14 Mitigating and Adapting Agriculture of Coastal Areas in the Netherlands Wadden Sea Region to Increasing Salinization

From a Vision towards a Practical Implementation

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14.1 INTRODUCTION

Our study area is situated in the Netherlands province of Friesland (also known as Fryslân), especially the area bordering the Wadden Sea. This area is considered rural, with some towns and villages, with a dominance of intense agriculture on the clay rich soils close to the coastline and dairy farming on the clay-peat soils, more inland. Agriculture is dominated by seed potato cropping and grain production; these have great importance for the local economy and for export. The area is largely below sea-level and is protected by a dike system. In the last decade, more attention has been put to the issues related to land subsidence, water management, and salinization of the groundwater and surface water in agricultural areas (e.g. Pauw et al., 2012). Due to the rising ambient temperature, increasing evaporation, increasing precipitation caused by climate change, and occurrence of some severe droughts, notably in the summer of 2018, there has been an increased sense of urgency to adapt water management and control salinization. It is expected that in coming decades an acceleration of sea-level rise and continuation of land subsidence will further exacerbate the issue.

The aim of this chapter is to first provide an overview of the status and then outline a vision (similar to Speelman et al., 2009) and strategy towards managing the salinization issue. This approach is based on the joint efforts of a working group on salinization that produced a shared analysis and a shared perspective that was accepted by government, farmers collectives, knowledge institutes, NGOs of the region. A more detailed description is found in Mooi Werk and Mooi Wad (2020). In the next section, the baseline situation will be described, and this will be followed by a section elaborating the innovative approach to managing salinization in the area.

14.2 ESTABLISHING A BASELINE

The larger Wadden region nowadays consists of an area of diked salt marshes and reclaimed coastal peat bogs bordering a dynamic area of complex natural large-scale, intertidal ecosystems where natural processes continue to take place largely undisturbed (Vos, 2015). It is viewed as a landscape of exceptional cultural historical value. Human impact on this region has occurred in stages, with changes in the way of life, development of agriculture, and increasing abilities to use technology for flood protection and maintaining productivity at large scales playing key roles.

With each stage, the impact of people on the natural environment increased. From the end of the early middle ages, after many centuries of continual adaptation to the dynamics of the sea, the inhabitants of the Wadden Sea coastal region were increasingly successful at bending their unruly environment to their will. Controlling the external seawater, and later the internal polder and lake water, was the critical factor here (Schultz, 1992). Between roughly 800 and 1760, colonization of the salt marshes was completed, large parts of the coastal area were dyked and the coastal peat bogs behind the salt marsh zone were converted into prosperous farmland. By these means, a predominantly natural landscape was transformed in the space of just a few centuries into a vast and varied productive cultural landscape (Bazelmans et al., 2012).

14.2.1 GEOGRAPHY

Large parts of the former peat and salt marsh areas are now enclosed by dikes and under the influence of freshwater, but underground still carry the legacy of the past influence of the sea. During the centuries the diked areas have been compacting and subsiding. At the present time, the resulting geography is recognizable in the topography of the region as illustrated in [Figure 14.1](#). The areas of the mainland close to the Wadden Sea are youngest and therefore most elevated. The areas more inland are gradually lower until the Pleistocene sand formations in the East are reached. Towns and villages are often somewhat elevated due to their origin as man-made mounds in the landscape. Clearly, the bands parallel to the shorelines can be seen, resulting from centuries of step by step land reclamation, where the saltmarshes were reclaimed along the Middelzee and the Wadden Sea.

14.2.2 SOIL TYPES

The soil types of the region (shown in [Figure 14.2](#)) are dominated by clay, peat, and sand, in diverse compositions. Going from the Wadden Sea and former branches of the Middelzee and Lauwerszee, we find clay-dominated regions. Inland, marsh formation has created peat layers, sometimes covered by clay. Further eastward, the remains of glacial moraines surface, creating sandy and sometimes loamy soils.

FIGURE 14.1 Elevation map of the Province of Fryslân and bathymetry of the Wadden Sea (projected from elevated viewpoint south of the province, color scheme: blue hues inland (approximate elevation below m.s.l.; green hues approx. 0–2 m and yellow hues more than 2 m above m.s.l.). (Source: FAST Open Earth Geoserver.)

FIGURE 14.2 Soil types of the province of Fryslân (clay-dominated soils (greens), peat soils (purples), sandy soils (yellow-browns)). (Source: Province of Fryslân (2020).)

14.2.3 LAND SUBSIDENCE

Land is subsiding gradually in the area. This is caused by two main processes. Firstly, compaction and oxidation of peat layers is causing a lowering of the land surface. This can be seen in [Figure 14.3](#) (left) in the peat areas somewhat distance from the shoreline of the Wadden Sea (Haasnoot et al, 1999). However, in clay areas along the coastline, the dominant subsidence factor at present is the occurrence of gas and salt mining from underground (De Louw and Oude Essink, 2005; Verkaik and Oude Essink, 2008), seen as almost point sources surrounded with areas of influence on the map (caused by gas mining and salt mining activities). [Figure 14.3](#) (right) extrapolates the impact of these mining activities into the near future.

14.2.4 WATER MANAGEMENT AND GROUNDWATER

The province of Fryslân is situated for a large part below sea-level (Pauw et al, 2012). Rainwater and water flowing from the higher grounds in the east provide water to the central area of the province. A major freshwater source is Lake IJsselmeer that is connected to the Fryslân water system (the ‘boezem’) in times of water shortage. The surplus water from Fryslân is pumped out to Lake IJsselmeer, the Wadden Sea, and the Lake Lauwersmeer. From [Figure 14.4](#) it becomes clear that the higher clay areas near the Wadden Sea coastline are quite detached from the freshwater source IJsselmeer. This is especially critical in periods of drought. In dry periods, the flow direction is reversed and Lake IJsselmeer water is pumped into the ‘boezem’ to provide water for irrigation. In an average year, more rainwater is pumped out of the province into the large receiving systems than is imported in dry periods in order to manage the accessibility of arable fields and meadows in the spring. This infrastructure

FIGURE 14.3 Subsidence rate observed from remote sensing sources in the province of Fryslân (left, mm/year, green colors approx. 0 mm/yr, red colors in the order of -5 mm/yr). (Source: map portal of the province of Fryslân.) The analysis is based on INSAR techniques. InSAR (Interferometric Synthetic Aperture Radar) maps millimeter-scale deformations of the earth's surface with radar satellite measurements. Total subsidence due to gas and salt mining predicted between 2010 and 2025 on the right. (Source: SWECO (2018).)

FIGURE 14.4 The Fryslân water system, depicting the larger channels and lakes. Note connections to the fresh lake IJsselmeer (South-West, blue arrows), the Wadden Sea and the exit points at Harlingen and lake Lauwersmeer (North, near Lauwersoog, blue arrows). Distance between Lemmer and Lauwersoog is about 70 km. (Adapted from Visplan Friese Boezem (2017).)

is not aiming at replenishing groundwater in wet periods and is therefore not optimal for combating the salinization trend observed in the groundwater. From [Figure 14.5](#) it becomes clear that the average groundwater table in the province is quite close to the surface. In large areas, the distance is between 40 and 150 cm (green hues). It can be seen that in the coastal clay areas this distance is somewhat larger than in the low-lying central peaty areas, where average groundwater level is less than 40 cm below the surface (blue hues).

Depending on groundwater level and water pressures water will either flow upwards (seep) or flow downwards (infiltrate) with respect to the surface level (De Louw et al., 2011, 2013, 2015). [Figure 14.5](#) (right) shows the distribution over the province (Grondwater Atlas van Fryslân, Boukes et al., 2019).

14.2.5 SALINIZATION OF THE GROUNDWATER AND SURFACE WATER

The extent of salinization of the phreatic groundwater is dependent on many factors. This is related to the geography and history of the area. In the case of Fryslân, it is to be expected that the diked and reclaimed areas of the former Middelzee and other branches will contain shallow saline groundwater (De Louw et al., 2009; Oude Essink and Van Baaren, 2009). As there is a fresh groundwater flow going from the

higher East to the lower West a transition zone is found in the center of the province. [Figure 14.6](#) (left) shows the salinity of the top of the saturated groundwater zone and illustrates this process. It is also shown in the figure (right) that in areas of diffuse upward groundwater seepage, the surface level will be exposed to a flux of salt that scales with the concentration in the groundwater times the strength of the seepage flux. From this, it becomes clear that the coastal agricultural areas in Fryslân (but likewise in other areas) are subject to upward fluxes in some places of more than 10,000 kilograms of chloride per hectare per year in the present situation. The risk to vegetation increases when the saline water reaches the root zone in dry periods with high evaporation as the fresh rainwater lens diminishes. Maintaining a salt balance in times of climate change (higher evaporation, more extreme dry periods) requires an adequate water management strategy.

The loading of salt to the surface as calculated by 3D groundwater salinity models is reflected in the measurement of chloride in the surface water found in ditches

FIGURE 14.5 Calculated average distance of groundwater table under surface level (top). Lower picture shows calculated classification of seepage (blue hues) and infiltration (red hues). (Source: Boukes et al, 2019.) *(Continued)*

FIGURE 14.5 (Continued)

FIGURE 14.6 Calculated chloride concentration in shallow groundwater (mg Cl/l, left) and calculated yearly chloride load to the surface caused by seepage (kg/ha/year). (Source: Oude Essink and Van Baaren (2009).) *(Continued)*

FIGURE 14.6 (Continued)

and canals in the coastal area of Fryslân. Figure 14.7 gives an impression of actual measurements. When Figures 14.6 and 14.7 are compared the patterns of the spatial distribution of chloride roughly align.

14.2.6 AGRICULTURE

The type of arable agriculture is always very specific to location and is mainly driven by soil type, water availability, and supporting technical and commercial infrastructure. In Figure 14.8 the spatial distribution of agriculture becomes very clear. The potato is the main cash crop of the region. Within a century of its introduction to the Netherlands, in the 1600s, the potato had become one of the country’s most important food crops. The Netherlands is the world’s major supplier of certified seed potatoes, with exports of some 700,000 tons a year, with a production of on average 45 tons per hectare (yearly value of export is approximately 250 million euro; source: potato-pro website, 2020). A considerable part is grown on the clay soils in Fryslân and Groningen (respectively 21,000 and 85,000 hectares of total cropped area with approximately 20% used for seed potatoes; source: CBS Statline website). In addition, grains and sugar beets are economically important crops of the area.

FIGURE 14.7 Average Chloride concentrations based on biweekly samplings in 1996 (top). Actual Chloride concentrations measured in surface water in the coastal area of Fryslân (bottom). (Source: Wetterskip Fryslan (2020).)

(Continued)

Legend of chloride map

values and color-ranges:

- 0 - 300 mg Cl⁻ /l
- 300 - 600 mg Cl⁻ /l
- 600 - 900 mg Cl⁻ /l
- 900 - 1200 mg Cl⁻ /l
- > 1200 mg Cl⁻ /l

FIGURE 14.7 (Continued)

14.2.6.1 Sensitivity of Vegetation to Salinization

The sensitivity of crops to saline groundwater conditions can vary with a factor of 40 (Maas and Hoffman, 1977; Van Bakel and Stuyt, 2011; Stuyt et al., 2016). Crops such as flower bulbs and cut flowers sustain damage at chloride concentrations below 200 mg/L, potatoes and silage maize at concentrations from 700 to 800 mg/L upwards, grains, grass, and sugar beets at concentrations from 3600 to 4800 mg/L upwards. Sources used by the authors describe research within and outside of the Netherlands and will therefore represent various climatic conditions. Salinization is expected to have a relatively low impact on Dutch dairy farming. Both grassland and dairy cows easily tolerate chloride concentrations up to 2700 mg/L. However, the cultivation of silage maize, an important fodder crop, will already sustain damage at chloride concentrations from 800 mg/L upwards (de Boer and Radersma, 2011). [Figure 14.7](#) gives an impression of chloride concentrations in surface water along the coast of the Wadden sea. Water with the salinities coded with the green and yellow

FIGURE 14.8 Rural land use map of Fryslân. The coastal areas show a dominance of cropping: potatoes (dark brown), grains (yellow) and beets/other crops (light purple); the central and eastern areas show the dominance of dairy farming (green). (Source: WUR LGN map (2020).)

dots are in the critical zone mentioned by de Boer and Radersma (2011) and could produce risks for crops when used for irrigation.

In addition to these large ranges, there is uncertainty on the coupling between the salinity of surface water, irrigation water, and the buildup of salinity in the groundwater. There is scarce data on this topic. Often it is assumed that the root systems are more tolerant to exposure to salinity than the above-ground biomass (van Dam et al, 2007).

Figure 14.9 shows the typical depths of the root systems of common herbs and of a potato plant. Their development is strongly influenced by soil type and water availability. For potato plants, the majority of roots develop in the area between 0 and 60 cm depending on soil conditions.

14.2.7 RISK OF SALINIZATION EFFECTS ON AGRICULTURE

At present, occasional salt damage on crop production is reported (Figure 14.10) (Rozema and Flowers, 2008; Van Bakel and Stuyt, 2011; Stuyt et al., 2016). This was a reason for a consortium of farmers and researchers to start measuring salinization on fields that were suspected of possible salt damage (see also De Louw et al., 2006). It has become clear that impact of salinization is very local, and dependent on small-scale variations in elevation, the configuration of tile drainage, soil type, diffuse upward seepage conditions, and also on the type and sensitivity of crops (e.g., Stuyt et al, 2011; Stofberg et al., 2017).

FIGURE 14.9 Typical root development of various common herbs (left in cm) and potato (in feet, 1 foot = 30,48cm). The potato plant was harvested after 94 days of growth. (Source: Soil and Health (2020).)

FIGURE 14.10 Monitoring ditches and groundwater at plot level (top). Damage of crops due to salinization at a site near Sexbierum (lower left, photo Jouke Velstra, Acacia Water). The graph on the lower right shows a measured cross section of the same field (ERT geophysical measurement) (blue, freshwater; red, salt water).

FIGURE 14.11 Risk of salinization of the root zone of vegetation in the coastal area of Fryslân (Source: Jouke Velstra, Acacia Water) for the present situation (2017) and 2050 (insert) based on average thickness of the freshwater lens above the saline groundwater table. Yellow (low risk), orange (medium risk), purple (high risk of thickness becoming less than 50 cm). (Source: Spaarwaterproject (2020).)

When geographical information on saline groundwater occurrence, seepage, groundwater table, evaporation, and water use by vegetation is combined, a risk of salinization of the root zone of plants can be estimated (see also Stofberg et al, 2017). In Figure 14.11 salinization risk is mapped in three classes based on average thickness of the freshwater lens above the saline groundwater table in relation to the depth of the root zone of vegetation. The calculation includes land subsidence, sea-level rise and a business-as-usual climate change scenario. In the climate change scenario, the risk of a dry year with a net surplus of evaporation of approximately 300 mm has increased in 2050 from 1 in 30 years to 1 in 15–25 years. At present some areas are at high risk; in 2050 these areas have extended due to the increasing risk of salinization in areas that are now classified at medium risk. More information can be found on the Spaarwater website (Spaarwater, 2020).

14.2.8 MONITORING PROJECTS

Many data sources relevant to the salinization issues are available in the Netherlands and in the province of Fryslân. Very important generic information is derived from the monitoring services set up by government and knowledge institutes (for instance elevation maps or land use maps). Information on trends is increasingly derived from free to use high resolution spaceborne remote sensing sources (such as the subsidence data and land use data). Large-scale national and regional modeling and monitoring is based on projects such as FRESHM (FRESH Salt groundwater distribution by Helicopter ElectroMagnetic survey; Delsman et al., 2018, Van Baaren et al., 2018).

In projects like GO-FRESH (www.go-fresh.info; Oude Essink et al., 2018; Pauw et al., 2015), and SPAARWATER (www.spaarwater.com), local-scale fresh groundwater storage and utilization solutions are investigated, while in the project ‘boeren meten water’, participative local-scale monitoring and citizen science is executed (Boeren meten Water, 2020, <https://boerenmetenwater.nl/>). Examples of monitoring and modeling are shown in Figure 14.12. Often the monitoring is supplemented with numerical modeling of variable groundwater flow and coupled salt transport to create a process-based understanding of the hydrogeological situation and to provide a tool ‘to do’ scenario analysis; an example of such a tool is The Netherlands Hydrological Instrument (De Lange et al., 2014). Monitoring is then crucial for validating model outputs. See for instance Deltares Zoetvout (2020) for an overview. In 2019 the Groundwater Atlas of Fryslân was published, based on monitoring and modeling work, in a cooperation between the provincial government, waterboard Wetterskip Fryslân and water company Vitens, providing lots of insights in the status of flows and salinization. More information can be found in Groundwater in Fryslân (2020), based on research funded and published by the Provincial government. Oude Essink and Forzoni (2017) provide an in-depth analysis of the groundwater processes of the province.

These projects are important to establish the groundwater baseline. A project that is focusing on creating awareness on the potential for adaptation to increasing salinity by introducing salt-tolerant crops and links to culinary markets is Interreg SalFar (2017–2020). The website of SalFar can provide more information (SalFar, 2017).

14.2.9 LEARNING FROM THE BASELINE

It becomes clear from this baseline analysis that salinization is a real issue in Fryslân. It can also be concluded that the situation is well understood on the large-scale. Model predictions and observations are in agreement. On the small-scale of farmers’ plots, the situation is quite variable due to variations in farming practices, in soil type and structures, depth to groundwater, and seepage and bed elevation. The sensitivity of plants to salinization is also highly variable. Several cash crops are moderately sensitive; others are quite tolerant. The trend is negative; the risk of salinization effects is increasing in large part due to land subsidence and climate change (Pauw et al., 2010; see for the provinces South-Holland and Zeeland, Oude Essink et al., 2010 and Van Baaren et al., 2016, resp.). In addition, in a 10–30 km zone bordering the coastline, sea-level rise will also become a factor (Oude Essink, 2007; Oude Essink and Van Baaren, 2009; Voorde and Velstra, 2009). In general, it is clear that time scales for change are related to the spatial scale that is observed; changes on regional scale (50–100 km) with deep layers of groundwaters (100s of meters) are measured in decades and centuries. On the local scale of plots, 100s of meters, 2–3 m depth of groundwater, time scales are seasonal, and trends are observed in years to decades. From the baseline data in combination with climate and sea-level rise scenarios, it is clear that salinity levels will increase in more areas and closer to the surface. This will increase the pressure on mitigation and the move towards finding solutions for sustainable adaptation.

Source: Deltares

Source: Deltares, Oude Essink and Forzoni, 2017

(a)

FIGURE 14.12 Examples of regional scale monitoring and modeling of salinity and salinization (a), local-scale monitoring and modeling (b) and a participative monitoring facility on local-scale, see Hoogland et al, 2020 (c).

(Continued)

Source: Acacia Water

Source: Acacia Water

(b)

FIGURE 14.12 (Continued)

(c)

FIGURE 14.12 (Continued)

14.3 TOWARDS A STRATEGIC VISION AND A STRUCTURED IMPLEMENTATION PROCESS

In recent years, anecdotal information on crop damage caused by salinization has been shared by farmers and researchers. During the dry and hot summers of 2018–2019 questions were raised by many on the increasing impact of drought and limited availability of freshwater and the role of salinization as part of this impact. This was the starting point of a process leading to the building of a community of farmers, other stakeholders, and experts in relation to these issues and the setting up of a strategy and implementation process to further the systematic understanding of the issues and stimulate progress toward solutions.

In a bottom-up approach, a working group on salinization with stakeholders (agricultural representatives, entrepreneurs, government, nature management organizations) and salinization experts from various organizations, on request of the government, set up in 2018–2019 an approach towards establishing a vision and strategy to manage the salinization issues.

From the baseline analysis, it was clear that the coastal area of Fryslân (and of the Netherlands as a whole) is sensitive to salinization and that in the remainder of this century the risk of damage to the present type of agricultural production is increasing (Haasnoot et al., 2013, 2018, 2020). This will also impact on the characteristics of natural areas as they are situated in the same areas that will be affected. The baseline analysis shows that this impact will be variable in time and space. There is an increasing need to shift from a freshwater-dominated system towards a system that needs to accept and deal with more saline conditions (Speelman et al., 2009). The timing and location and necessity for such a shift will depend on the local situation.

From this perspective a distinction was made between mitigation and adaptation driven pathways to solutions (e.g., Stuyt et al., 2006; Kempenaer et al., 2007; Haasnoot et al., 2013; 2018).

- *Mitigation:* Taking measures (on small- and on larger-scale) to maintain the present system of cropping. This points to measures (optimized drainage, anti-salinization drainage, optimized irrigation, water management) that guarantee the long-term availability of sufficient freshwater resources.
- *Adaptation:* Adapting the land use to the changing environment. For example, switching from sensitive crops or varieties to tolerant crops or varieties, switching from agriculture to other land uses such as nature, or adapting the nature type of the area. This also means that local drainage and water management for a larger area should be adapted.

This has led towards formulating the following strategic objective for the region:

To aim at creating a climate robust area, with solutions implemented on the right scale that fit within the variable timing and location of increasing salinization, supported by the communities, and that are taking care of the local social, economic and natural values.

From this strategic objective, four operational objectives were formulated, that will be guiding the practical approach towards achieving the strategic objective:

1. *Increase the awareness of risk of salinization:* This will be made operational by implementing monitoring campaigns, sharing information, and overcoming taboos by initiating discussions on the topic. Awareness will help initiate a transformation process that is supported by stakeholders and citizens. The transformation process will help to find and accept location- and region-specific solutions that lead to a new socio-economic élan in the affected area.
2. *Increase understanding of the salinization impact:* Increasing knowledge needs to be translated into information that can be used for decision-making. This means that for each location and region a clear link between existing land use and functions needs to be established with salinization level and trends. This should lead towards the definition of tipping points that can help to decide if, where and when, decision-making and investments are needed for mitigation and adaptation solutions (Kwadijk et al., 2010).
3. *Clarify the effectiveness and scope of solutions:* Through field trials and learning from existing cases insight has been created on the various types of solutions that are effective from a technical, business, biological, ecological, and landscape perspective for the mitigation and adaptation pathways. Through cooperation and sharing of information this portfolio of solutions is shared and supported by stakeholders. Through experiments and pilots, new solutions will be researched leading toward innovations in technical, business, financial, and governance domains.
4. *Preparing financial arrangements and facilitating governance:* It is expected that mitigation and adaptation changes on local and regional scales will require large investments to adjust infrastructure on the scale of individual entrepreneurs and farmers (drainage, equipment, crops) and on the scale of regions (for instance in relation to water management). It is obvious that municipal, water board, provincial and national governments will be instrumental in facilitating this change as many regulations managing the present status quo will be challenged (for instance water levels and water quality related). It is very important to stimulate change by selecting and facilitating the frontrunners to develop pilots with the aim of creating convincing demonstrations fitting into the local and regional context.

The four operational objectives resemble four major hurdles that are to be overcome in order to realize transformations (awareness, understanding of the system, feasible solutions, operational financial and governance arrangements). Working along the lines of these operational objectives will result in a diversity of solutions, ensuing business models on a diversity of locations, and result in a coastal landscape and land uses that are probably more diverse in space and variable in time than today.

14.3.1 IMPLEMENTATION OF A STRUCTURED PROCESS-BASED APPROACH

After formulating the strategic vision and the four operational objectives, a process is needed to be set in motion. For this process, the ABCD roadmap structure has been selected as an important building block (Figure 14.13). The roadmap encompasses an iterative process where the establishment of a baseline of system understanding (B, described in Section 1) and visioning (A, described as strategic and operational objectives in Section 2), are logical starting points and endpoints of a road (or in our case, the two pathways of mitigation and adaptation). Along the road, many solutions are proposed and studied (C in Figure 14.13) and a so-called ‘Living Lab’ process is implemented to evaluate solutions’ success and decide on next steps fitting in the operational objectives and towards the strategic objective (D). In time, due to increased understanding, in an iterative manner, the baseline will move forward and the vision will be reiterated to better reflect what is known at that point in time.

14.3.2 SETUP OF THE FJILDLAB LIVING LAB

To make this ABCD Roadmap process work, people should work together towards the shared vision. In Fryslân emphasis by government is put on organizing and stimulating the ‘Mienskip’, the community, as supporter and host of transformational processes. As this process needs a home, the Fjildlab Living Lab (Figure 14.14 for an illustration) was set up in the region, involving representatives from the quadruple helix. In a Living Lab, the conditions are created to make progress as a group, welcome new ideas, support project teams, learn from each other and from projects

FIGURE 14.13 ABCD Roadmap backcasting and strategic planning approach to innovation. (Source: Holmberg and Robèrt, 2000.)

FIGURE 14.14 Fjildlab Living Lab as ‘Mienskip’ (Frisian word for ‘Community’) of many partners for learning, research and innovation is implemented in the Fjildlab Regiideal program.

and pilots, consolidate knowledge and create support and awareness by involving stakeholders and citizens. A Living Lab is linked to a region; it is therefore culturally and socio-economically connected and sensitive and is open to new projects and contributors in order to allow adaptation of focus in time.

For the coming 5 years (2020–2025), the Fjildlab Living Lab (www.fjildlab.nl) is stimulating the interaction between the involved parties and project teams by providing a home with supportive infrastructure. In addition, the community is promoting the Agricultural Research Institute SPNA as a central location for experimenting and demonstrating salinization mitigation and adaptation solutions at a plot scale on clay-dominated soils (<https://www.spna.nl/>).

14.4 NEXT STEPS TOWARD SALINIZATION-PROOF AGRICULTURE

So far, a baseline has been established, a vision has been formulated, a process and hosting organization has been put in place. These are the major building blocks to achieve progress and assist in working toward the transformation that is required. At this point in time focus is put on working on the awareness raising objective and further increasing the understanding of the impact of increasing salinization. Many projects have been put forward and are now under consideration by funding organizations. The list of projects under execution and in planning (status September 2020) is impressive:

- Saline Farming, Interreg, 2016–2020, led by Province of Groningen;
- Implementation of salinization experimental farming facility on clay soil (2020–onwards), led by SPNA;
- Boeren meten Water awareness raising projects with implementation of monitoring on clay and peat soils, leads Acacia Water and LTO;
- Spaarwater projects, smart underground storage of freshwater, lead Acacia Water;

- Zoet op Zout program, overarching program structure integrating monitoring work, experiments and water management issues related to salinization, lead LTO;
- Zoute Verdienmodellen (investigation of business models for farmers in salinizing areas), Acacia Water for Programma Rijke Waddenzee;
- Fjildlab Living Lab, with an expert group on the theme of salinization and link to academic and professional education; Lead by farmers collectives, entrepreneurs and applied sciences university;
- Weerbare Waddenkust, A vision on creating a Wadden Sea coast that is economically vital and safe against flooding in times of sea-level rise, product of WUR, Deltares and VHL.
- Setting up a center of expertise on Salt-tolerant Farming, initiative of Province of Fryslân and The Potato Valley alliance.

Given this wealth of initiatives, a need arises to do a meta-level analysis to identify underdeveloped subjects that still need more focus to allow required innovation. This can be done in the Fjildlab Living Lab facility. For instance, viable business models, for instance on creating new products and developing new markets, are needed but are still rare or under-developed. A good mix of pilots linking the local- and regional-scale will be instrumental in developing new business models. All projects need to feed information on findings into a steady growing base of generic pre-competitive knowledge and know-how that is shared and can be used for training and education, and to facilitate the next generation of innovations, even beyond this Northern region. At this crucial stage of the process active support from government is needed to facilitate financial and regulation opportunities to frontrunners in exploring the mitigation and adaptation pathways, and in establishing a Center where the knowledge and know-how can be shared for the benefit of all.

From a governance perspective, this regional initiative needs to be embedded in a national perspective and programming. This is relevant for ministries of I&W and LNV in their task to manage and steer developments toward climate adaptation. In all coastal provinces of the Netherlands, salinization is recognized by politicians as a topic of importance and as a result it is getting embedded in supportive policies of the ruling parties. In 2020, the ‘Zoet-Zout Knooppunt’ initiative is taking off to facilitate this link between regional and national perspectives.

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