STAPLE CROPS PROCESSING ZONEs (SCPZs): Promoting Sustainable Agricultural Value Chains.

TECHNICAL DESCRIPTION OF AGROMETEOROLOGICAL AND RAINFALL STATIONS FOR STAPLE CROPS PROCESSING ZONES IN TOGO, SENEGAL, AND GUINEA

African Development Bank

April 2023

Introduction

The agricultural sector is highly sensitive to weather and climate conditions, which can significantly influence agricultural operations, from planting to harvesting, and therefore determine a significant portion of the yield variations. Issues around climate change and variability steers the growing interest in understanding the possible impact of natural- and human-induced climate variability and long-term climate change on agriculture and forestry resulting in the increase in demands for information and assessments from agrometeorologists and farmers. This coupled with the rising demands for food and discussion around the need for achieving greater efficiency in natural resource use while protecting the environment, a much greater emphasis is required to be placed on understanding and exploiting the local climate conditions for the benefit of agriculture and forestry.

Thus, there is now an increasing understanding of the importance of operational agrometeorological services for different sectors, such as, agricultural, livestock, forestry, and fishery sectors. The relevant services[1] required within this context include:

- Services to help reduce the impact of natural disasters, including pests and diseases;
- Early warning and monitoring systems;
- Short- and medium-range weather forecasts;
- Climate prediction/forecasting; and,
- Services to help reduce the contributions of agricultural production to global warming.

Central to achieving these defined services is the availability of dense network of agrometeorological and rainfall stations within and around the farm sites. Also, the National Meteorological and Hydrological Services (NMHSs), who provide operational agrometeorological services to the various user communities at the national levels, are necessary to play important roles in terms of identifying shortcomings and limitations in data, analytical tools, and the methods of provision of operational agrometeorological services. Other important areas to address include the coordination among the National Services, government and private stakeholders to meet the customers' needs; using appropriate methods and tools to deliver operational agrometeorological services to decision makers in a timely manner; and, capacity building of the NMHSs in the aspect of improved operational agrometeorological services.

Future climate projections indicate that one of the most serious consequences of global warming is the likelihood of greater frequency and intensity of extreme weather events. This will have devastating consequences for human health and wellbeing including the livelihood options of rural people, who majorly engage in agricultural activities in poor countries. Africa is undoubtedly the most vulnerable continent to climate change, prone to a wide variety of climate and human-induced disasters. Recent climate vulnerability assessments for Africa reveal that the impacts will mostly be felt in the most climate-sensitive sectors of agriculture, energy, water and infrastructure assets, among others. For example, simulated crop yields of maize, pearl millet and sorghum in the West African Sudan Savanna under 1.5°C and 2.0°C

[1] Raymond P. Motha, M.V.K. Sivakumar, and Michele Bernardi (Eds.) 2006. Strengthening Operational Agrometeorological Services at the National Level. Proceedings of the Inter-Regional Workshop, March 22-26, 2004, Manila, Philippines. Washington, D.C., USA: United States Department of Agriculture; Geneva, Switzerland: World Meteorological Organization; Rome, Italy: Food and Agriculture Organization of the United Nations. Technical Bulletin WAOB-2006-1 and AGM-9, WMO/TD No.1277. 238 pp.

global warming scenarios, reveal an average of 2% higher losses for maize and sorghum with 2.0°C compared to 1.5°C warming, with no change in millet yields for either scenario. Similar simulations on net farm revenues across Africa indicate that farm revenues could decline as much as 90% by 2100 because of rising temperatures and declining precipitation levels.

Togo, Senegal and Guinea, which are situated in the Horn of Africa/part of Sahel and Sudanian agro-ecological zones (AEZs) of Africa, are among the major climate 'hotspots' in the continent. These countries are already being impacted by the effects of climate change as a result of historical warming and variable precipitation trends. Their vulnerabilities to climate extremes are high due to the strong dependence of the economies on rain-fed agriculture, largely dominated by smallholder farmers (about 80%) for daily subsistence. Reliance on rain-fed farming and pastoralism for income and subsistence mean that livelihoods and food security in these regions and countries are strongly affected by climate variability and change. On top of this challenge, farmers in these countries have no or inadequate access to climate information to guide their farm management decision-making process.

The Staple Crops Processing Zone (SCPZ) program is focusing on Guinea, Senegal and Togo as beneficial countries. It is specifically designed to help rationalize interventions in the agriculture sector towards activities that contribute to emission reduction from agricultural activities and improves resilience of agroecosystems, agricultural assets, and beneficiaries. The program aims to reduce climate change vulnerability and greenhouse gas (GHG) emissions within the agricultural value chains in these four highly indebted poor countries in Africa. This will help stimulate productivity and value addition, competitiveness, generate employment and increase incomes of the most vulnerable people and communities in these countries in ways that will also contribute to the achievement of targets set for their respective Nationally Determined Contributions (NDCs). As part of the proposed intervention, the programme will help to strengthen the generation, access and use of climate information services within the SCPZs to ensure that agro-advisory services and farm management practices are climate-informed.

Agrometeorological Station

An agrometeorological station uses the advanced remote data-acquisition unit geared with multi-parameter weather sensors which can simultaneously measure wind speed and direction; air temperature; air humidity; air pressure, rain amount, duration and intensity, soil moisture and temperature, solar radiation, and sunshine duration. The station gets data from the sensor for transmission via SMS or satellite network.

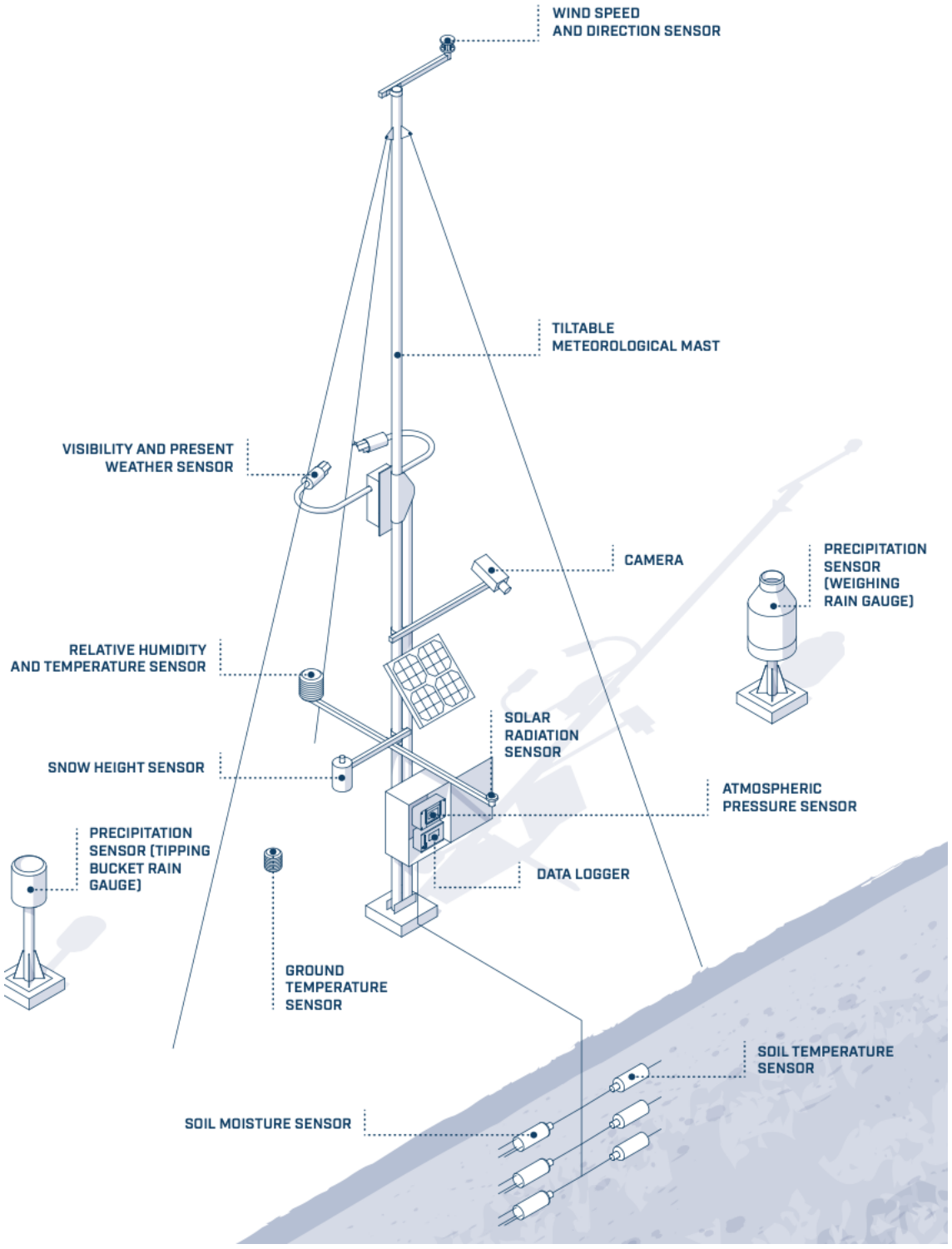

Figure 1: Proposed Setup for Automatic Agrometeorological System for the SCPZs (Source: Prototype from MicroStep MIS)

Sensor Configuration modules

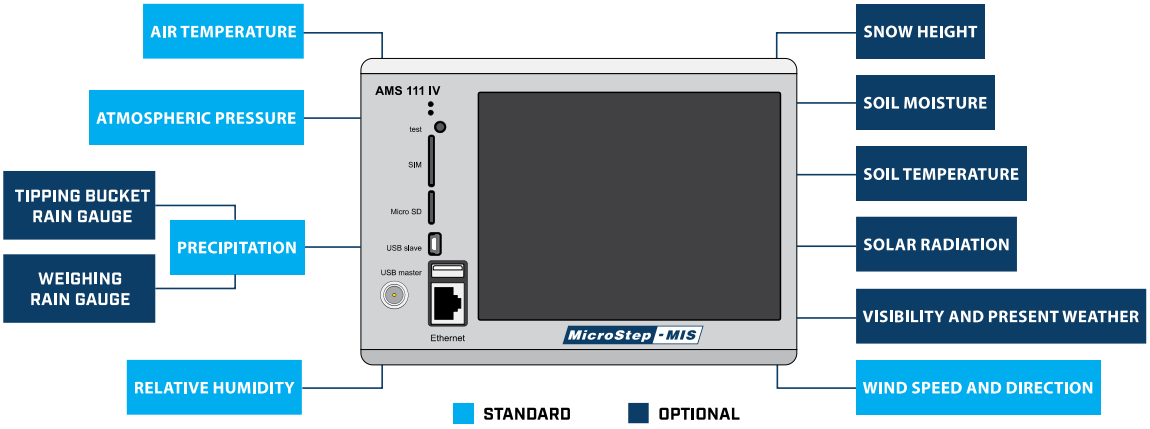

Figure 2: *Sensor configuration modules (Source: Prototype from MicroStep MIS)*

Technical Specification

Data Logger AMS 111 IV
Internal 128 MB Flash memory
Internal 128 MB DRAM memory
Secure digital card up to 64 GB
External USB mass storage up to 256 GB
Real time clock (backup with Lithium battery)

(Source: Prototype from MicroStep MIS)

Communication I/O ports	
3x RS-232 port (baud rate: 300 to 115200), 1x UART	
2x RS-485 port	
Interface for GSM / Wifi / Radio module	
Ethernet 10/100 Mbit	
USB master, USB slave	
2x SDI-12	
Supported Protocols	FTP server, FTP client, HTTP server, telnet, SMTP, SMTPS, MODBUS RS-485, MODBUS, NTP Ethernet

P4-4G modem	
Data rates	• LTE-FDD Max 100 Mbps (DL) Max 50 Mbps (UL) • LTE-TDD Max 61 Mbps (DL) Max 18 Mbps (UL) • DC-HSPA+ Max 42 Mbps (DL) Max 5.76 Mbps (UL) • UMTS Max 384 Kbps (DL) Max 384 Kbps (UL) • TD-SCDMA Max 4.2 Mbps (DL) Max 2.2 Mbps (UL) • CDMA Max 5.4 Mbps (DL) Max 14.7 Mbps (UL) • EDGE Max 236.8 Kbps (DL) Max 236.8 Kbps (UL)

	• GPRS Max 85.6 Kbps (DL) Max 85.6 Kbps (UL)
Operating temperature range	−40 °C to +85 °C
Environmental conditions	Operating temperature range: −40 °C to +70 °C Operating humidity range: 0 to 100 %

P4-GSM modem

Specification	• Quad Band GSM/GPRS/3G modem E-GSM 850/900/1800/1900 • Class 4 (2 W at 900 MHz) • Class 1 (1W at 1800 MHz) • Data, SMS • Fax and data transmission without extra hardware
Operating temperature range	−40 °C to +85 °C
Environmental conditions	Operating temperature range: −40 °C to +70 °C Operating humidity range: 0 to 100 %

Air temperature sensor

Measurement range	−65 °C to +75 °C
Accuracy	±0.2 (-40 to +60) °C

Atmospheric pressure sensor

Pressure range	500 to 1100 hPa (or custom)
Measurement principle	piezoresistive transducer
Accuracy	±0.3* hPa (−40 °C to +60°C) *custom range or accuracy available upon request
Long-term stability	±0.2 hPa / year

Ground temperature sensor

Measurement range	−65 °C to +75 °C
Accuracy	±(0.1 + 0.00167 x |temperature|) °C
Long-term stability	< 0.1 °C / year

Precipitation sensor

Tipping bucket rain gauge

Catch area	200 cm^2		
Output	pulses - switching contact		
Resolution	0.1 mm	0.2 mm	0.5 mm
Measuring range	0 to 600 mm/h	0 to 900 mm/h	0 to 2500 mm/h
Measurement error for different rainfall	intensity < 20 mm/h → measurement error < 1 % intensity 20 to 600 mm/h → measurement error < 2 %		

Weighing rain gauge

Orifice area	200 cm^2	500 cm^2	200 cm^2	400 cm^2
Range or precipitation	750 mm	250 mm	1500 mm	750 mm
Accuracy	0.1 %			
Maximum rain intensity	120 mm / min			
Resolution	0.001 mm			

Soil moisture sensor

Accuracy	± 0.03 m3.m-3 (3 %)
Soil moisture measurement range	full range 0 to 1.0 $m^3.m^{-3}$
Salinity range	50 to 1000 $mS.m^{-1}$

Soil temperature sensor

Measurement range	−65 °C to +75 °C
Accuracy	±(0.1 + 0.00167 x |temperature|) °C
Long-term stability	< 0.1 °C / year

Solar radiation sensor

Classification to ISO 9060: 1990	Secondary Standard
Sensitivity	7 to 14 µV/W/m2
Maximum operational irradiance	4000 W/m2
Detector type	Thermopile
Spectral range (20 % points)	270 to 3000 nm

Non-stability (change/year)	< 0,5 %
Non-linearity (100 to 1000 W/m²)	< 0,2 %

Relative humidity sensor

Measurement range	0 to 100 %RH
Accuracy (@ 25 °C)	±1 %RH
Short term hysteresis	< 0.6 %RH
Accuracy over temperature range	1 + |t - 25| *(0.008 + 0.00052 *RH)
Typical long-term stability	±1.0* % per year
Sensor type	thin film capacitive

** dependent on operating environment*

Visibility and present weather sensor

Range	default 10 m to 75 km
Measurement error	≤4.5 % at 600 m ≤5.0 % at 1,500 m ≤5.1 % at 2 km ≤12.5 % at 15 km ≤20 % at 30 km
Measurement resolution	10 m (default), 1 m (optional)
Present weather output	WMO Table 4680 codes

Wind sensor

Wind speed

Range	0 to 60 m/s (116 knots)
Accuracy	±2 % @ 12 m/s
Resolution	0.01 m/s (0.02 knots)
Response time	0.25 seconds
Threshold	0.01 m/s

Wind direction

Range	0 to 359° (no dead band)
Accuracy	±2° @ 12 m/s
Resolution	1°
Response time	0.25 seconds

Tiltable meteorological mast

Length	10 m
Material	aluminium alloy
Color	white, red / white red RAL3000 / white RAL9016
Load	200 km/h, 250 km/h optional

Proposed Budget (GCF Financed)

Agrometeorological station with the following sensors:				
Item	**Description**	**Qty**	**Unit Cost (USD$)**	**Total (USD$)**
1	Wind Speed & Direction Sensor	1	940,00	940,00
2	Temperature Sensor	1	550,00	550,00
3	Solar Radiation Sensor	1	770,00	770,00
4	Soil Moisture Sensor	1	2.780,00	2.780,00
5	Soil Temperature Sensor	1	1.235,00	1.235,00
6	Rain Gauge	1	725,00	725,00
7	Precipitation Sensor	1	700,00	700,00
8	Relative Humidity Sensor	1	840,00	840,00
9	Barometric Pressure Sensor	1	714,00	714,00
10	Data logger with Modem & Connectors	1	1.750,00	1.750,00
11	Levelling Plates & Mounts for sensors	1	650,00	650,00
12	Solar Power unit battery plus inverter	1	1.250,00	1.250,00
	Total for Station minus server & Mast			**12.904,00**
13	Mast 2m	0	2.200,00	-
14	Mast 10m (Frangible)option	1	6.500,00	**6.500,00**
			-	-
15	Server system & Software for data management	1	4.500,00	**4.500,00**
16	Maintenance	**5**	3.585,60	17.928,00
	Total Ex Works (USD)			**41.832,00**
	Automatic Rain Gauge system:			
1	Rain Gauge with telemetry system & Mountings	1	1.250,00	1.250,00
2	Temperature sensor	1	550,00	550,00
3	Solar Power system	1	1.250,00	1.250,00

	Total for system minus Server			**3.050,00**
4	Server system & Software, if available, for data management	1	4.500,00	**4.500,00**
5	Maintenance	**5**	1.132,50	5.662,50
	Total Ex Works (USD)			**7.550,00**
	Sensor calibration kits:			
1	Calibration tools	1	1.050,00	1.050,00
2	Maintenance	**5**	157,50	787,50
	Total			**1.837,50**
	Total Ex Works (USD)			**1.837,50**
	Project vehicles:			
1	Four-wheel project	2	100.000,00	200.000,00
2	Maintenance	**5**	6.000,00	30.000,00
	Total Ex Works (USD)			**230.000,00**
	Grand Total Ex Works (USD)		Total cost of 10 agromet stations and 50 rain stations in each region	**10,120,060**

***** *The agrometeorological systems will be procured through International Competitive Bidding (ICB) method*