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Working paper

An expert workshop on integrated drought risk management (DRM): Identifying synergies and trade-offs for the Austrian agricultural sector

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Abstract

In this working paper we present the findings from an expert workshop on integrated drought risk management (DRM) for the Austrian agricultural sector, with a focus on crop farming. We argue that the nature of most DRM measures, which serve several purposes besides addressing drought risk such as soil management, requires an integrated approach, considering risk management efforts from actors beyond the farm level. Thus, the main objective was to identify synergies and trade-offs between decision areas from plant production to trade, across the spectrum of public, private and third sector actors.

We describe the expert elicitation process including the workshop design and pre- and post-workshop procedure. We had limited success encouraging systems thinking in this process and highlight the potential for developing such methods further. Most importantly, however, our findings intend to inform deliberations on holistic and integrated DRM, with the aim of achieving greater policy coherence in relevant decision areas, and ultimately, enabling greater societal drought resilience. While on-farm production-based DRM is well advanced, the links (synergies and trade-offs) to related areas of decision making such as trade, spatial planning, and transport need to be better understood.

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Introduction

Thinking about drought risk management (DRM), farm-level and production-based measures come immediately to mind, most importantly irrigation, crop selection, soil management, and, if available, perhaps drought insurance. Many of these measures serve multiple purposes: Crop-selection can be targeted to reduce impacts of heat and drought, but is driven by many other factors, such as soil, market value and crop rotation. Similarly, soil management does not exclusively target drought risk, but serves many other purposes, for example, reducing soil erosion and carbon emissions. In Austria, drought insurance can be purchased only in combination with other insurance products. Ultimately, only irrigation remains a management option with the explicit and single purpose of addressing drought.

Indeed, there are many risk management options at farm level that may not target drought risk directly but serve overall risk-management, such as income diversification, various insurance products and savings. Such measures can serve to manage the follow-on effects of droughts.

DRM may also happen at other levels of decision making, often, but not always, attempting to enable farm-level DRM. Public and private actors may, for example, provide large scale infrastructure for water distribution, groundwater recharge and irrigation; or foster R&D with respect to plant breeding. In the future, digitization and artificial intelligence may improve (drought) risk management and resilience. Public policies and regulations may provide carrots or sticks for DRM. For instance, providing subsidies for irrigation or by creating incentives for adapting tillage practices.

However, because DRM is so tightly embedded in other farming practices, policy areas, and sectors, any policies or regulations affecting the agricultural sector may inadvertently increase drought risk or decrease drought resilience. Thus, apart from manifold synergies, we might also face trade-offs. It is of key importance to be aware of both synergies and trade-offs, as well as the current limitations of DRM. Identifying these was the main task of the FARM expert workshop.

Most importantly, our findings intend to inform deliberations on holistic and integrated DRM, with the aim of achieving greater policy coherence in relevant decision areas, enabling greater societal drought resilience. For this purpose, we produced a German language policy brief which we distribute together with experts, so it can be brought into deliberation and decision-making processes, for example in the context of climate change adaptation. The most important purpose was, however, to bring these integrated issues to the attention of the experts present, most of whom are part of important multiplication platforms themselves, and are now equipped to bring a more integrated view into relevant policy processes in their own institutions.

Drought risk management vs. drought resilience

Integrated and holistic risk management strategies ideally build resilience, i.e. they enable a system to manage risks, while achieving its other social and economic objectives. We therefore can think of drought resilience, when we consider DRM in an integrated and holistic way, i.e. as the purposive combination of risk management measures in a mutually reinforcing way, aiming to reduce negative trade-offs and increasing synergies. While resilience can be applied at different scales (e.g. an organism, the farm), we consider the bigger – societal – picture including those measures and strategies, taken at higher levels of governance and by private actors (see section 2).

Trade-offs and synergies

Figure 1 provides a loose reference framework for DRM and resilience measures and for identifying synergies and trade-offs: We assume the farm as the baseline, where most DRM measures are put into place, and which is strongly influenced by measures at higher levels of governance from public ministries, associated agencies, to national and international markets, retailers, and consumers. In the center of this spectrum are actors, such as interest groups, non-profit research, and insurance companies, which operate with public subsidies, and/or in close cooperation with public institutions.

The arrows in the figure broadly indicate areas for synergies and trade-offs within and across public and private domains. The yellow backdrop reflects the scope of measures ranging from specific risk management measures to broader, integrated efforts to enhance resilience.

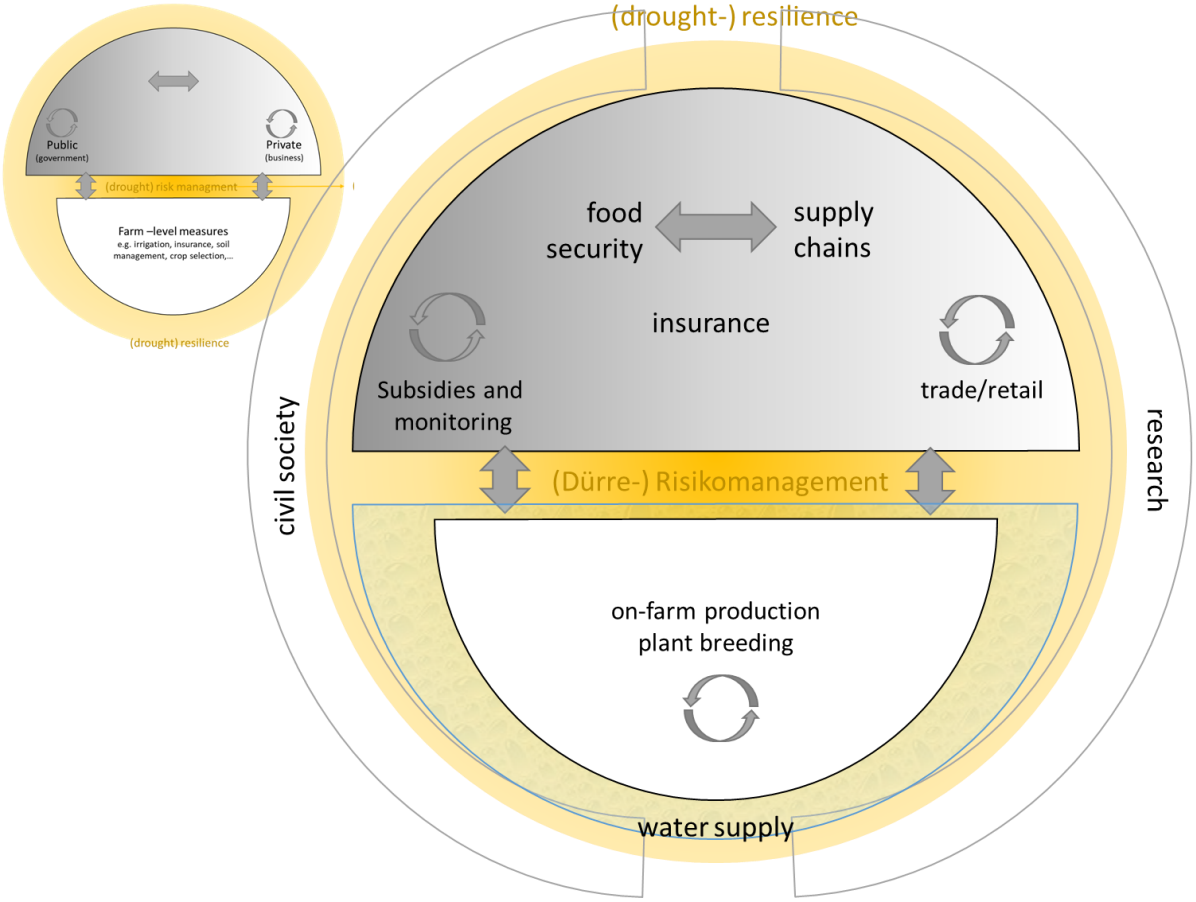

Figure 1: Reference framework for identifying drought risk and resilience measures, and respective synergies and trade-offs. We adapted an early version reflecting the workshop participants and their contributions.

Risk management vs. resilience[1]

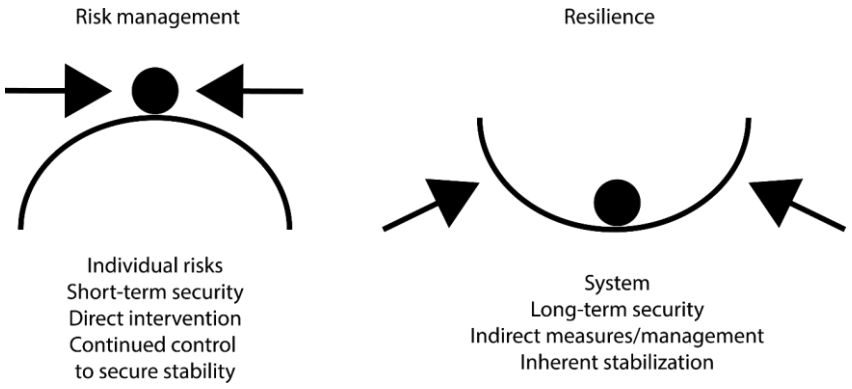

Figure 2: Conceptual framing of risk management and resilience. Adapted from by Erisman (2016) and Ten Napel et al. (2006)

Conceptually, a useful distinction between risk management[2] and resilience has been proposed by Ten Napel et al. and Erisman et al. (Figure 2): On the one hand, risk management frequently addresses single risks, in our case drought, and is concerned with short term risk reduction or coping. It involves direct interventions seeking stable equilibriums. On the other hand, resilience is concerned about the system, i.e. a holistic view, thereby establishing long-term stability that is an inherent part of the system design. It involves indirect management measures that address not only the problem at hand. This also means, that risk management and resilience are not mutually exclusive applications but can be considered complementary. Then risk management is a means that may help create a more resilient system. This is particularly the case, when we consider advanced risk management, where multiple risks or even systemic risks are considered (Renn and Klinke 2004).

While a holistic approach seems reasonable, if not intuitive, it is important to acknowledge that resilience thinking is only useful if it encompasses risk management. Unlike with sudden onset disasters, where the distinction between risk management and resilience can be very pronounced, this is less so the case with slow-onset events such as drought. The fact that droughts may happen over long periods of time requires a more resilience type of thinking, such as the long-term perspective and the relevance of indirect management. This is reflected in different classifications of DRM measures (section **Error! Reference source not found.**). These instances show that DRM, adaptive behavior and resilience are tightly linked, even overlapping, and thus largely synonymous ideas. From a systems perspective on the present case of drought we find it comprehensible to consider DRM as a (bundle of) measure for achieving drought resilience as the target.

[1] This text is from Hanger-Kopp, S. and M. Palka, M.: "Exploring drought resilience through a drought risk management lens in Austria". In: Muneta, Y. and Hochrainer-Stigler S.: Disaster Risk Reduction and Resilience. Springer

[2] We use the term risk management as a verb denoting the process of choosing a measure that may reduce anticipated negative impacts or helps coping with those impacts once occurred. This may imply also a level of (informal) risk assessment.

Moreover, it has to be clear at what levels the system boundaries are drawn for an application of resilience. The negative effects of any drought firstly affect farmer's livelihoods, and only then markets and political decisions. Therefore no "one-size-fits-all strategy" can and should be presented. In fact, any choice of management measures will be influenced by regional climatic and ecological conditions, market mechanisms and the political situation (Azadi et al. 2018; Bressers, Bressers, and Larrue 2016).

Method – Expert elicitation workshop

The workshop followed an exploratory approach, aiming to identify trade-offs and synergies faced by actors in various areas of drought risk management. Thus, we provided only limited guidance in a simplified systems approach with the intention of creating as little bias as possible. In line with our project set-up and resources we combined elements from various approaches that focus on eliciting information from individuals (Morgan 2014; Trutnevyte and Azevedo 2018) as well as group-based efforts (e.g. Doria et al. 2009). We did not aim at generating quantitative data or quantitatively analyzing results or generating consensus on topics as, for example, attempted in the Delphi method. This means we followed a set of pre-elicitation activities including problem definition, identification and recruitment of experts, development of an elicitation protocol and briefing material. We designed a group elicitation session (the workshop), which included motivating experts, as well as information presentation and discussion. Finally, post-elicitation activities included individual debriefing based on the workshop protocol to elaborate on and confirm insights.

Expert selection

We approached Austrian experts, focusing on the national level, to represent diverse decision areas associated with agricultural DRM. Farmers were not our explicit target groups as in related work we focused heavily on the farmer's perception. We deliberately chose the vague term "decision area" to encompass any aspect or topic that is relevant to DRM, but may be found institutionalized in different shapes and form, or not institutionalized at all. For example, those aspects relevant to DRM, such as plant production, which is a decision area of a dedicated section of a ministerial department, but also of plant breeding companies and farmers. Or food security which is an overarching area that is topic of an entire government agency, but obviously related to different organizational units in and outside the government.

Our rationale was to have a small number of participants, who would all actively participate in the workshop, rather than a large audience that would listen to a set of presentations. This set a limit to the different decision areas represented at the workshop.

We consider experts not necessarily to be academics or researchers but knowledgeable in their decision areas. Moreover, we asked participants to self-determine whether they felt capable to address the questions posed in the workshop. We thus tried to achieve diversity across a public-private spectrum of decision areas, with research and civil society as overarching these two domains (Table 1). We approached the heads of department of institutions and companies, whom we knew from prior research in the FARM project to be relevant for this topic.

Public				**Private**
Government ministries	Government agencies	Legal interest groups[3]	Non-profit insurance	Company/private research
Ministry for Tourism and Sustainability - Department for Plant production	Austrian Agency for Health and Food Safety (AGES), Austrian Paying Agency for Agriculture and Rural Development (AMA)	The chamber of agriculture did not react to our invitation	Austrian Hail Insurance	Raiffeisen Ware Austria AG (RWA), Marchfeld Kanal Gmbh, Donau Saatzucht
Research and civil society University of Natural Resources and Life Sciences – Department of Economics and Social Sciences Global 2000				

Table 1: Participants in the FARM expert workshop on a stylized public-private spectrum.

We asked participants if they considered the workshop participation to be inclusive, that is, whether all relevant experts were represented (or invited to attend). We received no additional suggestions, which we had not (unsuccessfully) explored before.

Expert preparation

All experts who participated received a briefing document prior to the workshop to prepare for the contents to be discussed and our workshop rationale. This included instructions for the focus of their presentations. The materials overlap largely with the introduction to this document, and the analytical framework (sections 1 and 2), as well as some stylized systems diagrams to illustrate how we would like them to think about synergies and trade-offs (Figure 2).

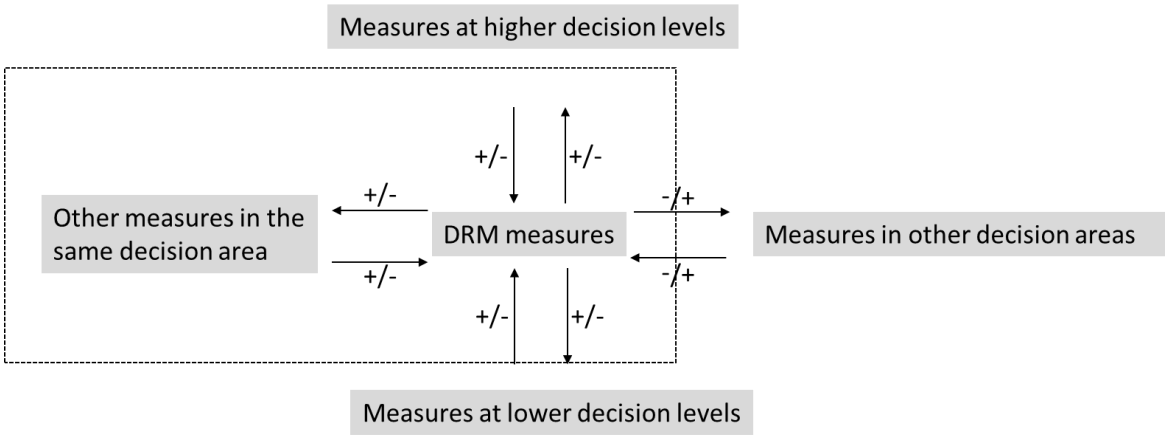

Figure 3: Stylized causal diagram illustrating boundaries of the problem from a participant's perspective as well as potential areas levels of synergies and trade-offs. The dashed lines indicate the boundary of the respective decision area

We asked three guiding questions, which we also used to structure the results section:

[3] Austria has a system of public interest groups representing business, employees, and agriculture, which is established and governed by law. These interest groups are particularly influential in the public decision space, have considerable resources, and serve as important platforms providing and sharing information among different actor groups.

1. From your professional point of view, how would you define drought risk?
2. Which DRM measures are important in your decision area?
3. Which synergies and trade-offs do you see with other measures in your and adjacent decision areas?

We highlighted that presentations should focus on their own area of expertise and that of their department/organization/institution.

The workshop – eliciting information

We designed the workshop to allow for active involvement of all 13 participants (for participant list see Annex II). Thus, the number of participants was limited by the time available, which in turn was subject to the amount of time participants were willing to spend on a workshop.

Two short introductory presentations served to reiterate the rationale and purpose of the workshop and give some insight into relevant FARM research on the farmers' perspective – this served as a baseline (see figure two for the expert inputs). The experts provided their response to our questions in the format of short presentations of about 10-15 minutes – one per institutional department present which was directly followed-up with discussions of the respective contents. This discussion followed only a brief informal summary, whereas a systematic synthesis was planned as part of creating a joint policy brief as output of the workshop. We decided to go with the shorter, informal summary to allow enough flexibility for presentations and discussions given the short amount of time available (see Agenda in Annex II).

All participants who signed up were present at the workshop, however, during the afternoon part many left. This shows that time available for productive work is limited.

Preparation of joint policy-brief

Based on the workshop briefing document we developed a policy brief that included a systematic summary of the presentations according to the three questions and including the discussions. This allowed us to systematically follow up on inputs and ensured an accurate representation of the contents and issues presented.

The extent of involvement of participants in developing the brief varied from a read and consent to publish the text as is to extensive comments on content and language.

The joint policy-brief is written in German (see Annex I) and is in evidence with all participants in order to serve as input for upcoming policy-discussions. We thereby take into account that the information provided may not be of immediate use apart from the individual information gains of workshop participants. We rather expect windows of opportunity, when the workshop results can usefully contribute to policy discussions going on in various private and public contexts. The intention is to follow up and monitor uses throughout the coming year and incorporating feedback and comments in new research (proposals).

Limitations and methodological lessons

The advantages of an expert workshop are to get the focused attention of several experts at the same time, the interaction between experts of different areas, and the opportunity to immediately ask clarifying questions. Expert workshops, or expert elicitation as a method are also subject to limitations. Most importantly they are limited by the available time that most experts are able and willing to spend on such events, thus planning for the most productive workshop set-up is difficult. Also, time for pre- and post-workshop collaboration may be limited. This in turn as well as the diversity of expertise and background requires a certain amount of flexibility in the workshop design as expected contributions may vary. Individual interviews might have given the chance of more in-depth discussion and better unfolding the systems

perspective, but also required more resources. Moreover, it does not provide the opportunity to exchange information and knowledge across decision areas, which is an important incentive for many decision makers to participate in elicitation events.
Any elicitation of information from individual or groups of stakeholders are subject to a list of potential systematic errors. At each stage we aimed to reduce these errors, most importantly selection bias – for which we tried to avoid over- or underrepresenting relevant decision areas; and availability bias – where we refrained from prompting specific categories or aspects, in order to not influence the range of measures and options. However, it was our conscious choice and we explicitly asked participants to move away from a strictly on-farm production-based view of DRM.

Results

We present results according to the various decision areas represented at the workshop, and structure each sub-section based on the guiding questions we provided for all participating experts. Presenting the results based on cross-sectional issues was not feasible, as perspectives are still very much restricted to existing domains. This is an important finding in itself, and a challenge, which this workshop attempted but could only start to overcome.

On-farm agricultural production

The insights for this section also constitute a summary of findings from elsewhere in the FARM project. They were inevitably part of the discussion during the workshop and were thus included here for completeness.

1. What does drought risk mean?

As reported by crop farmers, drought risk refers most importantly to losses in yield and thus income due to extreme heat and dryness. Not even in Austria is this a completely new phenomenon; however, recently farmers' awareness and anticipation of frequent heat and drought has grown considerably (Hanger-Kopp and Palka, submitted).

2. Which management measures are important

Measures that crop farmers associated with DRM are irrigation, soil management measures, and crop selection, as well as adapted sowing and harvesting times. These are also those measures targeted by public policy and research and development measures.

3. Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?

- Irrigation is expensive and time-consuming.
- Conflicts between water uses, e.g., drinking water, agricultural irrigation, industrial uses, swimming pools, over available water resources in especially hot and dry periods are very likely.
- Conservation tillage (as a measure for better infiltration, soil health, increasing water retention capacity, and reducing erosion) may increase susceptibility to pests and plant diseases.
- For plant breeding and -licensing see section 5.2

Plant breeding and licensing

1. What does drought risk mean?

With respect to plant breeding, drought risk refers to excessive dryness and heat with at the same time extreme precipitation events. Frequent drought negatively affects the reliability of results of field experiments, unless drought is the primary interest.

2. Which management measures are important?

Breeding drought and heat tolerant crops may be considered DRM in and of itself. This means that breeding and testing modalities are adapted to highlight crops with earlier development, more comprehensive testing of winter crops, and reduced testing of summer crops for grains, as well as testing of additional types of crops. Apart from this, breeding and licensing may provide many on-farm risk management options:

- More winter crops are possible. In Austria a trend to winter grains started in the 1980s. For several summer grains, breeding efforts were reduced or completely halted. However, the potential for moving to winter grains has been exhausted for example for wheat and other grains.
- Heat tolerant grains, which mature early, may stabilize yields.
- Double cropping, i.e. harvesting twice a year, combining for example winter wheat and soy, corn or millet, is another risk management option.
- Reducing drought risk via crop rotation means that plant specific water needs are considered together with periods of increased drought risk.

3. Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?

- Focusing on winter grains may reduce nitrate concentrations in the soil because of extended soil coverage during winter.
- Soil breeding requires long periods of research and experimentation. Currently most research is funded privately. Public funding efforts should take into account these time requirements.
- Double cropping might require additional irrigation.
- Drought resilient crops that rely on faster plant development are less suited for intensive agricultural production, because of comparably low yields in drought-free years.
- Experts expect little progress in breeding drought and heat tolerant crops. This is because drought tolerance as a characteristic is difficult to determine. Moreover, reaction to drought depends on the developmental stage of a plant.

Trade in agricultural products

1. What does drought risk mean?

In the context of trade, the most important long-term objective is to secure supply chains in terms of both regional supply as well as market potential. Thus, drought risk for actors in trading manifests primarily as unfulfilled contracts with respect to quality and/or quantity. Subsequently, drought may lead to low flow on waterways important for transporting agricultural products. Ultimately, all measures across different areas presented here help securing stable supply chains and need to be considered. However, there are specific measures to this decision domain as explained below.

2. Which management measures are important?

Measures that relevant actors in Austria have used in the recent past were the adaptation of quality criteria. This happened, for example, in the case of brewing barley in 2012, 2017, and 2018. In less extreme years,

the agricultural commodity exchange in Vienna accepts summer brewing barley with a maximal protein content of 12% only. In those years, they accepted summer brewing barley with protein contents of up to 14%. Future measures may be adapting cultivation contracts by defining secure level of yields and/or including the condition of participating in risk reduction programs. Safety buffers could be introduced for supply contracts. Internationally, trade networks could enable more flexible arbitration.

3. **Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?**

- Changes in quality that change product characteristics and impact the marketing potential
- Having to import additional products from abroad or having to switch from waterways to land transport may increase emissions.
- Cultivation contracts with attached conditions may lead to increased administrative and controlling efforts.

Water management

1. **What does drought risk mean?**

Public and/or private authorities need to provide water for agricultural use and ensure quality and quantity of the resource for drinking water supply, commercial and private use. From the perspective of public and private water management, drought risk refers to lack of available water as a result of insufficient precipitation. This may in turn lead to negative impacts on water quality.

2. **Which management measures are important?**

In order to avoid a water shortage several measures can be taken; e.g. ground water resources may be recharged and fed by canal systems. In Austria the project Marchfeldkanal is a system of such canals diverting water from the Danube into an Austrian breadbasket region that suffered from loss of ground water. Ensuring run-off capability for treated wastewater and implementing measures fulfilling the EU water framework directive help securing water quality.

3. **Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?**

- The implementation of large-scale measures for regional water management for irrigation and ground water recharge requires coordinated support of a large and diverse group of actors, including most if not all affected farmers (the small-scale structure of Austria's agricultural sector is a disadvantage in this case).
- Depending on the extent of such an intervention, considerable costs may incur.
- Detailed information is still lacking on potential trade-offs downstream such as impacts on water discharge and availability.
- Large-scale projects such as the Marchfeldkanal in Eastern Austria may not be feasible in any region. Some soils may not be worthy of irrigation from an economic efficiency point of view; the retention potential needs to be considered.

Public institutions and controlling

1. **What does drought risk mean?**

From a public point of view drought is a problem if one or more economic sectors and/or the general public are significantly affected by lack of precipitation or extreme heat. Drought in agriculture is problematic when

yields are affected to an extent that sector-wide implications are expected that go beyond individual farms or very small damages.

2. **Which management measures are important?**

From this perspective DRM in agriculture predominantly entails the support of risk reduction on farms: For example, through public subsidies for insurance premiums, incentives for risk management by means of conditions linked to other agricultural subsidies. Other measures relate to water management (see 4.4). In exceptionally extreme cases, ad-hoc measures may be implemented. In Austria, for droughts, these are so called "Dürreaktionen", which for example may entail direct payments for food stuff, or tax relief.

3. **Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?**

- Subsidies in one area may lead to reduction or elimination of subsidies in other areas. Thus, public DRM needs to consider whether other adaptation strategies may be affected.
- Synergistic development of new or alternative insurance products (expanding products to new types of crops, or income insurance)
- Public subsidies may create an incentive to switch to organic farming. Organic farming is in many ways synergistic with DRM as its organic yields are more robust vis-a-vis drought and heat.
- Direct payments and subsidies are often attached to terms and conditions and in turn to administrative efforts on behalf of farmers. This may affect the implementation of subsidized DRM measures on the farm.
- The effective allocation of subsidies may require training of farmers in the implementation and use of new technologies and methods.

Insurance

1. **What does drought risk mean?**

In insurance, drought risk is the financial damage occurring to agricultural production as a result of a lack of precipitation and heat. Drought risk is particularly difficult to handle as it typically affects many farmers simultaneously (dependent risk) and assessing damage in a fast and complete fashion requires extensive human and financial resources. This affects insurance premiums or requires an index-based insurance product.

2. **Which management measures are important?**

Drought insurance may be considered a risk management measure. More specifically, it is a risk-transfer measure, which exchanges damage compensation for regular premium payments. In Austria currently yield-based and index-based products are available (Hanger and Hochrainer-Stigler 2017). However, also from an insurance point of view, avoiding and reducing risks to the farm is crucial. For this purpose, the Austrian Hail Insurance offers weather forecasts and warning services.

3. **Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?**

- Ideally, insurance complements risk avoidance and reduction. This means that insurance policies should not replace risk reduction efforts at farm level but be applied for those cases where damages cannot be cost-effectively avoided.
- Public subsidies for agricultural insurance premiums are essential, because of the character of drought risk. It may considerably reduce public ad-hoc payments after a drought event.

Food security

1. **What does drought risk mean?**

Here, drought risk means a reduction of the degree to which a country can supply itself with agricultural products. Changes in climate may affect soil quality and productivity. Haslmayr et al. (2016), for example, show this for regions in Eastern Austria. These effects may lead to the loss of valuable arable land and a reduction of yields. Moreover, food security is a matter of product stability.

2. **Which management measures are important?**

Measures to maintain soil quality are crop selection and conservation tillage (see 4.1). The limits of these measures in this context need to be researched. Food security, however, is a meta-topic, of which drought risk is only one aspect. Thus, most measures discussed in previous sections, considering the diverse synergies and trade-offs, may contribute to food security.

3. **Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?**

The metaviewpoint provided here may lead us to consider additional trade-offs and synergies, beyond those discussed in previous sections.

- The classification of agricultural property and thus the amount of taxes and social insurance premiums for farmers depend on assessed value of land holdings, which in turn depends on the quality of arable land.
- From a regional planning perspective, valuable agricultural production areas need to be secured as future resources for food production. This may in turn require trade-offs with other claims on this space such as from transport and housing sectors.
- Total yields either increase by intensifying production or by increasing cropping areas. In order to reduce further pressure on crop production to increase yields valuable agricultural land and productive soils of high quality have to be allocated to agricultural crop production.

Civil society

1. **What does drought risk mean?**

From a civil society point of view, the holistic consideration of social risks is key. This includes food security, social justice, biodiversity, and many other aspects. Drought risk is not a high priority but should not be neglected.

2. **Which management measures are important?**

Taking such a holistic view, multi-dimensional solutions are key. For example, organic farming, including conservation tillage should be prioritized over irrigation. The NGOs support such measures by means of awareness-raising, education, and efforts at persuasion. The objectives of such measures are increasing acceptance for strategies avoiding food waste in retail and gastronomy, as well as the introduction of fair-trade labels for national products.

3. **Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?**

Frequently multi-dimensional solutions have a higher benefit-cost ratio than one-dimensional solutions, if all costs and benefits for society are considered. This is, for example, the case for conservation tillage, which is

not only a DRM measure, but also increases resilience towards torrential rain and erosion risk. Particularly, the consideration of non-agricultural costs and benefits such as health may highlight cross-sectoral synergies. At this level trade-offs and synergies manifest mostly in conflicts of interests, or in specific advantages or disadvantages of promoted measures. This is a level of detail that goes beyond the scope of this workshop report.

Research

1. What does drought risk mean?

Scientific research distinguishes four stages of drought, which provide different perspectives on drought risk: meteorological drought, hydrological drought, agricultural drought, and socio-economic drought (Wilhite and Glantz 1985). Meteorological drought manifests when certain weather variables, such as total amount of precipitation, remain under a predefined threshold level over a certain time and is realized if it is lower than a pre-specified threshold level. Hydrological drought is determined by significantly reduced water levels in waterbodies and ground water. Agricultural drought occurs when insufficient soil moisture and precipitation negatively affect yields. Finally, agricultural drought may turn into socio-economic drought when supply and demand of agricultural products are negatively affected (see also the seminal paper of Wilhite/Glantz, 1985). These categories cover most of the different perspectives highlighted in previous sections. For example, the farmers' view and that of breeders and insurers coincide with the concept of agricultural drought. Whereas public institutions are more interested in socio-economic drought.

2. Which management measures are important?

Scientific research aims at understanding these types of drought risk and developing DRM measures. Supporting and conducting this kind of research is thus an important step towards DRM. Most if not all areas discussed here see the need for further research. For example:

- The development of high-resolution weather prognoses (drought information and warning).
- Plant breeding targeting yield stability (2.2).
- Efficient irrigation technologies, e.g. sensor-based irrigation, fertigation
- Modelling of soil quality under different climate scenarios
- Modeling of efficient and multi-dimensional management portfolios considering policy- and climate scenarios
- Matrix of management and adaptation measures in line with drought warning services
- Impacts of management and adaptation measures on environmental indicators such as biodiversity
- Development of climate services at regional and national level, considering different target groups and actors across sectors.
- Drought risk for different categories e.g. agricultural production, income, product prices, food availability
- Drought vulnerability of different geographical regions
- Management strategies and adaptation intentions of farmers.

3. Which are the most important synergies and trade-offs in association with other measures in this and adjacent areas of decision-making?

The overarching objective of scientific research is creating new knowledge. Scientific research needs to navigate between various interests, such as scientific standards, public interest, social relevance, and financing.

In order to guarantee high quality, but also socially relevant research, long-term planning of research foci and the availability or creation of state-of-the-art, high-resolution data are essential. Only in this way can results be used effectively in planning and decision-making for public and private adaptation measures.
At the same time, scientific results need to be presented in ways that are accessible to target groups.

Discussion

This working paper presents findings from an expert workshop on DRM for the Austrian agricultural crop producing sector. The main objective was to identify synergies and trade-offs between risk management measure decision areas from plant production to trade, across the spectrum of public, private and third sector actors. The results provide insight into current perception and practices with respect to drought risk management, as well as the frontiers for developing new management options and improving policy coherence. Moreover, they provide important methodological lessons for social empirical research with respect to using systems thinking and the concept of risk in expert elicitation.

Current perceptions of and practices in drought risk management strongly build on production-based efforts at the farm. Across the public and private spectrums, DRM builds on existing holistic practices such as soil management. Also, insurers operate on the premise that on-farm risk reduction measures are essential, with insurance products aiming to transfer risk of unavoidable yield loss. While production-based DRM is well advanced, the links (synergies and trade-offs) to related areas of decision making such as trade, spatial planning, and transport needs to be better understood.
Some of the most important workshop insights highlight the limits of current practice, opportunities for future developments, and the need to coordinate and communicate across new decision areas:

- Successful DRM considers interactions between areas of decision-making across the spectrum of public, private, and third sector actors. Avoiding and reducing drought risk ex-ante must remain priority number one, only then should come in mechanisms of risk transfer and ad-hoc compensation.
- **R&D vs. Funding and time constraints:** Research, technological innovation, and plant breeding are essential in order to increase efficiency of DRM measures. It is important to consider the - often long - timeframe of research efforts, for example, in funding programs.
- **The limits of plant breeding:** Crop selection is a fundamental measure in dealing with drought. However, in Austria the potential to stabilize yields through winter crops is largely exhausted for many types of crops, most importantly wheat. The development of drought tolerant crops in the strictest sense cannot be expected, although plant development will contribute to reducing damages.
- **Food production vs. spatial development:** Climate change may affect soil quality; thus, high-quality arable land should be reserved for food production.
- **Irrigation vs. coordination:** Securing water for irrigation will face challenges in many regions, i.e. the technical implementation, financing, and the coordination of multiple users.
- **Trade vs. transport:** Actors in trade and retail can manage effects of agricultural drought risk through adapting cultivation and delivery contracts. From their perspective it is important to also consider potential transport issues associated with low flow of important water ways.

These insights imply that while DRM measures related to plant production are well understood and managed, most of the so called low-hanging fruits have been harvested and less well-charted territory lies ahead and warrants further research and expanding thinking beyond plant production. Our workshop results reflect how DRM is not an institutionalized policy field but happens in the context of various decision areas. This provides additional communication challenges, particularly in fields where it has not been a constant concern but may

be increasingly relevant and frequent, as cascading consequences need to be considered, such as in spatial planning, transport, data collection and monitoring, marketing and trade.
The contributions to the workshop further highlight research gaps that may be relevant for future work in and beyond Austria. Many of these gaps have in common that they are broadly defined, and almost exclusively of a systemic nature: First, they all require better understanding of impacts and management practices. Second, the impacts of these management practices need to be explored and understood as well. Third, any impact study should be conducted across policy areas, sectors. For example, modelling soil quality under different climate scenarios; modelling of efficient and multi-dimensional management portfolios considering policy- and climate scenarios; and exploring matrices of management and adaptation measures in line with drought warning services.

With respect to our method and framework we find most interesting the different responses to our question about risk management and trade-offs/synergies. We notice that risks are rarely framed as probabilities, but rather with a focus on expected negative impacts. Not surprisingly, drought risk is seen slightly differently across decision areas. Moreover, experts seemed to have difficulties formulating concrete trade-offs. Experts mostly talked about barriers or, again, negative impacts. This may have two reasons which both need to be explored further elsewhere: First, it may be due to the fact that experts are very much settled in their own respective decision areas and institutional set-ups, with limited time or capacity to consider cross-cutting issues. Second, it may be due to inappropriate framing on our side and/or the lack of time in preparing the input. The systems thinking our tasks involved may require deeper preparation and more time interacting with experts. This is an important finding in itself, showing that we cannot assume systems thinking in an expert setting and that there is a need to develop adequate methods. In order to increase policy coherence, we need these methods, as well as increased opportunities – such as the FARM expert workshop – for experts in different decision areas to interact. Small platforms such as the FARM workshop may be useful to individuals and their perception of a topic simply by providing space for discussion and exchange. However, wider and lasting impact to establish effective and integrated drought risk management requires interventions not only from research but in several relevant arenas, such as policy-making, the third sector, and also business platforms. In Austria, this happens for example in the context of the Austrian Rural Network "Netzwerk Zukunftsraum Land", a networking center to support cooperation and share experience between different parties affected by and involved in the Austrian Rural Development Program 2014-2020 ("LE 14-20"), including stakeholders from the agricultural and forestry sector, downstream businesses in the value chain, environmental protection, energy production, SMEs, and social organizations.
Yet, even in such a set-up, we see how difficult coordination and communication efforts are.

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Annex I: Drought risk management for Austrian Agriculture: Synergies and Trade-offs

Annex II: Workshop details

Agenda

- 9:30-9:45 Introductory presentations
- 9:45-11:00 Block 1 (5 expert inputs)
  11:00-11:15 Coffee break
- 11:15-12:30 Block 2 (4 expert inputs)
  12:30-13:15 Lunch break
- 13:15-14:30 Block 3 (4 expert inputs)
  14:30-14:45 Coffee break
- 14:45-15:30 Summary

Participant list

1. Johann Birschitzky (Donau Saatzucht)
2. Johann Fank (Österreichische Hagelversicherung)
3. Helmut Gaugitsch (Umweltbundesamt)
4. Ernst Gauhs (Raiffeisen Ware Austria)
5. Patrik Herz (Agrar Markt Austria)
6. Alois Leidwein (Österreichische Agentur für Gesundheit und Ernährungssicherheit)
7. Hermine Mitter (Universität für Bodenkultur)
8. Wolfgang Neudorfer (Betriebsgesellschaft Marchfeldkanal)
9. Michael Oberforster (Österreichische Agentur für Gesundheit und Ernährungssicherheit)
10. Ruth Pammer (Global 2000)
11. Josef Pinkl (Österreichische Agentur für Gesundheit und Ernährungssicherheit)
12. Monika Stangl (Bundesministerium für Nachhaltigkeit und Tourismus)
13. Marlene Tasser (Bundesministerium für Nachhaltigkeit und Tourismus)

The FARM Project (FARM – Farmers and Risk Management: Examining subsidized drought insurance and its alternatives)

FARM commenced in May 2016 as a three-year research project funded by the Austrian Climate Research Program. In the light of increasing climate and market risks, the project examines agricultural DRM both in a broad European context and more specifically in Austria. Austria, as a country where subsidized hail and frost policies have an outstanding penetration rate of 85% and index insurance for grassland and maize has recently been introduced, is well suited as a case study that explores the risks and opportunities of alternative insurance and risk management schemes. The continuous involvement of key actors and interest groups, through interviews and workshops, is an integral part of FARM.

The project combines multiple disciplines and areas of expertise, including crop modeling (EPIC model), mathematics and statistics (the copula approach), economics (assessing fiscal and other economic impacts), anthropology (the theory of plural rationality or cultural theory), social empirical research (questionnaire survey), participatory methods and decision analysis (group multi-criteria analysis and robust decision making). FARM investigates probabilistic crop loss and risk management responses tailored to different risk layers (high, medium and low consequence risks) under different climate scenarios. Policy options are scrutinized by eliciting the risk management preferences of farmers, insurers and government authorities.