



Proceeding Paper

The Emergence of a Governance Landscape for Saline Agriculture in Europe, the Middle East and North Africa [†]

Katarzyna Negacz ^{1,*}, Pim van Tongeren ¹, Lucia Ferrone ², Federico Martellozzo ² and Filippo Randelli ²

¹ Department of Environmental Policy Analysis, Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam, De Boelelaan 1111, 1081 HV Amsterdam, The Netherlands; p.van.tongeren@vu.nl

² Department of Economics and Management, University of Florence, Via delle Pandette 27, 50127 Firenze, Italy; lucia.ferrone@unifi.it (L.F.); federico.martellozzo@unifi.it (F.M.); filippo.randelli@unifi.it (F.R.)

* Correspondence: k.e.negacz@vu.nl

[†] Presented at the 2nd International Laayoune Forum on Biosaline Agriculture, 14–16 June 2022; Available online: <https://lafoba2.sciforum.net/>.

Abstract: Salinization is one of the main challenges of contemporary agriculture affecting food security and sustainability. Climate change with more persistent droughts, floods and sea-level rise is expected to increase this challenge, making it one of the most common land degradation processes. At the same time, an increasingly complex institutional landscape has emerged across multiple issue areas of global environmental governance related to salinization. This can be seen in a myriad of public, private, and hybrid actors coming together by creating initiatives to address the issue of growing salinization through saline agriculture. Therefore, the aim of this paper is to characterize the development of a governance landscape of cooperative initiatives for saline agriculture in Europe, North Africa, and the Middle East, and to discuss how to harness their potential and orchestrate their efforts. The preliminary findings suggest that the fragmented landscape of initiatives is predominated by public actors and research institutions. This potentially hampers benefit sharing and upscaling efforts. Operational activities are most frequently the governance function, followed by information and networking efforts thereafter. Thematically, initiatives focus on the development of new crop varieties and water and soil management practices. Linkages to the Sustainable Development Goals suggest saline agriculture is connected to policy debates on sustainable food systems, climate change, water security, and land degradation.

Keywords: salinization; governance; international cooperative initiatives; policy; saline agriculture



Citation: Negacz, K.; van Tongeren, P.; Ferrone, L.; Martellozzo, F.; Randelli, F. The Emergence of a Governance Landscape for Saline Agriculture in Europe, the Middle East and North Africa. *Environ. Sci. Proc.* **2022**, *16*, 33. <https://doi.org/10.3390/environsciproc2022016033>

Academic Editor: Abdelaziz Hirich

Published: 16 June 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Salinization of water and soil resources is a substantial driver of land degradation and stresses freshwater provisions, particularly in arid and semi-arid regions [1]. It depletes the soil of pivotal nutrients, decreases the water quality and is a significant constituent of desertification processes [2,3]. This potentially threatens global food security and nutrition needs [4]. Moreover, it can trigger the collapse of local fishery industries, reduce biodiversity, and change local climatic conditions [3]. Salinization thus poses a significant barrier to ensure food security under the pressures of population growth and climate change [5]. Anthropogenic salinization has occasionally contributed to the destruction of formerly successful agrarian societies, such as ancient Mesopotamia and the Tigris–Euphrates valley [6]. Effective management can mitigate factors accounted both to high environmental and social costs [3].

The extent of salinized land is difficult to determine accurately. One billion hectares of land, divided over more than 100 countries, can be classified as salt-affected [7]. Around 10% of the global arable land [8] and 20% of irrigated lands [9] are salt-affected. However,

estimates vary widely among different countries. In some countries, up to 50% of irrigated land is salt-affected as mapped through remote sensing [10].

Current academic research focuses on the identification and exploration of strategies that mitigate or adapt to salinization. Saline agriculture often translates to mitigation techniques that aim to either move soluble salts to lower soil depths through leaching, natural or artificial drainage systems, or by removing salt through mechanical or biological means [11]. Moreover, halophytic plants with desalinizing properties have been utilized successfully for soil reclamation [12]. Furthermore, humic substances [13] and microorganisms [14] may also mitigate salinity stress. Next to saline mitigation techniques, there is a growing field of knowledge and practice on saline adaptation. Saline agriculture seems feasible for crops that can withstand relatively large amounts of salts that have been built up in root zones [15]. This could be achieved by using salt resistant rootstocks, either by genetic modification or classical breeding [15].

In order to mitigate salinization and freshwater shortage, a sustainable transition needs to occur in the environmental policy landscape. A sustainable transition can be set in motion by a collective effort of experimental niche initiatives [16]. Transitions require system innovations that transcend individual actors and construct relationships between private and public entities [17]. Sustainable development can occur in innovative environments through these initiatives. One of the earliest examples of an initiative investigating the potential of saline agriculture dates back to 1954, when the U.S. Salinity laboratory was launched. The number of initiatives exploring saline agriculture has exponentially increased over the past two decades, highlighted by examples such as the International Centre for Biosaline Agriculture (ICBA), founded in 2000 in the United Arab Emirates.

Salinization on a global scale is a problem positioned in a complex and fragmented institutional landscape [18]. No clear pathway or solution can solve the issues caused by salinity, threatening global food and water security. Many stakeholders are involved, with volatile perceptions regarding associated problems and solutions. These characteristics make this a vital problem [19] which must be resolved by incorporating design thinking in the process [20]. To achieve this, a systematic, structured, and interdisciplinary approach must be taken. This short paper aims to structure and explore the field of saline agriculture by mapping and analyzing suitable initiatives in a comprehensive way. At the time of writing, this approach has never been adopted with regard to saline agriculture.

2. Materials and Methods

Using a systematic approach, we created a database of cooperative initiatives for saline agriculture by internet snowballing and expert interviews. Further, we applied a semi-automated content analysis to the mission and vision statements and about sections of initiatives websites in order to validate their link with saline agriculture.

To describe the evolving institutional landscape and make policy recommendations, we code characteristics of each initiative including *inter alia*, their members, governance functions, goals, and geographic coverage. We analyzed the characteristics of these initiatives using descriptive statistics to illustrate the patterns across the sample. The data were collected from publicly available online data sources.

3. Preliminary Results

The preliminary results show a few overarching trends in the sample of ca. 100 initiatives selected for the analysis. There is an increasing number of cooperative initiatives focusing on saline agriculture over time, particularly in years 2019–2020. The majority of initiatives lasted for a finite period of time, with an average duration of 3 years. The initiatives are often led by diversified sets of actors, but the public actors are predominant. A significant number of initiatives are related to research institutions. Their main governance functions focus on operational activities followed by information sharing and networking. The main themes for the initiatives are cultivation of conventional crops under saline conditions and water management practices. Around 20% of the initiatives incorpo-

rate halophytic plants for saline mitigation within their operations. The key sustainable development goals (SDGs), i.e., global goals for sustainable development constructed by the United Nations [21], addressed are SDG2 “Zero hunger”, SDG13 “Climate action”, SDG6 “Clean water and sanitation”, and SDG8 “Decent work and economic growth”. Our preliminary results indicate that most of the initiatives do not report publicly, but those with reports exhibit high verification rates.

4. Discussion and Conclusions

Our findings suggest that the governance landscape for saline agriculture is dominated by public and research initiatives. This may indicate a high interest of national government and international organizations, as well as good access to the public funding. This could indicate a low involvement of other stakeholders such as farmers, distributors, or environmental associations can influence access and benefit sharing and potentially hamper upscaling efforts. Further research in a form of network analysis could help in understanding connections between main actors.

The main governance functions of saline agriculture initiatives indicate high interest in practical application, field trials, and experiments. This is consistent with the main themes discussed in the literature on saline agriculture, which focuses on the development of new crop varieties and soil and water management practices [22,23]. Although of great importance in the field of saline agriculture, and often tackled with a scenario-based approach [24], the analysis of salinity parameters within the governance landscape falls outside the scope of our contribution. The second most common function, information sharing and networking, points to an increased interest in building a saline agriculture community [25], which is also reflected in a rising number of initiatives in recent years.

The key SDGs partially correspond with previous research [26]. However, climate change adaptation is found to have a more prominent role in our analysis of initiatives. This could serve as a link to increase the presence of saline agriculture as a point on the policy agenda. As a multifaceted topic, saline agriculture is connected to policy debates on climate change, sustainable food systems, water security, and land degradation. Integration of saline agriculture in these policy domains can contribute to addressing multiple SDGs through synergistic actions and instruments. Furthermore, the orchestration of this fragmented landscape potentially led by international organizations, such as FAO, could provide a pathway to harness the potential of international initiatives for saline agriculture for addressing climate change, water, and food security.

Author Contributions: Conceptualization: K.N.; methodology: K.N. and P.v.T.; Software: P.v.T.; validation: K.N., P.v.T. and L.F.; formal analysis: K.N. and P.v.T.; investigation: P.v.T.; data curation, K.N. and P.v.T.; writing—original draft preparation: K.N. and P.v.T.; writing—review and editing: K.N., P.v.T., L.F., F.M. and F.R.; project administration: K.N. and P.v.T.; funding acquisition: K.N., F.M. and F.R. All authors have read and agreed to the published version of the manuscript.

Funding: This project is part of the programme of the ERA-NET Cofund FOSC that has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 862555.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: For the data supporting reported results, please contact the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Vengosh, A. Salinization and Saline Environments. *Treatise Geochem.* **2003**, *9*, 612.
2. Thomas, D.S.G.; Middleton, N.J. Salinization: New Perspectives on a Major Desertification Issue. *J. Arid Environ.* **1993**, *24*, 95–105. [[CrossRef](#)]

3. Williams, W.D. Anthropogenic Salinisation of Inland Waters. In *Saline Lakes*; Springer: Berlin/Heidelberg, Germany, 2001; pp. 329–337.
4. Ingram, J. A Food Systems Approach to Researching Food Security and Its Interactions with Global Environmental Change. *Food Secur.* **2011**, *3*, 417–431. [[CrossRef](#)]
5. Rojas, R.V.; Achouri, M.; Maroulis, J.; Caon, L. Healthy Soils: A Prerequisite for Sustainable Food Security. *Environ. Earth Sci.* **2016**, *75*, 180. [[CrossRef](#)]
6. Gelburd, D.E. Managing Salinity Lessons from the Past. *J. Soil Water Conserv.* **1985**, *40*, 329–331.
7. Ivushkin, K.; Bartholomeus, H.; Bregt, A.K.; Pulatov, A.; Kempen, B.; De Sousa, L. Global Mapping of Soil Salinity Change. *Remote Sens. Environ.* **2019**, *231*, 111260. [[CrossRef](#)]
8. Shahid, S.A.; Zaman, M.; Heng, L. Soil Salinity: Historical Perspectives and a World Overview of the Problem. In *Guideline for Salinity Assessment, Mitigation and Adaptation Using Nuclear and Related Techniques*; Springer: Berlin/Heidelberg, Germany, 2018; pp. 43–53.
9. Ghassemi, F.; Jakeman, A.J.; Nix, H.A. *Salinisation of Land and Water Resources: Human Causes, Extent, Management and Case Studies*; CAB International: Wallingford, UK, 1995.
10. Metternicht, G.I.; Zinck, J.A. Remote Sensing of Soil Salinity: Potentials and Constraints. *Remote Sens. Environ.* **2003**, *85*, 1–20. [[CrossRef](#)]
11. Qadir, M.; Schubert, S.; Noble, A.D.; Saqib, M. Amelioration Strategies for Salinity-Induced Land Degradation. *CAB Rev.* **2006**, *1*, 12. [[CrossRef](#)]
12. Saddhe, A.A.; Manuka, R.; Nikalje, G.C.; Penna, S. Halophytes as a Potential Resource for Phytodesalination. In *Handbook of Halophytes: From Molecules to Ecosystems towards Biosaline Agriculture*; Springer: Cham, Switzerland, 2020; pp. 1–21.
13. Ouni, Y.; Ghnaya, T.; Montemurro, F.; Abdelly, C.; Lakhdar, A. The Role of Humic Substances in Mitigating the Harmful Effects of Soil Salinity and Improve Plant Productivity. *Int. J. Plant Prod.* **2014**, *8*, 353–374.
14. Banerjee, A.; Sarkar, S.; Cuadros-Orellana, S.; Bandopadhyay, R. Exopolysaccharides and Biofilms in Mitigating Salinity Stress: The Biotechnological Potential of Halophilic and Soil-Inhabiting Pgpr Microorganisms. In *Microorganisms in Saline Environments: Strategies and Functions*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 133–153.
15. Cuevas, J.; Daliakopoulos, I.N.; del Moral, F.; Hueso, J.J.; Tsanis, I.K. A Review of Soil- Improving Cropping Systems for Soil Salinization. *Agronomy* **2019**, *9*, 295. [[CrossRef](#)]
16. Rotmans, J.; Loorbach, D.; Kemp, R. Complexity and Transition Management. In *Complexity and Planning*; Routledge: London, UK, 2016; pp. 195–216.
17. Rotmans, J. Societal Innovation: Between Dream and Reality Lies Complexity. 2005. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=878564 (accessed on 22 February 2022).
18. Pattberg, P.; Widerberg, O.; Isailovic, M.; Dias Guerra, F. Mapping and Measuring Fragmentation in Global Governance Architectures: A Framework for Analysis. 2014. Available online: <https://ssrn.com/abstract=2484513> (accessed on 22 February 2022).
19. Rittel, H.W.J.; Webber, M.M.; Huppertz, D.J. Dilemmas in a General Theory of Planning. *Policy Sci.* **1973**, *4*, 155–169. [[CrossRef](#)]
20. von Thienen, J.; Meinel, C.; Nicolai, C. How Design Thinking Tools Help to Solve Wicked Problems. In *Design Thinking Research*; Springer: Berlin/Heidelberg, Germany, 2014; pp. 97–102.
21. Desa, U.N. Transforming Our World: The 2030 Agenda for Sustainable Development. 2016. Available online: <https://stg-wedocs.unep.org/bitstream/handle/20.500.11822/11125/unepswiosm1inf7sdg.pdf?sequence=1> (accessed on 22 February 2022).
22. Vargas, R.; Pankova, E.I.; Balyuk, S.A.; Krasilnikov, P.V.; Khasankhanova, G.M. *Handbook for Saline Soil Management*; FAO/LMSU: Washington, DC, USA, 2018.
23. Hamdy, A.; Abdel-Dayem, S.; Abu-Zeid, M. Saline Water Management for Optimum Crop Production. *Agric. Water Manag.* **1993**, *24*, 189–203. [[CrossRef](#)]
24. Lee, D.J.; Howitt, R.E. Modeling Regional Agricultural Production and Salinity Control Alternatives for Water Quality Policy Analysis. *Am. J. Agric. Econ.* **1996**, *78*, 41–53. [[CrossRef](#)]
25. Negacz, K.; Vellinga, P.; Barrett-Lennard, E.; Choukr-Allah, R.; Elzenga, T. Saline Agriculture: A Call to Action. In *Future of Sustainable Agriculture in Saline Environments*; CRC Press: Boca Raton, FL, USA, 2021; pp. 3–12.
26. Negacz, K.; Bruning, B.; Vellinga, P. Achieving Multiple Sustainable Development Goals through Saline Agriculture. *Future Sustain. Agric. Saline Environ.* **2021**, *13*, 187.