# Improving soil structure of an arable crop farm in the district of Heilbronn (Germany) [1]

Image from Climate Adapt about this case study [2]

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In the framework of the LIFE AgriAdapt [3] project, more than 120 pilot farms are testing sustainable adaptation measures to enhance the farm resilience to climate change, reduce greenhouse gas emissions and improve the farm competitiveness. One of the pilot farms is located in the hilly Kraichgau region of the Heilbronn district in Germany (Baden-Württemberg State), at an elevation of 120-250 m above sea level (another case study taken from AgriAdapt is available for Segovia, Spain [4]). 80% of the soils of the region are loamy clay with a high water storing capacity.

The yearly average temperature in the main production site is about 10°C, while average yearly precipitation is 720 mm (both calculated for the period 1987-2016). The main cultivated crops are irrigated potatoes and sugar beet. However, from the 240 ha of the Utilized Agricultural Area (UAA) of the farm, 90 ha are cultivated in the Rhine-plain, where the average temperature is 1º C higher. This condition allows the farmer to grow early potatoes and soybeans. The main crop rotation is “sugar beet – winter soft wheat – winter rapeseed – winter soft wheat – potatoes – winter soft wheat” in the main production site, and “soybean - winter soft wheat – winter rapeseed – winter soft wheat” in the Rhine-plain.

Increasing extreme weather conditions, such as spring and summer droughts and spring heavy precipitations, are already affecting the agricultural sector in the region, causing an increase in crop yield variability and a risk of losses in crop productivity. These conditions impose the urgency to adopt effective adaptation options to stabilise crop yields and to produce high quality crops. To cope with climate change, the farm is implementing different crop management measures, in particular to improve the soil structure. Indeed, a good soil structure is essential to increase the water storage capacity of the soil, reduce erosion, enhance soil biota and increase the nutrient availability for the crops, which help overcoming climate change challenges affecting the farm. Four different and very versatile catch crop mixtures are grown before spring crops and after early potatoes to tackle the improvement of soils. These mixtures are mainly composed of species such as tillage radish, clover, phacelia, pea, *Avena strigosa*, vetch or mustard, among others.

Case Study Description

**Challenges:**

The AgriAdapt project assessed the vulnerability of the farm in the hilly Kraichgau region for the current period and for the coming 30 years, considering the climate projections developed by ETH Zürich (Institute for Atmospheric and Climate Science) for the SRES scenario A1B, the one used in the Agri4Cast [5] portal of the European Commission which provides agro-climatic indicators. According to such projections, the number of days with temperatures above 25°C is expected to increase from 25 to 38 days per year in the period May-August in the next 30 years. A decrease in the water balance (difference between precipitation and evapotranspiration) during the summer months, especially in July and August, is also projected. This implies that less water is expected to enter the system through precipitations, and more water is expected to exit the system through evaporation and transpiration. These conditions will directly affect grain filling and ripening phases of cereals, leading to an earlier ripening which means smaller seeds and lower yields. Sugar beet yields will be affected negatively by these two factors as well, since they will lead to a lower growing rate and consequently lower yields.

According to above projections, number of tropical days (days with peaks of maximum temperatures above 30ºC) from May to August are expected to increase as well of about 27% in the near future (next 30 years). This, in addition to the expected drier conditions in July and August, can interrupt tuber growth in potatoes, lead to a greater dependency on water irrigation and also to a lower quality of crop production, as recorded in the hot and dry summer of 2018. Moreover, the occurrence of drought periods during harvest can cause the formation of hard soil clusters in drier soil that can damage the potato peel. The expected increase in heavy precipitation during the growing period (late spring) can also damage potato by washing away the ridges and exposing tubers to solar radiation.

Although the yearly average temperature is increasing, according to the AgriAdapt vulnerability assessment there is a slightly higher risk for late frost in April when the potato plants are in their juvenile phase. Two or more days with temperatures below -4°C can lead to a dying off of the potato leaves and therefore to a developmental delay.

Winter rapeseed will also be affected by the projected increase in tropical days and drier conditions, especially if extreme events will occur during the most sensitive flowering and ripening phases, causing a reduction of the seed oil content and an earlier ripening with consequent lower yields. Finally, the expected warmer conditions in autumn and winter could lead to a higher risk of weed, insect and pathogens infestation.

**Objectives:**
Based on the results of the assessment, the farm in Kraichgau region implemented measures and practices to reduce its vulnerability to climate change in the near future, in particular improving soil conditions, increasing soil organic matter and making farmers more aware of expected risks and possible solutions.

**Solutions:**
Based on the vulnerability assessment a set of adaptation measures was selected to be implemented in the farm, focusing on improving the soil structure as a way to cope with climate change challenges. A good soil structure, with an active and diverse soil biota, allows, among other benefits, to: (i) increase the infiltration rate, the capacity to absorb the (heavy) rain and store it over a longer period, (ii) avoid nutrient loss and (iii) reduce wind or water erosion.

To reach this objective, the farm is using four different and very versatile catch crop mixtures with 15 different species (e.g. tillage radish, clover, phacelia, pea, *Avena strigosa*, vetch, mustard). These species have different characteristics in terms of root development, root exudates production, resistances against pests and diseases and nutrient requirements. Different root systems are able to reach nutrients at different depths and avoid their loss by leaching or water runoff, releasing them in the upper layers when the catch crop is mown. Legumes species (pea, clover or vetch) in the catch crop mixture can fix the atmospheric nitrogen in the soil thanks to their symbiosis with bacteria, while brassicas species (such as radish or mustard) can reduce the risk of fungal diseases and nematodes attacks due to the glucosinolates they release when are mown. Moreover, the high diversity of species within the mixture allows the farmer to break pest cycles and cover the soil as much as

possible to minimize erosion.

No tillage on the hilly sites in the direction of the slope and reduced tillage in the rest of the farm (except in the case of areas cultivated with potatoes) are other measures being implemented to reduce soil erosion. Moreover, the tyre pressure of tractors and other agriculture machinery is controlled and adapted to preserve the good structure of the soil during field work. Wheat is also sown between the rows after potato planting to avoid washing away of the soil during a (heavy) rainfall.

Beyond improvement of soil structure, other measures such as the inclusion of new varieties better adapted to climate change are also being implemented. For instance, in the Rhine-plane clover-grass was replaced by alfalfa grass, as this has the ability of very deep rooting and therefore is more drought-tolerant than clover. An earlier ripening winter soft wheat variety "*Rubisco*" is cultivated to avoid the mid-summer heat in August. Moreover, this variety has a high yield potential even under dry conditions and its long awns protect the plant from heat stress. Six other winter soft wheat varieties are cultivated on a smaller plot in the farm to find out the most suitable variety for this location. In the Rhine-plane, also soy beans, which prosper under warmer conditions, are cultivated.

The sowing dates are also being adapted to the increase in temperature: (i) later sowing in autumn aims to reduce the sensitivity of plants to pests like aphids and cicadas, which could be vectors of pathogens, while (ii) earlier sowing in spring enables to avoid the summer heat and drought. In particularly hot days the farmers applies supplementary irrigation to cool down the ridges of potatoes and avoid the overheating of the tubers. Moreover, algae products are applied to improve the rooting of the main crops cultivated in the farm.

Within the project, a new climate risk assessment will be performed to monitor the performance and efficiency of the implemented adaptation measures. Moreover, yields and feedback from the farmers are regularly checked to verify the expected benefits of these measures.

**Importance and relevance of the adaptation:**
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Additional Details
**Stakeholder engagement:**
The key actors involved within the frame of the LIFE AgriAdapt project in the vulnerability assessment and implementation of proposed adaptation measures are the owners of the farm and the Lake Constance Foundation (leader of the LIFE AgriAdapt project).

Furthermore, project objectives and results are communicated to other farmers, cooperatives, technicians and agronomists (at both local and national level) through workshops, conferences and seminars.

**Success and limiting factors:**
The farmers involved in the project are aware of the risks entailed by climate change and therefore willing to adopt measures dealing with the expected impacts, to ensure stable yields and high level quality of the products. The success of the adaptation measures is strongly dependant on farmers' local knowledge about specific implementation aspects and expected benefits of the measures. Positive experiences with the new implemented solutions (e.g. cultivation of new varieties and crops or a versatile catch crop mixture) may also convince neighbouring farms to implement similar adaptation strategies.

In the case of the introduction of news crops, one of the major constrains which may affect the implementation of the adaptation measures is related to the market demand or possible alternative uses of these new products (e.g. soy beans produced in the farm can be sold to a cooperative for horse feed). A further limiting factor is that, at the moment, there are not varieties tolerant to drought and heat for every crop, and plant breeding takes about 10 years to develop new varieties. The implementation of different soil tillage techniques may be constrained by high cost (for example, an integrated automatic tyre pressure control system may cost about 3500 – 8000 €) and also because the agricultural contractors have not included this technique among the services they provide to

the farmers.

**Budget, funding and additional benefits:**
The vulnerability assessment and the elaboration of the action plan to implement sustainable adaptation measures was financed by the AgriAdapt project, funded by the European Commission through the LIFE Program and co-financed by the Ministry of Rural Affairs and Consumer Protection of Baden-Württemberg, Landwirtschaftliche Rentenbank, OMIRA and Landkreis Bodenseekreis. The cost for producing the assessment and the action plan of this farm amounted to 5,000 €. Adaptation measures are being implemented between 2017 and 2019, so there is not still a proper estimation of costs. However, most of them are not supposed to have extra costs for the farmer, and in some cases, savings are expected.

The implemented adaptation measures are expected to: increase the production efficiency of the farm, reduce farming costs, improve soil conservation, reduce erosion, prevent pest and diseases, increase soil carbon sequestration, increase nitrogen content and avoid nutrient loss. The monitoring process of the expected benefits of the implemented measures entails permanent contacts with the farmers, enabling to check feedback and assess yields during the lifetime of the project.

**Legal aspects:**
The EU Flood Directive is implemented by German Federal States through flood strategies, as in the case of the “The Strategy to reduce the flood risk in Baden-Württemberg”. According to such strategy, measures which can reduce the flood and soil erosion risk on agricultural fields focus on the improvement of the soil structure, including: versatile catch crops cultivation, diversified crop rotation, vegetation on the fields (preferably throughout the year) and reduced soil management.

The European Nitrate Directive was implemented into German law by the fertiliser ordinance (*Düngeverordnung* ), aiming to reduce the amount of nitrate in the groundwater. The use of catch crops before summer crops is one of the measures being discussed to contribute to the implementation of the fertiliser ordinance. In fact, catch crops hold the nitrogen in place and avoid its loss by leaching or water runoff, preventing pollution of nearby water bodies. At the moment this is still considered an optional measure, but farmers get remuneration if they commit to its implementation, as in the case of the farm involved in AgriAdapt.

**Implementation time:**
AgriAdapt project started in 2016. The vulnerability of the pilot farm in the hilly Kraichgau region was assessed in 2017 and adaptation measures were proposed in 2018. At the moment, the implementation phase is in process.

Reference Information
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**Websites:**
http://www.agriadapt.eu [7]

**Sources:**
AgriAdapt project, co-funded by the LIFE programme

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