crop	stage number	stage name	Actions	
Beans	1	emergence	Show	Edit
Beans	2	budding	Show	Edit
Beans	3	flowering	Show	Edit
Beans	4	ripeness	Show	Edit
Cashew	1	appearance of new shoots	Show	Edit
Cashew	2	budding	Show	Edit
Cashew	3	flowering	Show	Edit
Cashew	4	appearance of nuts		

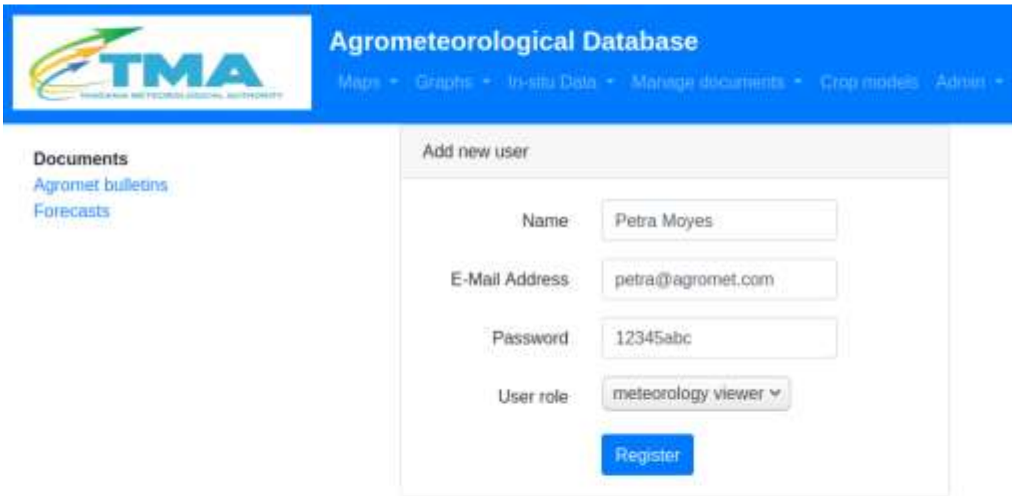
12. User administration

The administrator can manage users with access to the database by adding new users, removing users and changing a user's privileges (roles). This facility is accessed by clicking the *Admin* > *Users* menu path on the main menu. This menu item is only available to users logged on as Admin.

To add a new user, click the "Add New User" button at the top-left of the screen.

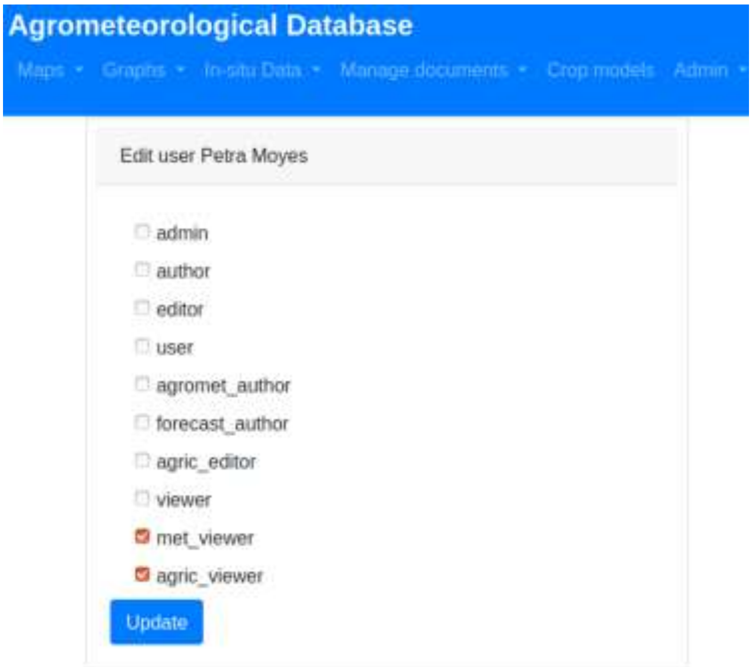


On the following screen, specify the name, email address, password and primary user role of the new user, and then click the "Register" button.



During setup, a user can only be assigned a single role, but if multiple roles are required, the administrator can edit the user's roles and assign multiple roles. To edit a user's roles, click the Edit button next to the user's name on the Administration panel.

In editing the user, the Administrator can assign different roles to the user which will allow the user access to different parts of the database. Some roles allow a user to only view certain parts of the database, other roles allow the user to publish documents (authors), yet other roles allow users to add new data (editors), and the administrator role allows a user to have full access to the database.



13. Conclusion

The TMA agrometeorological database facilitates the provision of a wide range of data and reports to stakeholders in agriculture, food security monitoring, research and related fields. The database is a secure facility as user access control is implemented for viewing and updating station data. At the same time, the database facilitates public utility by providing open access to public datasets such as already available via internet from various satellite imagery data producers, but customized for Tanzania. The platform contains a spectrum of useful agrometeorological data and analysis ranging from meteorological data to yield estimates. In order to match requirements of different users, the database also provides different definitions for key agrometeorological parameters as options. The platform is also a good disaster management tool as the home page containing drought hazard map. The database is flexible, with the facility for TMA to include other datasets and analysis as they specify additional needs. The database is expandable to allow the addition of more and new datasets, both station data and gridded datasets. Further refinement and new functions can be made to the database over time to improve its functionality as user needs of TMA and its agrometeorological stakeholders evolve.

14. Glossary

CHIRPS: A near-global, satellite-based rainfall dataset that combines infrared satellite data with station data, and is produced at a monthly time period, with datasets available for daily through monthly time-steps. CHIRPS is an acronym for Climate Hazards Infrared Precipitation with Stations, and is produced by Climate Hazards Group at University of California Santa Barbara

Crop yield regressions: Crop yield regressions represent the statistical relationship between historical crop yields and predictive parameter such as WRSI, NDVI or rainfall. In the Agromet Database, these relationships are established as a linear regression that estimates the equation of the best fit line that matches WRSI (or other suitable agrometeorological parameters) and crop yield. In this way, crop yields can be estimated if the value of the predictive agrometeorological parameter is known.

CSV : Comma-separated values. A text format file that represents data rows and columns separated by commas. CSV files can be exported from or imported into Excel or other spreadsheet programs, thus facilitating data sharing among different applications. Some of the datasets from the TMA agrometeorology database are exported in CSV format and can be imported into Excel for further analysis

eMODIS : eMODIS data is a specially processed format of Normalized Difference Vegetation Index (NDVI) data developed by the United States Geological Survey (USGS) using MODIS satellite data. The processing done by USGS reduces the effects of clouds on NDVI using temporal smoothing. MODIS, the Moderate Resolution Imaging Spectrometer, is a satellite sensor that views the entire earth's surface every one to two days, capturing images that are useful for the earth's land, oceans and atmosphere

FAO : Food and Agriculture Organization of the United Nations.

FEWS NET: Famine Early Warning System Network. A project of the United States Agency for International Development (USAID) that focuses of producing early warning information pertaining to food security. As part of its processes for early warning analysis, FEWS NET produces many datasets that are useful for agrometeorological analysis.

FLDAS: FEWS NET Land Data Assimilation System. A customized version of the National Aeronautics and Space Administration's (NASA) Land Information System that specifically deals with physical land-hydrological datasets and simulation models that can support food security analysis.

GIS: Geographic Information System. A system designed to capture, archive, manage, analyze and display geographic data and its attributes. GIS software are specifically designed to facilitate GIS analysis and can be used to further analyze data that is exported from the TMA Agrometeorological Database.

MAM: March-April-May period. This covers the *Masika* season.

NDJFMA: The November to April period (November-December-January-February-March-April). It is often referred to as the unimodal or *Msimu* season in Tanzania.

NOAA : National Oceanic and Atmospheric Administration is a United States government agency that, among other things, provides meteorological services for the United States.

Noah Land Surface Model: Land surface models are simulations or models that calculate the exchange of energy (including heat) and water between land surfaces, water surfaces and the atmosphere.

NDVI : Normalized Difference Vegetation Index. A satellite derived index that depicts the health and quantity of green (photosynthetic) vegetation in an area. Higher NDVI values are synonymous with higher density or better health of vegetation.

OND : October-November-December period. This covers the *Vuli* season.

Percentiles (e.g. 20th percentile): A percentile is a statistical value indicating the percentage of all samples in a population that fall below that specific percentile value. For example, if the 20th percentile for Oct-to-Dec rainfall in a particular location is 150mm, then 20% of all Oct-to-Dec rainfall totals made historically for that dataset will be equal observations made historically for that dataset will equal to or less than 150mm.

PNG : A file format that is used to show graphics and can depict items of interest such as graphs and maps in a format that can be imported reports and presentations.

Representation of change from averages : Difference from average and percent of average calculations. Agrometeorological parameters such as rainfall, NDVI and WRSI are often represented as anomalies in order to enable users to observe the extent to which current conditions differ from average conditions, and whether this is a negative or positive change. There are typically two common ways of representing this change: (1) A difference from average, in which the actual value for the time period being analyzed has the long term average for the same time period subtracted from it and (2) a percent of average, in which the actual value for the time period being analyzed is expressed as a percentage of the long term average for the same time period.

RFE 2.0 : Rainfall estimates version 2.0, a satellite rainfall estimate covering Africa, produced by the National Oceanic and Atmospheric Administration (NOAA), using a combination of satellite images and station data.

U.S. Drought Monitor : The United States Drought Monitor (USDM) is a weekly-produced drought map showing areas of the United affected by varying severities of drought. The map is produced by the US. National Drought Mitigation Centre, NOAA and the U.S. Department of Agriculture, using inputs from several indices as well as expert interpretation by professionals and reports of impacts by local observers in the affected areas. Part of the input on classification of drought is based on use of percentiles, however, human intervention is and interpretation is also used. More information is available at https://droughtmonitor.unl.edu/About/WhatistheUSDM.aspx

WMS: Web Map Service (WMS) is a protocol for sharing georeferenced maps on the internet, served by a web server where the maps reside. WMS was developed by the

Open Geospatial Consortium. The Agromet Database uses the WMS protocol to display the maps of agrometeorological parameters that it archives.

WRSI : Water Requirements Satisfaction Index. An index that indicates the extent to which crops have received the water that they required throughout the growing season on a cumulative basis. The index is calculated from a soil water balance model that uses rainfall, evapotranspiration, soil water holding capacity, crop type, crop cycle length and planting dates.

Z-score : A statistical parameter in which data is transformed into a standard normal distribution, with an average of 0 and a standard deviation on 1. Z-scores are sometimes referred to as standardized values.