Factors Influencing Farmers' Climate Change Mitigation and Adaptation Behavior: A Systematic Literature Review

Bernadette Kropf and Hermine Mitter

Abstract

Researchers increasingly explore farmers' climate change behavior and the respective influencing factors. This has resulted in extensive, but hitherto unstructured knowledge. We analyze 50 peer-reviewed scientific studies and identify behavioral factors and their influence on farmers' mitigation and adaptation behavior. Our results show a broad variety of behavioral factors, including cognitive factors which refer to perceptions of a specific risk or behavior, social factors which are influenced by farmers' interactions with their social peers, and factors which depend on farmers' personal disposition. Depending on the characteristics of the respective behavioral factor, the implementation of mitigation and adaptation measures is facilitated or impeded.

Keywords

Farmers' behavior · Climate change · Behavioral theories · Perception · Agriculture

B. Kropf (✉) · H. Mitter
Department of Economics and Social Sciences, Institute for Sustainable Economic Development, University of Natural Resources and Life Sciences, Vienna, Vienna, Austria
E-Mail: bernadette.kropf@boku.ac.at

H. Mitter
E-Mail: hermine.mitter@boku.ac.at

M. Larcher und E. Schmid (Hrsg.), *Alpine Landgesellschaften zwischen Urbanisierung und Globalisierung*,
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1 Introduction

Agriculture offers specific potential to reduce greenhouse gas (GHG) emissions, for instance, by substituting fossil fuels with renewable energy sources, by applying energy-saving technologies, and by reducing inorganic fertilizer use and soil degradation (Moerkerken et al. 2020). At the same time, agriculture is one of the sectors most vulnerable to climate change. For instance, projected changes in climate, such as an increase in the frequency and severity of droughts, spring frosts, or heavy precipitation events, may adversely affect agricultural yields and farm income and may threaten food security (Arbuckle et al. 2013; Niles et al. 2016). Hence, farmers' climate change behavior, i.e., implementing mitigation and adaptation measures, is decisive to cut GHG emissions, to reduce or avoid adverse climate change impacts and to grasp emerging opportunities.

Human behavior results from complex relationships between individual behavioral factors and is specific to the cultural and geographic context. The characteristics of behavioral factors and their relationships facilitate or impede the implementation of climate change behavior (Grothmann and Patt 2005). Scientists develop and apply behavioral theories in order to identify behavioral factors, structure their relationships, and explain and analyze their influence on behavior. Behavioral theories vary in scope and may include not only behavioral but also context factors (e.g., regional, farm, and sociodemographic farmer characteristics) that also influence behavior (Grothmann and Patt 2005; West et al. 2019).

A detailed understanding of behavioral factors is essential to explain the antecedents of individuals' mitigative and adaptive behavior in different contexts. It also facilitates the development of empirically informed public measures, and thereby increases their adoption by farmers and their effectiveness (Dessart et al. 2019; Grothmann and Patt 2005; van Valkengoed and Steg 2019). Behavioral factors, their relationships, and influence on farmers' climate change behavior have been the subject of various scientific studies in recent years. This has resulted in comprehensive, though unstructured scientific knowledge. We analyze peer-reviewed scientific studies that analyze factors influencing farmers' climate change behavior in order to organize and structure empirically investigated behavioral factors and make the scientific knowledge more accessible to a wider audience. We focus exclusively on behavioral factors and do not include context factors. In particular, we aim to i) summarize mitigation and adaptation measures relevant to agriculture, ii) elicit applied behavioral theories, and iii) identify behavioral factors and their influence on farmers' mitigation and adaptation behavior.

2 Data and Method

We apply a systematic multistep literature review to identify relevant peer-reviewed studies. Consecutive review steps as well as the defined criteria are summarized in Table 1. A total of 50 studies met the defined criteria. The complete list of reviewed studies is available upon request.

We analyze the selected 50 studies using a qualitative content analysis, computer-assisted with the Atlas.ti text analysis software, and deploy a deductive-inductive coding approach (Friese 2020; Mayring 2015). Deductive codes are mainly derived from behavioral theories on climate change behavior (Grothmann and Patt 2005; van Valkengoed and Steg 2019). They are refined by inductive codes derived from behavioral factors identified in the reviewed studies.

The definition of investigated behavioral factors varies substantially between the reviewed studies, which hampers their comparison. For instance, Niles et al. (2016) define social norms as favorable perception of environmental regulations, but do not explicitly refer to farmers' interactions with peers or other important social contacts. Another example is perceived outcome efficacy (a behavioral factor of Protection Motivation Theory (PMT) and the Model of Private Proactive Adaptation to Climate Change (MPPACC)) and attitude toward behavior (a behavioral factor of the Theory of Planned Behavior (TPB)), both relate to evaluating the perceived and expected outcomes of a particular measure. We address this challenge by structuring and summarizing relevant text passages, such as definitions of behavioral factors and merging similar or nearly identical behavioral factors.

Table 1 Overview of the systematic literature review process. Own illustration

	Step	No. of studies	Review criteria
1	Identification of peer-reviewed studies through database queries in Web of Science and Scopus[a]	974	Studies included in the literature review: • Passed a peer-review process and are published since 2000; • Deal with individual farmers' intended or actual climate change mitigation or adaptation behavior and investigate behavioral factors (i.e., studies that merely include sociodemographic or context factors are excluded); • Were conducted in developed countries including Europe, the U.S., Canada, Australia and New Zealand; • Result from quantitative or qualitative research methods; • Apply or refrain from the application of behavioral theories.
2	1st screening: Reading of titles and abstracts; exclusion of studies that do not meet the defined review criteria	−875	
3	Inclusion of additional studies identified through a snowballing approach and expert knowledge	+15	
4	2nd screening: Reading of studies with focus on research aims, applied methods, and results	114	
5	Exclusion of studies that do not meet the review criteria or are not accessible (2)	−64	
6	Studies considered for the literature review process	50	

[a] Applied search terms on April 29, 2021
Web of Science—all Databases: TITLE: ((climat* AND (farm* OR agri*)) AND TOPIC: (behavi* OR mitigat* OR adapt* OR deci* OR belief OR perc*) AND (Europ* OR Portug* OR Spain OR Spanish OR France OR French OR Ireland OR Irish OR United Kingdom OR Brit* OR Engl* OR Wales OR Welsh OR Scot* OR Belg* OR Dutch OR Netherland* OR Holland OR Swiss OR Switzerland OR German* OR Ital* OR Austria* OR Denmark OR Danish OR Norw* OR Swed* OR Finland OR Finnish OR Icel* OR Poland OR Polish OR Czech OR Slovak* OR Sloven* OR Lithuan* OR Latvi* OR Eston* OR Hungar* OR Croat* OR Serb* OR Bosn* OR Bulgar* OR Romania* OR Kosov* OR Moldav* OR Moldova OR Ukrain* OR Belarus* OR Greek OR Greece OR Cypr* OR Malt* OR Macedon* OR Makedon* OR Montenegr* OR Alban* OR Andor* OR Luxemburg* OR Lichtenstein* OR "U.S." OR Canad* OR Australi* OR New Zealand*))
Scopus: TITLE, ABSTRACT OR AUTHOR SPECIFIED KEYWORDS ((climate OR climatic) AND (farm OR agri)) AND FIND ARTICLES WITHIN THESE TERMS (behavior OR mitigation OR mitigate OR adaptation OR adapt OR decision OR belief OR perception OR perceive))

3 Results of the Systematic Literature Review

3.1 Sample Description

The reviewed studies are almost evenly distributed across the considered regions (i.e., 16 studies from Australia and New Zealand, 18 from North America, and 16 from Europe, with a focus on northern and western European countries). It is salient that all reviewed studies have been conducted since 2005, with a peak in data collection in 2011 and 2012 (12 each). Some datasets are used to investigate several aspects and are referenced in more than one of the reviewed studies (e.g., Arbuckle et al. 2013; Mase et al. 2017). Most studies were published in 2017 (8), followed by 2016 and 2019 (7 each). With regard to applied data collection methods, quantitative methods (such as standardized online, personal, postal, or telephone surveys) are dominant, in 31 of the reviewed studies. Qualitative methods (such as workshops and/or semi-structured or unstructured interviews) are used in 11 studies. A combination of quantitative and qualitative methods is applied in 8 studies.

3.2 Applied Theories

More than half (28 of 50) of the reviewed studies refer to behavioral and other sociopsychological theories or models. The theories are either used as originally developed or are adjusted to the respective research objectives, cultural or geographic contexts. For this reason, selected theories are combined or specific behavioral factors are extracted to guide the qualitative or quantitative analysis. Adjustments were made in most studies, and few refer to more than one behavioral theory.

The most frequently cited theory is the TPB (8) (e.g., Roesch-McNally et al. 2017; Wheeler et al. 2013), followed by the MPPACC (6) (e.g., Eakin et al. 2016; Mitter et al. 2019), the Value-Beliefs-Norm Theory (VBN, 4) (e.g., Davidson et al. 2019; Sanderson and Curtis 2016), the PMT, (3) (e.g., Käyhkö 2019; van Duinen et al. 2015), and the Five Capitals Model (3) (e.g., Seidl et al. 2021; Wheeler et al. 2013). Other theories or models, such as the Construal Level Theory (Niles et al. 2015; van Haden et al. 2012), the Identity Control Model (Morton et al. 2017), and the Model of Adaptive Capacity (e.g., Marshall et al. 2012) are applied in only one or two studies each.

3.3 Farmers' Actual and Intended Climate Change Behavior

The reviewed studies address a wide range of mitigation and adaptation measures on farms. The examples given in Table 2 are structured along the categories defined by IPCC (2014) and Wheeler et al. (2013). Behavioral intentions are considered the most proximal antecedent of behavior (Ajzen 1985, 1991; Grothmann and Patt 2005). Despite a likely discrepancy between farmers' intended and actual climate change behavior (Niles et al. 2016), for simplicity, we do not differentiate between intended and implemented mitigation and adaptation measures.

Table 2 Examples of investigated mitigation and adaptation measures on farms. Own illustration

<table>
<tr><td colspan="6">Mitigation measures</td></tr>
<tr><td colspan="6">Reduce GHG emissions or enhance carbon sinks</td></tr>
<tr><td colspan="3">Agronomic measures:
• Reduce (inorganic) fertilizer use
• Apply soil conservation practices
• Implement cultivation activities (e.g., planting trees)
• Improve manure management</td><td colspan="3">Work organization & financial measures:
• Switch to renewable energy sources (e.g., for irrigation or other farm machinery)
• Use information tools to learn about the potential for saving GHG emissions</td></tr>
<tr><td colspan="6">Incremental adaptation measures</td></tr>
<tr><td colspan="6">Maintain the essence and integrity of farm systems or processes</td></tr>
<tr><td colspan="3">Agronomic measures:
• Change planting and harvesting dates
• Adjust plant protection and tillage practices
• Switch to heat or drought tolerant species
• Improve irrigation efficiency</td><td colspan="3">Work organization & financial measures:
• Purchase an agricultural insurance
• Improve monitoring (of weather, pest pressure, water resources, or rangelands)
• Develop a drought management plan
• Use forecasting technology</td></tr>
<tr><td colspan="6">Transformational adaptation measures</td></tr>
<tr><td colspan="6">Change fundamental attributes of farm systems or processes</td></tr>
<tr><td colspan="2">Structural measures:
• Build water storage facilities
• Drill additional wells
• Relocate the farm
• Increase share of irrigated land</td><td colspan="2">Expansive measures:
• Purchase/rent additional farm land
• Purchase water allocations
• Establish additional farm activities</td><td colspan="2">Contractive measures:
• Sell/rent farm land
• Switch to part-time farming
• Abandon certain (or all) farm activities</td></tr>
</table>

The vast majority of studies (40 of 50) investigate farmers' adaptation behavior, six examine farmers' mitigation behavior, and four analyze both. We note that some measures could serve both mitigation and adaptation purposes. These measures are assigned to the categories analyzed in the reviewed studies.

3.4 Behavioral Factors

We categorize the identified behavioral factors into cognitive, social, and dispositional factors, following Dessart et al. (2019). Cognitive factors refer to the perception of a specific risk or behavior and the associated thought processes, such as learning and reasoning. We further differentiate between three subcategories of cognitive factors: risk-specific, behavior-specific, and avoidance factors. Social factors refer to relationships with other individuals or groups of individuals. Dispositional factors reflect farmers' personalities. They are relatively permanent and do not relate to a specific risk or behavior (Dessart et al. 2019).

3.4.1 Cognitive Factors

Risk-Specific Factors refer to climate change beliefs, perceptions, and evaluations of climate change risks including their impacts on one's farm or region.

Climate Change Beliefs refer to farmers' beliefs in anthropogenic climate change and its causes which are frequently measured, resulting in diverging types of climate change believers (Arbuckle et al. 2013; Davidson et al. 2019; Hyland et al. 2016; Kuehne 2014; van Haden et al. 2012). However, climate change belief has shown to be an imprecise antecedent of farmers' climate change behavior. While some studies find a significant positive correlation between farmers' climate change beliefs and mitigation and adaptation measures (e.g. Hamilton-Webb et al. 2017; van Haden et al. 2012; Woods et al. 2017), others did not (e.g. Arbuckle et al. 2013; Davidson et al. 2019; Mase et al. 2017). Interestingly, Niles et al. (2016) and Rogers et al. (2012) identify climate change belief as an antecedent of adaptation intentions, but not of farmers' actual adaptation behavior. Doll et al. (2017), Kuehne (2014), and Merloni et al. (2018) point out that farmers adapt to climate change in order to respond to immediate risks and ensure the viability of their farms, irrespective of their climate change belief.

Risk Perception is indicated by farmers' perceived and expected changes in climate and induced adverse and beneficial impacts on agricultural production and marketing (Mitter et al. 2019; van Valkengoed and Steg 2019). Farmers most frequently mention rising temperatures and increasingly severe extreme weather events such as droughts or intense rainfall, hail or storm events. When asked about adverse climate change impacts (i.e., risks), they often refer to declining water availability and crop yields (Nicholas and Durham 2012; van Haden et al. 2012). Furthermore, they mention aggravated working conditions (Doll et al. 2017; Yoder et al. 2021), increasingly severe soil erosion (Roesch-McNally et al. 2017), and lower farm incomes (Barnes and Toma 2012). Perceived beneficial impacts (i.e., opportunities) include an extended vegetation period and yield increases (Hyland et al. 2016; Mitter et al. 2019). Perceived changes in climate and induced impacts have been found to significantly facilitate the implementation of adaptation measures (Li et al. 2017; Morton et al. 2017; van Duinen et al. 2015). Morton et al. (2017) even reveal that farmers who have experienced two extreme events in the past five years are more likely to implement contractive measures. Wheeler et al. (2021) point to feedback loops between farmers' risk perceptions and their adaptation behavior. I.e., farmers who were already facing high risk and therefore implemented structural and contractive measures showed decreasing risk perceptions, while others who initially perceived less adverse climate change impacts and therefore took structural or expansive measures showed increasing risk perceptions.

Behavior-Specific Factors refer to the perception and evaluation of climate change mitigation and adaptation measures.

Perception of Outcome Efficacy refers to farmers' individual experiences and expectations about the effectiveness of mitigation and adaptation measures and has been identified as an important antecedent of climate change behavior (Kragt et al. 2017; Moerkerken et al. 2020; van Duinen et al. 2015). For example, the implementation of mitigation and adaptation measures is more likely if farmers believe that these measures effectively reduce GHG emissions (Kragt et al. 2017), increase the resilience of farms to climate change (Kragt et al. 2017), or provide synergies with other desirable farming goals, such as improving soil quality (Roesch-McNally et al. 2018). Although farmers are positive about the effectiveness of some measures, perceived tradeoffs impede the implementation, such as increased use of pesticides or additional costs associated with direct sowing or frost protection measures in vineyards (Käyhkö 2019; Nicholas and Durham 2012). Some farmers disagree with the effectiveness of financial adaptation measures, such as insurance against drought or hail damage. They argue that these measures may create a financial dependence, instead of stimulating more climate-friendly or adaptive farming practices (Wheeler and Lobley 2021). Perceived low outcome efficacy of incremental adaptation measures facilitates the implementation of contractive measures that are assumed to be more effective in reducing economic risks resulting from climate change (Käyhkö 2019). However, the perceived outcome efficacy of measures already implemented on one's own farm land significantly influences farmer's willingness to implement expansive measures (Morton et al. 2017).

Perception of Costs refers to money, time, or effort spent on climate change behavior. The implementation of mitigation and adaption measures is impeded when investment costs are perceived to be high and benefits in the immediate future are perceived to be low (van Duinen et al. 2015; van Haden et al. 2012; Wheeler and Lobley 2021). The review results also indicate that climate change mitigation and adaptation measures that allow farmers to harness synergies with other desirable farming goals, such as efficiency improvement in fuel, electricity or nitrogen use, and hence increase farm incomes, are more likely to be implemented (Mitter et al. 2019; Tzemi and Breen 2019; van Haden et al. 2012).

Perception of Self-Efficacy refers to farmers' individual evaluations of their own capabilities and confidence in effectively implementing mitigation and adaptation measures (Roesch-McNally et al. 2017). Numerous studies identify perceived self-efficacy as a significant positive antecedent of farmers' climate change mitigation and adaptation behavior (e.g. Arbuckle et al. 2013; Niles et al. 2016; Raymond and Spoehr 2013). In contrast, some studies show a significant negative influence of perceived self-efficacy on farmers' climate change behavior. They conclude that farmers with a high confidence in already implemented measures may (consciously or unconsciously) disregard the implementation of additional incremental or transformational adaptation measures (Roesch-McNally et al. 2017; Rogers et al. 2012) or may favor contractive adaptation measures (Morton et al. 2017). Van Duinen et al. (2015) reveal a non-significant correlation between farmers' perceived self-efficacy and the implementation of incremental adaptation measures and explain this finding with the widespread implementation of these measures.

Avoidance Factors are emotional responses to perceived climate change risks. They do not reduce monetary or physical harm, but rather avert negative emotional impacts of the perceived risk and act as a barrier to successful long-term climate change adaptation (Grothmann and Patt 2005).

Denial of climate change impacts means that the risks of climate change are underestimated which impedes the implementation of adaptation measures. Farmers doubt to be adversely affected by climate change in the future although they have already experienced adverse impacts (Mitter et al. 2019). They do not have strong opinions about climate change and its impacts, or perceive other risks, such as policy changes and public pressure more pressing (Barnes and Toma 2012; Wheeler and Lobley 2021).

Wishful Thinking is about downplaying adverse climate change impacts and believing that one's own farm may not be affected. Therefore, farmers do not see the need to adapt their behavior to climate change (Barnes and Toma 2012; Mitter et al. 2019).

Religious Faith refers to the belief that adverse climate change impacts are an act of God and that perceived risks can be reduced through spiritual actions (Mitter et al. 2019), such as praying instead of implementing frost protection measures (Nicholas and Durham 2012).

Fatalism is related to the perception and expectation of adverse climate change impacts, while neglecting one's own possibilities to implement adaptation measures. For example, farmers have not implemented measures due to conflicting information about climate change (Kuehne 2014) or their lacking knowledge about potential adaptation measures (Mitter et al. 2019), leading them into fatalism and resignation.

3.4.2 Social Factors

Descriptive Social Norms, i.e., perceptions of how other people behave, significantly influence farmers' climate change behavior. For example, knowing and learning from peers (Hamilton-Webb et al. 2017; Kragt et al. 2017; Lu et al. 2021), belonging to a professional agricultural network, and visiting other farmers (Marshall et al. 2012; Niles et al. 2016; Roesch-McNally et al. 2017) have a significant positive influence on the farmer's behavior to mirror mitigation and adaptation measures. Moreover, how often and with whom an individual farmer interacts is critical (Niles et al. 2016).

Injunctive Social Norms refer to perceptions about what ought to be done and are not identified as a significant antecedent for farmers' climate change behavior (Lu et al. 2021). They may even impede the implementation of innovative mitigation and adaptation measures that deviate from traditional practices and may cause problems or failures (Käyhkö 2019; Yoder et al. 2021).

Trust in Advice and Media such as from natural resource managers, significantly influences farmers' adaptation behavior (Raymond and Spoehr 2013). Wheeler and Lobley (2021) find that supporting farmers to identify reliable information is important in implementing adaptation measures.

3.4.3 Dispositional Factors

General Risk Attitude as indicated by farmer self-assessment (Wheeler et al. 2013) or number of insurance products purchased (Seidl et al. 2021), is identified as a significant antecedent for incremental and transformational adaptation measures.

Place Attachment refers to farmers' connectedness with their physical and social environment, including their social and professional network, home region, farm, and other entities (Marshall et al. 2012). Place attachment significantly strengthens the implementation of incremental, but hampers the introduction of structural adaptation measures such as farm relocation (Eakin et al. 2016; Marshall et al. 2012; Rogers et al. 2012).

Personal Responsibility which translates into a perceived moral obligation to implement measures, significantly facilitates farmers' mitigation (Davidson et al. 2019; Kragt et al. 2017) and adaptation behavior (Roesch-McNally et al. 2017). For instance, Sanderson and Curtis (2016) identify perceived personal responsibility to mitigate GHG emissions and to protect groundwater as significant antecedents of adaptation measures.

Value Systems reflect solid and deeply engrained ideas of desirable and undesirable behavior (Morton et al. 2017; Sanderson and Curtis 2016). Farmers, who value openness, innovation, and technology prefer to implement innovative mitigation and adaptation measures (Davidson et al. 2019; Lu et al. 2021; Moerkerken et al. 2020; Rogers et al. 2012; Tzemi and Breen 2019; Wheeler et al. 2013) but do not intend to implement contractive adaptation measures (Mase et al. 2017). Farmers, who endorse environmental protection and conservation values, significantly prioritize the implementation of agronomic mitigation and adaptation measures (Davidson et al. 2019; Roesch-McNally et al. 2017; Wheeler et al. 2013). However, farmers holding these values hesitate to implement contractive measures, suggesting that these farmers value their land for more than short-term profitability (Morton et al. 2017) and do not implement these measures solely in response to perceived climate change (Mitter et al. 2019). In contrast, farmers valuing profit and resource maximization significantly prioritize expansive (Morton et al. 2017) or contractive measures (Wheeler et al. 2013). Käyhkö (2019) notes that farmers with a strong profit orientation may favor financial measures to deal with economic risks. Farmers with dominant traditional and conservative values prefer to postpone adaptation measures and are significantly less likely to implement contractive measures, indicating that they want to preserve their farm endowments for the next generation (Wheeler et al. 2013). Conversely, Eggers et al. (2015) find that traditionalists are more skeptical of adaptation measures and more prone to abandon their farms. However, it remains an open question whether this result is rather driven by farmers' values or by farm characteristics, i.e., small farm size and a lower competitiveness relative to other farms.

4 Discussion and Conclusions

The systematic literature review provides a comprehensive and structured summary of behavioral factors and their influence on farmers' climate change behavior in developed countries. We find that farmers across regions implement mitigation as well as incremental and transformational adaptation measures, which is influenced by a combination of cognitive, social and dispositional behavioral factors.

It is salient that some factors, such as risk perception and outcome efficacy, have been investigated in more regional and cultural contexts with similar results in terms of direction of influence. In contrast, avoidance factors, which impede the implementation of mitigation and adaptation measures and thus are highly relevant for the development of public measures, have rarely been investigated. These results are in line with the meta-analysis of van Valkengoed and Steg (2019) on factors influencing climate change adaptation behavior in the general public. They – inter alia – identify descriptive norms, perceived self-efficacy and outcome efficacy as the strongest antecedents of adaptation behavior and argue for putting a greater research emphasize on these and other understudied behavioral factors. For instance, farmers' emotional states due to climate change impacts have been sparsely investigated yet.

The behavioral theories applied in the analyzed studies synthesize empirically tested sets of behavioral factors and their influence on climate change behavior. Frequently applied modifications suggest that behavioral theories allow for adjustments to the particular research interest and context. At the same time, they offer transparent and clear guidance for research processes and build an adequate basis for understanding farmers' climate change behavior more properly. Nevertheless, definitions of behavioral factors partly overlap and their boundaries are blurred, which points to the importance of concretizing commonalities and differences. Despite effortful, this could facilitate comparing and upscaling of results, as well as knowledge sharing across contexts. It may also support the development of public measures that aim to encourage farmers' behavior change (West et al. 2019).

It is evident that the reviewed studies deal to a larger share with adaptation than with mitigation measures. This may be due to the fact that adaptation is mainly considered a private and mitigation mainly a public endeavor. However, results indicate that the implementation of mitigation and adaptation measures underlie similar behavioral factors, such as perceived outcome efficacy, perceived costs, social norms, and values toward innovation or the environment. With regard to perceived outcome efficacy and perceived costs, it is apparent that perceived synergies with other desirable farming goals facilitate the implementation of climate change measures. This is of particular relevance for mitigation measures which primarily benefit the general public through reduced GHG emissions and only secondarily provide private benefits to farmers. However, recently adopted public strategies, such as specified targets for the European agricultural sector based on the Paris Agreement (LULUCF Regulation 2018) or the European Green Deal (EU COM 2019) increasingly force the agricultural sector to reduce GHG emissions which makes farmers' climate change mitigation behavior more relevant. Future public measures aiming to encourage on-farm mitigation should thus emphasize private benefits to facilitate their implementation.

Investigations on the mutual influence of behavioral factors, as well as a complementary review of the influence of regional, farm and sociodemographic farmer characteristics on climate change behavior, may further deepen the understanding for farmers' climate change behavior. The behavioral factors identified may form the basis for further research. For instance, they may inform the design of behavior change interventions or the elicitation and development of empirically based farmer types that diverge in their mitigation and adaptation behavior. In addition, previously understudied behavioral factors such as farmers' social norms, avoidance factors, or their emotional state due to climate change impacts point to a future research agenda in the agricultural context.

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