Publizierbarer Endbericht

Gilt für Studien aus der Programmlinie Forschung

A) Projektdaten

Allgemeines zum Projekt	
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B) Project overview

1 Kurzfassung

In der EU-27 werden über 4 Mill. ha. entwässerter organischer Böden als Acker- oder Grünland bewirtschaftet. Dies entspricht nur ca. 2 % der Acker- und Grünlandfläche in der EU, die Treibhausgasemissionen aus diesen Böden machen aber 20 % der landwirtschaftlichen Emissionen der EU-27 aus. Die EU strebt an, bis 2050 klimaneutral zu sein. Anstrengungen, Emissionen aus den genutzten Moorböden zu reduzieren, könnten also einen wesentlichen Beitrag zur Erreichung dieses Klimaziels leisten. Emissionsminderungen sind in erster Linie durch Anhebung der Wasserstände auf entwässerten Flächen zu erreichen. Dabei könnten "klimasmarte Lösungen" entwickelt werden, welche landwirtschaftliche Produktion mit der Erhaltung der Torfkörper und der Bereitstellung anderer Ökosystemleistungen in Einklang bringen.

Die österreichische Regierung hat sich verpflichtet, die THG-Emissionen in den Nicht-ETS-Sektoren bis 2030 um 36% zu reduzieren und bis 2040 Klimaneutralität zu erreichen. Obwohl Moore als Kohlenstoffspeicher anerkannt sind, ist das Flächenausmaß an Torfböden in Österreich noch immer nicht vollständig bekannt. Grünig (2010) schätzte die Torfbodenfläche auf 120.000 ha, aktuelle Schätzungen reichen von 50.000 bis 80.000 ha (BMLRT, 2022). Aufgrund der fehlenden Datenbasis wurden in Österreich bislang keine Emissionen aus genutzten Torfböden in der nationalen Berichterstattung ausgewiesen. Im Februar 2022 verabschiedete die österreichische Regierung die nationale Moorstrategie. Diese zielt darauf ab, eine Prioritätenliste der sanierungsbedürftigen Moore zu erstellen, mit dem Ziel, bis 2030 leicht entwässerte Moore wieder zu vernässen. Die Wiedervernässung stark entwässerter Moore soll bis 2040 erfolgen.

Vor diesem Hintergrund zielte PeatGov-Austria darauf ab, die gegenwärtige Bewirtschaftung von Torfböden in Österreich zu analysieren, das Potenzial zur Emissionsreduktion abzuschätzen und Maßnahmen zur Unterstützung einer klimafreundlichen Landwirtschaft auf Mooren zu identifizieren. Die Auswertung von Sekundärdaten ermöglichte eine Ableitung des Flächenausmaßes und der Nutzung landwirtschaftlich genutzter organischer Böden in Österreich. Zudem konnten die wichtigsten Typen moorbewirtschaftender Betriebe in Österreich und ihre räumliche Verteilung identifiziert und drei typische Fallstudienregionen in Kärnten, Salzburg und Vorarlberg ausgewählt werden. Persönliche Interviews mit 5-6 landwirtschaftlichen Betrieben in den Regionen lieferten Daten zur spezifischen Moorbewirtschaftung, zur Sichtweise der Landwirte und zur Akzeptanz potenzieller Maßnahmen zur Emissionsminderung. Auf Basis dieser Primärdaten wurden Produktivität und wirtschaftliche Bedeutung von Torfböden berechnet und in Folge sozioökonomische Auswirkungen klimafreundlicher Bewirtschaftungsanpassungen abschätzt.

Durch die Zuordnung repräsentativer Grundwasserstände zu einzelnen Landnutzungen konnten Landnutzungsänderungen mit hohem Potenzial zur Verringerung der Treibhausgasemissionen ermittelt werden. Die Umstellung der Landnutzung von Acker- auf Grünland ist unsere beste und konservative Annäherung an die vermiedenen THG-Emissionen durch alternative Bewirtschaftungsoptionen. Auf der Grundlage der verfügbaren Daten über die Verteilung von Torfböden ist es derzeit nicht möglich, eine verlässliche Bewertung der Treibhausgasemissionen aus Torfböden vorzunehmen. Unsere beste Schätzung ist, dass die Treibhausgasemissionen aus landwirtschaftlichen organischen Böden in Österreich derzeit zwischen 1 und 2 % der Gesamtemissionen ausmachen. Die Ergebnisse von PeatGov zeigen aber auch, dass das Potenzial für eine großflächige Umsetzung von Maßnahmen zur Emissionsreduktion derzeit begrenzt ist. Landwirtschaftlich genutzte Moorflächen spielen in Österreich insbesondere in ihrer Rolle als Futterflächen eine ökonomisch wichtige Rolle für moorbewirtschaftende Betriebe. Hohe Anteile an Moorflächen an der landwirtschaftlichen Nutzfläche dieser Betriebe schränken die Anpassungspotenziale der Betriebe zusätzlich zum Teil stark ein.

Eine Bestandsaufnahme von Governance-Ansätzen ermittelte eine Reihe guter Praxisbeispiele aus ausgewählten EU-Mitgliedstaaten, die politische Instrumente zur Unterstützung eines klimagerechten Torfbodenmanagements einsetzen. Drei Stakeholder-Workshops in den Fallstudienregionen ermöglichten es uns, die Projektergebnisse mit Landwirten und anderen Stakeholdern zu diskutieren und zu reflektieren. Keine der drei Fallstudienregionen ist vollständig auf Veränderungen hin zu klimafreundlichem Moormanagement vorbereitet, zumal es aktuell keine Kompensationen landwirtschaftlicher Einkommensverluste gibt. Alternative Bewirtschaftungsoptionen, wie z. B. die Paludikultur, die das Potenzial haben die Bewirtschaftungssysteme langfristig zu verändern, sind den Landwirten weitgehend unbekannt. Darüber hinaus haben die Interviews und Stakeholder-Workshops gezeigt, dass die Stakeholder den bestehenden Finanzierungsmöglichkeiten für die Umsetzung neuer Ziele zum Schutz der Moorböden eher kritisch gegenüberstehen. Insbesondere die klassischen Fördermöglichkeiten werden als unzureichend für einen langfristigen Wandel angesehen. Dennoch wurden Maßnahmen, die die zukünftige landwirtschaftliche Nutzbarkeit der Flächen sicherstellen und gleichzeitig den Wasserrückhalt verbessern, als gewinnbringende Lösungen wahrgenommen. Auch wenn die technische Machbarkeit eine wichtige Rolle spielen wird, besteht ein allgemeines Interesse. Pilotprojekte könnten ein nächster Schritt sein, um Umsetzungsmöglichkeiten zu finden, Lösungen zu erforschen und Bewertungen der tatsächlichen Verringerung der Treibhausgasemissionen durch solche Lösungen sowie der Veränderungen der landwirtschaftlichen Erträge und der Produktqualität vorzunehmen. Angesichts des großen Wissensmangels über die Klimarelevanz der Moorbewirtschaftung empfehlen wir, den Wissensaustausch zwischen Wissenschaft und Praxis stark zu fördern. Nicht zuletzt empfehlen wir nachdrücklich die Entwicklung von maßgeschneiderten, regionalspezifischen Lösungen, und insbesondere die Integration der landwirtschaftlichen Perspektive in den Diskurs.

2 Executive Summary

In the EU-27, more than 4 mill. ha. of drained organic soils are cultivated as arable land or grassland. This represents only about 2% of the arable and grassland area in the EU, but greenhouse gas emissions from these soils account for 20% of EU-27 agricultural emissions. The EU aims to be carbon neutral by 2050. Efforts to reduce emissions from used peatland soils could therefore make a significant contribution to achieving this climate goal. Emission reductions can be achieved primarily by raising water levels on drained land. In this context, "climate-smart solutions" could be developed that balance agricultural production with the conservation of peat bodies and the provision of other ecosystem services.

The Austrian government has committed to reduce GHG emissions in non-ETS sectors by 36% by 2030 and achieve climate neutrality by 2040. Although peatlands are recognized as carbon reservoirs, the area extent of peatlands in Austria is still not fully known. Grünig (2010) estimated the peat soil area at 120,000 ha, current estimates range from 50,000 to 80,000 ha (BMLRT, 2022). Due to the lack of data, no emissions from used peat soils have been reported in national reporting in Austria to date. In February 2022, the Austrian government adopted the national peatland strategy. This aims to establish a priority list of peatlands in need of restoration, with the goal of rewetting lightly drained peatlands by 2030. The rewetting of heavily drained peatlands is to take place by 2040.

Against this background, PeatGov-Austria aimed at analyzing the current management of peat soils in Austria, estimating the potential for emission reduction and identifying measures to support climate-friendly agriculture on peatlands. Mining available data and assessing different modelling approaches enabled a derivation of the area extent and the use of agriculturally used organic soils in Austria. In addition, a two-step cluster analysis could identify the most important types of peatland farms in Austria and their spatial distribution. On this basis three typical case study regions in Carinthia, Salzburg and Vorarlberg could be selected. Personal interviews with 5-6 farms in the regions provided data on specific peatland management, farmers' views and acceptance of potential mitigation measures. Based on these primary data, productivity and economic importance of peatlands were assessed and subsequently socio-economic impacts of climate-friendly management adaptations were estimated.

By assigning representative groundwater levels to individual land uses, land use changes with high potential to reduce greenhouse gas emissions were identified. Land use conversion from cropland to grassland is our best and conservative approximation of avoided GHG emissions from alternative management options. Based on available data on the distribution of peat soils, it is currently not possible to make a reliable assessment of GHG emissions from peat soils, but our best estimate is that GHG emissions from agricultural organic soils in Austria currently account for between 1 and 2% of total emissions. However, the results of PeatGov also show that the potential for large-scale implementation of such measures currently appears to be limited. Agriculturally used peatlands in Austria play an economically important role for peatland farms, especially in their role as forage areas. High shares of peatland in the agricultural area of these farms additionally limit their adaptation potential. A strong extensification or restoration of the sites would in many cases threaten the continuation of the typical farming systems currently in place.

A stocktaking of governance approaches identified a number of good practices from selected EU member states that use policy instruments to support climate-smart peatland management. Three stakeholder workshops in the case study regions allowed us to discuss and reflect on the project findings with farmers and other stakeholders. None of the three case study regions are fully prepared for changes toward climate-smart peatland management, especially since there is currently no compensation for agricultural income loss. Alternative management options, such as paludiculture, that have the potential to change management systems in the long term are largely unknown to farmers. In addition, the interviews and stakeholder workshops revealed that stakeholders are rather critical of existing funding options for implementing new goals around peatland soil conservation. In particular, traditional funding opportunities are seen as insufficient for long-term change. Nevertheless, measures that ensure the future agricultural usability of the land while improving water retention were perceived as profitable solutions. Although technical feasibility will play an important role, there is a general interest. Pilot projects could be a next step to find implementation options, explore solutions, and conduct assessments of actual greenhouse gas emission reductions from such solutions, as well as changes in agricultural yields and product quality. Given the great lack of knowledge about the climate relevance of peatland management, we recommend that knowledge exchange between science and practice be strongly encouraged. Last but not least, we strongly recommend the development of tailored, region-specific solutions, and especially the integration of the agricultural perspective into the discourse.

3 Background and objectives

Peatlands provide a wide range of ecosystem services, most importantly regulating services, including climate regulation through carbon sequestration and storage. They are the most efficient terrestrial ecosystem type for carbon storage. In the EU, peatlands cover 7.7% of the land surface. They are mainly concentrated in Northern, Eastern and Central Europe, where they cover up to 25% of the land surface. However, many peatlands either no longer provide the vital services they used to, or their provision is severely threatened, including by drainage and climate change. In Central Europe, more than 90% of all peatlands have been or are being used for agriculture, forestry or peat extraction. Agricultural use of peatlands usually requires lowering the water table through drainage, while the depth of drainage determines the possible land use and intensity of use (Drösler 2013). Drainage causes huge greenhouse gas (GHG) emissions and loss of water storage capacity. Globally, emissions from peat oxidation due to drainage account for about 5% of all anthropogenic carbon dioxide (CO2) emissions (Joosten et al., 2016). Globally, peatlands converted to cropland produce nearly one-third of all agricultural greenhouse gas emissions (Carlson et al., 2017). Emissions from cultivated peatlands accounted for 3.5-4% of EU emissions in 2010 (EU, 2013). In some EU Member States, GHG emissions from drained peatlands account for more than 20% of total emissions. This highlights the particular mitigation potential of actions on drained peatlands. In addition to peatland drainage for agricultural use, climate change itself is a major driver of peatland degradation through increased drought. According to a recent study, the continent's peatlands are in such a dry and fragile state that they could reverse course and become sources rather than sinks of atmospheric carbon (Swindles et al., 2019).

The realisation of GHG mitigation measures on peatland often implies important socioeconomic consequences for affected farms. These effects mainly depend on the farm-types affected, the amount of area affected, the kind and intensity of land-use change and the change of productivity induced by the land use change. From a governance perspective, greater flexibility for locally adapted management options for peatland GHG mitigation and climate change adaptation is needed to support climate smart agriculture. Wise land-use is key for reducing the negative effects of peatland drainage while offering reasonable and acceptable options to landowners and managers. But decisions on land use policies and management are often made without sufficient knowledge about climate impacts. Promoting better policies and practices may require changes in terms of agricultural and climate policies, incentive systems, and information for farmers and land managers.

The Austrian Government is committed to reduce GHG emissions by 36% by 2030 in the non-ETS sectors and to reach climate neutrality by 2040. While peatlands are recognized as a key environment for carbon sequestration, the area covered by peat soils in Austria is unknown. Often, the area of intact mires in Austria (21.000 ha, Seehofer et al., 2003) is used as estimate for the area covered by peat soils, ignoring the peat soils under agricultural or forestry land cover. Grünig (2010), who estimates a peat soil cover of 121.003 ha, has presented a more realistic estimate. For Austria, no emission factors (i.e. expected greenhouse release per area) have been calculated due to a lacking database. When applying emission factors from neighboring Germany (Tiemeyer et al., 2020), the total emissions from drained peat soils could make up to 4.6% of the Austrian GHG emissions. Furthermore, remaining Austrian peatlands store huge amounts of carbon, which are threatened by severe to total loss of occurrence due to climatic risks toward the end of the 21st century (Essl et al., 2012).

PeatGov-Austria aimed to evaluate alternative options for peatland management in Austria, to assess their potential for emission reduction and to identify the most effective governance approaches and policies to support a transformation and adaption towards climate-smart agriculture on peatlands. The objectives of PeatGov-Austria were therefore as follows:

- To assess and compare governance approaches and policies for climate-smart agriculture on peatlands in EU member states, and to evaluate their potentials for implementation in different agricultural contexts in Austria.
- To assess agricultural land use and management on peatland sites in Austria (arable, grassland; intensities of use, use of products, etc.) for typical farms and context situations, including an economic assessment of productivity.
- To analyze socio-economic aspects and acceptance of climate-smart management adaptations and policy options in different natural and socioeconomic contexts and for typical farms.
- To assess the regional potential for avoiding GHG emissions by alternative policies and land-management options in different Austrian contexts (e.g. farm types).
- Inter- and transdisciplinary evaluation of alternative governance and land-management approaches in selected cases studies at the local/regional level. Assessing the economics of alternative results-based management options (typical regional and agricultural contexts).
- To synthesize (and upscale) case study findings to assess realistic potentials of avoided GHG emissions in scenarios of different natural contexts, farm types and policy and management options of climate-smart agriculture in Austria.

4 Project content and results

The overall aim of PeatGov-Austria was to assess alternative options for peatland management in Austria and their potential for GHG emission reduction. To achieve the project aim, the work plan was organized into six work packages (WPs) as outlined above. The main results of these WPs can be summarized as follows:

Assessing alternative governance approaches and policy instruments to support climate smart agriculture on peatlands (WP1)

The transition from drainage-based peat utilization to wet and rewetted peatlands is a paradigm shift. Policy makers can use a variety of policy instruments to support this transition and make it ecologically, economically and socially sustainable. The toolbox ranges from classic regulation to protect and restore peatlands, incentive-based instruments such as agri-environmental subsidies, water charges or the creation of new markets, cooperative instruments to foster dialogue and networking among stakeholders to informative instruments to raise public awareness about peatland management.

The literature-based stocktaking in WP1 identified a number of good practical examples from selected EU Member States using different policy instruments to: a) establish a national policy strategy, b) protect and restore peatlands, c) provide incentives to invest in rewetting, to maintain target water levels, and to adapt management, and d) raise awareness and foster cooperation. The literature review documents the current state of affairs regarding peatland governance from an instrumental perspective. It sheds some light on the strengths and potentials of the current governance approach, but it also highlights the current shortcomings and challenges for climate-smart peatland governance. Some general recommendations in particular for the design of the funding measures can be formulated (see also Hirschelmann et al., 2019):

- Develop comprehensive, well-resourced, long-term support programs: The establishment of climate-smart peatland use requires a long build-up.
- Promote pilot projects: The implementation of wet peatland use is still in its infancy. The promotion of pilot projects and the creation of good examples are therefore particularly important in order to establish alternatives to drainage-based peatland use through development, testing, demonstration and long-term monitoring.
- Establish a coherent system of subsidies and funding: Funding must be coordinated and well aligned. Funding measures, e.g. via ERDF funds, must be well delimited so that EAFRD funds remain additionally usable (combinability without risk of double funding).
- Consider regional differences and find regional solutions: The different initial situations in the states and regions must be considered when designing support measures.

- Address all phases of conversion: The support programs for peatland protection in agriculture should offer support from preparatory measures such as the establishment of cooperation, the preparation of expert reports and concepts, accompanying advice and support, through investments, the promotion of peat conservation and conversion to low peat-consuming cultivation, to product development.

The stocktaking also highlighted the importance of EU funding for climate-smart peatland management in almost all selected countries, in particular the importance of the EAFRD fund. Our analysis of the current Austrian CAP Strategic Plan for the funding period 2023-2027 showed that there are many potential linkages in the Strategic Plan that could be used to promote climate-smart peatland management. These include several agri-environment measures, investment support measures, and measures to promote regional cooperation. However, we learned from discussions with different agricultural interest groups during the formulation of the Austrian National Peatland Strategy that these groups were not very interested in using CAP funds for peatland management. This was later confirmed by our survey of peatland farmers in the selected case regions.

In March-April 2022 a survey among peat farmers in the three selected case regions in Carinthia, Salzburg and Vorarlberg was conducted by WP2. In each region 5-6 farmers were interviewed, in total 16 interviews were conducted. One part of the survey consisted of four questions developed by and feeding into WP1, focusing on the acceptance of compensation payments. The empirical results can be summarized as follows:

- The first question tried to find out the general opinion of the peat farmers regarding financial support for operational measures for climate-smart peatland management. The farmers' answers were mostly neutral to negative. The answers highlight the general reluctance and skepticism of peat farmers in Austria towards new support measures for changes in peatland management. Farmers fear that new subsidies will lead to further restrictions on peatland management and ultimately to the loss of their property rights.
- The second question was related to the framework that should be used to financially support climate-smart peatland management. We asked whether farmers preferred national or EU funding. The farmers overwhelmingly preferred national programmes over EU funding either through a national peatland protection programme or a national programme to compensate for ecosystem services.
- The third question asked the peat farmers what operational measures they think should be financially supported. Three measures were chosen most frequently: (i) advice and information, (b) land consolidation, and (iii) measures to support extensive cultivation. Other measures such as product marketing, buying technical equipment, preparatory measures or the support of paludiculture were chosen less frequently. The least interest was shown by

farmers in the promotion of cooperative measures and water level regulation measures.

- The fourth question aimed to find out farmers' preferences for different forms of compensation. Two options were clearly preferred by the farmers: (i) exchanging their peatland for non-peatland, and (ii) managing the peatland in accordance with the requirements of a national peatland protection program. All other options - such as purchase of the land by public authorities with or without leaseback, registration in the land register or long-term lease to public authorities - were considered much less suitable.

Based on these responses, one can conclude that Austria´s peat farmers generally prefer to keep their peatlands and manage them sustainably in accordance with a national program. However, if the restrictions are too strict, exchanging these peatlands for equivalent land becomes the second-best choice.

Assessing farm-level socio-economic effects (WP2)

In WP2, first, based on secondary data and literature review an overview on agricultural peatland management in Austria was elaborated and a set of selection criteria and socio-economic indicators for typical farms was developed. Together with selection criteria from WP1 and WP3, three case study regions (CSR) were selected.

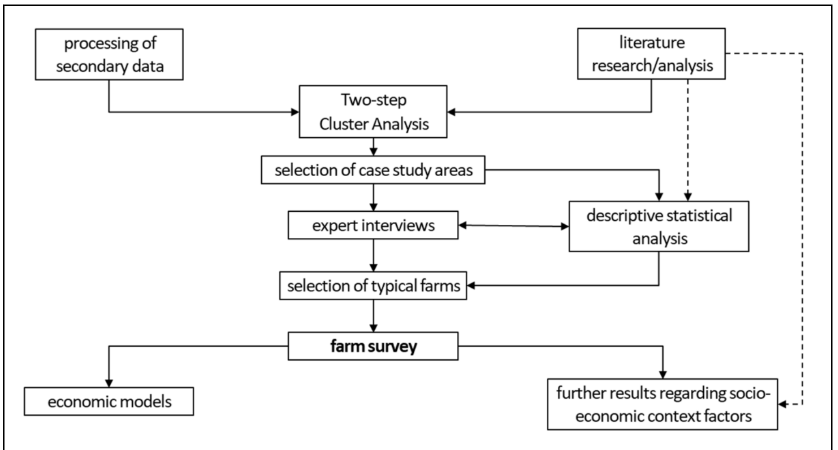


Figure 1: WP2 methodological approach

Main results of secondary data analysis (intersection of digital soil map (eBod) and spatial IACS data) results in a "gross field area"[1] of about 79.300 ha of agricultural fields located (at least partly) on peat soils (excl. alpine pastures), accounting for ca. 2,5% of total Utilised Agricultural Area (UAA) in Austria. "Net area" of UAA fully located on peat soils amounts to 31.000 ha. In sum, peatland area is managed by 13.480 farms.

[1] In this estimate, the total area of agricultural fields located on peat soils is considered, even if the agricultural field is only partly located on peat soils

Table 1: Overview on extent and land use on peat soils (excl. alpine pastures). Source: own illustration

Total UAA on peatsoils	79.330 ha gross UAA	30.970 ha net UAA
Most important land use categories (share of individual crops):		
	of "gross area"	of "net area"
Grassland ≥ 3 uses/year	37,6%	33,4%
Grassland 2 uses/year	13,5%	12,4%
Winter wheat	7,2%	6,9%
Corn	6,5%	7,0%
Alternating meadow	3,9%	5,7%
Litter meadow	2,6%	5,4%

61,3% of gross field area on peat soils is grassland, 32,8% arable land (winter wheat and corn being the most common crops in 2020). About 60% of total grassland on peat soil is used intensively (≥3 cuts/year), 30% is used with less intensity (Table 1).

The literature review identified 80 socio-economic context factors of peatland management, which were classified into five categories, represented by subcategories and describing factors (see Table 2). Partly these factors were included as variables into the cluster analysis.

Table 2: Summary of socio-economic context factors identified in literature review. Source: own illustration

Category	Subcategory	Factor/Indicator
Farm	Farm characteristics	Farm size, farm type, farm organisation…
	Land management	Structure of use (grassland, arable land), intensity, field productivity…
	Economic aspects	Investment/capital intensity, productivity, fixed/variable costs…
	Animal husbandry	Species, livestock density…
Peatland site		Peatland type, field structure, state of drainage system…
Policy/Institutions		Subsidies, prices, stakeholder networks…
Social aspects		Acceptance of alternative uses, problem awareness…
Location	Climate change	Precipitation
	Location	Land availability/land pressure, local economic structure, water availability…
	Structural change	Number of farms, share of land in main occupation…

Cluster analysis results (see Figure 2) show that 62% of farms managing peat soils in Austria are grassland farms. These manage 55% of the overall peat soil area, where the majority of this area is managed intensively. Hereby cattle farming, especially dairy farming, is the most common farming system. One of the most striking results of the analysis was that the average affectedness across the whole sample of peatland managing farms is remarkably high. Table 3 gives an overview on the identified clusters while Figure 2 shows the distribution of agriculturally used peat soils as well as the prevailing farm types. Farms managing peatland and being grassland oriented are located in the west, while arable farms managing peatlands are rather found in the east and southeast of Austria.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
Variable	*Average per cluster*						
Share of cattle in livestock	17%	58%	91%	7%	85%	73%	57%
Livestock density (livestock units (LU)/ha)	0,44	0,97	1,48	0,99	1,5	1,17	1,02
Share of arable land in total UAA	89%	8%	14%	86%	20%	19%	9%
Share of extensive grassland in UAA on peat soils	3%	80%	8%	8%	9%	42%	91%
Share of intensive grassland in UAA on peat soils	3%	11%	86%	3%	76%	46%	4%
Share of peat soils in total UAA	17%	30%	32%	25%	30%	25%	26%
Farm size in ha	53,56	15,05	23,66	89,12	25,12	21,32	14,81
Predominant soil type (number of farms): Bog	0	0	0	1	0	999	0
Predominant soil type (number of farms): Transitional Bog	0	0	0	5	0	765	0
Predominant soil type (number of farms): Fen	0	0	0	508	2.081	0	1288
Predominant soil type (number of farms): Anmoor	2.502	2.170	2.483	64	0	0	0
	Number/share of farms and areas in each cluster						
Number of farms	2.502	2.170	2.483	578	2.081	1.764	1.288
Share of all farms managing peat soils	19%	17%	19%	4%	16%	14%	10%
Share of total area on peat soils	24%	10%	22%	12%	18%	9%	5%

Table 3: Results of the two-step cluster analysis. Source: own illustration.

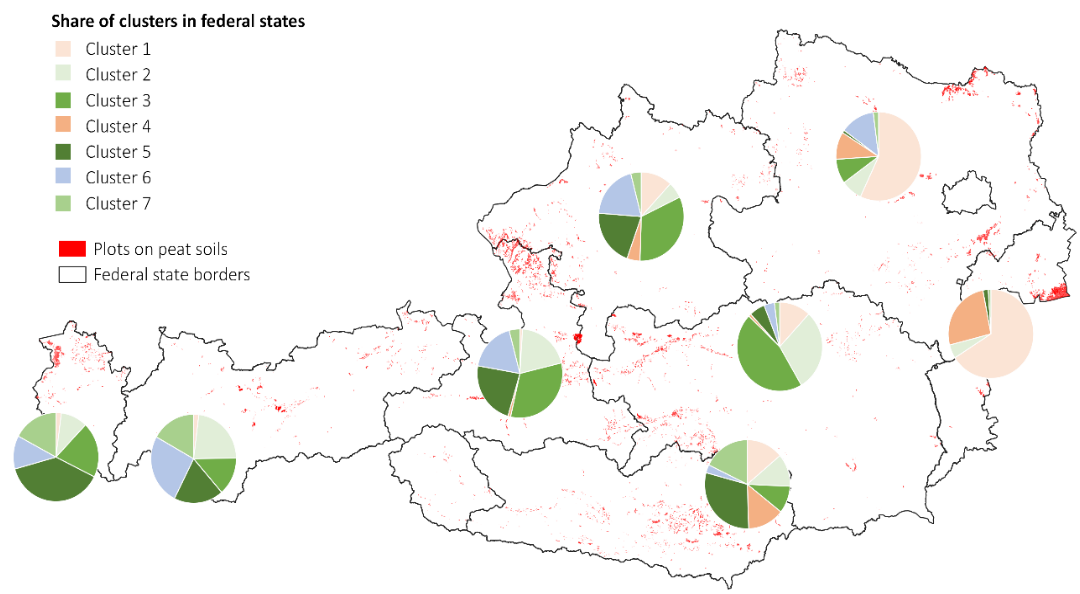


Figure 2: Distribution of agriculturally used peat soils and identified clusters in Austria. Source: own illustration.

Farm survey: For the in-depth analysis of management and productivity, based on results of secondary data analysis and expert interviews, in the 3 case study regions 16 farms typical for regional peatland management were identified and interviewed in March – April 2022 by means of questionnaire-based face-to-face interviews (for farm characteristics see Table 4). Data collection included quantitative data such as farm characteristics, land use, husbandry etc., as well as more qualitative data on perceptions and acceptance.

Table 4: Characteristics of surveyed farms; numbers in () show average numbers for all farms managing peat soils in the region, based on secondary data. *ORW=Oichten-Riede/Weidmoos, LR=Lauteracher Ried, TM=Thoner Moor. Source: own illustration

Indicator *(regional share/average)*	**ORW*** (number (n) = 6)	**LR*** (n=5)	**TM*** (n=5)
Farm types	6 dairy	3 dairy, 1 suckler cow, 1 other	1 dairy, 2 pig, 2 cash crops
Ø farm size	44 ha *(27 ha)*	43 ha *(24 ha)*	121 ha *(56ha)*
Ø LU/ha	1,3 LU/ha *(1,4 LU/ha)*	1,9 LU/ha *(1,4 LU/ha)*	1,6 LU/ha *(1,3 LU/ha)*
Share of organic farms	33% *(35%)*	20% *(16%)*	0% *(14%)*
Ø share of peat soils	65% *(42%)*	75% *(39%)*	47% *(32%)*
Ø share arable land	15% *(13%)*	10% *(6%)*	83% *(80%)*
Ø share intensive grassland	79% *(79%)*	76% *(73%)*	11% *(10%)*
Ø share extensive grassland	7% *(8%)*	9% *(20%)*	5% *(8%)*

The analysis of current peatland management of typical farms revealed that peat soils in all regions are used differently than mineral soils. Particularly in Lauteracher Ried (LR) and Oichten-Riede/Weidmoos (OWR) arable land use is mostly found on mineral soils while on peat soils grassland use is dominant. Figure 3 shows that peat soils of typical farms in the CSR ORW cases are exclusively used as grassland, of which nearly 60% is used intensively with up to six cuts per year, only 15% is used extensively. Almost 90% of yields are directly used to feed mainly cattle.

In LR, typical farms use ca. 85% of peatland as grassland, mainly with high intensities (4-4,5 cuts/year). In LR peat soils are also used as arable land, mainly to produce fodder for cattle.

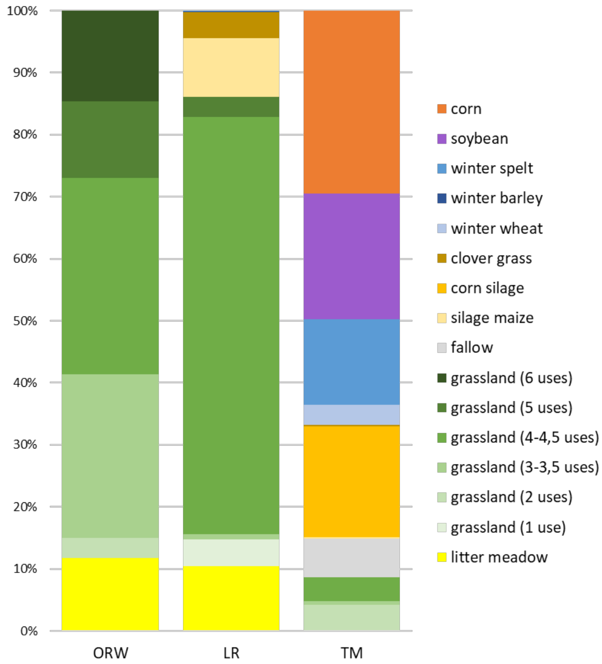


Figure 3: Land use on peat soils of surveyed farms; ORW=Oichten-Riede/Weidmoos, LR=Lauteracher Ried, TM=Thoner Moor. Source: own illustration.

In Thoner Moor (TM), arable peatland use is dominating with corn and soybean being the most important crops. Products are used as feedstock in pig production, and sold as market crops.

Value of production: To assess economic values representing typical agricultural production on Austrian peat soils, a calculation model was developed using data collected in the farm surveys, as well as agricultural standard data. Standardisation was used to ensure results were "typical" as regards farming and management system, but not distorted by farm specifics. Standard data stem mainly from the IDB provided by BAB[2] (years 2015-2019), validated by regional experts. The calculation model considers plot level costs. For cash crop production, gross margins were calculated. For area used for the production of feedstock, due to the lack of market prices, "gross margins" are derived from the calculation of processing values of nutrient units, based on gross margins of animal production[3]. Values were calculated excluding subsidies.

Table 5: Results on production value of peatland use of interviewed farms in the 3 case study regions; Source: own illustration

	Oichten-Riede/Weidmoos		Lauteracher Ried		Thoner Moor	
Land use type (excl. fallow	Ø monetary value In €/ha	Ø energy/ha	Ø monetary value in €/ha	Ø energy/ha	Ø monetary value in €/ha	Ø energy/ha
Intensive grassland	1.600 – 4.300	41.700 – 61.500 MJ NEL	1.300 – 2.500	38.700 – 57.150 MJ NEL	2.100	49.400 MJ NEL
Extensive grassland	2.300 €	30.000 MJ NEL	100 (pasture)	19.000 MJ NEL	700	(sold)
Litter meadows	100 €	-	100	-	-	-
Arable fodder	-		4.600 - 4.800	63.300-83.300 MJ NEL	Dairy 5.000 Pigs 2.200	70.000 MJ NEL 172.700 MJ ME
Cash crops	-	-	300 €	-	500	-

[2] IDB = Internet-Deckungsbeiträge (internet gross margins) by BAB (Bundesanstalt für Agrarwirtschaft u. Bergbauernfragen).

[3] They thus represent the loss that would occur if the processing of the crop via animal husbandry had to be restricted due to the loss of the area.

Table 5 shows the results of the calculation of short-term production values of peatland use of the interviewed farms in the 3 case study regions (CSRs). Especially in the case study regions OWR and LR, peat soils are mainly used for the production of forage for (dairy) cattle husbandry (see Figure 3). The economic value of production for the farmers on these areas, calculated through the processing values of energy units of feedstock produced, are particularly high. Basically, these values represent the value of own feed production in creating the gross margin in animal husbandry. Consequently, these values also represent the short-term loss of production value at the moment land is taken out of use, or transformed into litter meadows with close to surface water tables, as this area can't be used for feedstock production anymore and will result in a necessary decrease in numbers of animals and the related loss of gross margin in animal husbandry. On very intensive forage area, such as arable feed production in LR, such short-term production values can reach averages up to 4.800 €/ha. Also, on intensive grassland, e.g. in ORW, where high production meets high prices for milk, production values based on processing values are high, and can reach average values up to 4.300 €/ha on intensive grasslands cut 5-6 times. Gross margins of typical cash crop rotations amount to an average of 300€/ha (LR) and 500€/ha (TM). Values for litter meadows assume, that litter produced has a sales value of 9€ per dt dry matter (DM). However, farmers normally also receive high subsidies for the management of litter meadows, which are not included in the assessment. While short-term effects of transforming the now rather intensive use of Austrian peat soils come with high losses of production values on affected areas, in the medium- and long-term farmers will try to find damage-reducing adjustments that would have to be considered in long term economic valuation. Such adjustments are, e.g. the on-farm replacement of forage by expansion of arable fodder cultivation on mineral soils, buying of feedstock, renting additional area or even a total reorganisation of the farming system. How farmers in their individual situation and region can adapt to potential management changes however depends on factors such as land markets, feedstock markets, etc. The discussion of adaptation possibilities is part of WP4.

Assessing regional potentials of avoided GHG emissions from alternative management options (WP3)

WP3 assessed available datasets on soil and environmental variables to develop a method for the derivation of probable peat areas in order to estimate potentials for GHG emissions from peat. The lack of standardized and comparable maps on organic soils, not only for Austria, is a challenge for reliable and comparable estimates on GHG emissions from peatlands. Tiemeyer (2020) highlights the influence of the map resolution on the land-use distribution for organic soils and the GHG-emission factors (EF) used. Tanneberger (2017) provided a peatland map for Europe by combining national datasets on organic soils and highlights the necessity of complete and standardized nationwide information. In most countries the existing data differs in mapping units, extents and diverging definitions on organic soils. Efforts in combining such data in a standardized way have been done for Germany (Roßkopf 2015) and Switzerland (Wüst-Galley 2015). Roßkopf (2015) described a systematic assessment approach using secondary national and local data, to define homogenous pedological classes for organic soil. Wüst-Galley (2015) presented a semi-automatized assessment process for organic soils based on scores for peat-suitability for every input-dataset. Ground truthing methods were used to validate input data as well as the resulting map. Different soil mapping units of input data have been identified as one of the mayor unsolved problems in homogenizing data of organic soils. For international comparability between maps, the recommendations for organic soils specified by IPCC (2014) were used for all recently established maps.

Organic soil area:

We collected all available data on soil and environmental variables in order to assess them on their potential to show the presence or absence of organic soil. A probability assessment was accomplished using the organic soil type from eBOD (https://bodenkarte.at) as reference for known peatland in order to specify the probability of the indicators to appear in conjunction with organic soil. Every indicator received a score value according to their likelihood to appear in conjunction with organic soil. The individual Indicator scores were cumulated and an empirical threshold were built distinguishing between organic soil/non-organic soil. As this background should give information about areas suitable for the emergence of organic soils but not necessarily show as organic soil in eBOD (we assume that the area of organic soils is higher than eBOD shows us) this attempt should classify more area. There is further soil information needed to specify probable organic soil areas. As both statistical methods (probability score and k-means clustering did not yield satisfactory results, we used the areas of eBOD2 to estimate CO2-emissions from organic soil. At the time this is the best dataset for organic soil on agricultural land except forests.

Tab. 6: modelled probable organic soil area in comparison to peat soil area from eBOD and amount of probable organic soil area not inside eBOD organic soil areas in hectares and percent of eBOD org. soil.

case study region	eBOD org. soil [ha]	modelled area on eBOD org. soil [ha]	additional probable peat area modelled in eBOD non organic	Percentage modelled area in eBOD org soil	additional probable peat area in eBOD non organic soil
1	4273	3285	6765	77%	158%
2	2531	1326	9272	52%	366%
3	3283	2431	1474	74%	45%

Average score-means at eBOD2 organic soils and non-organic soils differ significantly for all case study regions showing the potential of this attempt to distinguish between organic and mineral soils.

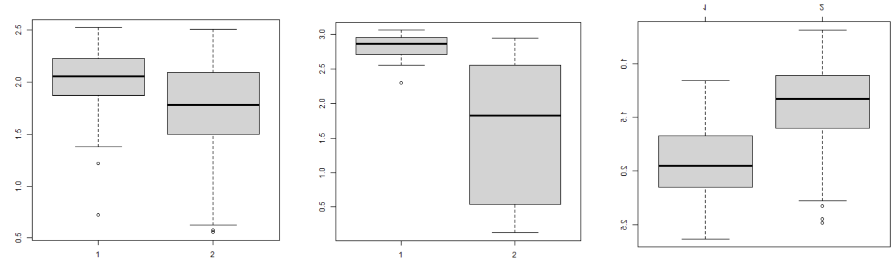


Fig. 4 Probability score means for areas of eBOD2 with organic soil presence (1) or absence (2)

<u>Avoided emissions in the focus regions:</u>

Land use in the focus regions estimated organic soil area was merged with the organic soil layer. The resulting maps (Fig.2) also show the potential for alternative soil management. Our analyses reveal that cropland is never associated with "wet" conditions (e.g. a groundwater table of <10 cm) and even "moist" conditions (e.g. a groundwater table of 10-30 cm) are very rare. Grassland use is concentrated in "moist" conditions. Therefore, a land use change from cropland to grassland is our best, and conservative approximation for avoided GHG emissions from alternative management options. This is further elaborated in WP6.

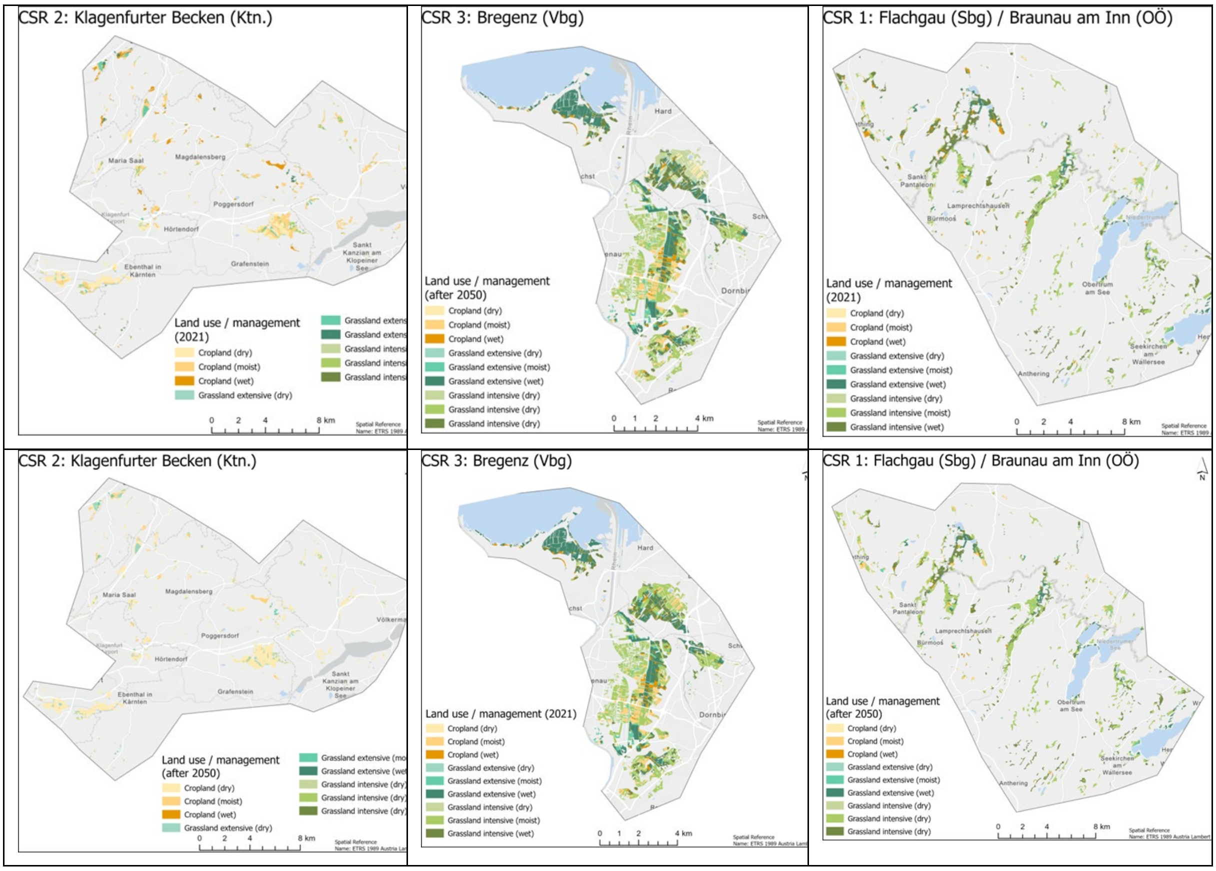


Fig. 5 Land use on peat soils in the three focus regions.

Development of an integrative evaluation matrix: policy options, management alternatives and potential for mitigating GHG emissions (WP4)

WP4 assessed the potential of the case study regions to implement climate smart agriculture and propose implementation pathways. Based on the results of the preceding WPs, in WP4 we developed an integrative evaluation matrix, built on indicators representing the socio-economic, natural scientific and "regional societal" perspective of changing the current peatland management. We evaluated the characterisation of these indicators for the three typical context situations of peatland management represented by the three case study regions, making use of the results derived in WP1, WP2, WP3 and WP5, but also from additional empirical research based on the analysis of secondary data and the additional information gathered in the farmers' interviews. Based on our assessment we qualitatively discuss development potentials and derive recommendations for climate smart management adaptation and governance options.

Assessment indictors:

Class	Indicator	Description
SE	Value of production	*Based on WP2 calculations; the indicator is used to describe short term losses of production values under the 2 scenarios of management adaptations*
SE	Affectedness	*based on the results of the analysis of land use, the indicator describes the average amount of UAA on peat soils for the region (or the interviewed farms) and therefor the amount of area potentially affected by management changes*
SE	Importance of peatland management	*Based on the results of the farm survey, the indicator describes farmers perspective on the role and integration of peatland management into their farming systems.*
SE	Adaptation potentials	*This composite indicator evaluated the farmers survey results of three aspects, namely 1.) potential compensation options in cases of forage losses, and 2.) potential use of products from restored areas and, lastly, 3.) acceptance of management alternatives. The indicator logic is that the less farmers have the potential to adapt to losses of yields and feedstock and the lower their acceptance of alternative management, the lower are implantation potentials*
SE	Regional heterogeneity of land use/land use structure	*Based on the analysis of secondary data, the indicator describes implementation potentials due to 1.) landscape structure (measured in field sizes), 2.) the distribution of different land uses, as well as 3.) the number of different farmers managing the area and 4.) the numbers of lessors as an indicator for ownership structures. The indicator is applied to characterise the implementation potential due to the effort to develop a common strategy of enhancing water tables on a wider area.*
CLIM	Emission reduction potential	*The indicator emission reduction potential describes the potential of the land use systems on peat soils to contribute to the mitigation of climate change*
REG/SOC	Awareness of stakeholder	Indicator describes the knowledge and perception of stakeholders about the pressure on peatlands and potential climate-smart solutions
REG/SOC	Natura 2000	Indicator for current management practices directed towards protection

Interdisciplinary evaluation of implementation potentials in the case study regions

For the characterisation of the assessment indicators, we make use of a heatmap representation, applying 5 levels, describing how strong the indicator characterisation in the three case study regions will foster of hinder implementation.

Table 7: Heat map of implementation potentials for the 3 PeatGov case study regions

	Indicators	ORW	LR	TM
SE1	Value of production			
SE2	Affectedness			
SE3	Perceived role of peatland area for typical farms			
SE4	Adaptation potentials			
SE5	Regional heterogeneity of land use/land use structure			
CLIM1	Emission reduction potential			
SOC1	Awareness of stakeholders			
SOC2	Natura 2000 designation			
SE= Socioeconomic; CLIM=Climate; SOC=regional societal perspectives				

Legend:

	Can strongly foster implementation
	Can foster implementation
	Neither fosters nor hinders
	Can hinder implementation
	Can strongly hinder implementation

Our analyses indicate that implementation potentials in the three case study regions are strongly hindered by the socio-economic basic condition of typical farms managing peatlands in Austria. The characteristics of the economic indicators SE1–SE3 make voluntary changes of peatland management into climate neutral land use forms (restoration or wet litter meadows) in all regions most unlikely. Lack of adaptation options (SE4) will further hinder the compensation of income losses on typical farms. In contrast, all regions have high potentials to reduce emissions from agriculturally used peat soils, given management is changed into restoration/rewetting, or into litter meadows with groundwater levels, which are close to surface. As regards the regional societal perspectives and the potentials due to the societal discourse, results show that the topic has reached the community of stakeholders and practitioners and awareness is high. However, concern against climate friendly management changes prevails amongst agricultural stakeholders. Also, in all regions there is a high level of uncertainty about the climate relevance of managed peatlands which is a hindering factor for acceptance. For voluntary implementation of such measures, in our view, creation of a common scientific knowledge base is a key element for acceptance and rethinking. Already existing nature protection regulations in the 2 regions of ORW and LR, both being partly located in Natura2000 areas, might represent an advantage for implementation, because farmers are already used to nature conservation and are moreover aware of the specific character of the area. Nevertheless, discussions at the workshop in Salzburg showed, that existing nature conservation can also be perceived as negative for farming, and, if implemented with the crowbar, as perceived by some agricultural stakeholders, might represent even a barrier for future nature conservation projects.

Stakeholder workshops (WP5)

In WP5, we used the interdisciplinary findings from WP1-4 as scientific input and stimulus for a localized discussion on the contextual conditions, management and policy options, and climate impacts of climate-smart agriculture on peatlands. The stakeholder workshops - one in each case study region - provided the tools for stakeholder participation, structured reflection on contextual vulnerabilities, and concluded with a discussion on potential adaptation measures for climate-smart peatland management in the selected regions. WP5 started with the identification of relevant stakeholders, the organization of participatory workshops and the preparation of presentations.

To prepare for the stakeholder workshops, we first organized a meeting with the members of the project's Advisory Board (AB) in July 2022 to present and discuss our preliminary findings and the selected case study regions. The AB meeting started with three presentations of the disciplinary results. The second half of the meeting was dedicated to a facilitated discussion. The preliminary results of the project were welcomed by the participants. Further exchange on the project results was considered desirable and agreed upon.

The stakeholder workshops in the selected case study regions were planned to explore and discuss key issues affecting the capacity for adaptive management of agricultural peatlands in the selected case regions. The objectives of the workshops were to: (i) improve the quality of information on the contextual conditions, barriers and drivers of climate-smart agriculture on peatlands; and (ii) deepen the understanding of the likely impacts, vulnerabilities and resulting adaptation options for farmers in the selected regions by integrating farm management data, analysis of policy options and the potential for GHG emission mitigation through adaptation to climate-smart agriculture. Stakeholder workshops were conducted in each case study region in February, March and June 2023. The workshops lasted half a day and included elements of presentation and discussion. Between 13 and 17 participants with different interests in agricultural peatland management attended the stakeholder workshops - e.g. different authorities, peat farmers, chambers of agriculture and consultants. The workshops started with an introduction to the physical, economic and political aspects of climate-smart peatland management. The aim was to raise awareness among stakeholders of different mitigation and adaptation options in terms of alternative policy and management options. Participants were encouraged to develop their own views and visions on climate-smart agriculture by discussing management options that make sense to them, and to complement these elements with the concrete contextual conditions of their region and farms.

The three workshops shed some lights on the similarities and differences between the case study regions. For instance, it became clear that the problem pressure and awareness among stakeholders varied significantly between the three regions. The potential of managing the water tables on peatlands was also viewed quite differently in the three regions. There was great uncertainty about the climate relevance of peatlands in all our case study regions. It is an obstacle that agriculture feels overrun by politics, a feeling of expropriation through the back door by the GLÖZ2 standard, and a lack of trust in the data basis of the maps.

Assessing realistic potentials for mitigating GHG emissions by climate smart agriculture in the Austrian context (WP6)

Emission factor calculation

We used the method of Tiemeyer et al. (2020) for the estimate of Austrian emission factors. We applied the dataset provided in this publication as well, which shows Carbon emission, type of land use and groundwater table depths for German mires. As northern German mires are very different from Austrian ones, we only used the southern German mire data to retrieve Emission factors. According to Tiemeyer et al. (2020), we used a Gompertz-Function to estimate the relationship between water table depth and carbon emission. We neglected dissolved carbon losses, because they should be very small. We stratified carbon emission by land use intensity, by calculating distinct emission factors for extensive used grassland, intensive used grassland and cropland. The class extensive was used for litter meadows, meadows which are not mown more than once a year and for pastures. We classified pastures into the extensive class under the presumption, that it is not possible to have large amount of livestock on organic soil, because the wet soil is to sensible for large livestock.

In the Austrian assessment report on climate change following changes for Austrian climate are proposed: Temperature will increase in all Regions. Precipitation will most likely increase in winter months (~10%) and decrease in summer months (~20%) depending on region. The northwestern region will face less decrease than the southwestern part of Austria. For soil-moisture there is very little change expected until 2050. Afterwards a decrease is mainly expected from March to August. We used Copernicus Sentinel 2 – Soil moisture dataset in 5'' resolution from 2005 to 2021 and ASCAT soil moisture dataset in 0.5° resolution since 1978 to retrieve the deviation into southwest and northwest. First the more accurate Sentinel-Data were compared to the coarse ASCAT dataset. After we could confirm a satisfying accordance, we used the timeseries on the ASCAT dataset for 20year averages between 1978 and 1997 and 2002 to 2021 and compared these datasets for differences. The results showed very low differences within this 40-year period, which is in accordance to the Austrian Assessment report, which does not expect changes in soil moisture until 2050. We could not find clear evidence for a division of Austria in a southeast and northwestern part yet but assumed that this will happen after 2050. Regarding the expected decrease in precipitation in the southwestern part of Austria, we divided the Austrian organic soil area into a northwestern and southeastern part alongside the alpine main ridge, the "Mur-Mürz-Furche" up to the Viennese forest and the Pannonic climate region.

To account for this change in soil moisture in a future climate we shifted in the southwestern region of Austria all 16 soil classes two steps in the dry direction and for the northwestern Area one step in the dry direction. The 16 classes were generalized again in the 3 classes dry, moist wet. For the southwestern part this resulted into the loss of the wet class, in the northeastern region the wet-class still exists but declined. These calculations allowed us to estimate the present and future CO2 emissions from peat soils under agriculture in Austria, as illustrated in Table 8.

Table 8: Area and estimated CO_2- Emissions from peat soils under agriculture in Austria 2021 and after 2050

		2021		after 2050			
NORTHWEST	**CO2 t/ha**	**Area ha**	**CO2 t**	**Area ha**	**CO2 t**	**Difference (ha)**	**Difference CO2 (t)**
Cropland (wet)	3.53	799	2817	686	2418	-113	-399
Cropland (moist)	25.89	1765	45694	795	20581	-970	-25113
Cropland (dry)	37.41	243	9099	1326	49618	1083	40519
SUM		**2807**	**57610**	**2807**	**72618**	**0**	**15007**
Grassland intensive (wet)	3.53	5411	19084	4512	15915	-898	-3169
Grassland intensive (moist)	25.89	5465	141494	5111	132331	-354	-9163
Grassland intensive (dry)	37.92	148	5599	1400	53093	1252	47494
SUM		**11024**	**166177**	**11024**	**201339**	**0**	**35162**
Grassland extensive (wet)	3.53	2294	8090	2087	7363	-206	-727
Grassland extensive (moist)	20.01	651	13020	731	14626	80	1606
Grassland extensive (dry)	34.35	18	628	144	4954	126	4327
		2963	**21738**	**2963**	**26943**	0	**5206**

		2021		after 2050			
SOUTHEAST	**CO2 t/ha**	**Area ha**	**CO2 t**	**Area ha**	**CO2 t**	**Difference (ha)**	**Difference CO2 (t)**
Cropland (wet)	3.53	915	3229	0	0	-915	-3229
Cropland (moist)	25.89	6873	177938	915	23700	-5957	-154238
Cropland (dry)	37.41	1114	41665	7987	298772	6873	257107
SUM		**8902**	**222831**	**8902**	**322471**	**0**	**99640**
Grassland intensive (wet)	3.53	691	2437	0	0	-691	-2437
Grassland intensive (moist)	25.89	1176	30442	691	17891	-485	-12551
Grassland intensive (dry)	37.92	125	4733	1301	49322	1176	44589
SUM		**1992**	**37612**	**1992**	**67213**	**0**	**29601**
Grassland extensive (wet)	3.53	545	1921	0	0	-545	-1921
Grassland extensive (moist)	20.01	879	17598	545	10897	-335	-6701
Grassland extensive (dry)	34.35	56	1940	936	32145	879	30205
		1480	**21458**	**1480**	**43042**	0	**21584**

Based on the available data on the distribution of peat soils, it is currently not possible to make a reliable assessment of greenhouse gas emissions from peat soils. Based on Tiemeyer et al. (2016), an average release of 25 t CO2 equivalent ha/year can be assumed from peat soils under arable and grassland. In Switzerland, greenhouse gas emissions from agricultural organic soils account for between 1 and 2% of total emissions (FOEN 2020, Leifeld & Wüst-Galley 2021). From today's perspective, emissions in Austria can also be expected to be in this range.

5 Conclusions and recommendations

The project PeatGov-Austria generated novel insights into Austria's peatland management, in particular assessing the amount of peatland area under agricultural management and typical management practices on these sites as well as estimating the potential for reducing GHG emissions. The main conclusions from the project can be summarized as follows:

Greenhouse gas emissions from peat soils

The total area of Austria's organic soils as well as the greenhouse gas emissions released from these soils are still not known. This impedes our ability to draw sound conclusions in terms of the potential of mitigating emissions by adapted land use policies. However, based on our assessments of secondary data we can confidently approximate both the area of Austria's organic soils under agriculture as well as the expected greenhouse gas release, so this lack of sound information should not be a reason for lacking action. Climate change can be expected to further increase the greenhouse gas release from peat soils in Austria.

Climate-smart peatland management – a challenge for cross-sectoral policy integration

Designing a coherent policy regime that promotes and supports climate-smart peatland management is a serious institutional challenge. Peatland management poses a cross-sectoral policy integration challenge due to its complex and multifaceted nature, spanning different policy sectors such as agriculture, climate change mitigation and adaptation, energy, forestry, nature conservation and water management (Nordbeck and Hogl, 2023). Sectoral policies aim at different policy objectives, such as peatland restoration, carbon sequestration, and sustainable land use management. These functions are not inherently in conflict, but trade-offs and synergies need to be recognized to develop an integrated policy approach and avoid misalignment. Our study shows a lack of cross-sectoral policy integration. In particular, the Common Agricultural Policy works against climate objectives because direct payments currently encourage unsustainable peatland management. First pillar direct payments support current drainage-based agriculture, while second pillar payments co-finance AECM and promote implementation measures to reduce emissions. In the absence of clear guidelines for raising groundwater levels, current incentive-based policy instruments are ineffective in reducing emissions (Chen et al, 2023).

Peatland governance – striking the right balance between regulation and financial incentives

There is currently an ongoing scientific debate on how best to design a policy framework that promotes climate-smart peatland management. Some researchers argue that banning peatland drainage is necessary to achieve long-term climate goals, and therefore call for regulation and complementary compensation. Other authors argue for a stronger use of regulatory instruments, as they consider incentive-based policies inappropriate to achieve climate goals for peatlands, given the high pressure on land use (Ekardt et al., 2020). However, there are only few examples where governments in Europe have chosen hard regulatory instruments for climate-smart peatland management. For example, the ban on new cultivation on peatlands to reduce agricultural emissions in Norway in 2020 was highly controversial as it violated farmers' rights to manage their own property (Farstad et al., 2022). Accordingly, the majority of researchers and stakeholders prefer incentive-based instruments (Chen et al., 2023).

Our stocktaking of policy instruments for climate-smart peatland management in Europe supports the thesis that most European governments rely on incentive-based instruments. We found a wide variety of support measures using co-financing from the EU Agricultural Fund for Rural Development (EAFRD) or the EU Regional Development Fund (ERDF) to promote climate-smart peatland management in different EU Member States. In general, there is no convincing argument why these support measures could not also be adopted in Austria. Therefore, the transferability of the measures is not the main issue. The Strategic Plan for the period 2023-2027 provides many potential linkages to support climate-smart peatland management. More importantly for the Austrian context, the stakeholder workshop in the selected case regions and additional background discussions with interest groups revealed a rather strong reluctance among peat farmers and interest groups to use EU funds to promote climate-smart peatland management. Peat farmers were much more in favour of a national policy strategy as a framework for designing incentive-based instruments.

Agricultural peatland management – an important factor for the creation of income for farms

Our analysis of the management of agriculturally used peat soils on typical farms in Austria showed that these areas to a large extent are managed intensively as arable land or grassland and are well integrated into the respective farming systems. Peatland areas are particularly used for forage production in dairy but also pig husbandry systems, but also for cash crop production. Extensive use forms, such as litter meadows or fallow land are carried out on only small amounts of areas. Products from peat soils are usually used in the same way as products from mineral soils.

The assessment of the economic production values of typical peatland management shows, that especially if used for the production of forage for (dairy) cattle husbandry, the current management on peat soils creates high short-term production values for the farms. In combination with high shares of peatland areas in total UAA of the typical farms, the high short-term losses of production value at the moment land is taken out of use, will make voluntary changes of peatland management into climate neutral land use forms (restoration or wet litter meadows) unlikely. Especially as adaptation options, such as land renting or buying of forage, in most regions seem limited, such management changes would jeopardize the future viability of the current farming systems. Thereby it is clear, that in the medium- and long-term farmers will try to find damage-reducing adjustments that would have to be considered in a long-term economic valuation.

In conclusion, against the background of climate change, we see a dichotomy arising. On the one hand, farmers could help to mitigate climate change and reduce emissions by adapting their management on peat soils. On the other hand, peat soils are an important source of income and, moreover, an opportunity for farmers to buffer the impacts of climate change. Peat soils are particularly important in dry years to buffer yield losses on mineral soils. This role is expected to be even more important if dry periods become more common in the course of climate change.

Climate smart management – the need for knowledge exchange and tailored solutions

A general conclusion we draw from the project is that much more information transfer from science to practice is needed, to close the severe knowledge gap about the climate relevance of peatland management – to the aim of increasing awareness and acceptance of climate-smart management. Nevertheless, our project results also make clear that beyond that, for the future implementation of climate-smart peatland management, new and potentially more innovative ways of financial compensation might be needed. A strong concluding recommendation or our project is that the development of tailored, region specific solutions, will need a transdisciplinary as well as interdisciplinary approach and – given the importance of these areas for affected farms - will not succeed without integrating the agricultural perspective into the discourse and the development of feasible solutions.

Relevance for other target groups and further steps

The project team will continue to publish the results of PeatGov-Austria. A joint publication is in preparation. We will also proceed with other research projects. For instance, Prof. Glatzel submitted a proposal to the BMK together with other soil researchers to improve the mapping of peat soils in Austria. The results of PeatGov-Austria are already used by other target groups:

- A project team bringing together farmers and nature conservationists to work out a "regional nature conservation plan" has been set up in the Lauteracher Ried (Vorarlberg) as a consequence of our project. In Nov. 2023, this project team will begin its work and Prof. Glatzel has been invited to hold a presentation in the kick off workshop.

- In Salzburg, the farmer’s association invited the PeatGov Austria team to pursue future projects together to evaluate possible positive benefits by installing weirs with variable drainage depths.
- In Styria, the regional government is using an impulse triggered, among others by PeatGov Austria, to establish variable drainage depths in ditches to test their effect on crop yield and peat conservation.

C) Project details

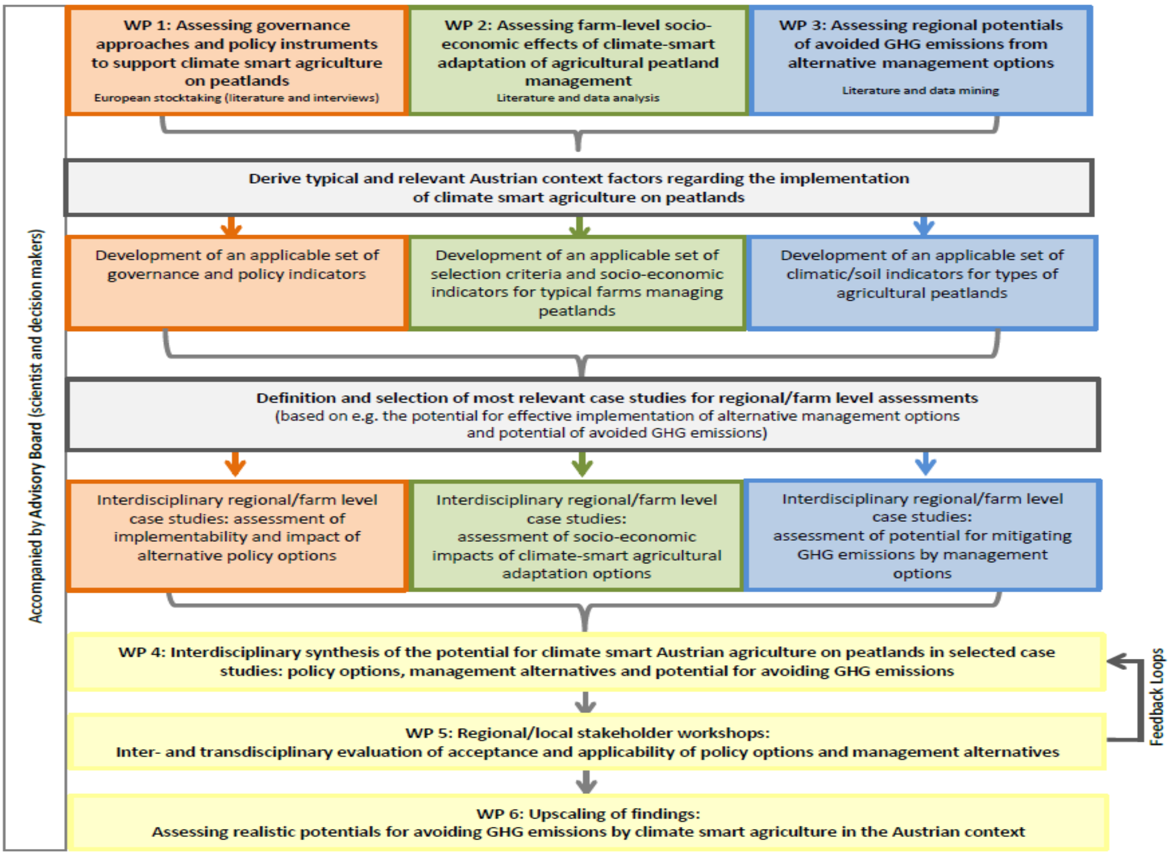
6 Methodology

PeatGov-Austria started from the three main pillars of the conception of “climate smart agriculture” (CSA), as advocated by the United Nations (cf. FAO 2013, 2017) and the World Bank (2018). CSA aims at contributing to the achievement of sustainable development goals by a) sustainably increasing agricultural productivity and incomes; b) adapting and building resilience to climate change; and c) reducing and/or removing GHG emissions, where possible (FAO 2013). Thus, it aims to address simultaneously the challenges of food security, climate change mitigation and adaptation to climate change. For integrating these pillars, which are often in conflict at field level implementation, CSA promotes a landscape level approach for intensive involvement of land managers and preserving biological processes and valuable ecosystems such as peatlands for their regulatory services and large carbon sinks (ibid., p. 50). The concept of CSA has raised broad interest in both the science and the policy community. In fact, it “has consistently been positioned between science and policy” (Saj et al. 2017, 20). A meta-analysis by Saj et al. (2017) shows an absence of studies that simultaneously address all three CSA pillars, and a prevalence of articles which address issues of adaptation, but fewer articles dealing with productivity and GHG mitigation. Furthermore, research has a predominant focus on developing countries, global agendas and issues of agricultural management (see Chandra et al. 2017). Thus, there is a lack of studies aiming to integrate all three pillars of CSA and studying its applicability in developed countries. PeatGov-Austria contributes to fill these gaps.

In short, CSA presents an approach that aims at landscape-level integration of agricultural production and the adaptation to and mitigation of climate change, covering different levels of actions from agricultural practices to policy change (Engel and Muller 2016, 174). This perspective provided a fruitful conceptual starting point for PeatGov-Austria to take an integrated approach for assessing alternative options for peatland management in Austria, their potential for emission reductions and to identify applicable and effective governance approaches and policy instruments to support a transformation towards more climate-smart agriculture on organic soils.

Translating the core theme of the CSA pillars to our research topic "agricultural management of peatlands" called for an inter- and transdisciplinary approach of PeatGov-Austria, considering issues of agricultural productivity and profitability, adaptation and resilience to climate change, and the reduction of GHG emissions. PeatGov-Austria implemented this approach using a case study research design (Yin, 2018). Three case study regions were selected with the goal to capture most common, typical Austrian farm types and agricultural peatland management, and most relevant Austrian peatlands featuring significant potentials for adaptation and reduction of GHG emissions. The case study regions represent livestock farms such as specialist milk and cattle farms managing peatland mainly as grassland, but also as arable land for forage production, mixed crops and livestock farms, and mixed livestock farms, both managing grassland as well as arable peatland sites for forage and cash crop production. Figure 6 outlines the integrative implementation of the conceptual framework.

Figure 6: The interdisciplinary and integrative research design of PeatGov-Austria



The project consisted of six WPs, five of which were concerned with research and the sixth with organizing three stakeholder workshops in the selected case region in Carinthia, Salzburg, and Vorarlberg. The six WPs and the activities performed hereunder can be summarized as follows:

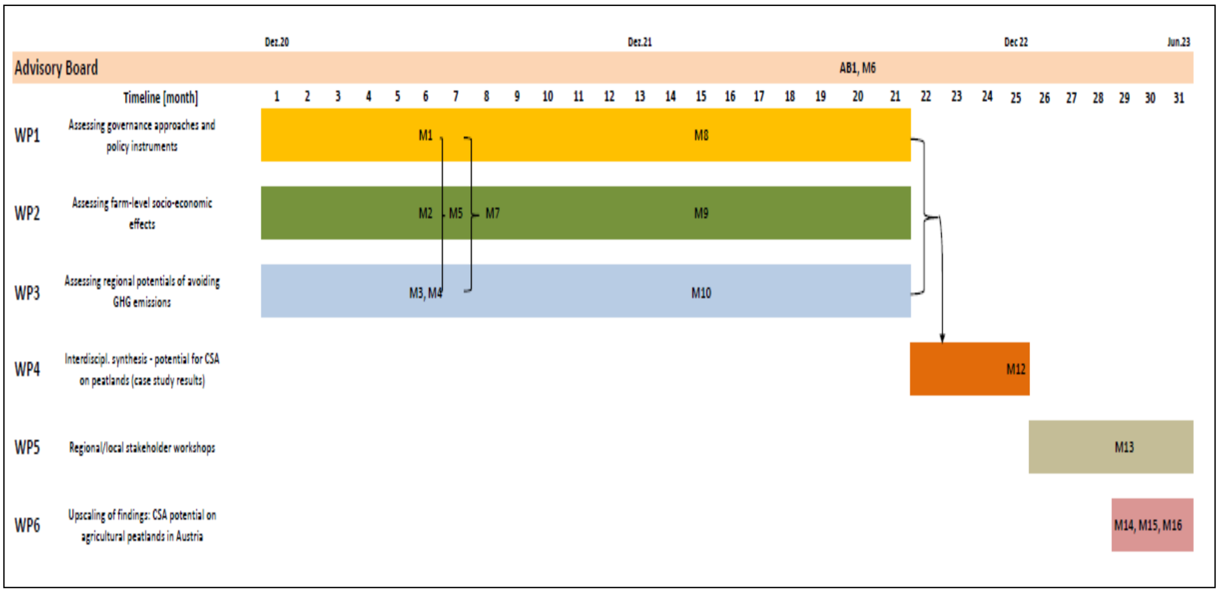
- In **WP1** we conducted a stocktaking of governance approaches and policy instruments to support climate-smart agriculture on peatlands in Europe. The stocktaking identified a number of good practical examples from selected EU Member States using different policy instruments. Based on document analysis and a survey among peatland farmers we explored possibilities for a policy transfer and discussed policy options in the selected 3 case study regions to deepen our understanding of the challenges and benefits of the respective governance arrangements from an instrumental perspective.
- **WP2** secondary data analysis provided an overview on agricultural use of peat soils while literature review identified relevant socio-economic context factors for peatland management. A two-step cluster analysis identified major farm types, their relevance in Austrian peat soil management and their spatial distribution, being a major basis for the choice of case studies. Online expert interviews validated first results and identified "typical farms". Face-to-face interviews on 5-6 farms in each case study region delivered in-depth data on peatland management (intensities, productivity, use of products, etc.), farmers' perspectives and acceptance of potential measures towards climate smart management. Primary interview data plus standard data, fed into a calculation model, to calculate productivity and economic importance of peat soils and estimating socio-economic effects of climate-smart management adaptations.
- Within **WP3**, we mined available data and assessed different modelling approaches to derive a best estimate for the area covered by organic soils on agricultural land in Austria, focussing on three regions. Assigning representative ground water tables to the respective land use in the focus regions enabled us to identify land use change options that bear a high potential for reducing greenhouse gas emissions: A land use change from cropland to grassland is our best, and conservative approximation for avoided GHG emissions from alternative management options.
- **WP4** used the results of the previous work packages, as well as the results of the regional workshops, to identify the most important input factors influencing the feasibility of management changes and their output variables. We elicited 8 output indicators for 3 different input factors, evaluated them with empirical results from our studies, and presented them by means of a heat map matrix comparing the potential of the case study regions to change current peatland management towards climate smart management. Through a qualitative discussion, we assess the implementation potential for each region and provide recommendations for implementation pathways.
- In **WP5** three stakeholder workshops were conducted in the selected case study regions of Oichtenried/Weidmoos in Salzburg, Lauteracher Ried in Vorarlberg and Thoner Moor in Carinthia. The aim of the stakeholder workshops was to jointly reflect the interdisciplinary approach of Peat-Gov with relevant

stakeholders and to discuss the specific results in each of the case study regions.

- In **WP6**, we adapted the method by Tiemeyer et al. (2020) lo local conditions to estimate Austrian emission factors. This required some simplifications, as neglecting losses of dissolved organic carbon in water. To derive a future scenario, emissions were re-calculated with Sentinel datasets and state of the art prognoses on the development of soil moisture in Austria. Following this application, one may assume drier soils and increased greenhouse gas emission from organic soils especially in the southeast of Austria after 2050. Based on the available data on the distribution of peat soils, it is currently not possible to make a reliable assessment of greenhouse gas emissions from peat soils, but our best estimate is that greenhouse gas emissions from agricultural organic soils in Austria currently account for between 1 and 2% of total emissions

7 Work and time schedule

The work and time schedule of PeatGov-Austria is characterised by a cost-neutral extension of the project duration to 31 months. This extension enabled us to cope with the complexities of peatland management as a cross-sectoral research topic, the three regional case studies, and the organization of stakeholder workshops in the selected case study regions. All milestones of WP1-WP6 described in the project proposal were successfully completed. The sequence of activities in PeatGov-Austria followed the work and time schedule outlined in the project proposal.



8 Publications and dissemination activities

One of the main purposes of the PeatGov-Austria project was to deliver high-quality journal manuscripts, to be presented at academic conferences and published in peer-reviewed journals. As indicated here, more publications and presentations have been delivered than envisioned in the project proposal:

Publications:

(1) Eckart L., Kantelhardt J., Schaller L. (2022): Die Nutzungs- und Betriebsstruktur auf landwirtschaftlich genutzten Moorböden in Österreich und deren Bedeutung für klimaangepasste Managementoptionen; Austrian Journal of Agricultural Economics and Rural Studies Vol. 31, DOI10.15203/OEGA_31.8 https://oega.boku.ac.at/fileadmin/user_upload/Tagung/2021/AJARS31/10_Eckart_et_al.pdf

(2) Nordbeck R., Hogl K. (2023): National peatland strategies in Europe: Current status, key themes and challenges. Submitted to Regional Environmental Change.

(3) Glatzel S. (2021): Moore und Klimawandel: Intakte Moore schützen, degradierte revitalisieren. Natur. Raum. Management., 50(04), 10-11. https://www.bundesforste.at/fileadmin/publikationen/naturraum/NRM_Journal_4_2021_screen.pdf

(4) Dinesen, L. Joosten, H., Rochefort, L., Lindsay, R., Glatzel, S. (2021): Restoring drained peatlands: A necessary step to achieve global climate goals. Ramsar Policy Brief No. 5. Gland, Switzerland: Secretariat of the Convention on Wetlands.

(5) Kroisleitner, C., Glatzel, S., Ascher, S., & Deng, Y. (2022): Mapping Austrian organic soil by using hydro-geomorphological probabilities. https://doi.org/10.5194/egusphere-egu22-3655

(6) Tanneberger, F., Larmola, T., Sirin, A., Arias-Navarro, C., Farrell, C., Glatzel, S., Kozulin, A., Laerke, P-E., Leifeld, J., Mäkipää, R., Minayeva, T., Moen, A., Oskarsson, H., Pakalne, M., & Sendžikaitė, J. (2022): Global Peatlands Assessment: Regional Assessment for Europe. in Global Peatlands Assessment: The State of the World’s Peatlands: Evidence for action toward the conservation, restoration, and sustainable management of peatlands (S. 123-154). United Nations Environment Programme. https://www.unep.org/resources/global-peatlands-assessment-2022

Presentations

(1) Schaller L., Eckart L., Kantelhardt J., Glatzel S., Kroisleitner C., Nordbeck R., Hogl K. (2021): PEATGOV – Governance Options for Climate Smart

Agriculture on Austrian Peatlands. 21. Österreichischer Klimatag - Clash of Cultures? Klimaforschung trifft Industrie, 12./13.04.2021, Online

(2) Eckart, L.; Glatzel, S.; Hogl, K.; Kantelhardt, J.; Kroisleitner, C.; Nordbeck, R.; Schaller, L. (2021): Structural differences of farms managing peatlands in Austria. 31. Jahrestagung der Österreichischen Gesellschaft für Agrarökonomie, online, Wien, September 16-17, 2021.

(3) Eckart, L. Kantelhardt, J. & L. Schaller (2022): Towards climate-friendly agriculture on peatlands – insights from Austria, Agricultural Economics Society of Ireland Conference, 12th and 13th May 2022, National University of Ireland (NUI) Galway https://ageconireland.files.wordpress.com/2022/05/aesi_boa_final.pdf

(4) Eckart, L. Schaller, J. Kantelhardt (2022)::Rewetting peatlands means reducing emissions – but what does it mean for farmers? A socio-economic case study analysis in Austria, 11th AIEAA Congress, CAP, Farm to Fork and Green Deal: policy coherence, governance and future challenges. 16-17 June 2022, Viterbo, Italy. https://www.aieaa.org/node/697

(5) Eckart L, Schaller L., Kantelhardt J. (2022). Peat soils from the farmers' perspective: integration, importance and implications in the context of climate change. Joint Conference of the Slovenian Association of Agricultural Economists (DAES) and the Austrian Association of Agricultural Economists (ÖGA), Societal changes and their implications on agri-food systems and rural areas Ljubiljana, Slovenien, https://www.daes.si/storage/category/QW4YBLsFRsV8ZcwO257yqeMLiK4PhdA7Be2n5j9K.pdf

Master thesis:

(1) Ascher, S. (2023): Ackerbaukulturen auf Moorböden in Österreich: Genauigkeiten bestehender Kartierungen. MSc Thesis University of Vienna. 135 p.

Podcast:

(1) Eckart L., Schaller L. (2022): Landwirtschaftlich genutzte Moorböden als Klimaretter? Hörndl, Körndl & Co, https://open.spotify.com/episode/0bvpU6n5XpoWetatrrzKh

9 References

Bundesministerium für Landwirtschaft, Regionen und Tourismus (BMLRT) (2022). Moorstrategie Österreich 2030+. BMLRT, Wien.

Carlson, K.M., Gerber, J.S., Mueller, N.D., Herrero, M., MacDonald, G.K., Brauman, K.A., Havlik, P., O'Connell, C.S., Johnson, J.A., Saatchi, S., West, P.C. (2017). Greenhouse gas emissions intensity of global croplands. Nat. Clim. Chang. 7, 63–68.

Chandra, A., McNamara, K.E., Dargusch, P. (2017). Climate-smart agriculture: perspectives and framings, Climate Policy, 18:4, 526-541, doi: 10.1080/14693062.2017.1316968

Chen C., Loft L., Matzdorf B. (2023). Lost in action: Climate friendly use of European peatlands needs coherence and incentive-based policies. Environmental Science and Policy 145, 104–115.

Drösler, M., Adelmann, W., Augustin, J., Bergman, L., Beyer, C., Chojnicki, B., Forster, C., Freibauer, A., Giebels, M., Gorlitz, S., Hoper, H., Kantelhardt, J., Liebersbach, H., Hahn-Schofl, M., Minke, M., Petschow, U., Pfadenhauer, J., Schaller, L., Schagner, P., Sommer, M., Thuille, A., Wehrhan, M. (2013). Klimaschutz durch Moorschutz: Schlussbericht des Vorhabens "Klimaschutz–Moorschutzstrategien" 2006–2010. Technische Universität, München.

Engel, S., Muller, A. (2016). Payments for environmental services to promote "climate-smart agriculture"? Potential and challenges, Agricultural Economics 4, 7 supplement, 173–184.

Essl, F., Dullinger, S., Moser, D., Rabitsch, W., Kleinbauer, I (2012). Vulnerability of mires under climate change: implications for nature conservation and climate change adaptation. Biodivers Conserv 21: 655-699.

EU (2013). Decision No 529/2013/EU of the European Parliament and the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities. Brussels: Official Journal of the European Union.

Ekardt F., Jacobs B., Stubenrauch J., Garske B. (2020). Peatland Governance: The Problem of Depicting in Sustainability Governance, Regulatory Law, and Economic Instruments. Land, 9, 83; doi:10.3390/land9030083

FAO (2013). Climate-Smart Agriculture Sourcebook, Food and Agriculture Organization of the United Nations, Rom.

FAO (2017). Climate-Smart Agriculture Sourcebook, Summary 2nd Edition, Food and Agriculture Organization of the United Nations, Rome.

Farstad F.M., Tveiten Hermansen E.A., Sødal Grasbekk B., Brudevoll K., van Oort B. (2022). Explaining radical policy change: Norwegian climate policy and the ban on cultivating peatlands. Global Environmental Change 74, 102517. https://doi.org/10.1016/j.gloenvcha.2022.102517

FOEN (2020): Switzerland's Greenhouse Gas Inventory 1990–2018: National Inventory Report and reporting tables (CRF). Submission of April 2020 under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol. Federal Office for the Envi-ronment, Bern. http://www.climatereporting.ch

Grünig, A. (2010). Moore – Vom Aschenputtel zur Prinzessin? Natur & Land 96, 1, 4-9.

Hirschelmann S., Raschke I., Stüber M., Wichmann S., Peters J. (2019). Moorschutz in der Gemeinsamen Agrarpolitik – Instrumente für eine klimaverträgliche Moornutzung in Deutschland. Berichte über Landwirtschaft – Zeitschrift für Agrarpolitik und Landwirtschaft, Band 98, 3. BMEL, Bonn.

IPCC (2014). 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, In: Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (Eds.), IPCC, Switzerland.

Joosten, H., Sirin, A., Couwenberg, J., Laine, J., Smith, P. (2016). The role of peatlands in climate regulation (2016) In: Bonn, A., Allott, T., Evans, M., Joosten, H., Stoneman, R. (Eds.), Peatland Restoration and Ecosystem Services: Science, Policy and Practice. Cambridge University Press, Cambridge, pp. 63–76.

Leifeld & Wüst-Galley C. (2021) Kohlenstoffsenke Moorboden: Zustand und Entwicklung. Hotspot 43, pp 6-7.

Roßkopf, N., Fell, H., Zeitz, J. (2015). Organic soils in Germany, their distribution and carbon stocks. Catena 133: 157-170.

Saja, S., Torquebiau, E., Hainzelin, E., Pages, J., Maraux, F. (2017). The way forward: An agroecological perspective for Climate-Smart Agriculture. Agriculture, Ecosystems & Environment, 250, 1, 20-24.

Seehofer, H., Steiner, G.M., Langmair-Kovacs, S., Plattner, G., Dick, G., Weber, P. (2003). Aktiv für Moore. Schutz und Renaturierung österreichischer Moore. WWF Österreich.

Swindles G.T. et al. (2019). Widespread drying of European peatlands in recent centuries. Nature Geoscience, Vol 12, 922–928. https://doi.org/10.1038/s41561-019-0462-z

Tanneberger, F., Tegetmeyer, C., Busse, S., Barthelmes, A., Shumka, S., Moles Marine, A., Jenderedjian, K., Steiner, G.M., Essl, F., Etzold, J. (2017). The peatland map of Europe. Mires Peat 19 (Art. 22), 1–17.

Tiemeyer B. et al. (2016): High emissions of greenhouse gases from grasslands on peat and other organic soils. Global Change Biology doi: 10.1111/gcb.13303. 16 p.

Tiemeyer, B., Freibauer, A., Albiac Borraz, E., Augustin, J., Bechtold, M., Beetz, S., Beyer, C., Ebli, M., Eickenscheidt, T., Fiedler, S., Forster, C., Gensior, A., Giebels, M., Glatzel, S., Heinichen, J., Hoffmann, M., Hoper, H., Jurasinski, G., Laggner, A., Leiber-Sauheitl, K., Peichl-Brak, M., Drösler, M. (2020). A new methodology for organic soils in national greenhouse gas inventories: Data synthesis, derivation and application. Ecological Indicators 109: 105838.

World Bank 2018: Bringing the Concept of Climate-Smart Agriculture to Life. International Bank for Reconstruction and Development / World Bank, Washington DC.

Wüst-Galley, C., Grünig, A., Leifeld, J. (2015): Locating Organic Soils for the Swiss Greenhouse Gas Inventory. Agroscope Science 26.

Yin, R.K. (2018): Case study research and application: Design and methods. Los Angeles: Sage.

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