



INITIATIVE ON
West and Central African
Food Systems Transformation



Transforming Agrifood Systems in West and Central Africa Initiative (TAFS-WCA)

Tailoring the Digital Agro-Climate Advisory (DACA) platform in Ghana

By Patrick Mvuyibwami, Desire M. Kagabo, Livingstone Byandaga, Nasson Ntwari, Manjari Singh.



December 2023

1. Climate threats: A call to action

Climate change continues to be the main threat to Africa's agriculture in general and Ghana in particular. The country has not yet been able to realize its full production potential to enable it feed its growing population, a situation that is worsened by increasing political instabilities in the West and Central Africa. Furthermore, rapid land degradation and increasing incidence of invasive pests and diseases have emerged as a persistent threat, disrupting the markets and value chains in the country. In addition, due to inadequate infrastructure, the agriculture sector experiences huge post-harvest losses.

2. Workshop: A transformative Initiative

Through the Transforming Agri-Food Systems in West and Central Africa (TAFS-WCA) initiative, the Alliance of Bioversity International and CIAT organised a workshop in December 2022. This workshop brought together key stakeholders in Ghana's agricultural sector, along with representatives from three major agro-ecological zones: The Savannah zone, Transitional zone and the Forest zone.

The main objective of the workshop was to gather crop characteristics—days to maturity, water requirement, Growing Degree Days (GDD), crop suitability and fertilizer recommendations tied to their growing areas/regions in Ghana and integrate them into Digital AgroClimate Advisory (DACA) for location and context specific agroclimatic advisories such as which crop/crop variety to grow for a specific season and location, what time to plant and the appropriate fertilizer recommendations.

3. Digital AgroClimate Advisory (DACA): Revolutionizing access to bundled agroclimate advisories

DACA is a mobile-based web platform meant to reach millions of agricultural value chain actors with information, services, and products that are location-specific and are tailored to user's needs in relation to climate, crops and farm type.

DACA allows agriculture value chain actors to access a range of tailored information, products and services to digitally inform their decisions and have a room for maneuver into the digital system through the tutorial board (videos, audios, pictures, texts) and the advisory board that provides bundled services including weather, climate and crop Information.

4. Program and Participants of the workshop

The workshop took place over 3 days, and covered in details the activities of: (1) developing a template to gather information on crops (days to maturity, crop water requirement, fertilizer recommendations, etc.) with respect to their specific locations. This was a key part of this workshop, (2) Mapping the top 10 major crops/varieties per Agro-ecological zones using Ghana land use/cover map, (3) Producing a list of major crops specific descriptors such as district, altitude, base temperature, maximum and minimum temperatures, fertilizer recommendations, crop coefficient (KC) per crop stage and the seasonal average of KC for every crop, days to maturity, water requirement, Growing Degree Days (GDD), crop suitability, etc...tied to their growing areas/regions, and (4) Evaluate and validate of crops specific descriptors.

Participants were from different institutions including Savannah Agriculture Research Institute of the Council for Scientific and Industrial Research (CSIR-SARI), Crop research institute of the Council for Scientific and Industrial Research (CSIR-CRI), Nuclear Agricultural Research Institute (BNARI), Ghana Atomic Energy Commission, and University for Development Studies (UDS). In addition, all the 3 major Agro-ecological zones were also represented. In total participants were 8 including 1 woman (12.5%) and 2 youth (25%).



Figure 1: Participants during presentations and group works

5. Methodology: Inclusive and Participatory Approach

The workshop was scheduled for three consecutive days in which both presentations as well as group works were carried out. As the participants in this workshop represented three different agro ecological zones, they were divided into 3 groups in order to gather context- and location specific information, and also to maximize the output from their participation and have attention of everyone.

Through the use of different techniques, including PowerPoint presentations, participants were presented about the Transforming Agri-Food Systems in West and Central Africa (TAFSWCA) CGIAR Initiative and its objectives, relationship between climate and crop information, and how to use various types of climate information to assist their agricultural decision making.

By focusing primarily on food and nutrition security and making agri-food systems more climate adapted, the Transforming Agri-Food Systems in West and Central Africa (TAFSWCA) CGIAR Initiative is making contributions to the five Impact Areas of the One CGIAR which are: (1) Nutrition, Health & Food Security, (2) Poverty Reduction, Livelihoods & Jobs, (3) Gender Equality, Youth & Social Inclusion, (4) Climate Adaptation & Mitigation, and (5) Environmental Health & Biodiversity.

Informed Digital Agriculture for Climate Resilience is one of the 5 working packages of TAFSWCA, which aims to create or improve, contextualize, and complement existing digital services for small-scale farmers, value chain actors and governments for informed decision making through data harmonization, governance, analysis, and tailored advisories.

Digital AgroClimate Advisory (DACA) is one of the perfectly bundles and delivers digital agro-climatic advisory services that are location and context specific. DACA was implemented to rollout climate information services across several regions of Ghana under the auspices of the Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) Ghana cluster. DACA includes an important module on crops and this module requires local and context crop characteristics. It is in this perspective that crop characteristics and fertilizer recommendations from different agro-ecological zones of Ghana were collected to customize DACA in Ghana context. The table 1 depicts the methodology being used across Africa to customize DACA for crops and others variables such as fertilizer recommendations.

Table 1: Steps sequence in the process of customizing DACA for crops across Africa

Steps	1 Defining crop profiling and prioritization framework and method		3 Mapping of crops per AEZ	
Results	Definition of priority crops, units of analysis and regions to be assessed		Digitalizing and Mapping major crops with their specific descriptors through DACA	
Methods	<ol style="list-style-type: none"> 1. Scientific and grey literature review 2. Consultation meetings with stakeholders from organizations such as National Agricultural Research Systems, Universities, Agricultural Extension Services, etc. 3. Organize GIS analysis and other weather/climate analytics 	2 Validation of the crop profiling	<ol style="list-style-type: none"> 1. National participatory mapping of crops based on agro-ecological zones 2. Digitalization of crop maps produced during participatory workshops/meetings 3. GIS-Attribute tables of crops 4. Creation on NetCDF files 5. Digital automation of agro-advisory services through a mobile app 	4 Validation of the final results
Activities	<ol style="list-style-type: none"> 4. Contacting organizations and data acquisition 5. Database compilation 6. Identification of agro-ecological regions of analysis and data collection 7. Prioritization of crop priorities per Agro-Ecological Zone 8. Produce a list of major crops specific descriptors such as days to maturity, water requirement, Growing Degree Days (GDD), crop suitability tied to geographical coordinates of their growing areas/regions— "this could be a range not a fixed GPS point". (https://glistest.planttreaty.org/glis/static/en/cropdesc.html) and https://www.biodiversityinternational.org/fileadmin/migrated/uploads/tx_news/Developing_crop_descriptor_lists_1226.pdf) 			

The steps followed to collect data during the workshop are given below:

5.1. Mapping major crops in each Agro-ecological zone

The objective of this activity was to identify priority crops in each Agroecological zone of Ghana. The materials used for this activity were maps of each agro-ecological, round stickers and markers.

Procedure:

1. Produce the land use land cover (LULC) map
2. Identify the major agroecological zones.
3. Using LULC maps, draw polygons (map layouts) where each polygon represents one agroecological zone i.e. areas with similar soil, land, and climate characteristics
4. Give each map layout the code as a reference and legend
5. Print each map layout
6. Distribute the map layouts to the participants according to their agro-ecological zones
7. Participants look for the locations on the map layouts.

8. Participants prepare a list of all crops grown in their agro ecological zones (AEZ) and assign a code to each of these crops.
9. Rank all crops based on how important they are in terms of:
 - i. Food security*: for a household means access by all members at all times to enough food for an active and healthy life
 - ii. Economic value*: as a source of income by selling agricultural products; or the exchange of agricultural products for obtaining household appliances, working tools to develop living standards. a crop is considered as economically valuable when it contributes to the income of the family, helping the farmers pay their investments and living expenses
 - iii. Cultivation area*: total arable land available for ploughing, sowing and raising crops
 - iv. Number of farming households*: number of farmers currently growing a given crop

The methodology used to rank the crops was to use the range of importance (1: very low importance, 2: low, 3: medium, 4: high, 5: very high) of each crop on food security, economic value, cultivation area and number of farming households. Then sum up the score for each crop. Table 2 provides the details on how the process of ranking crops was done.

Table 2: Example of crop ranking in Savana zone.

Crops/ commodities	Food security	Economic value	Cultivation area	Number of farming households	Total
	how important it is for food security?	How important is of earning economic income?	How important is the cultivation area of the crops/commodities?	How important is the crops/commodities by the number of farmers?	
Maize	5	5	5	5	20
Cowpea	5	5	3	5	18
Rice	5	5	3	3	16
Yam	5	5	3	3	16
Soybean	2	5	5	3	15
Tomato	5	5	3	2	15

Onion	5	5	3	2	15
Groundnut	3	5	3	3	14
Sweet potato	5	4	2	2	13
Pepper	3	3	3	2	11
Sorghum	2	4	2	1	9
Millet	2	4	1	1	8
Bambara groundnut	3	2	1	1	7
Pigeon pea	3	2	1	1	7
Cassava	2	3	1	1	7

10. Mapping the first 10 crops with the highest scores

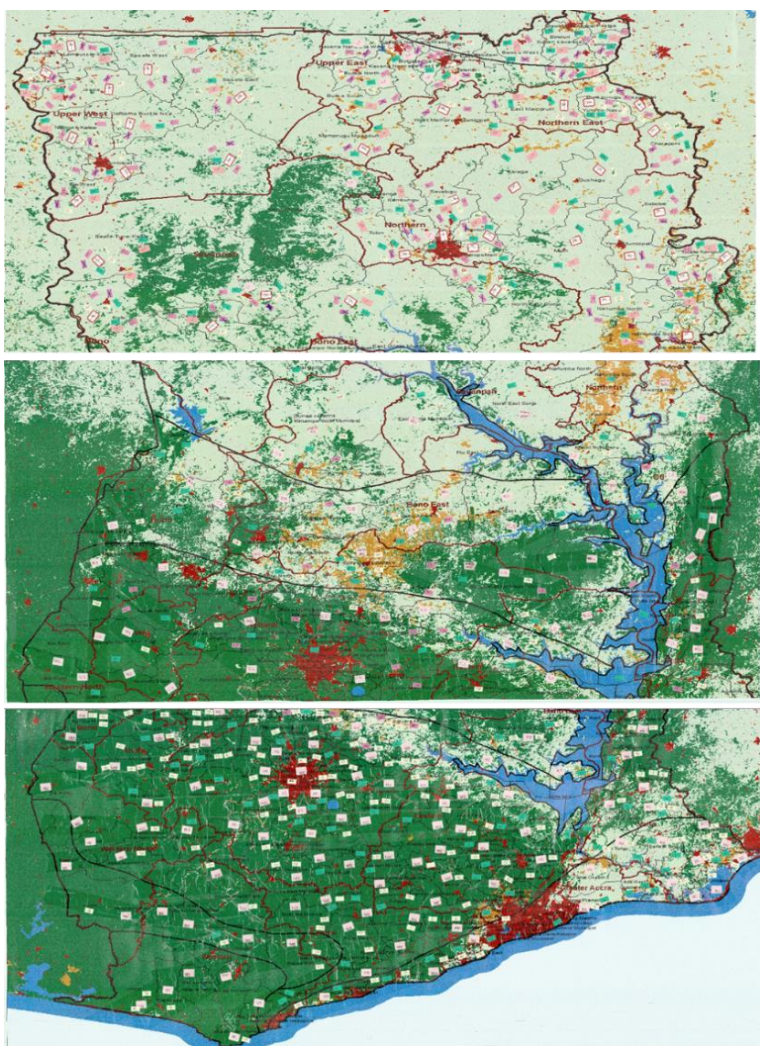


Figure 2: Major crops mapped by the participants for each agro-ecological zone

5.2. Gathering information on crops and fertilizer recommendation

The top 10 crops per AEZ that were ranked best were further subjected to a detailed analysis and find out their descriptors such as region, district, altitude, GDD, base temperature, maximum temperature, minimum temperature, fertilizer recommendations, crop water requirement, crop coefficient (Kc) per crop stage and the seasonal average of Kc for every crop, etc. The main objective of this activity was to collect location-specific crop and fertilizer recommendations for bundling with climate information to provide sustainable and actionable recommendations along the agricultural value chains.

In cases where participants lacked some of the main information, they used available methods or secondary sources to retrieve a particular information. The method used to compute Crop water requirement is described below:

The steps involved in calculating crop water requirement (CWR) are:

The CWR was estimated using reference evapotranspiration (ET_o), the water requirement of a given crop in mm/day (ET_{crop}), crop factor (kc) and days to maturity. Below is how CWR was calculated:

1. Calculation of Actual ET using ET_o,

ET_{crop} = kc x ET_o where:

kc = the crop factor

ET_{crop} = The water requirement of a given crop in mm/day

ET_o = Reference Evapotranspiration in mm/day.

2. Compute Crop water requirement

The basic formula that was used to calculate the crop water requirements is:

Crop water requirement (CWR) = ET_{crop} x Days to maturity of a given crop

Note: In case where there is no local data on pan evaporation, theoretical method like the Blaney-Criddle method was used to estimate reference crop evapotranspiration (ET_o). The Blaney-Criddle method is simple, using only temperature data. However, it is not very accurate and provides a rough estimate. Here is how to use the Blaney-Criddle method:

1. Gather Data: mean daily temperature: T_{mean}

The Blaney-Criddle method always refers to mean **monthly** values, both for the temperature and the ET_o. If, for example, it is found that T_{mean} in April is 28°C, it means that during the whole month of April the mean daily temperature is 28°C. If in a local meteorological station,

the daily minimum and maximum temperatures are measured, the mean daily temperature is calculated as follows:

T_{max} = Sum of all T_{max} values during the month/number of days of the month

T_{min} = Sum of all T_{min} values during the month/number of days of the month

T_{mean} = $(T_{max} + T_{min}) / 2$

2. Determine Mean Daily Percentage of Annual Daytime Hours (p):

Refer to the below Table 3 using the latitude of your location, find the value of p for the specific month.

Latitude	North	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	South	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
60°		0.15	0.2	0.26	0.32	0.38	0.41	0.4	0.34	0.28	0.22	0.17	0.13
55		0.17	0.21	0.26	0.32	0.36	0.39	0.38	0.33	0.28	0.23	0.18	0.16
50		0.19	0.23	0.27	0.31	0.34	0.36	0.35	0.32	0.28	0.24	0.2	0.18
45		0.2	0.23	0.27	0.3	0.34	0.35	0.34	0.32	0.28	0.24	0.21	0.2
40		0.22	0.24	0.27	0.3	0.32	0.34	0.33	0.31	0.28	0.25	0.22	0.21
35		0.23	0.25	0.27	0.29	0.31	0.32	0.32	0.3	0.28	0.25	0.23	0.22
30		0.24	0.25	0.27	0.29	0.31	0.32	0.31	0.3	0.28	0.26	0.24	0.23
25		0.24	0.26	0.27	0.29	0.3	0.31	0.31	0.29	0.28	0.26	0.25	0.24
20		0.25	0.26	0.27	0.28	0.29	0.3	0.3	0.29	0.28	0.26	0.25	0.25
15		0.26	0.26	0.27	0.28	0.29	0.29	0.29	0.28	0.28	0.27	0.26	0.25
10		0.26	0.27	0.27	0.28	0.28	0.29	0.29	0.28	0.28	0.27	0.26	0.26
5		0.27	0.27	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.27	0.27	0.27
0		0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27

3. Use the Blaney-Criddle Formula:

The Blaney-Criddle formula: $ET_o = p (0.46 T_{mean} + 8)$

ET_o = Reference crop evapotranspiration (mm/day) as an average for a period of 1 month

T_{mean} = mean daily temperature (°C) p = mean daily percentage of annual daytime hours

4. Calculation example (Blaney-Criddle):

Given:

Latitude: 35° North

Mean Tmax in April = 35.5°C

Mean Tmin in April = 20.5°C

Question

Determine for the month April the mean ETo in mm/day using the Blaney-Criddle method

Answer

Formula: $E_{To} = p (0.46 T_{mean} + 8)$

$T_{mean} = (35.5 + 20.5) / 2 = 28^{\circ}C$

$E_{To} = 0.29 (0.46 \times 28 + 8) = 6.05 \text{ mm/day}$

So, the mean reference crop evapotranspiration (ETo) for the whole month of April is estimated to be 6.05 mm/day.

5.3. Fertilizer recommendations

The data on fertilizer recommendations was sourced from the Ministry of Agriculture in Ghana and comprises information on officially endorsed commercial fertilizers. This extensive dataset was systematically organized based on various factors including Agro-ecological zones, regions, districts, crop types, and crop varieties. The collected information includes recommendations for both organic within each location and recommendations for chemical fertilizers. Below is an example of the collected fertilizer recommendation

Agro_ecological zone	Region	District	Elevation (masl)	Crop name	Crop variety name	Recommended Organic inputs (OM) for good soil	Recommended Organic inputs (OM) for poor soil	Chemical fertilizer recommendation
Forest Transition & Guinea Savannah	Ashanti/Bono/Ahafo/ Bono East/Western North/ Eastern/Volta/Oti/Savannah	all districts in the Agroecozone	0-100m	Maize	Opeaburo	6000-15000kg	15000-20000kg	500kg (NPK 90:60:60)
Forest Transition & Guinea Savannah	Ashanti/Bono/Ahafo/ Bono East/Western North/ Eastern/Volta/Oti/Savannah	all districts in the Agroecozone	0-200m	Rice	CRI-Amankwatia	4000kg-6500kg	6500-10000kg	400kg (NPK 90:60:60)

6. Key achievements of the workshop

- (1) A template to gather information on crops (days to maturity, crop water requirement, fertilizer recommendations, etc.) in specific locations from Ghana were developed
- (2) 10 Major crops per AEZ were mapped. Criteria used to rank crops were how important a given crop is for: (a) Food security, (b) Earning economic income, (c) Cultivation area and (d) Number of farming households.

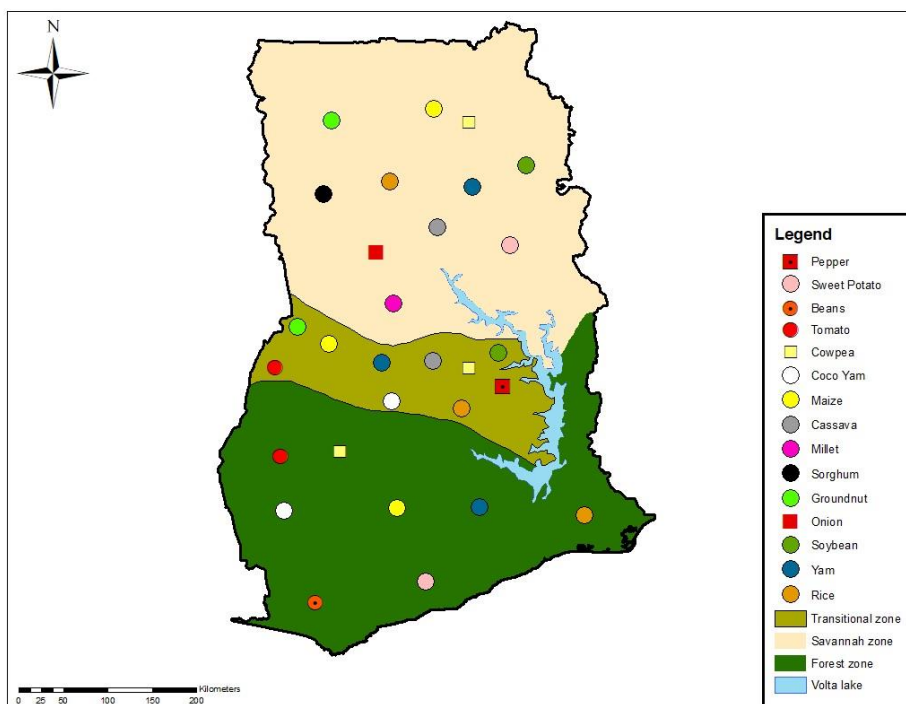


Figure 2: Map showing major crops in the 3 major Agro-ecological zones

- (3) Important crop descriptors and fertilizer recommendation of the 10 priority crops for the 3 agro-ecological zones were collected. Below is the GIS attribute table comprising of all variables per crop, region, AEZ created. Below is the format of attribute table created.

Ghana_agroecologicalzones																		
PERIMETER	ID	CAPTION	STYLE	Maize	Yam	Cowpea	Rice	Coco_Yam	Tomato	Beans	Sweet_Pota	Pepper	Soybean	Ground_nut	Onion	Sorghum	Millet	Cassava
2180005.944	6	Guinea savanna	6	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1
2088059.474	4	Deciduous forest	4	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1203115.492	5	Transitional zone	5	1	1	1	1	1	1	0	0	1	1	1	0	0	0	1
821005.129	1	Coastal savanna	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
611831.47	3	Moist evergreen	3	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
478518.483	2	Wet evergreen	2	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1683189.95	8	Volta lake	8	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
340973.746	7	Sudan savanna	7	1	1	1	1	0	0	0	0	1	0	1	1	1	1	1

- (4) The database for important crop-specific descriptors such as days to maturity, water requirement, Growing Degree Days (GDD) and fertilizer recommendations for every crop in specific agro-ecological zone were also built.
- (5) WhatsApp group was created for continuing interaction and discussions on Digital AgroClimate Advisories and integration of collected information into DACA app

6.1. DACA's potential: Tailoring Agro-Climate Advisories

Information collected during the workshop was integrated into DACA app and will be used to generate agro-climate advisories for farmers in the 3 major agro-ecological zones. DACA potentially provides location-specific crop advisories such as: (1) the list of crops and varieties that can be grown during a specific growing season, (2) list of fertilizers locally available along with their dose scientifically recommended by the Ministry of Agriculture of Ghana for achieving optimum yield; (3) scheduling the timing of important farm operations, including, planting and harvesting; and (4) expected total seasonal rainfall, among other advisories based on the short-term and seasonal forecasts.

6.2. Ensuring accuracy of information through validation

The successful integration of collected data into the DACA platform will streamline the development of agro-climate advisories tailored to the specific needs of farmers in Ghana's three major agro-ecological zones. Using the DACA app, various information can be bundled, including details on crops, climate conditions, and fertilizers. This allows farmers to access advisories on crop selection, planting schedules, fertilizer recommendations, and other climate informed decisions directly on their smartphones. However, validation is crucial to ensure the accuracy of this information before these advisories are released to end-users.

6.3. Interdisciplinary Collaboration: Key to success and trust leading to sustainability

The achievement of customizing DACA platform in Ghanaian context highlights the importance of interdisciplinary collaboration. The engagement of key stakeholders from diverse sectors such as agriculture, climate science, and technology are essential for developing impactful solutions. This collaborative effort guarantees that the information provided is finely tuned to meet the specific needs of local farmers, thereby increasing trust in the information and contributing to the platform's success. Ultimately, this can lead to a demand-driven approach to information and ownership, promoting the sustainable use of the provided information.

Moreover, this approach not only ensures the customization of information but also emphasizes the delivery of precise, science-based guidance to farmers. The goal is to enhance agricultural productivity by providing farmers with accurate insights for informed decision-making.

7. Lessons learnt

This report highlights the crucial role of technology-driven, location-specific agro-climate advisories in addressing the challenges posed by climate change in Ghana's agricultural sector. This approach is not exclusive to Ghana; it can be applied in other countries to increase people's willingness to use the information. The insights gained from this initiative underscore the importance of collaborative, customized, and technology-centric strategies as essential elements in empowering farmers and strengthening agricultural resilience.

8. Conclusion

The three-day workshop aimed at collecting crop characteristics from different agro-ecological zones of Ghana was successfully conducted. Participants were fully engaged during the workshop and clear plans for the next steps about contextualizing DACA in Ghana context by integrating crop information and fertilizer recommendations in DACA were discussed which is validation process. Every participant attending the workshop expressed their desire to be involved in the process of implementation of DACA app in Ghana.