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Drought and water management in the German agricultural sector - a participatory system dynamics approach

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Higher temperatures and changes in precipitation patterns caused by climate change may potentially affect water availability for agriculture and increase the risk of crop loss in Northeast Lower Saxony (NELS), Germany. The drought of 2018 showed that an intensification of irrigation might be a temporary solution. However, a long-term increase in water extraction, especially during drought periods, is not a sustainable solution. To assess possible water management solutions, we implement a participatory system dynamics approach, namely Group Model Building, to develop a qualitative system dynamics model (QSDM) describing the agricultural system and its relation to water resources in NELS.

The development of the QSDM seeks to understand the complexity of the interactions between agriculture and hydrological systems, recognize the stakeholders' needs and identify risks and weaknesses of both systems. By understanding this, we expect to reinforce the adaptation process, reduce conflict and be able to suggest tailored solutions and adaptation measures. The QSDM incorporates a wide range of perceptions, as twenty stakeholders ranging from farmers, government agencies, environmental protection organizations and local water authorities were involved in the QSDM development. Their perceptions were recorded in the QSDM through individual interviews and a group workshop.

Through the QSDM, we identified and mapped the structure and connections between agriculture and the water balance. It was also possible to identify the strongest feedback loops governing both sectors as well as their influence on the current situation. The loops represent behaviors and structures, which might become unmanageable under climate change conditions. The causal loops include the different uses for the available water of the region, the impact of irrigation, the significance of crop selection and the importance of sustainable soil management.

By analyzing the system this way, we confirmed that climate change poses a risk to the region as elevated temperatures could increase the crop water demand and increase the need for irrigation. In the same way, changes in the rain patterns could affect the water balance of the region. The agricultural system has, however, potential to adapt by implementing new water management strategies such as restructuring water rights, water storage and reuse and conjunctive water use. Other measures include increasing the irrigation efficiency, changing crops and enhancing the soil quality, among others.