Soil Hydric-Saline Balance in Mangrove Swamp Rice in Guinea Bissau

Gabriel Garbanzo León (**PhD candidate**)

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Introduction

Soil salinity affects **rice yield and quality**.

Farmers collect and use freshwater for rice production.

High cation levels contribute significantly to salinity issues.

Due to the **soil was originally mangrove soil**.

An approach for analyzing the hydric-saline balance

Research Question

What are the physicochemical properties of the soil ?

What is the current knowledge regarding rice sowing, particularly in relation to climate variability?

How much water in needed to prevent yield loss due to salinity stress?

Adaptive measures are necessary to address the impacts of climate variability.

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An approach for analyzing the hydric-saline balance

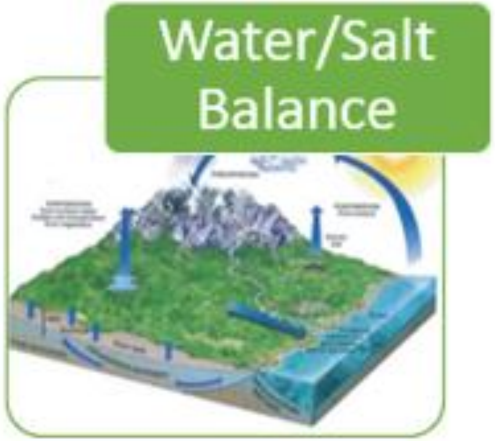
Main objective:

To Quantify the hydro-saline balances within the mangrove swamp rice production system, with the aim of improving land, water and crop management practices in Guinea Bissau

Biophysical Characterization MSR.

To characterize soil chemical composition.

To compute the soil-water balance.



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Biophysical Characterization MSR

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Review

The Mangrove Swamp Rice Production System of Guinea Bissau: Identification of the Main Constraints Associated with Soil Salinity and Rainfall Variability

Gabriel Garbanzo [1,2,3,*], Maria do Rosário Cameira [1] and Paula Paredes [1,*]

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Article

Moving toward the Biophysical Characterization of the Mangrove Swamp Rice Production System in Guinea Bissau: Exploring Tools to Improve Soil- and Water-Use Efficiencies

Gabriel Garbanzo [1,2,3,*], Jesus Céspedes [1], Joseph Sandoval [2], Marina Temudo [1], Paula Paredes [4] and Maria do Rosário Cameira [4,*]

Endogenous water management practices

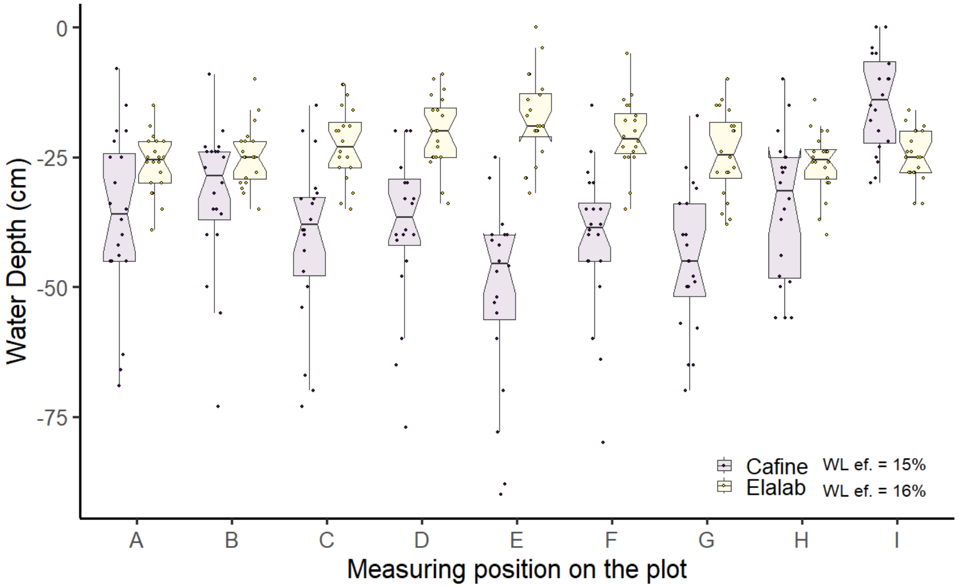
Cafine, Tombali

Elalab, Cacheu

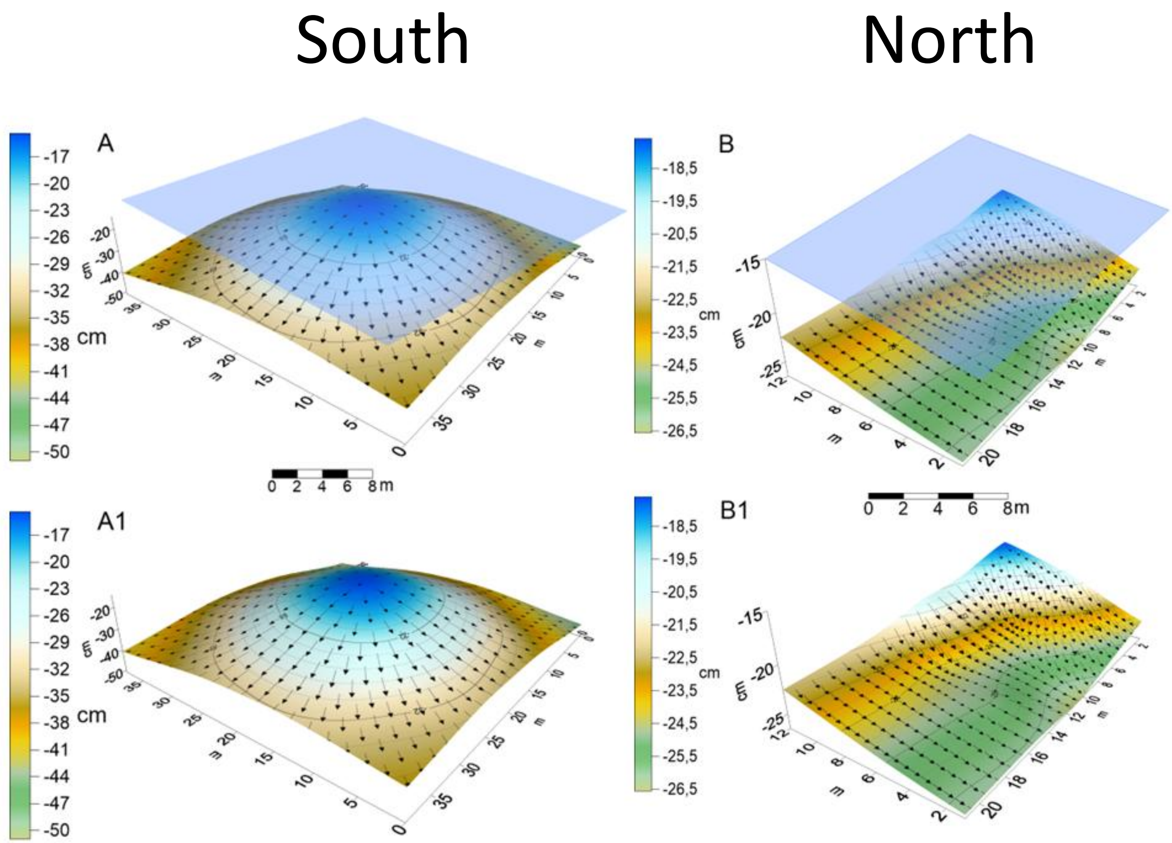
1 ha = 7 Plots

1 ha = 53 Plost

Larger plots tend to show higher variability in the water level



Variations in the waterlogging depth



Water level variation and water movement directions

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Efficiency of harvesting water in the plot

Southern

Northern

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Spatial distribution of soil salinity

Science of Remote Sensing 11 (2025) 100231

Contents lists available at ScienceDirect

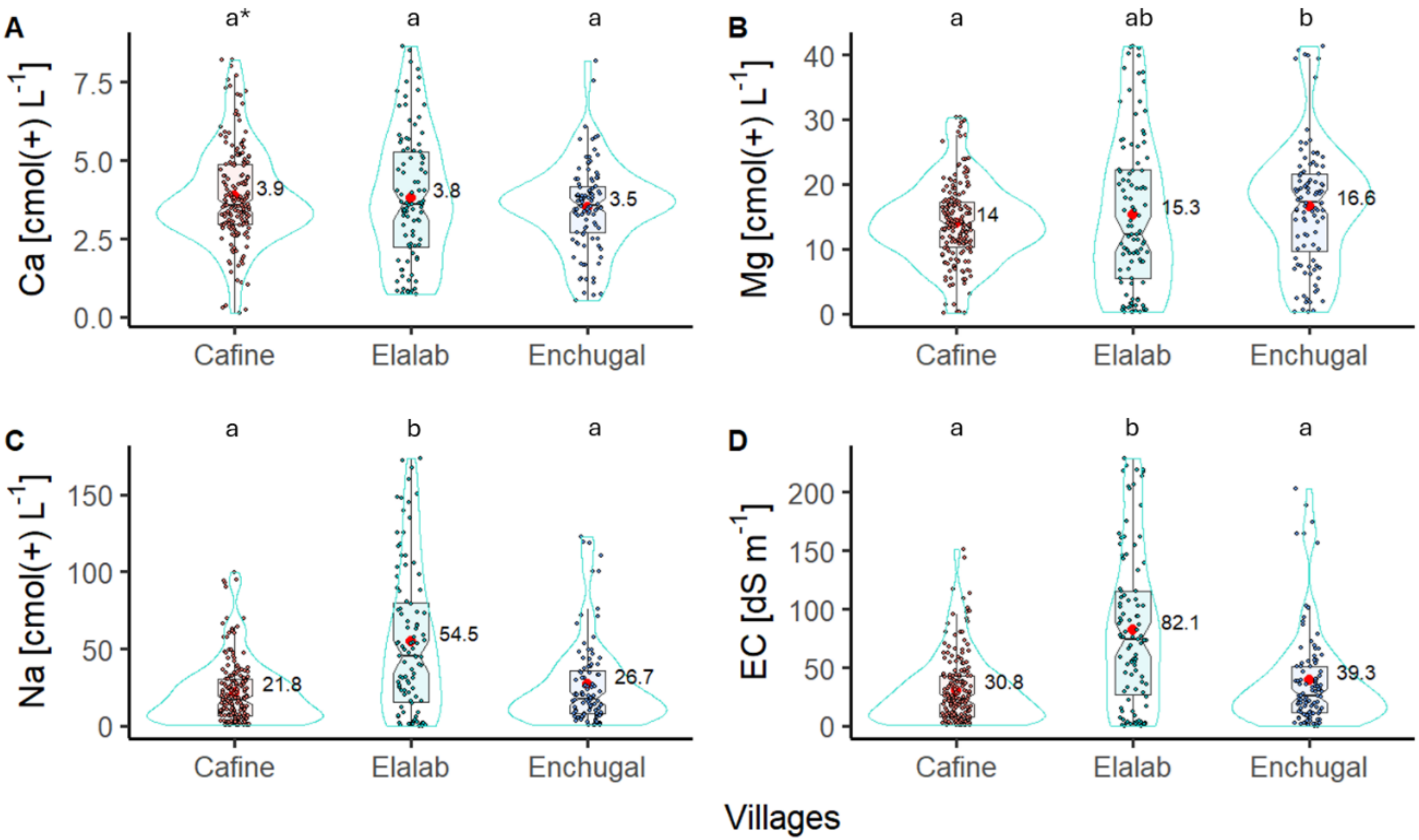
Science of Remote Sensing

journal homepage: www.sciencedirect.com/journal/science-of-remote-sensing

Advances in soil salinity diagnosis for mangrove swamp rice production in Guinea Bissau, West Africa

Gabriel Garbanzo [a,b,c,*], Jesus Céspedes [b,c], Marina Temudo [d], Maria do Rosário Cameira [b], Paula Paredes [b], Tiago Ramos [e]

Cations responsible for soil salinity concentration



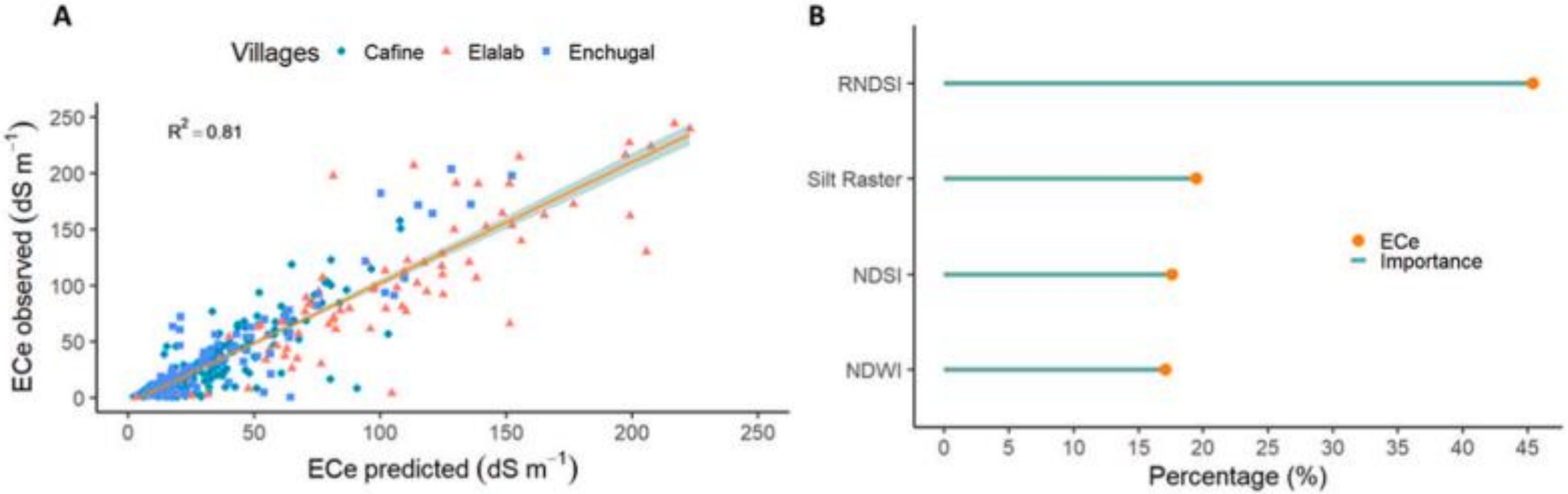
What is the status of other micro and macro nutrients in the paddies?

The best predictors of soil salinity distribution

Model accuracy in RF cross-validation between Elalab, Cafine-Cafal and Enchugal used to predict EC_e in Guinea Bissau.

RF by study sites	ρ	R^2	MAE ($dS\ m^{-1}$)	RMSE ($dS\ m^{-1}$)	NRMSE (%)	BIAS	PBIAS (%)	RPIQ
Elalab	0.88	0.76	24.85	38.98	42	−1.18	−1.27	2.43
Cafine-Cafal	0.84	0.68	11.74	17.26	54	2.24	7.01	2.13
Enchugal	0.90	0.78	12.77	20.80	51	−2.25	−5.49	2.01

RMSE = root means square error. NRMSE = Normalized root means square error. MAE = mean absolute error. PBIAS = Percent Bias. p = Pearson's correlation coefficient. R^2 = associated with Linear model. RPIQ = ratio of performance to interquartile range. RN= Random Forest.

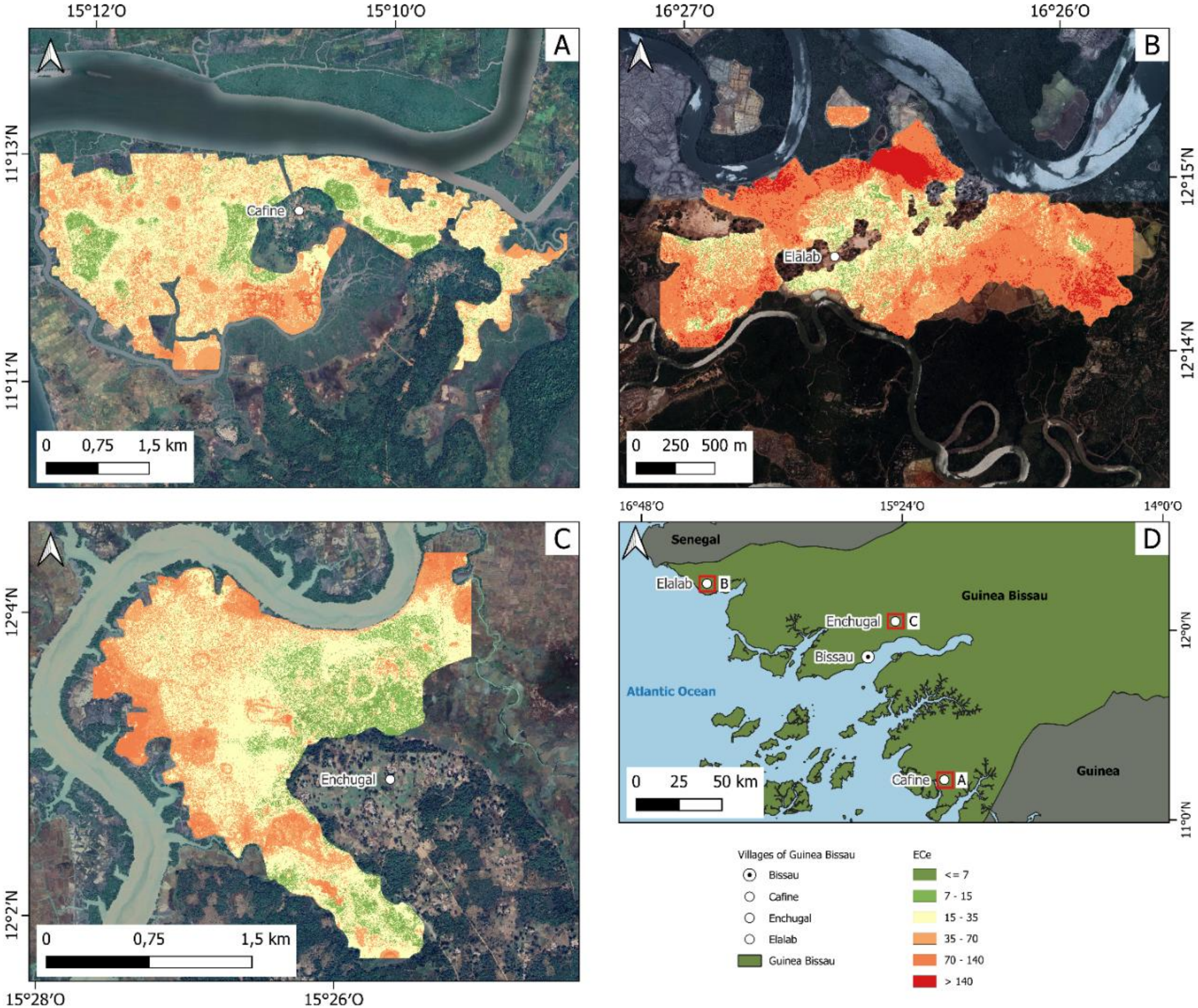


A) Scatterplot of predicted vs observed ECe.

B) Percentage of importance by index contribution in the model.

RNDSI = normalized difference salinity index; NDSI = normalized salinity index; NDWI = normalized difference water index.

Salinity Distribution Maps in the MSR

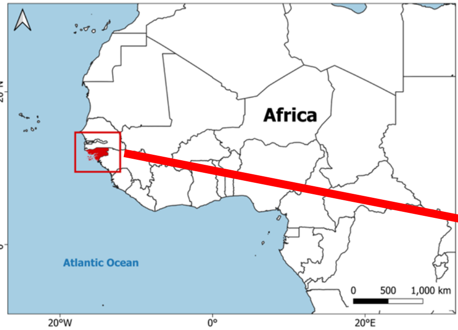


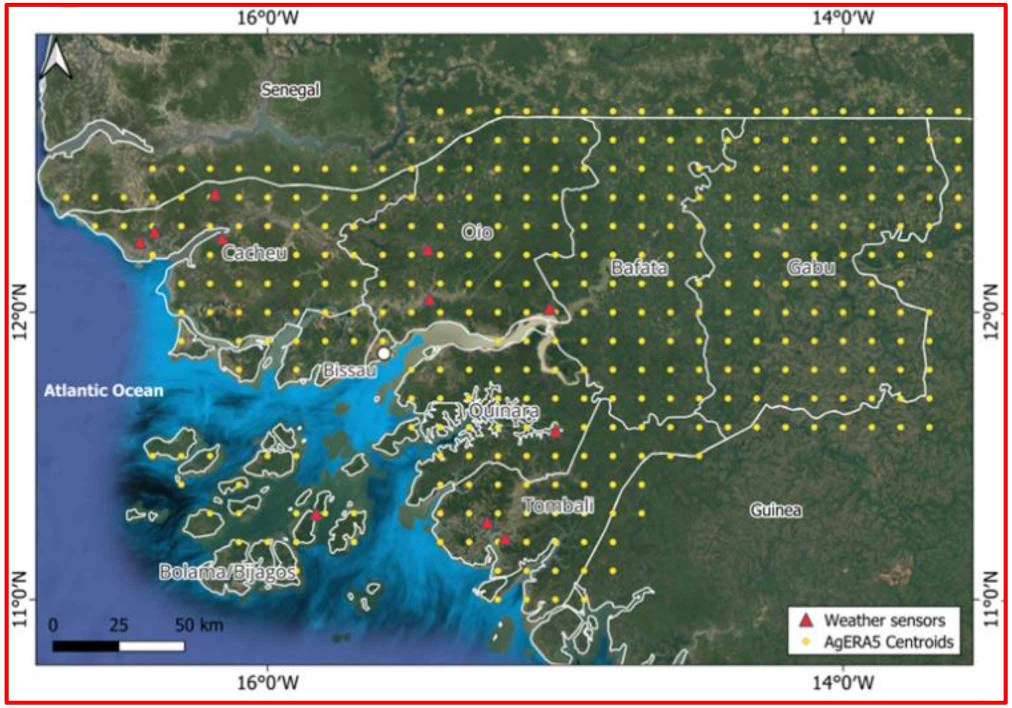
A practical recommendation for farmers is to make smaller plots in the tidal mangrove zones!

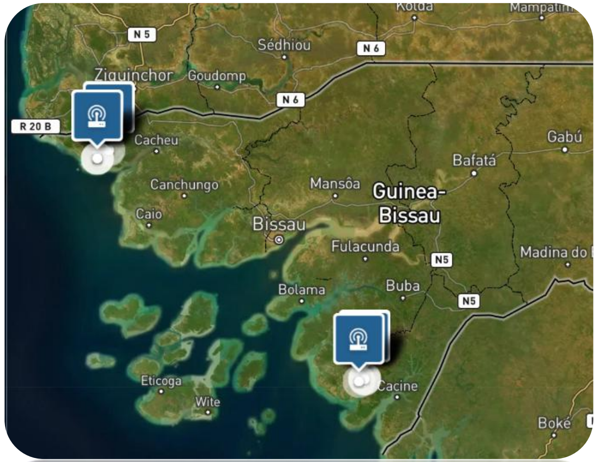
Highlights

- ✓ Na and Mg are predominant in soil salinity in the MSRP.
- ✓ Endogenous water management practices influence soil salinity levels.
- ✓ We recomended to segment saline zones (tidal mangrove) into smaller plots for better water management.
- ✓ Prepare the soil as early as possible to capture the maximum amount of freshwater.

Conducting environmental monitoring







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Improving water management in MSR

hydrology

MDPI

Article

Addressing Weather Data Gaps in Reference Crop Evapotranspiration Estimation: A Case Study in Guinea-Bissau, West Africa

Gabriel Garbanzo [1,2,3,*], Jesus Céspedes[3], Marina Temudo [4], Tiago B. Ramos [5], Maria do Rosário Cameira [2], Luis Santos Pereira [2] and Paula Paredes [2]

Using the FAO56 method

Defining zones with similar weather conditions

Performed cluster analysis to define zones with similar weather conditions.

Calibrated **the cluster-focused multiple linear regression equations** for estimating the radiation adjustment coefficient (k_{Rs}).

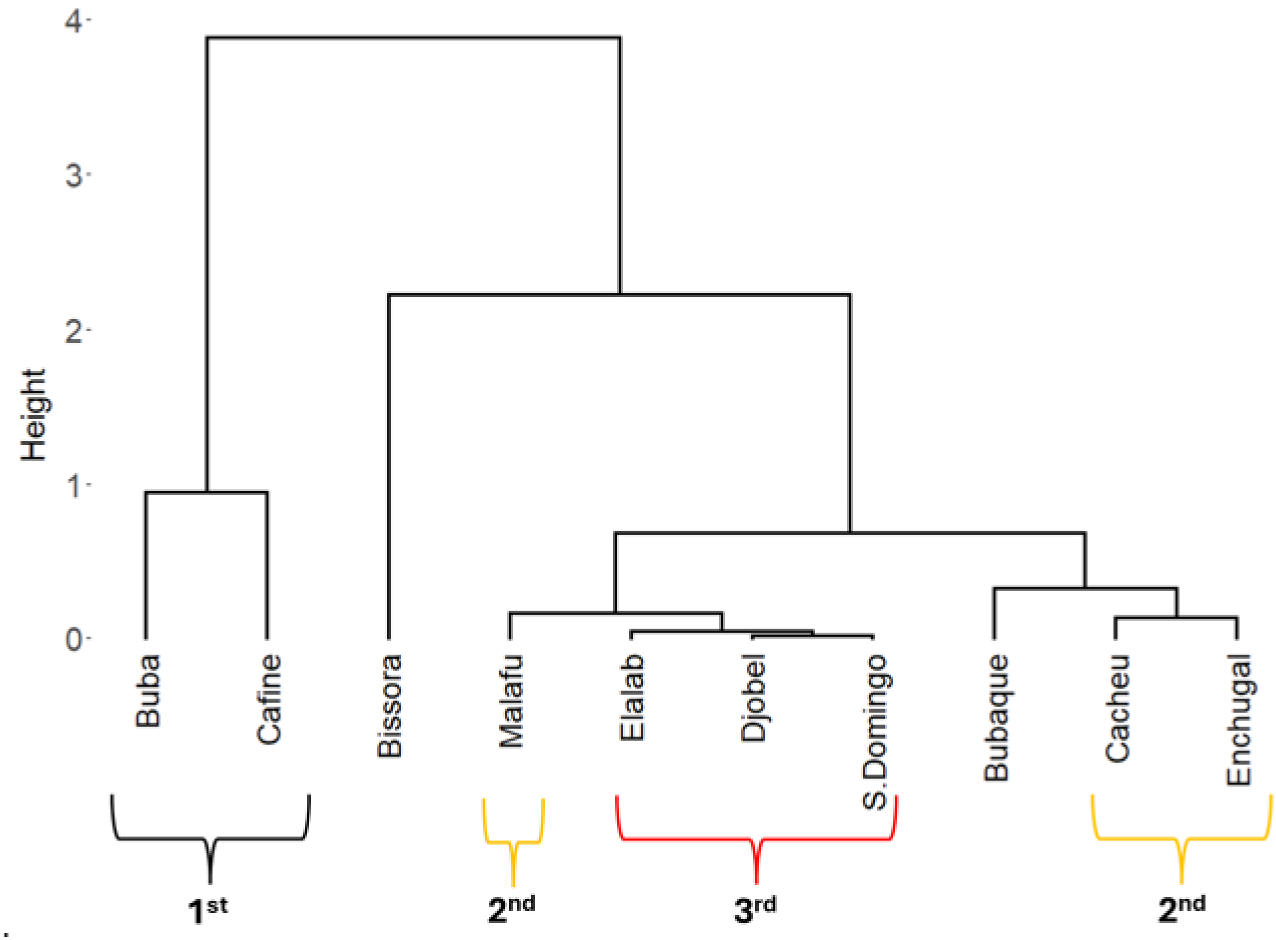

Figure 4. Dendrogram of a hierarchical clustering of the eleven sites. Clustering was performed using cumulative rainfall and ET_o for 2021-2023 and site elevation, considering their spatial distribution in Guinea-Bissau

An approach for calculating ET_o

Based on the aridity index for GB two climatic conditions:

A) Moist sub-humid

B) Humid

Wind velocity (**u_2 = 2 m s^{-1}**) and minimum temperature (**T_{min}**) serve as reliable predictors of dew point temperature (**T_{dew}**) in both climatic conditions

L-BFGS-B method
(Byrd et al., 1995)

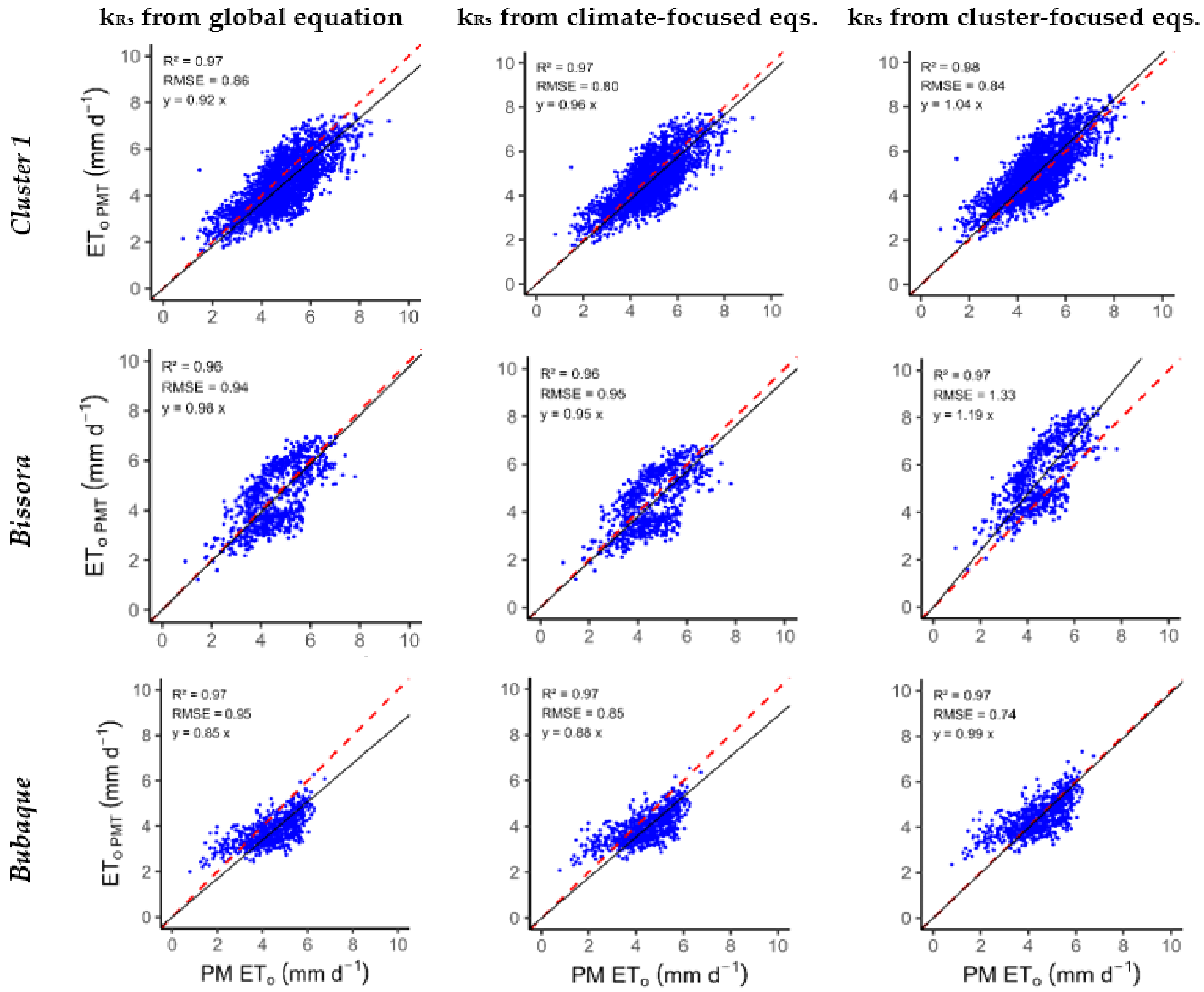

Figure 5. Comparing $ET_{o\,PMT}$ with PM-ET_o for each cluster and location when using $T_{dew} = T_{min}$, the default u_2 value, and the different MLR equations for estimating k_{Rs}. Included are the FTO regression equation, the OLS determination coefficient R^2, and the RMSE.

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Exploring reanalysis data

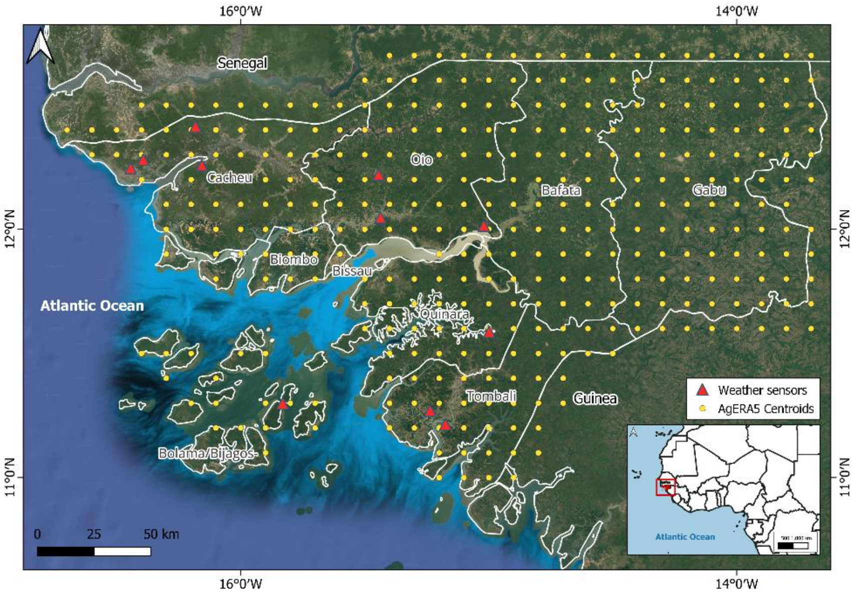
Table D1. Goodness-of-fit indicators relative to the estimation of ET_o when using AgERA5 and MERRA-2 reanalysis data compared to observed ground measurements.

Bias correction methods	PBias (%)	SD	Bias	SD	R^2	SD	RMSE (mm d^{-1})	SD	NRMSE (%)	SD
	AgERA5									
	$u_{2\ avg}$									
UN_c	5.17	7.22	0.2	0.34	0.96	0.01	1.12	0.17	23.6	3.9
ALM_c	0.00	0.00	0.0	0.00	0.90	0.03	1.63	0.27	34.0	5.7
$BIAS_c$	0.00	0.00	0.0	0.00	0.95	0.01	1.05	0.11	22.0	2.3
RLM_c	2.41	0.82	0.1	0.04	0.96	0.01	1.04	0.09	21.7	1.6
S_c	2.59	0.88	0.1	0.05	0.96	0.01	1.04	0.09	21.7	1.7
	$u_2 = 2\ m\ s^{-1}$									
UN_c	4.54	7.98	0.2	0.37	0.96	0.01	1.07	0.17	22.4	3.9
ALM_c	0.00	0.00	0.0	0.00	0.92	0.02	1.48	0.20	31.0	4.3
$BIAS_c$	0.00	0.00	0.0	0.00	0.96	0.01	0.99	0.10	20.7	2.0
RLM_c	2.39	0.78	0.1	0.04	0.96	0.01	0.97	0.08	20.3	1.4
S_c	2.66	0.81	0.1	0.04	0.96	0.01	0.98	0.09	20.4	1.5
	MERRA-2									
	$u_{2\ avg}$									
UN_c	-24.27	6.88	-1.18	0.39	0.94	0.00	1.57	0.33	32.51	5.44
ALM_c	0.00	0.00	0.00	0.00	0.93	0.02	1.38	0.22	28.71	3.94
$BIAS_c$	0.00	0.00	0.00	0.00	0.96	0.00	1.01	0.06	21.11	0.86
RLM_c	0.01	1.37	0.00	0.07	0.94	0.00	1.21	0.06	25.14	0.97
S_c	0.79	1.09	0.04	0.06	0.94	0.00	1.21	0.05	25.32	0.95
	$u_2 = 2\ m\ s^{-1}$									
UN_c	-18.63	9.61	-0.91	0.51	0.94	0.01	1.44	0.35	29.88	5.95
ALM_c	0.00	0.00	0.00	0.00	0.93	0.01	1.39	0.15	28.93	2.39
$BIAS_c$	0.00	0.00	0.00	0.00	0.96	0.01	1.05	0.06	21.95	1.54
RLM_c	-0.30	1.26	-0.01	0.06	0.94	0.01	1.18	0.05	24.67	1.11
S_c	0.93	0.78	0.05	0.04	0.94	0.01	1.20	0.05	24.94	1.17

SD= standard deviation; UN_c – raw data or uncorrected bias; bias correction methods: S_c- Slope, RLM_c – Robust linear model; $Bias_c$ - Bias; ALM_c – Adjusted linear model

AgERA5 = 385 centroids

MERRA-2 = 36 centroids



Best coverage for GB using AgERA5

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The Hydro-Saline balance in the MSR

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Modeling soil water and salinity dynamics in mangrove swamp rice production system of Guinea Bissau, West Africa

Gabriel Garbanzo [a,b,c,*], Maria do Rosário Cameira [b], Paula Paredes [b], Marina Temudo [d], Tiago B. Ramos [e]

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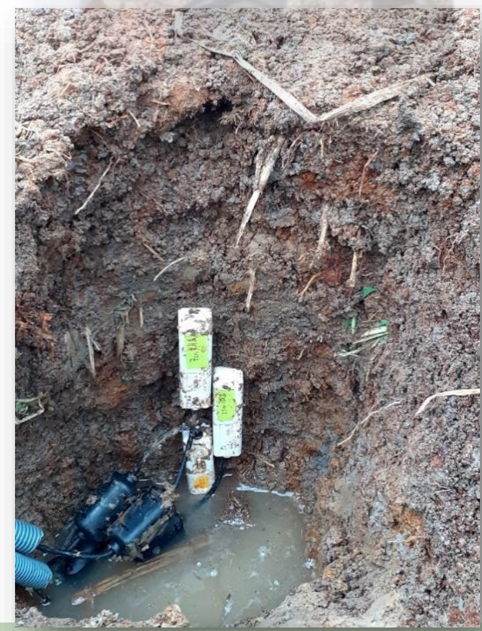
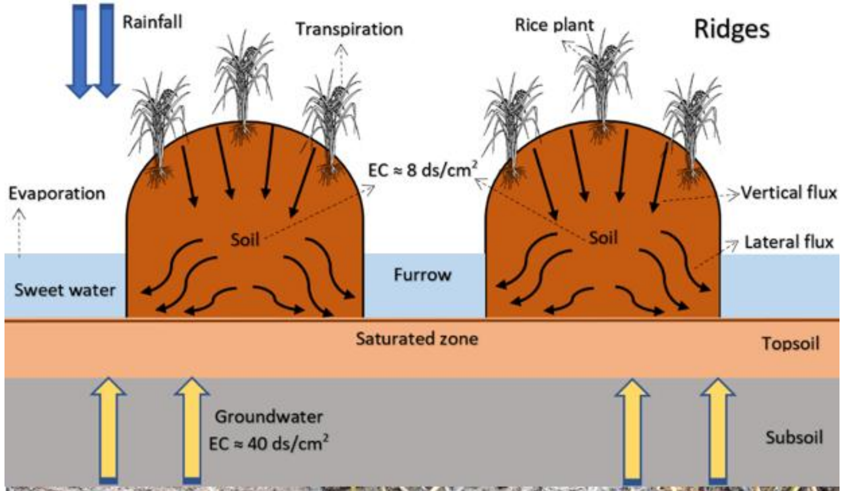
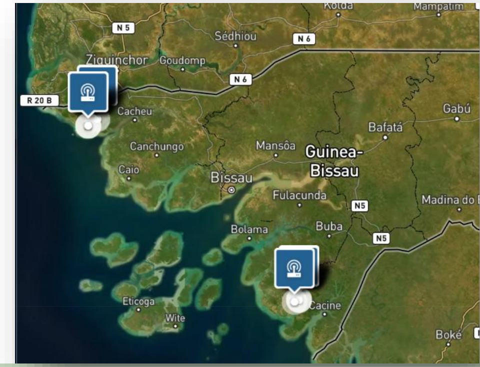
Soil water and saline monitoring







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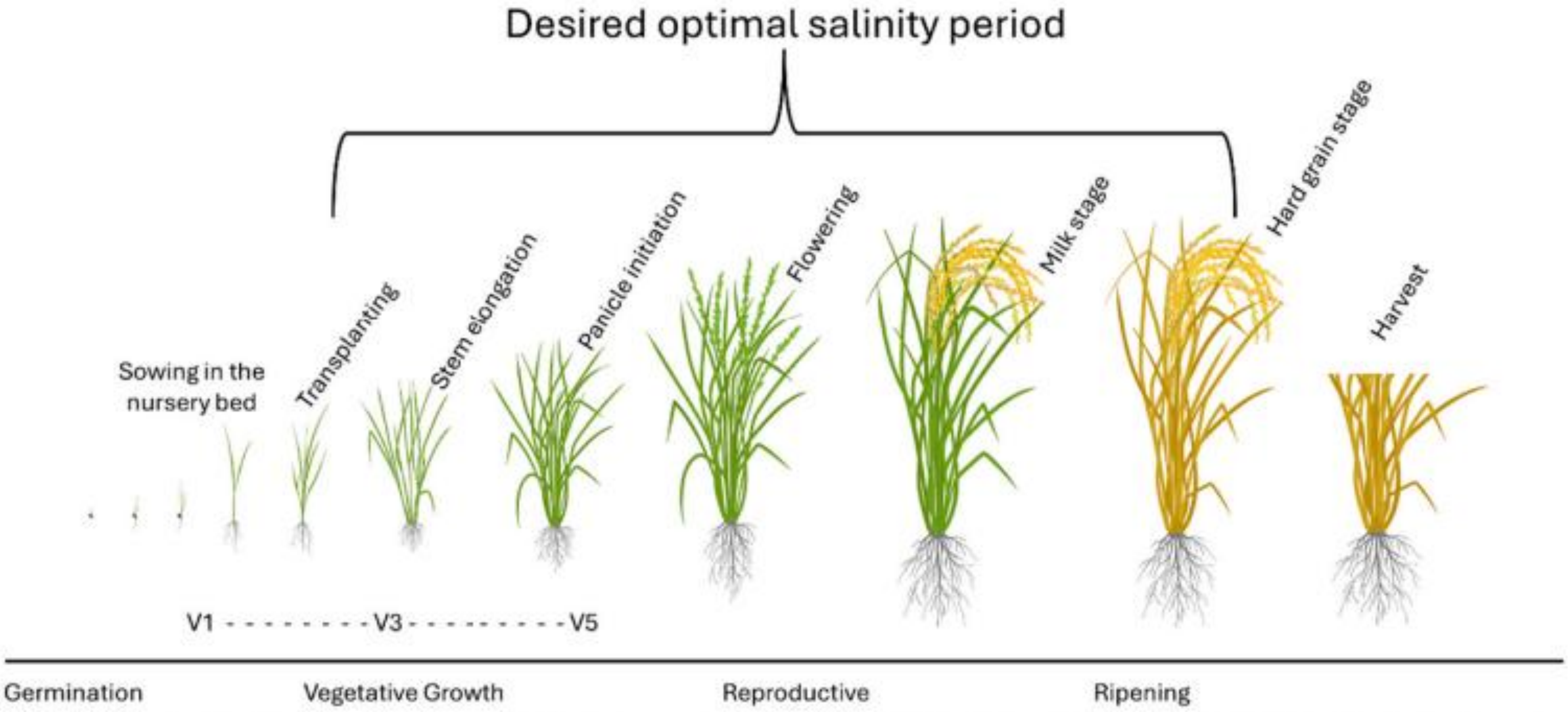
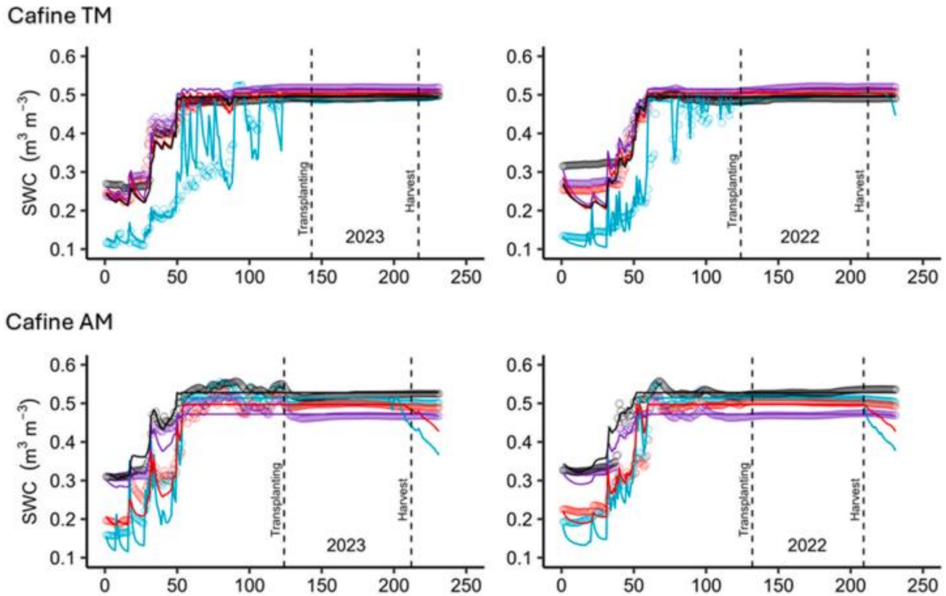
Monitoring rice growth and phenologic stages



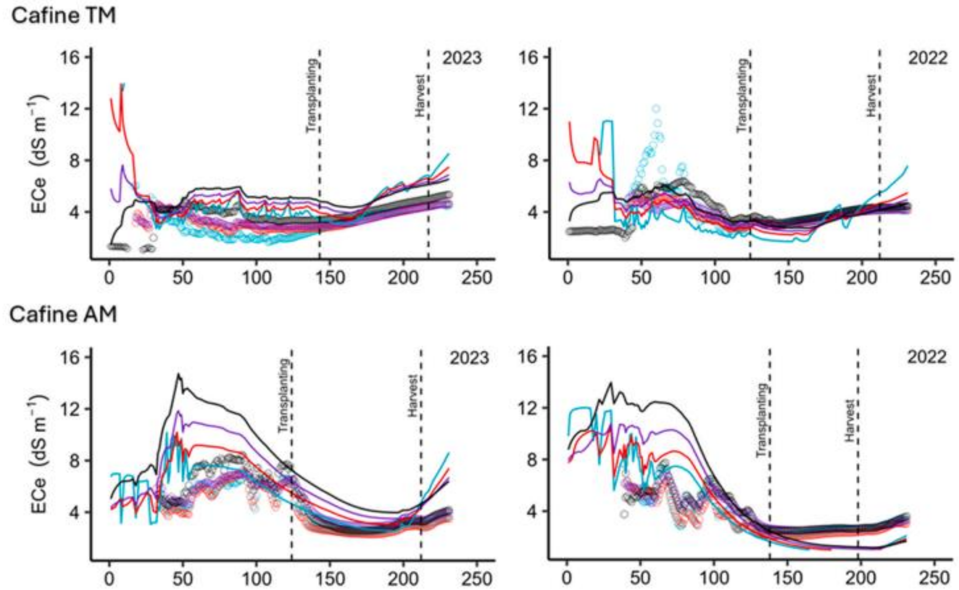
DOY	209	218	225	232	239	246	253	260	267	274	285	286	295	309	316	326	338	344	350	356	365
Week	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Month	July	August				September				October				November				December			

Fig. 3. The phenological stages of rice observed in the study sites during the 2022 and 2023 seasons.

One-dimensional water flow and solute transport using numerical methods with Hydrus 1D

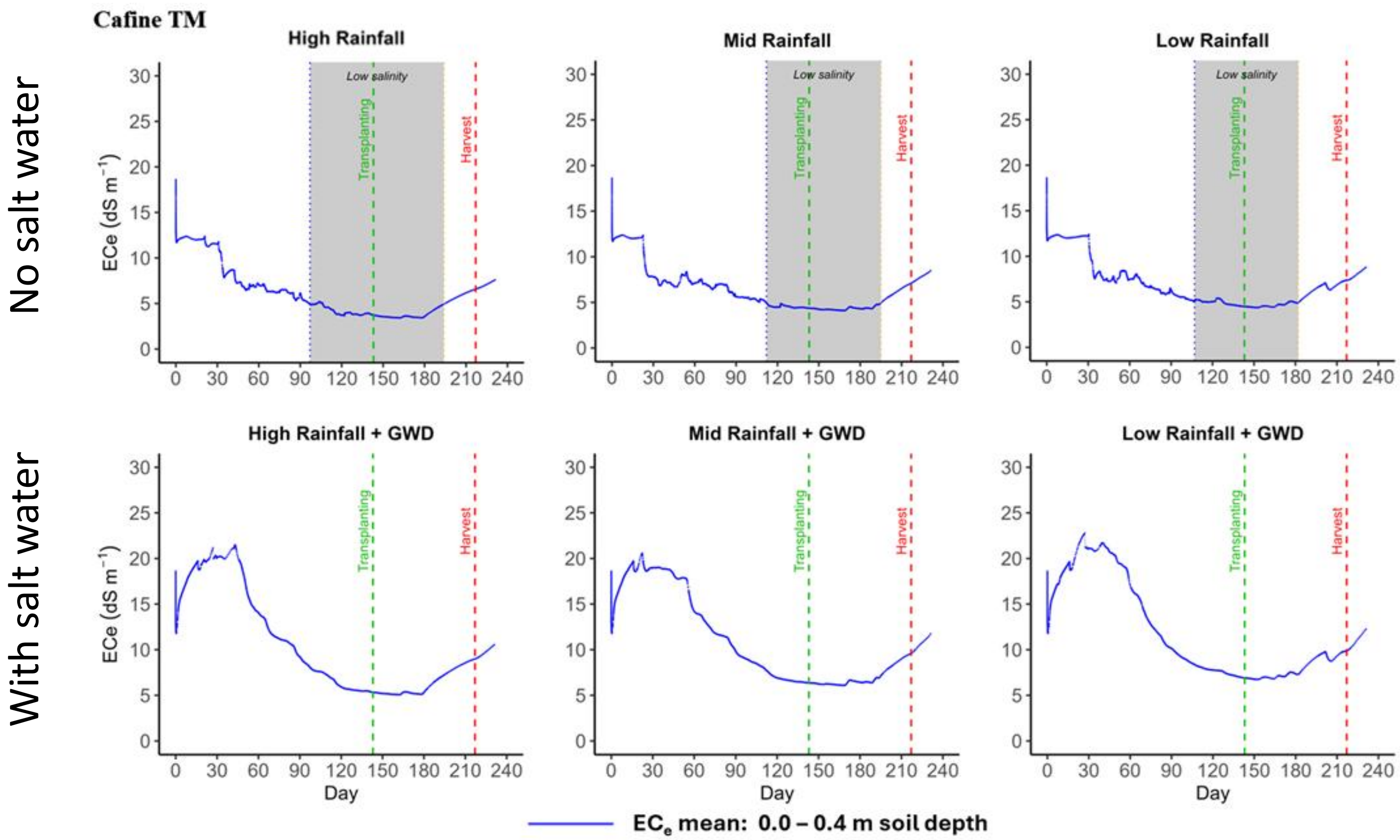


Measured and simulated soil water contents (SWC)



Measured and simulated values of electrical conductivity of the saturation paste extract (ECe)

Optimal timing for the "free-salt period"



The need for the regular maintenance of dikes to avoid brackish water entrance in growing season.

The salt-free period (Guei et al., 1997)

Highlights

- ✓ Innovative approaches for estimating reference evapotranspiration (ET_o) using only temperature data in data-scarce regions, now is calibrated.
- ✓ Groundwater depth and low rainfall significantly influence soil salinity concentration and plant growth.
- ✓ Effective drainage systems and regular maintenance of dikes are crucial for the sustainability of rice fields, **Specifically in growing season.**
- ✓ Farmers have to do soil preparation and the transplanting as early as possible.

Thank you very much for your attention

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