Integrated soil salinity management in rice-based systems of the Senegal River Valley (ISSM4RICE)

FINAL REPORT

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1. Introduction

Soil salinization, the most prevalent form of soil degradation in the Senegal River Valley (SRV), severely limits rice yields. Salinity affects 1.7 out of the 3.8 million ha of cultivable land of Senegal[1], leading to rice yield losses of 40 to 90% depending on cultivar, water management, and other issues including poor irrigation management and high evapotranspiration[2,3]. Soil salinization in Senegal can have natural or anthropogenic origins and is observed in two forms. Primary salinization stems from the parent rock, as seen in Eastern Senegal, while secondary salinization results from a range of processes and environmental factors, including marine intrusions caused by the advance of the saline wedge in estuarine and coastal areas. Salinity undermines agricultural productivity, devalues land, and threatens Senegal's food sovereignty. The Senegalese government has undertaken significant efforts to address the issue of salinity, particularly in agricultural lands and water resources. The key initiatives include the construction of anti-salt dykes and hydraulic infrastructure, such as the Diama Dam, to prevent saline intrusion and promote irrigation. The government has supported using salt-tolerant crop varieties, soil rehabilitation programs, and farmer training to enhance resilience in saline-prone areas. National policies, such as the National Action Plan for Adaptation to Climate Change (NAPA) and Integrated Water Resources Management (IWRM), prioritize salinity management as a critical focus. Additionally, Senegal collaborates with international organizations like the World Bank and FAO, while engaging in regional partnerships through the Senegal River Basin Development Organization (OMVS) to tackle transboundary water salinity. However, mitigative measures to counter salinity in irrigated rice systems are so far not widespread and are not perceived as cost-effective. In terms of adaptive measures, AfricaRice has developed agronomic salinity management options, namely salt-tolerant varieties and nutrient management strategies. Limited awareness translates into poor adoption of these options.

2. Initiative & project objective

Building on the Africa Rice Center's (AfricaRice) extensive expertise in adaptive trials, this initiative focused on joint learning to raise awareness and strengthen capacity on cost-effective farm solutions for salinity. AfricaRice, a pan-African Center of Excellence headquartered in Senegal, is dedicated to rice research, development, and capacity building. Its mission is to reduce poverty, achieve food security, and improve the livelihoods of farmers and stakeholders in the rice value chain across Africa. The Center prioritizes increasing the productivity and profitability of rice-based agri-food systems while safeguarding environmental sustainability. Since the 1990s, AfricaRice has advanced research in the Sahel region on salinity tolerance, water management, and soil fertility. This has led to the development of salinity-tolerant rice varieties and innovative salinity management technologies, which have transformed Africa's rice sector, benefiting millions of rural households through improved seeds, farming practices, processing technologies, policy recommendations, and capacity development. Complementing these efforts, MetaMeta is a Dutch Company with an engagement in water and land management on a global scale. MetaMeta aims to introduce practical

[1] FAO/CSE (2003) L'evaluation de la degradation des terres au Sénégal

[2] Asch, F., Dingkuhn, M., & Dorffling, K. (2000). Salinity increases CO2 assimilation but reduces growth in field-grown, irrigated rice. *Plant and soil*, *218*(1), 1-10.

[3] Asch, F., & Wopereis, M. C. (2001). Responses of field-grown irrigated rice cultivars to varying levels of floodwater salinity in a semi-arid environment. *Field Crops Research*, *70*(2), 127-137.

solutions that nurture international development, knowledge sharing and partnering, by conducting applied research and providing support on innovative topics. The impact themes and expertise provided range from water-oriented topics at landscape scale, such as local climates, floods and droughts management or green infrastructure, to irrigation management, vital water services, green and blue economy and agroecology. Initial results showed that agronomic options, such as nutrient management (introducing K, gypsum, and/or Zn) and using different varieties, both increase yield (up to 2.0 t/ha and 0.6 t/ha respectively) and are profitable for farmers. This was demonstrated and documented under the following project, with ongoing co-creative research on other options.

The ISSM4RICE project formulated its expected outcomes through three work packages (WP):

1. Strengthened capacity of farmers and extension staff, leading to reduced burden of salinity and increased value of land

2. Co-created knowledge product on preventive, mitigative, and adaptive measures, and wide-spread dissemination during and after project

3. Strengthened cooperation between Dutch and Senegalese water and agrifood sectors and fertile ground for follow-up.

This initiative was supported by the Netherlands Food Partnership (NFP) and the Netherlands Water Partnership (NWP), which facilitated the Saline Water & Food Systems partnership. This multi-stakeholder platform convenes diverse actors to address salinization through collaborative action, ensuring the dissemination of impactful solutions across regions affected by salinity.

3. Agenda

Work package	Objective	Output
WP1: Demonstrations at Farmer Field Schools Lead: AfricaRice	❖ Demonstration of rice varieties adapted to salinity and fertilizers management options ❖ 4 Farmer Field Schools (FFS) ❖ 200 farmers (50 per FFS) and 50 extension agents	❖ Fields visits and farmers mobilization at 4 Farmer Field Schools locations (Ndiaye, Thilène, Ngao, Mboundoum)
WP2: Knowledge co-creation Lead: MetaMeta	❖ Development of a knowledge product providing a practical overview of effective and cost-effective measures to combat salinity in the SRV ❖ Focus on measures of prevention, mitigation, and adaptation	❖ Knowledge product gathering findings from the literature, training material and training discussions ❖ Online blogs for knowledge dissemination
WP3: Capacity strengthening Lead: AfricaRice	❖ FFS for demonstrations of the adaptive package during field visits and stakeholder facilitation sessions to enhance dialogue and learning	❖ Collective training with extension officers and farmers: two days of theory sessions and three days of field excursions ❖ Webinar gathering the findings from the project and strengthening capacity

4. Outputs by work package

Work package 1: Demonstrations at Farmer Field Schools

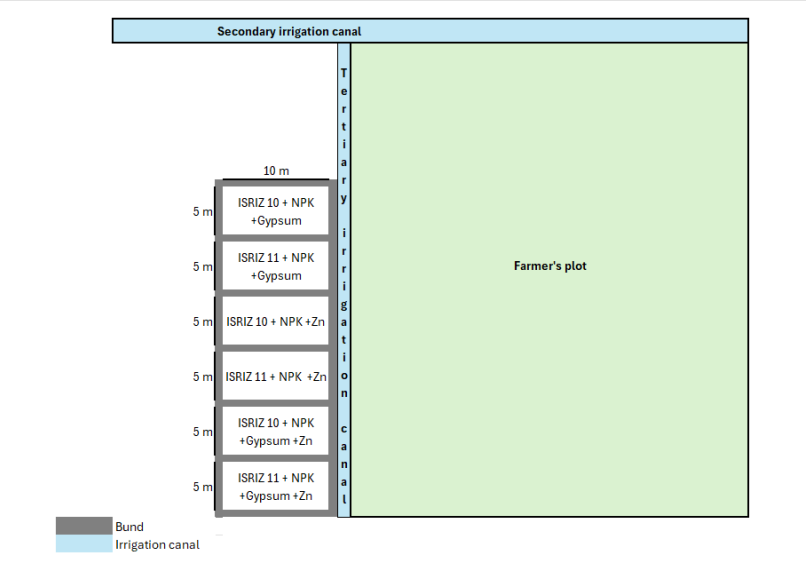


Figure 1: Example of an established field school

Farmers' field schools were established in four villages: Ndiaye, Thilène, Ngao, and Mboundoum. Six treatments consisted of two salt-tolerant rice varieties combined with nutrient management approaches were implemented to evaluate their effects compared to farmers practices and to analyze the associated fertilizer costs (See Figure 1). The fields were selected based on salinity levels, prioritizing areas with the highest salinity (EC values ranging from 2 to 5 $dS.m^{-1}$).

Figure 2: Explanation to farmers and extension agents on the use of Gypsum and Zinc in the reclaiming of salt-affected soils during a field visit

Figure 3: Overview of treatments

Farmers had the opportunity to ask questions about the treatments, how to address salinity using agronomic measures and share their views on the varieties tested. Farmers expressed their interest in having a greater implication in field experiments and development research, asking for consolidation of collaborations between stakeholders.

Beyond the use of improved varieties, visits in the farmer field schools allowed to discuss additional practices affecting yield and proper management of the fields, regarding for example sowing density, weed management and the importance of proper field levelling.

Nine field visits were organized (Figures 4–9). These "field days" engaged a total of 261 farmers, encompassing both men and women, as well as 90 extension agents. The visits provided hands-on training and facilitated knowledge sharing to improve rice cultivation practices, fostering collaboration between farmers and experts.

Figure 4: Field visit in Ndiaye at panicle initiation stage

Figure 5: Field visit in Ndiaye at maturity stage

Figure 6: Field visit in Thilène at panicle initiation stage

Figure 7: Field visit in Thilène at maturity stage

Figure 8: Field visit in Mboundoum at booting stage

Figure 9: Field visit in Mboundoum at maturity stage

The field visits allowed for the identification of additional concerns farmers encountered in their agricultural systems:

Table 1: Additional agricultural challenges mentioned by farmers

1.	Iron (Fe) toxicity
2.	Lack of drainage infrastructure
3.	Lack of maintenance of the irrigation canals
4.	Unproper field levelling
5.	High sowing density hindering plant growth
6.	Weed management
7.	Birds and rodent pests management
8.	Fertilizers management
9.	Community-level management of irrigated schemes

During the "field days", members (men and women) of both vegetable and rice farming groups expressed a critical need to develop effective strategies for reclaiming salt-affected lands. These challenges significantly hinder their agricultural activities, increasing their vulnerability. Addressing these issues is essential, given the vital role vegetable crops play in ensuring food and nutritional security for their communities.

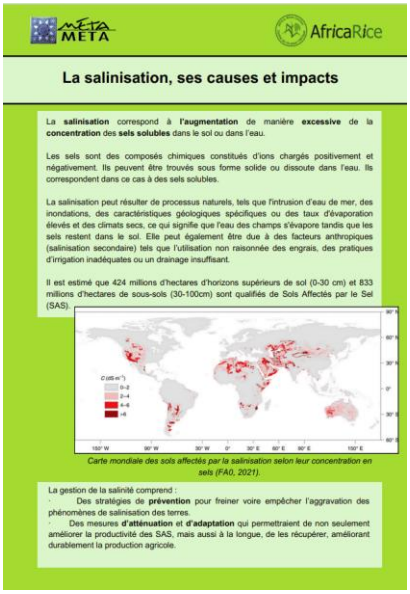
Work package 2: Knowledge co-creation

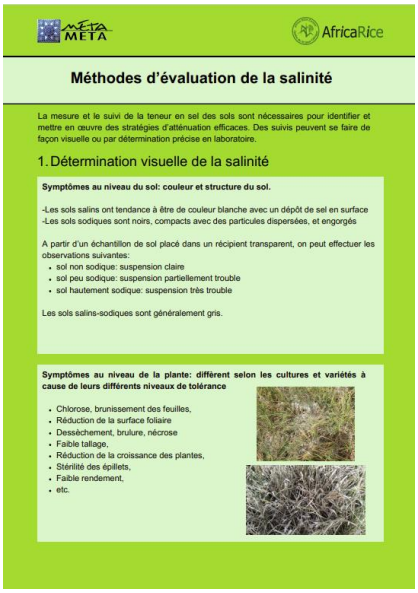
A first literature review was performed, elaborating on the current state of knowledge and practices regarding the salinization issue, prevention and mitigation management options to counter it in rice-based systems.

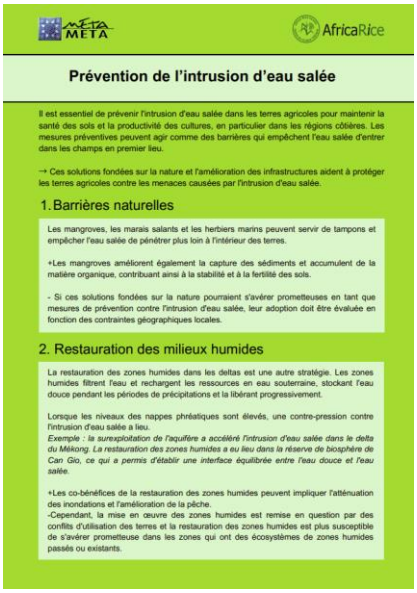
A knowledge product was developed based on the literature review and the training materials, collecting and classifying the information based on the management topic addressed. A total of 8 fascicules that can each be read as standalones or as a continuous collective were produced in French to ensure knowledge dissemination in a concise and straightforward way to the local audience.

- Definition and introduction to salinity
- Evaluation of salinity
- Prevention methods to saltwater intrusion
- Water management practices
- Land and cropping management practices
- Agronomic options to salinization
- Salt-tolerant varieties
- Sodic soils management

The knowledge product can be accessed via the following link: [Salinity management in rice fields manuals | MetaMeta]







Figures 8, 9 & 10: snapshots of the flyers forming the knowledge product

Next to that, communication materials are being developed on the Water Channel platform of MetaMeta as blogs. The following blogs were developed:

- Tackling soil salinity in rice-based systems - TheWaterChannel
- To be published: communication on water management to counter soil salinization
- To be published: communication on land and soil management to counter soil salinization

Work package 3: Capacity strengthening

This component was implemented through both Farmers' Field School (FFS) activities and in-class training sessions. The latter involved 25 extension agents and farmers from the Senegal River Valley (SRV) who participated in a two-day theoretical training program at the end of October. This was followed by three days of practical field excursions conducted across three FFS sites.

The training objectives were defined as follows:

- Understand the causes and impacts of salinization
- Distinguish the different types of salinity and their assessment methods
- Learn effective management techniques to reduce soil salinity
- Learn productive and economically viable adaptation strategies

Six modules were addressed for the theoretical part:

Table 2: Detailed training content

Day 1	Module 1	*Introduction to Salinity* **Definition**: What is salinity and what are the different types? **Causes**: Natural and anthropogenic factors of salinization.
	Module 2	*Effects of Salinity* **Impact on Agriculture**: How salinity affects crops and productivity. **Soil Health**: Influence on microbiological activity and nutrient uptake.
	Module 3	*Assessment methods* **Soil testing**: Techniques for measuring salinity. **Water monitoring**: Importance of groundwater monitoring.
Day 2	Module 4	*Management Strategies* **Irrigation practices:** Techniques to avoid waterlogging and reduce salt accumulation. **Soil amendments:** Use of gypsum and other amendments to improve soil structure. **Efficient drainage:** Drainage systems to remove salts
	Module 5	*Salt-resistant varieties* **Variety selection:** Choosing crops adapted to saline conditions
	Module 6	*Collective discussion* **Agricultural diagnosis**: Questionnaire for identification of local farms conditions and solutions formulation **Experience sharing and feedback**: Discussions on how to counteract salinity problems.

The theoretical training highlighted what the participants identified as necessary for further implementation of proper salinity management practices: emphasis was expressed for involvement and mobilization of farmers, demonstrating a wide range of practices in Farmer Field Schools and restitution of results to the producers. The needs for seeds availability, adequate drainage facilities and subsidies for fertilizers, especially those used in fields schools (gypsum, potassium sulfate and zinc sulfate) were expressed as well.

They also formulated their interest for an extension of the pilot tests to other locations. Visits to other sites, inviting farmers to see practical results and facilitating trainings, awareness raising and restitution of results to greater target groups. Furthermore, they highlighted the need to equip extension agents with proper tools for better electric conductivity assessment and to provide farmers with personalized recommendations.

Limits were addressed as well, namely concerning the underlying infrastructure issues, land tenure and governance. Hindering factors were mentioned: birds pests, lack of accessibility to improved varieties, lack of fertilizers access, lack of communication of efficient agricultural practices and poor drainage facilities, hindering water management practices to counter salinization (e.g. flushing the soil). Lack of monitoring was reported, as in the current situation it is only when the situation reaches critical levels that become visible that measures are taken to counteract the negative effects on the production. Tools for monitoring and measuring salinity levels are needed to prevent damaging situations.

Participants mentioned the importance in their view to involve structures that provide microcredits to support farmers with their input costs. Stakeholders with an influence capacity among farmers' groups could take part in knowledge dissemination by taking an advocating role about the issues addressed, e.g. lead farmers, village leaders and religious chiefs.

Other stakeholders were mentioned for possible involvement and further outscaling of solutions: scientific research institutes, technical operators (Direction Régionale du Développement Rural - DRDR, Société d'Aménagement et d'Exploitation des Terres du Delta du Fleuve Sénégal - SAED) and farmers' organizations.


Figures 8 & 9: Training on salinity management

5. Conclusion

As reported by the participants in the training and as highlighted in the FFS, there is room for further integration of salinity management practices, along with other challenges faced by farms in the Senegal River Region (cf. Table 1). An important limitation to the adoption of salt mitigation practices is the lack of suitable drainage facilities and water-related infrastructures, which are beyond the control of individual farmers. Access to adequate irrigation and drainage infrastructure is essential, and the integration of adequate water management practices should then be supported by suitable governance frameworks, reflected by the involvement of stakeholders on both technical and political levels. Concerning the direct field management measures to address salinization, participants reported having acquired new information on the issue and hands-on knowledge on management practices to face it. They emphasized the importance of combining the knowledge acquired with other agricultural enhancement practices for overall performance improvement. This suggests that further communication work could be realized to provide a global and holistic management approach to contribute to climate-resilient farming systems. Possible entry points for dissemination of information and follow-up include:

- Use of online platforms for communication about the project content and outcomes (e.g. The Water Channel, Africa Rice website)
- Updates and promotion via LinkedIn
- Referencing of the project on the Saline Agri Map
- A webinar organized together with project partners and parties within and beyond the SFWP
- Maintain of regular interactions and updates with extension officers and lead farmers, ensuring the involvement of local communities in a consistent manner over time
- Throughout the project we have been in close contact with the Dutch Embassy in Senegal, which will be followed-up in the next months
- Up to this day, the engagement facilitated by NWP and NFP helped Africa Rice and MetaMeta to connect to other players in the world of Saline Water & Food systems, including private and public parties.

Collaborative efforts and coordinated actions are required to ensure long-term mitigation of soil salinity, and we hope that the hereby project helped to set the scene for further achievements addressing soil salinization and food security-related issues.