Objective

The aim of this discussion paper is to provide a general overview on the challenges of salinisation to fresh-water resources and food production and steer the debate on possible opportunities to tackle salinisation. Cases are presented to exemplify the different approaches that can be followed to deal with salinisation.

This paper serves as input material for the Thematic Session on Saline Water & Food Systems at the Amsterdam International Water Week to be held on November 3, 2021, from 12:45 to 13:45 pm at RAI Amsterdam.

Salinisation threatens food security, biodiversity, and livelihoods

Challenges imposed by increased levels of salinity (salinisation) can occur in a kaleidoscope of different contexts and depending on the source of salts and the level of salinity, a variety of solutions is needed to deal with salinisation. These options range from understanding and adapting to changes in salt-fresh water systems, applying a combination of farming systems with innovations in crop and animal farming, as well as high-tech solutions. Higher salt concentration can occur naturally in soils, particularly in (semi)arid regions. Salinisation can also occur due to other factors, such as inefficient irrigation and poor drainage, which raises the water table and brings salts in the subsoil nearer the surface, as well as due to increased periods of droughts and salt water intrusion due to sea level rise caused by climate change (Fig. 1).

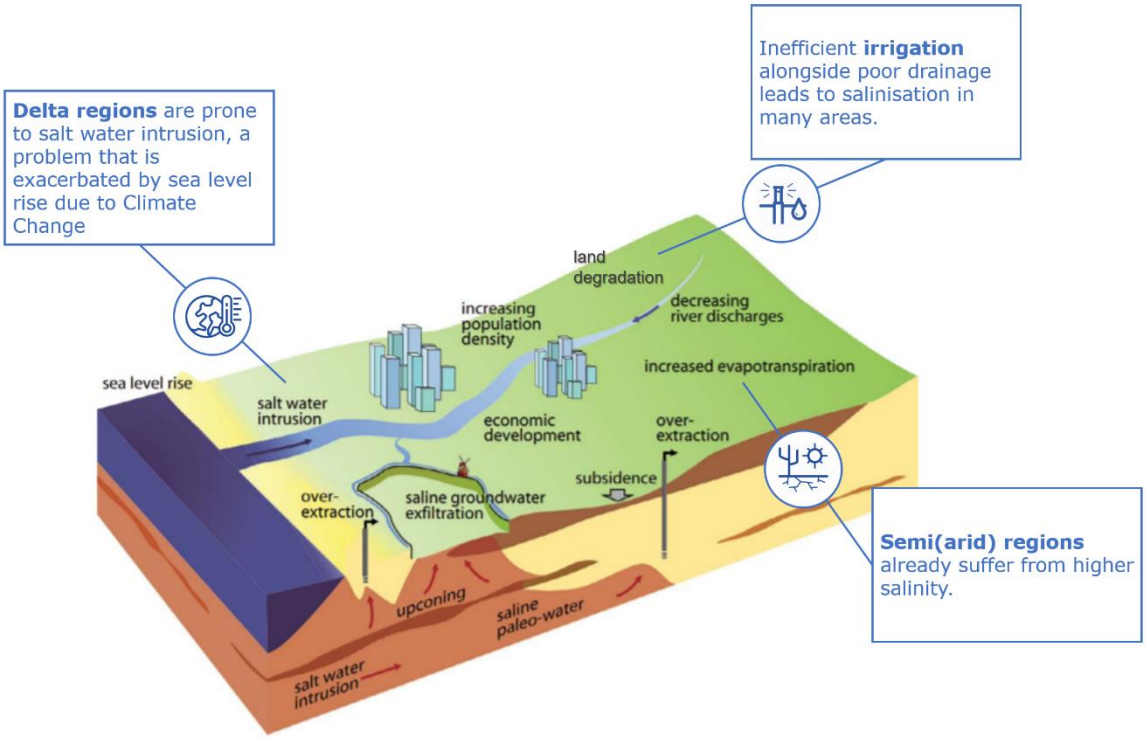

Fig. 1. General overview of potential causes of salinisation as well as other threats to (coastal) freshwater resources. Adapted from Beauchampet (2021)[1].

Salinisation is becoming one of the biggest challenges for food production worldwide as it severely impacts crop development and growth[2]. In fact, the World Soil Day on 5 December this year will be dedicated to salt-affected soils with the motto: "Halt soil salinization, boost soil productivity"[3]. Salt-affected soils can occur naturally, particularly in (semi)arid areas due to low precipitation (Fig. 2)[4]. Some other areas are vulnerable to the effects of climate change, such as sea level rise and consequently its effect on salt-fresh water levels in delta

regions (Fig. 3)[5], while other areas are prone to irrigation-induced salinisation (Fig. 4)[6]. For instance, global annual cost of salt-induced land degradation in irrigated areas has been estimated to be US$ 27.3 billion related to lost crop production[7]. Estimates predict that salinisation will impact 50% of all arable land by 2050[8], threatening food security, biodiversity and the livelihoods of millions of people[9].

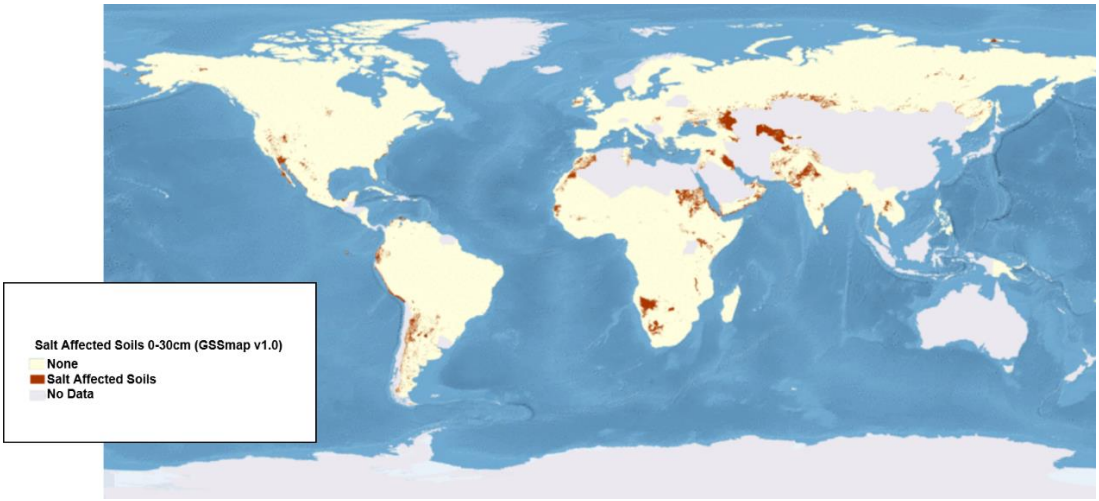

Fig. 2. Global distribution of salt-affected soils. Source: FAO (2021)[4].

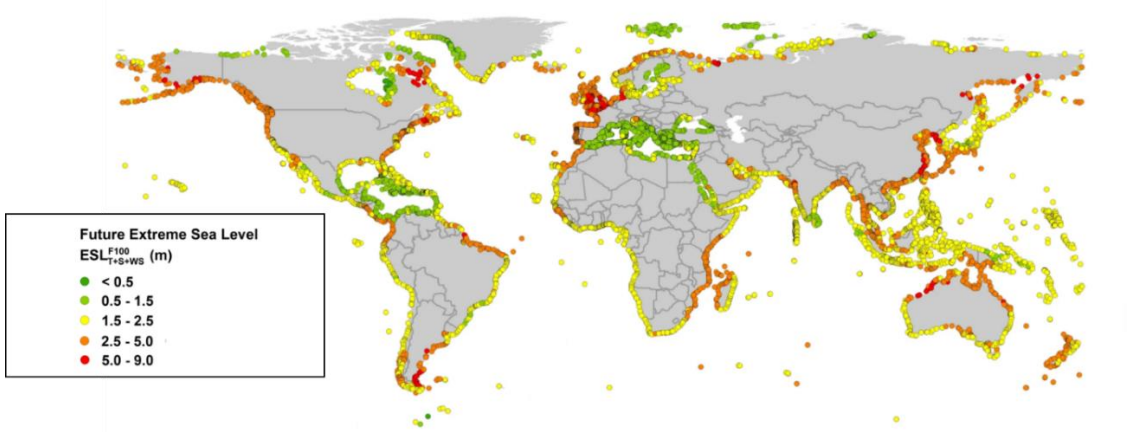

Fig. 3. Global distribution of projected 100-year return period extreme sea level. Source: Kirezci et al. (2020)[5].

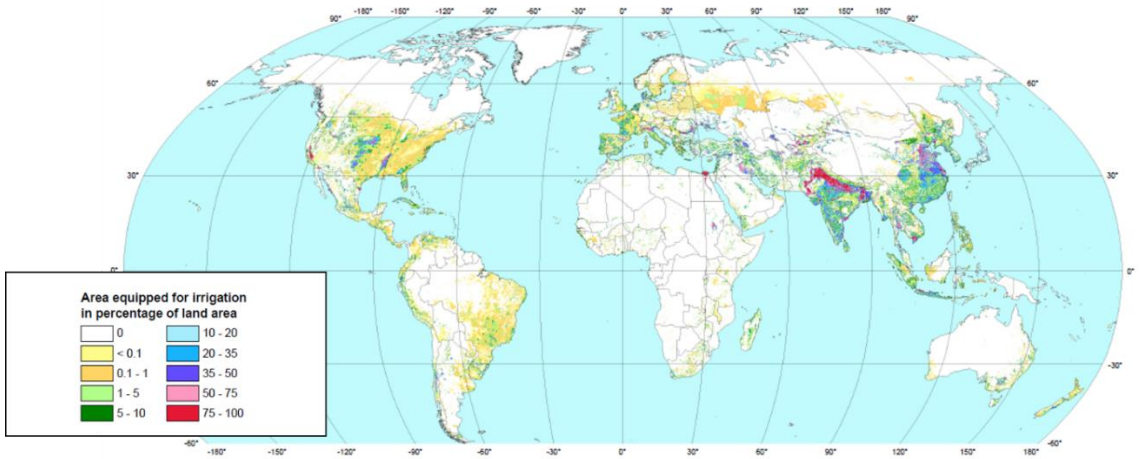

Fig. 4. Global distribution of the area equipped for irrigation in percentage of land area. Source: Siebert et al. (2013)[6].

The need for a systems approach

Salinisation is also one of the major causes of biodiversity loss and ecosystem degradation[9]. Moreover, increased demand for food due to population growth alongside with sea level rise and increased frequency of droughts due to climate change will exacerbate the challenges imposed by salinisation. As it concerns food, the challenges are more diverse than only producing more food. As global undernourishment's figure rise (16% of world's population suffers from food insecurity at moderate levels)[10], the lack of availability of and variety in ingredients for a healthy diet drifts as well (only in Asia and in the upper high income countries there are enough fruit and vegetables available for a healthy diet). Specific nutrition deficiencies lead, for instance, to anaemia caused by iron-deficiency (anaemia prevalence of around 30% are reported in woman and children in deltaic areas of Asia)[11]. Current food systems in low income countries deliver mainly cereals, roots, tubers and plantains, making up for 60% of all food available[10]. While adapting to high salinity, there is also the need to build in the growing need for diversification of diets. Providing healthy foods in a sustainable and equitable manner will be one of the greatest challenges of the decades ahead. For this to happen, structural changes are needed to guarantee provision of an adequate diet for a growing population in a changing climate. In this context, integrative approaches – such as the food systems approach[12], which takes into consideration the environmental and socioeconomic drivers that influence food production, distribution and consumption – can be useful to identify transformation pathways towards food systems that are more sustainable, healthy, and equitable. For instance, a food systems approach can be used to identify innovative ways to (re)use water resources more purposefully.

How to deal with salinisation?

Many areas in the world are already dealing with high soil salinity and brackish water conditions for different reasons. Dealing with salinisation is not a one-size-fits-all strategy. Local contexts must be considered since different levels of salinity will lead to different strategies to deal with salinisation (Fig. 5). Some areas might benefit to switch to a saline resistant potato, while in other areas, a switch to potato makes less sense. For instance, if a region has no agricultural or culinary tradition related to potato. In short, what works for one area does not ensure success for another area.

Fig. 5. General overview of possible strategies to deal with salinisation.

In learning how to live with (higher) salinity and using a water and food systems approach altogether, society should actively manage the fresh and saline water that is available. One should use saline water where possible and freshwater when needed[13]. Interventions and technologies can be selected by applying a three step approach that starts with a deep understanding of the local water and food systems:

1. Understanding systems, drivers, pressures, spatial planning, water management, governance and using the available freshwater more wisely (e.g. for fruit/ vegetables);
2. Adapting to higher or more varying salinity levels using (i) technology or (ii)mixed farming systems where possible, and
3. Developing new strategies based on innovative solutions to make use of high(er) salinity levels.

How does Dutch expertise look like in projects?

The Netherlands is actively involved in the topic of salinisation from problem definition and awareness raising to assessment of the feasibility of preventative and/or adaptive measures, as well as in the support of implementing such measures[14]. Dutch experts across sectors are working on several international projects where integrative approaches are often used to tackle the challenges that salinisation imposes to sustainable water and soil management. Next, we present 5 cases to exemplify different options to deal with salinisation.

1. Deltas Under Pressure

Delta regions are strong contributors to food production and other environmental services. However, they are also particularly vulnerable to the effects of climate change. Typical stresses for deltas are: sea level rise, floods, drought, salinity, acidity, humidity, waterlogging, subsidence, pest and other diseases (exacerbated by above abiotic stresses).

Availability of freshwater of sufficient quality and maximization of the use of salinizing regions (and flood protection) are the essential components of food systems in Deltas. Changes are happening rapidly and in a complex setting – it is difficult to foresee what a sustainable transition pathway could look like. The research program explores what is needed for viable and feasible transition pathways for the food system in deltas under pressure. It works in 2 case studies: one in Bangladesh and one in Vietnam. Specific attention is given to the influence of salinity in the food system, now and in the future.

Type: Research
Countries: Bangladesh and Vietnam
Organization: Wageningen University & Research and local partners.

2. Salt tolerant potatoes improve water and food security (STOP)

Many areas in the world must deal frequently with soil salinity and brackish water conditions because of different reasons. Due to these problems, food self-sufficiency is at stake in many of these countries. Potato is the champion staple crop with a high nutritional value and a low water footprint. The pilot project reported that it had as main objective to select salt tolerant potato

cultivars in order to make brackish waters available for food production

Some results include that (i) several potato varieties were found to perform well, for irrigating with water of a salinity up to 5 dS/m. Adequate water and crop management are a pre-requisite for this; (ii) soil moisture monitoring has been extended with monitoring of soil salinity and sensors proved to be important tools to extend knowledge. Placement of sensors in combination with nonuniform water application is not easy.

Type: Research
Countries: Egypt
Organization: Wageningen University & Research and local partners.

3. De-Salt Project

Many farmers are suffering from a high level of salinity in soils or irrigation water. These can negatively affect the yield and quality of the crops. One of De-Salt's aims is to train and build capacity for farmers and stakeholders. This included awareness raising and training of the farmers on saline agriculture, focusing on the lead farmer approach. Hence, regular training sessions for extension engineers from all over Egypt. The De-Salt project can reach especially those farmers who are affected by medium to high salinity and who need solutions for successful cultivation that do not harm the soil and environment. That is why currently two trials are being conducted: the first one compares eight different types of potatoes that are on one feddan (4200 m^2) under saline conditions. Outcome of the yield is that eight tons/feddan of potatoes were harvested [1] . Another trial was conducted on a one feddan area with extra high salinity (20 ds/m, half the salinity of the seawater). On this plot, salt-tolerant varieties were cultivated such as cauliflower, broccoli, white cabbage, red cabbage, and red beet. This plot represents a high challenge for the crops which usually grow in soils with 3 ds/m. This project shows that capacity building, and technology solutions are integrated for a sustainable approach to deal with saline conditions.

Type: Impact cluster
Country: Egypt
Organizations: Nectaerra, the Salt Doctors, Delphy, IV-Water and local partners.

4. Maghreb region

The Maghreb countries are facing increasing water scarcity amplified by inefficient water use and overexploitation of water resources. There is evidence that

[1] In organic agriculture potato, the yield normally ranges from 12 to 15 tons/ feddan.

surface water is diminishing and that ground water levels are lowering rapidly. Countires are affected by climate change as rainfall is more erratic and there are longer lasting and more severe periods of drought, alternated with severe rains and catastrophic flooding. The projected climate change impact on agriculture in the Maghreb will most likely increase further. This is accompanied by salinisation of soils and ground water, even strengthened by over-fertilization of soils, combined with a general low productivity and misuse of water. The Netherlands has world-renowned expertise when it comes to water management and agriculture, and finding sustainable and practical solutions for water use efficiency, quality improvement and circular agriculture. In order to link the Dutch experience and expertise to the issues at hand, an assessment of the current situation of water use and water problems in agriculture as well as the challenges for improvement is needed.

Type: Assessment of challenges and solutions
Countries: Morocco, Tunisia and Algeria
Organization: Salt Doctors and Acacia Water, commissioned by Dutch Embassies in Algiers and Rabat

5. Zoet Zout Knooppunt

The aim of the Zoet Zout Knooppunt is to make salinity issues a topic for discussion within the Netherlands, unlocking available knowledge, sharing practical experiences, and showing which innovations exists to deal with salt(er) water. The Zoet Zout Knooppunt is a network organization where the Regiomakelaars (Region knowledge brokers) ensure the connections between parties. The mission of this network is to raise awareness about the decreasing availability of freshwater and increasing salinisation. In addition, connections are made between users, knowledge institutions and governments to collect and share objective knowledge with each other. Work is done both within the region and between the regions and with the national programs in the Delta Program Freshwater. In the longer term, the ambition is to grow towards supplying information about salinisation in area processes and to develop a knowledge agenda.

Type: Network organization
Countries: The Netherlands
Organization: Hoogheemraadschap Noord Hollands Noorderkwartier, Provincie Noord-Holland, Puur Water & Natuur (PWN)

Future outlook

The challenges of salinisation also bring opportunities for stakeholders across sectors to collaborate and deal with salinisation from different perspectives. In this context, there is a need for the development of a strategic plan to enable the collaboration between Dutch experts and international partners in the topic. Here, integrative approaches are needed to provide a combination of policy, managerial and technological solutions to deal with salinisation across the globe.

This discussion paper is compiled by Carlos Alho[1], Judit Snethlage[1], Martijn van Stavaren[2], Roy Agterbos[2] and Frans Verberne[3].

[1] Wageningen Environmental Research; [2] Netherlands Water Partnership; [3] Netherlands Food Partnership

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