Research Article

Therese Asplund*, Tina-Simone Neset, Janina Käyhkö, Lotten Wiréhn, Sirkku Juhola

Benefits and challenges of serious gaming – the case of "The Maladaptation Game"

Abstract: The use of digital tools and interactive technologies for farming systems has increased rapidly in recent years and is likely to continue to play a significant role in meeting future challenges. Particularly games and gaming are promising new and innovative communication strategies to inform and engage public and stakeholders with scientific research. This study offers an analysis of how a research based game on climate change maladaptation can support, but also hinder players' sense-making processes. Through the analysis of eight gaming workshops, this study identifies challenges and support for the players' sense-making. While it concludes that conceptual thinking of game content sometimes clashes with players' everyday experiences and practice, possibly resulting in loss of credibility, this study also concludes that gaming may function as an eye-opener to new ways of thinking. Overall, this paper suggests that the communication of (social) science and agricultural practices through serious gaming has great potential but at the same time poses challenges due to different knowledge systems and interpretive frameworks among researchers and practitioners.

Keywords: climate change communication, maladaptation, serious gaming, focus groups, public understanding

*Corresponding author: Therese Asplund, Centre for Climate Science and Policy Research, Department of Thematic Studies – Environmental Change, Linköping University, 581 83 Linköping, Sweden, E-Mail: therese.asplund@liu.se
Tina-Simone Neset, Lotten Wiréhn, Centre for Climate Science and Policy Research, Department of Thematic Studies – Environmental Change, Linköping University, 581 83 Linköping, Sweden
Janina Käyhkö, Sirkku Juhola, Faculty of Biological and Environmental Science, University of Helsinki, 00014 Helsinki, Finland

1 Introduction

The use of digital tools and smart technologies for farming systems has increased rapidly in recent years and is likely to continue to play a significant role in meeting future challenges. While more and more studies recognize games and gaming as an opportunity to explore communication strategies to inform and engage different parts of the public with scientific research, studies have also questioned whether gaming has potential as a novel and innovative communication strategy (Ouariachi et al. 2017). However, there is limited empirical research exploring how gaming can contribute to the communication between science, technology and agricultural practice. To explore and assess the communication of research on climate change maladaptation and agricultural practice, we 1) developed a novel methodology, integrating visualization, participatory methods and serious gaming and 2) analysed agricultural stakeholders' perspectives on benefits and challenges of the game.

Addressing the impacts of climate change through adaptation is considered to be a complex challenge and the most recent assessment of the Intergovernmental Panel on Climate Change (IPCC) states that climate change will have considerable impacts on agricultural production (IPCC 2014). Nordic agriculture may benefit from climate change, as modelling results show more positive effects in comparison to other regions globally (Bindi and Olesen 2011; Rötter et al. 2012). Nevertheless, Nordic agriculture is also vulnerable to certain aspects of climate change, and farming adjustments are required in all areas both to adapt to challenges and possibilities. Studies on adaptation in the agricultural sector in the Nordic countries have shown that adaptation measures are already being taken (Juhola et al. 2017) but there is little knowledge of what the impacts of these measures are.

While the International Panel on Climate Change (IPCC) recognises the need for adaptation actions in agriculture, it also highlights the potential risks associated with adaptation measures, the concept of *mal*adaptation has remained largely unresearched. It refers to the outcomes of climate adaptation measures that fail to

reduce climate-related risk, or that generate negative consequences such as increased vulnerability for targeted or other systems, sectors or social groups (Barnett and O'Neill 2010; Juhola et al. 2016; Magnan et al. 2016).

The *Maladaptation Game for Nordic Agriculture* was developed as a research method to identify maladaptation in Nordic agriculture and hence increase our conceptual understanding of maladaptation for the agricultural sector. In this context, this paper explores the role of serious gaming in communicating social science and agricultural practices. The following research questions guide the analysis:

In what way(s) does the *Maladaptation Game for Nordic Agriculture* support player's sense-making processes on maladaptive outcomes?

In what way(s) does the *Maladaptation Game for Nordic Agriculture* hinder player's sense-making processes on maladaptive outcomes?

2 Analytical Framework

To interpret information meaningfully, individuals often apply unconscious structures that guide their sense-making processes (Goffman 1974). Interactional frame analysis holds that such processes of meaning construction and sense-making occur in interaction and dialogue with others (Asplund 2014; Dewulf et al. 2009). From this perspective, frames and framing are understood not only as the interpretation of an issue but also as an active process through which individuals and collective actors arrange and make sense of events.

The present study of ways in which the *Maladaptation Game for Nordic Agriculture* hinders or supports player's sense-making processes on maladaptive outcomes draws on interactional framing theory. From an interactional viewpoint, frames are formed during ongoing processes of interaction (Dewulf et al. 2009). Meaning is therefore located between people in interaction and ultimately depends on the reactions of others. Hence, the approach is concerned with how messages and people interact to produce meanings (Fiske 1990). In this study, we refer to such sense-makig process in which interlocutors – or in our case – players circulate ideas, beliefs, and understandings. As interactions do not exclusively apply to interaction between two or several individuals, but equally applies, in a more figurative sense, to interaction between *arguments rather than people* (Marková et al. 2007; Wibeck 2010), we have focused on how players in the conversations generate and circulate arguments and understandings of climate change maladaptation gaming.

2.1 The relationship between maladaptation perceptions and actions

Goffman (1974) argues that a frame allows its user to locate, perceive, identify, and label events so as to guide actions or, in the words of Entman (1993: 52), "to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation". In this sense, the framing concept links sense-making and action, suggesting that how we understand an issue focuses our attention on certain elements, defines what is problematic, and suggests courses of action appropriate to it. However, agreement about the causes of and solutions to a particular problem does not automatically generate action (Snow and Benford 1988). Hence, we cannot suppose that players' sense-making of climate adaptation is later on transformed into a real behavioral change, e.g adaptation actions or policies - as framing processes constitute only one of several rationales for action (Snow and Benford 1988). Nevertheless, this study focuses on the sense-making of players, and the results explore the roles of serious gaming in communicating social science and agricultural practices, in particular, to what extent serious gaming can hinder and support sense-making processes.

3 Method: Serious Gaming to assess Perspectives on Adaptation and Maladaptation in Nordic Agriculture

Adaptation and resulting maladaptation in agriculture involves both planned adaptation as well as adaptation taken by individual farmers. Farmers' perceptions and sense making of climate change are considered to be important factors when decisions to adapt are made (Abid et al. 2016; Marshall et al. 2013). Thus, learning how farmers perceive themselves to be impacted by climate change, what measures to take, and what their impacts may be, is important.

Issues of sense-making are directly related to the way in which climate related information is communicated, an area of intense research interest (Asplund 2018; Wibeck 2014). It has been recently claimed that conventional media, through one-way messaging has resulted in recipients becoming passive consumers of this information (Ouariachi et al. 2017). This in turn, the authors argue, can result in lack of understanding of context and connections of the information in relation to the recipients' everyday life. Serious games have been proposed to address this

gap by providing information in a way that is engaging and educational (Juhola et al. 2013; Ouairachi et al. 2017; Reckien and Eisenack 2013) The idea of the use of games for environmental issues, planning and decision-making can be traced to the mid-1970s (Wärneryd 1975). Since then, there are a number of studies that have used gaming to address a number of issues, including urban development (Bishop 2011; Mayer et al. 2004; Poplin 2012), land use models (Washington-Ottombre et al. 2010) and to explore the use of crop insurance (Patt et al. 2009) in Africa. More recently, climate change games have also become more frequent but focusing predominantly on mitigation rather than adaptation (Juhola et al. 2014; Reckien and Eisenack 2013). A recent review on climate change adaptation gaming suggest that serious games can provide communities with the opportunity to explore different climate futures, and build capability and capacity for dealing with complex challenges (Flood et al. 2018).

In general, it is argued that serious gaming presents a methodology for addressing complex issues in groups of participants that allows for participants to experiment with strategies, experience climate change personally, and see the consenquences of their actions more clearly (see studies in Ouariachi et al. 2017). Negative aspects have also been reported in the literature, showing how the information portayed by games can be simplistic and hence lead to simplified solutions.

3.1 The Maladaptation Game for Nordic Agriculture

In order to explore and assess the communication of research on climate change maladaptation and agricultural practice, we integrated visualization, participatory methods and serious gaming in the development of the *Maladaptation Game*. These features enable research and analysis of trade-offs between alternative adaptation options. Stakeholders from the agricultural sector in Sweden and Finland have been engaged in the exploration of potential maladaptive outcomes of climate adaptation measures in interactive gaming workshops, and discussed their perspectives on maladaptive outcomes, their relevance as well as related trade-offs.

The Maladaptation Game is a serious game, based on current research on climate maladaptation in the Nordic countries (Juhola et al. 2014; 2016; 2017; Neset et al. 2018). To identify maladaptive outcomes, we:

1. conducted reviews of the current national adaptation policies of each Nordic country (Juhola et al. 2014),
2. performed a literature review and presented a

typology of maladaptation that distinguishes between three types of maladaptive outcomes – rebounding vulnerability, shifting vulnerability and eroding sustainable development (Juhola et al. 2016),
3. conducted semi-structured interviews with Swedish and Finnish farmers and extension officers (Juhola et al. 2017)
4. synthesized literature and interviews with farmers and agricultural officials and experts in Sweden and Finland (Neset et al. 2018)

Based on the conceptual framework of maladaptation, we identified outcomes that either increase the vulnerability of the implementing actor, shift the vulnerability to other actors or sectors or affect common pool resources (Neset et al. 2018). We incorporated these research findings in the game by integrating climate adaptation options and potential negative outcomes in the game design. This synthesis indicates a number of trade-offs that are related to adaptation decision-making, which are important to address in future adaptation strategies (see also Neset et al. 2019).

The Maladaptation Game is designed as a web-based single player game with the objective to make decisions regarding adaptation to climate change while simultaneously producing low scores of maladaptive outcomes. However, for the purposes of this study – to explore *In what way(s) does the "Maladaptation Game" for Nordic Agriculture support/hinder player's sense-making processes on maladaptive outcomes* – we conducted gaming workshops with a designated moderator and players that initially engage individually in the game and later share their reflections.

The game setup allows the moderator of a session to collect the settings and results for each player involved, display the results on a 'moderator screen' and store them for analysis. The gameplay consists of four challenges, each involving multiple steps. At the start of the game, the player is equipped with a limited number of coins, which decrease for each measure that is selected. As such, the player has to consider the implications in terms of risk and potential negative effects of a selected measure as well as the costs for each of these measures. The player has to address four different climate related challenges – increased precipitation, drought, increased occurrence of pests and weeds, and a prolonged growing season - that are all relevant to Nordic agriculture (Wiréhn 2018).

The player selects one challenge at a time. Each challenge has to be addressed, and once a challenge has been concluded, the player cannot return and revise the selection. When entering a challenge (e.g. precipitation)
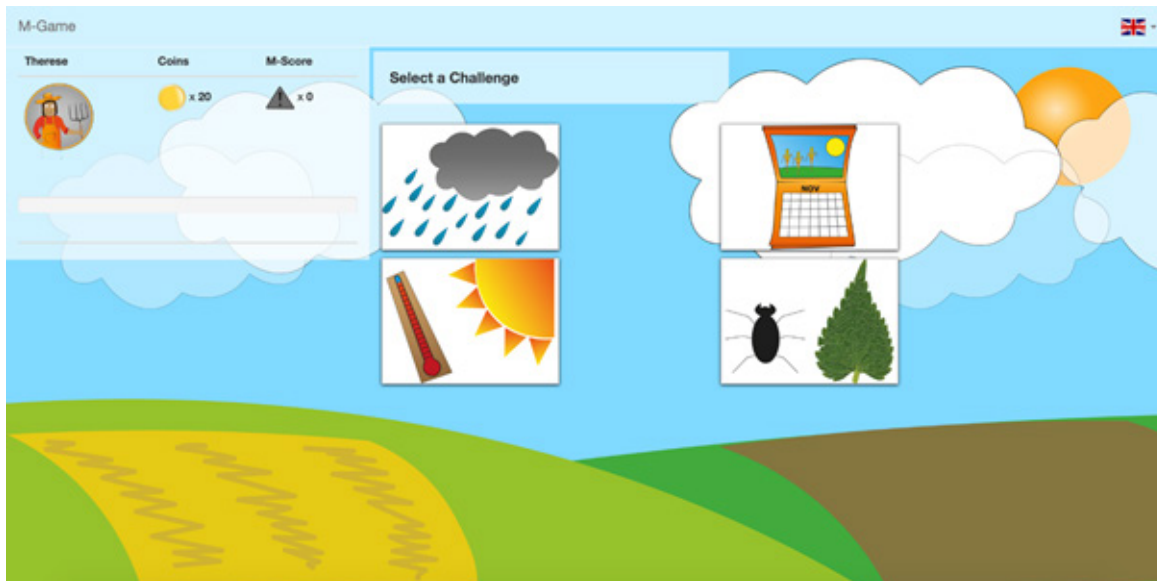
Figure 1: The interface of the Maladaptation Game featuring the four challenges

possible adaptation measures that can be taken to address this challenge in an agricultural context, are displayed as illustrated cards on the game interface. Each card can be turned to receive more information, i.e. a descriptive text and the related costs. The player is encouraged to explore all cards before selecting one. The selected adaptation measure is then leading to a potential maladaptive outcome, which is again displayed as an illustrated card with an explanatory text on the backside, which the player has to decide to reject or accept. If the maladaptive outcome is rejected, the player returns to the previous view, where all adaptation measures for the current challenge are displayed, and can select another measure, and make the decision whether to accept or reject the potential negative outcome that is presented for these. In order to complete a challenge, one adaptation measure with the related negative outcome has to be accepted.

After completing a challenge, the player returns to the entry page, where, in addition to the overview of all challenges, a small scoreboard summarizes the selection made, displays the updated amount of coins as well as a score of maladaptation-points. These points represent the negative maladaptation score for the selected measures. The game continues until selections have been made for all four challenges. At the end of the game, the player has an updated scoreboard with three main elements: the summary of the selections made for each challenge, the remaining number of coins, and the total sum of the negative maladaptation score. If the game is played in a session with multiple players, the scoreboards of all

players appear on the moderator view at this stage. This setup allows the individual player to compare his or her pathways and results with other players. The key feature of the game is hence the stimulation of discussions and reflections concerning adaptation measures and their potential negative outcomes, both with regard to adding knowledge about adaptation measures and their impact as well as the threshold of when an outcome is considered maladaptive.

3.2 Engaging agricultural stakeholders in visualization supported gaming workshops

During autumn 2016, eight focus groups were held in Sweden and Finland. While the maladaptation game was developed as a single player game, we arranged focus groups as gaming workshops to promote discussions among players. As small group discussions are particularly fruitful for the analysis of participant interactions and sense-making processes (Asplund 2014; Kitzinger 1994), each gaming workshop consisted of 3-6 participants. These workshops were designed as visualization supported focus groups, allowing for some general reflections, but also individual interaction with the web-based game. As our approach to the empirical question of communicating social science and agricultural practice through serious gaming is explorative, we aimed for a diversity of perspectives which can inform our research questions. The selection criteria for focus group participants was based on three key aspects:

Type of production – As the maladaptation game highlights climate challenges and adaptation measures for crop production, we included participants with knowledge in various types of crop production systems.

Perception and values - Perception studies of environmental values generally find that age and gender are variables influencing attitudes (e.g. Eurobarometer 2017), so we included participants of different ages and genders.

Experiences – As the importance of experience for environmental and climate perceptions has been recognized (e.g. Capstick and Pidgeon 2014; Asplund 2016), we recruited agricultural stakeholders with various professional experiences and assignments.

To respond to the research questions that address in what ways the Maladaptation Game for Nordic Agriculture supports and hinders the player's sense-making processes on maladaptive outcomes, we included farmers, agricultural extension officers, representatives of branch organizations as well as representatives of the agricultural authorities, on the national and regional level (see Table 1):

Focus group discussions were facilitated by two facilitators in each sesssion. A facilitation guide was developed to focus the discussion to the study topics: maladaptation and serious gaming. The discussions were recorded and transcribed (Linell 1994) in order to analyze the empirical results with focus on the role of serious gaming to assess perspectives on adaptation and maladaptation in Nordic Agriculture.

The focus group material was analysed as one set of material with focus on recurrent patterns throughout the eight groups (Marková et al. 2007). In the analysis, we paid particular attention to 1) spontaneous reactions during or after individual playing as well as 2) reflections after the gaming session ended with a reflective round on the question: What do you think is the most important issue that has been brought up today? The interdisciplinary group of researchers developing, evaluating and analysing the game have been part in all phases of the project. Hence, both the game development and analysis have been collaborative efforts of the project constellation.

Ethical approval: The conducted research is not related to either human or animal use.

4 Results: Serious gaming - benefits and challenges for agricultural stakeholders´ sense-making

4.1 Serious gaming as support to player's sense-making processes on maladaptive outcomes

4.1.1 Stimulating joint reflection

Generally, the *Maladaptation Game* requires an active processing of information and perspectives as players choose, think, take a stand, and discuss climate adaptation and maladaptation with the game as a starting point. Thus, the game can be seen as creating a dialogue between ideas built into the game when the *Maladaptation Game* works as a reference point from which the participants discuss their perspectives on and experiences of adaptation to climate challenges:

Table 1. Group composition of cross-country focus group study on climate maladaptation

Group	No of participants	Age	Type of stakeholder
Swedish Group 1	2 female 3 male	30-70	Farmer
Swedish Group 2	3 female	30-70	Extension officers
Swedish Group 3	1 female 3 male	30-70	National and county administrative agricultural boards
Swedish Group 4	1 female 4 male	30-70	Agricultural branch organizations
Finnish Group 1	4 male	30-70	Farmers
Finnish Group 2	1 female 4 male	30-70	Extension officers
Finnish Group 3	4 female 1 male	30-60	National and county administrative agricultural boards
Finnish Group 4	3 female 3 male	30-60	Agricultural branch organizations

F3 But just to sit and think. What does this lead to? When you are home, working, you might not think about it. It is important that you really think and discuss.
/ ... /
F2 One had to think ...
F3 We had great discussions ...
M1 That's what started the discussion so to say so it was good.
F3 A good platform to start from. (S1: 348/365-3681)

As the example above illustrates, participants found the gaming session, and in particular the "thinking and talking" dimensions highly important. As participants discussed in what ways and why they agreed or disagreed with maladaptive outcomes suggested in the game, the game content and design functioned as an incentive and start from which participants could generate and circulate their understandings of maladaptation. One participant described the game experience as "exciting" (S1: 6) and another found the game "thought provoking" (F1: 18).

While participants found in particular the *discussions* on climate change maladaptation to support their sense-making processes on maladaptive outcomes, they also recurrently pinpointed that the *game design* made them reflect:

F2 I think it was great to see that the coin has two sides. That if we do one thing we can have another effect. Just this awareness that one must always weigh different things at the same time. It´s very important.

F4 And it's about prioritizing. Partly to see the linkages but also to see what is most important really (S2: 337-338)

While the above example illustrates that the game successfully managed to represent the concept of climate maladaptation – as a potential negative effect of a positive adaptation measure, the example below illuminates participant positive judgement of game simplification of a complex concept:

M3 But now that we've been discussing, this (game), in fact, turns out to be a good background for discussion. Even though being simplistic, this actually goes right to the core of the matter. (F3: 24)

The game design was also seen as something that could be developed for educational and advisory use: *M4 "I think the idea is very good. --- provoking farmer's thoughts*

---

1 Transcription conventions: Finnish FGs have been coded with an "F" followed by their FG number as indicated in table 1. Swedish focus groups have been coded with "S" followed by their ascribed group number. Female players are anonymized to "F" and male players to "M". [...] denotes that a short sequence has been omitted.

on how and what kind of decisons they make, what options they have and what kind of consequences they might have. This would make a good advisory tool. (M1: Yes it would.) So that farmers could evaluate options that suit their farm, and not some general national solutions." (F1: 18)

Hence, most participants acknowledged that the *Maladaptation Game* challenged their thinking, made them reflect and discuss pros and cons of various climate adaptation measures. Some participants also believed the *Maladaptation Game* would function very well as a stand-alone version and a tool for discussions on climate maladaptation beyond the setting of the study.

4.1.2 Serious gaming for decision-making on climate adaptation

The entrypoints for, and logic of, the game design included climate challenges followed by adaptation measures and thirdly, potential maladaptive outcomes of such adaptation measures. Thus, while the game was designed with a conceptual entry-point, participants continously applied the game content to their own farm-level contexts. For example, one farmer stated that he "*chose direct sowing because I own a direct sowing machine – and I have been practising it."* (F1: 63). This example shows a recurrent pattern of participants´ use of previous experiences and knowledge to make sense of climate maladaptation. Secondly, participants also discussed future adaptation options by contextualising the game content to farm-level:

F2 It feels like a way into the future. To develop the ability to save water. Whether it's a dam like the one we have at our farm or if it's simply collecting it in tanks. (S1: 228)

Above excerpt illustrates the game´s potential as reflexive-incentive as it illustrates how game content is applied to the specific farm of the participating farmer and as such illuminates the potential for serious gaming for decision-making on climate adaptation and maladaptation. Furthermore, besides the relevance of certain kinds of knowledge and farm-level contextualization, participants applied game content by reasoning on its pros and cons to various types of crops, such as harvest potentials, nutrient leakage, and pest control.

In sum, participants' processing and elaboration of game-related content typically relied on prior knowledge and experiences to make climate adaptation and maladaptation more familiar and graspable. Hence, the game can be seen as functioning as a tool to support interpretation of climate change maladaptation.

4.2 Way(s) in which serious gaming hinders player's sense-making processes on maladaptive outcomes

While the *Maladaptation Game* in different ways promoted and encouraged participants' reasoning on maladaptive outcomes generated by climate adaptation options, the game, its content, design and narrative also gave rise to several questionmarks which hampered the discussions. The most common feedback was that participants lacked context, in terms of relevant game content. A second aspect concerned game symbols and text.

4.2.1 Lack of context-relevant content

Participants expressed that they in different ways lacked context for the decisions they were supposed to make, as no specific geographic setting or farm type was given as a point of departure. Furthermore, participants were expressing a lack of specific content, such as a lack of relevant choices or correct options/outcomes and argued that the game simplicity did not reflect the complex real life.

4.2.1.1 Experienced incorrectness

Some participants expressed that they did not agree with the game content – hence that they did not agree with the given options: M2 "*Some of these, one can really question*" (S1: 96), M3 "*If one does not believe in any of these - do I have to choose?*" (S1: 106). Or as shown in this example of participants disagreement with game mediated maladaptive outcomes:

> M3 *Why would fertilization increase if you change crop? It could almost be vice versa. It doesn't mean intensifying necessarily. You can choose, for example, hemp or even some pasture option or something like that. I think the starting point should be that the fertilization is planned and optimized according to profitability. And, in a way, according to yield potential.*" (F2: 91)

As above excerpts show, participants interpreted and anchored the information mediated in the game through experiences. Recurrently in the group discussion, participants expressed that game content did not align with their own experiences - resulting in a clash between participants' experiences and game content.

4.2.1.2 Lack of relevant choices

Participants further expressed an experienced lack of context relevant choices, e.g adaptation measures and maladaptive outcomes that they could relate to their particular physical setting or type of farm. Participant comments also related to the relevance of geographical specifics:

> M2 *There are, for example, regional differences, when on the other side of Finland the soil type is different. You don't even need to go far North from here. Hausjärvi or Hollola for example (Northern neigbouring region of the study region), when they already have much more sandy soil and very different types of problems. Or, not as much problems as here in the claye region.* (F1: 32)

In relation to the specific Swedish conditions a player in group 2 argued:

> F2 *No, I will not water with groundwater, I'll make a pond. I take surface water during winter. Should I reject it then? It will not lower any groundwater level.* (S2: 120)

The examples illuminate player interaction with ideas mediated by the game and further illuminate a clash of ideas. While the first example relates to context relevance in terms of physical and geographical conditions, the second example illustrates the challenge of specific Swedish/Nordic conditions. In this example, the player does not conform with the information mediated in the game. While the scientific literature identifies lowering of ground water as a potential maladaptive outcome from installing irrigation infrastructure, this player opposes the game options and contrasts them with others, according to the participant's more favoured options – to collect surface water in a dam.

These examples illustrate, how the aggregated and abstract character of the game can be considered as hindering the players' sense-making of maladaptive outcomes as the discussions in these cases predominantly circulated about whether the adaptation measures that the game suggests are perceived as relevant to a particular region or type of production. Altogether, the examples illustrate that regardless of background and interpretive framework of farmers, extension officers, county and national administrations and interest organizations, participants expressed the need for contextual information. Participants' suggestion for game development included multiple choices in dealing with negative effects, local scale selection and a production-specific startingpoint for the game to be perceived to match the choices that are relevant.

4.2.2 Simplistic game vs complex real life

The participants´ experience of agricultural production served as a startingpoint from which to discuss adaptation and maladaptation. The stakeholders frequently referred to their own experiences to support or counter arguments. For example, when participants found a game mediated adaptation option and its negative effects not matching their own experiences, participants stated *"It's not at all as simple as it is here"* (F1: 30), or argued based on 1) experiences: *"I have practiced so I know that is correct"* (S1: 129) or 2) more associative thought patterns and arguments: "*I read about the farmers on Öland [Swedish Island],how they tried to stop the water now.*" (S1: 142). Discussions were also characterised by the participants supporting previous statements by continuing to build on with more examples. However, while participants sometimes shared an understanding of a particular issue, there were also cases in which participants expressed different levels of understanding. In one case where the game indicated structural liming to avoid nutrient loss would potentially result in soil compacting, one participant argued that s/he choose structural liming since it was a familiar measure that s/he recognizes as benefical to his/her soils – even though the game suggests the opposite. Another participant however declared that s/he lacked knowledge and therefore couldn't answer. The example suggests that different levels of knowledge and interpretive frameworks lead to different points of departure in how they argue about climate adaptation and potential negative effects. Seemingly, what is perceived as too simplistic by one player can be seen as too complex for another. Independent of the specific entry point, most participants applied the game to a specific farm context while the game itself is structured so that results are aggregated regardless of farm and production. The game is targeted to crop production in general and then designed based on a set of ideas of how different adaptation options may result in increased vulnerability for groups, sectors or hinder/erode sustainable development. The participants see an overly schematic representation of a reality they experience infinitely more complex. In order to be able to play the game meaningfully, think, discuss and reason, the participants constructed their own narrative. Some played as potato growers, others as assuming a certain type of soil, or from an ecofarming perspective, while another always chose the cheapest option or what was perceived as the best for the environment. The simplistic representation of farming, from the participants viewpoint, can be seen as hindering their sense-making of maladaptive outcomes as discussions circulated around to what extent game proposed adaptation measures are relevant to a particular production or approach. Nevertheless, the participants appeared to find their own strategies to contextualize their gameplay.

4.2.3 The role of game text and symbols

Obviously, the use of technical concepts is unnecessary and should be avoided:

> F3   What is that? GHG?
> Moderator   It stands for greenhousegases
> M1   Jaha, jaja
> /.../
> M1 Would direct sowing increase, what it is called, greenhouses?
> Observer It might increase energy use
> F3 Energy use it was! (S1: 248-260)

Technical descriptions and abbriviations may have a negative effect on players´ meaning-making processes as it becomes hard to make sense, reason and apply. As in the above example, the abbreviation of GHG – greenhouse gases – was unknown to the participants who react at first when greenhouse gases are linked to "energy use". In a similar fashion, symbols and icons can confuse:

> F2 What's the difference between these, drainage systems and open drainage? The first seems to be tribal lines
> / ... / 14 lines omitted
> Observer The one with the pipes in the picture, it is more intended to be pipings.
> F2 I find it difficult based on these two pictures to understand what is what. (S2: 77-96)

The example illustrates the art of communicating through pictures and game icons. Here, one participant finds it difficult to find out what the icons represent.

5 Discussion

5.1 Benefits and challenges of serious gaming

This paper reflects on the design and analysis of the *Maladapatation Game*, drawing on the results of gaming sessions with Swedish and Finnish stakeholders. The results reason with previous findings in the climate change communication literature of the importance of local and concrete information (Moser 2010; 2016). While the game can be seen as an attempt to communicate research on maladaptation in a simple, structured, and

straigtforward way, the game setting, i.e. crop production and Nordic countries were experienced as too wide by participating stakeholders. However, it is not the simplification of climate adaptation and maladaptation that the participants oppose but rather the simplicity in the contextual application of the challenges climate change poses to agricultural practices. When participants consider management options as too simplified, the effects of the options, i.e. potentially increased vulnerability, are also considered to be partly inaccurate and inconsistent with the realities of the players. While the lack of context-dependent variables can be seen as hindering players´sense-making processes of maladaptation, it simultaneously can be seen as supporting sense-making as the game incentivises a discussion among participants. Discussions can therefore be seen as a dialogue between different ideas built on different interpretive frameworks. In such complex interactions characterised by multidimensional perspectives, we found the moderator to play a crucial role to facilitate a successful communication. Similarly, based on observations at The Wellcome Trust's "Gamify Your PhD", Curtis (2014) found the main challenge to be "the successful integration of science within a suitable gaming environment" (2014, p 381) – a balance between making the game entertaining and fun and the level of scientific detail and accuracy. Moreover, Burnet (2010) argues that games cannot sufficiently provide a communication relation between science and society. Considering the issue of trust, Burnet claims that a contact between the scientific world and the civil society requires circumstances in which the public meets scientists face to face. Hence, while games are expected to offer new ways of communicating they also raise communicative aspects of credibility and legitimacy. In line with Ingram et al. (2016) and Asplund (2018), our results suggest there is a need to provide opportunities for dialogue to engender better understanding between environmental research and agricultural practice.

5.2 How to adress the aspects that challenge participants´sense-making process

Serious gaming has been put forward in the scientific literature as particularly promising to engage stakeholders and scientists in a joint dialogue, and as such to integrate science, policy and practise. While our study showed that the maladaptation game indeed has a number of features that supported this integration and furthered dialogue, it also identified a number of obstacles that were specifically generated by the design of the game as such. The

participants of this study commented in particular on the use of technical concepts, terminology and abbreviations that should be avoided or addressed by improved illustrations or definitions within the game. Even though this game has been translated into the native language of our participants, the terminology might nevertheless be inconsistent in either its translation or due to a variety of terms that are used in the sector, and possibly also vary between e.g. cropping systems or regions. Similarly, participants might have different preconceptions of solutions which require to be acknowledged by the group and brought forward during discussions to avoid misunderstanding.

Similarly, games are often depending on an extensive use of illustrations and icons, which is a general challenge in terms of cultural representations. In this study, some participants express difficulties experienced when interpreting a number of the icons that refer to specific adaptation measures. While every icon card has a text explanation on its reverse side, the images nevertheless lead to different connotations for the participants, which were raised in the moderated discussions.

6 Conclusions and recommendations

As games and gaming have promoted new and innovative communication strategies to inform and engage stakeholders with scientific research, this study analyses the role of communication of (social) science and agricultural practices through serious gaming in stakeholder sense-making processes.

With the design and analysis of the *Maladapatation Game* we conclude that integrating social science and agricultural practice through serious gaming provides both challenges as well as support for the player's sense-making of potential negative effects of adaptation to climate change. While this study observed that the conceptual thinking of the game content sometimes clashes with players' everyday experiences and practice, possibly resulting in loss of credibility, we also conclude that gaming may function as an eye-opener to new ways of thinking. Based on the recent literature on serious gaming and climate communication and our results we recommend:

> That serious games are designed to include elements of "thinking and sharing", to stimulate joint reflections and discussions

> A careful integration of different knowledge systems – a balance between aggregated research results and context-specific every-day experiences

Nevertheless, if taking stakeholder value judgements into consideration in the development and in the presentation of the game content, we claim that serious games in general and the *Maladaptation Game* in particular has great potential to support discussions and development of how to address complex environmental issues. Thus, we recommend serious games as a communication strategy to complie, illustrate, visualize and communicate reserch findings.

Conflict of interest: Authors declare no conflict of interest.

References

Abid M., Schilling J., Scheffran J. and Zulfiqar F., Climate change vulnerability, adaptation and risk perceptions at farm level in Punjab, Pakistan, Science of the Total Environment, 2016, 547, 447-460

Asplund T., Climate Change Frames and Frame Formation – an analysis of climate change communication in the Swedish agricultural sector, PhD thesis, Linköping University, Linköping, Sweden, 2014

Asplund T., Natural versus anthropogenic climate change: Swedish farmers' joint construction of climate perceptions, Public Understanding of Science, 2016, 25, 5, 560- 575

Asplund T., Communicating Climate Science: A Matter of Credibility—Swedish Farmers' Perceptions of Climate-Change Information, The International Journal of Climate Change: Impacts and Responses, 2018, 10(1), 23-38

Barnett J. and O'Neill S., Maladaptation, Editorial: Global Environmental Change, 2010, 20, 211-213

Bindi M., and Olesen J.E., The responses of agriculture in Europe to climate change, Regional Environmental Change, 2011,11(1),151-158

Bishop I.D., Landscape planning is not a game: should it be?, Landscape and Urban Planning. 2011, 100, 390-392

Burnet F., More scientists and less surrogates, Journal of Science Communication 2010, 9, 2

Capstick S.B. and Pidgeon N.F., Public perception of cold weather events as evidence for and against climate change, Climatic Change, 2014, 122(4), 695–708

Curtis V., Public Engagement Through the Development of Science-Based Computer Games: The Wellcome Trust's "Gamify Your PhD" Initiative, Science Communication, 2014, 36(3), 379– 387

Dewulf A., Gray B., Putnam L., Lewicki R., Aarts N., Bouwen R. and Van Woerkum C., Disentangling approaches to framing in conflict and negotiation research: A meta-paradigmatic perspective, Human Relations, 2009, 62(2), 155–193

Entman R.M., Framing: Toward Clarification of a Fractured Paradigm, Journal of Communication, 1993, 43, 4, 51–58

Eurobarometer, Attitudes of European Citizens towards the environment, Special Eurobarometer 468, TNS opinion & social, 2017

Fiske J., Introduction To Communication Studies, Routledge, London, 1990

Flood S., Cradock-Henry N.A., Blackett P., Edwards P., Adaptive and interactive climate futures: systematic review of 'serious games' for engagement and decision-making, Environmental Research Letters, 2018, 13, 063005

Goffman E., Frame Analysis. An essay of the organization of experience. Reprint. Northeastern University Press, Boston, 1974

Ingram J., Mills J., Dibari C., Ferrise R., Ghaley B.B., Hansen J.G., Iglesias A., Karaczun Z., McVittie A., Merante P., and Molnar A., Communicating soil carbon science to farmers: Incorporating credibility, salience and legitimacy, Journal of Rural Studies, 2016, 48, 115-128

IPCC, AR 5 Climate Change 2014: Impacts, Adaptation, and Vulnerability, Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, 2014

Juhola S., Klein N., Käyhkö J., and Neset T.S.S., Climate change transformations in Nordic agriculture?,. Journal of Rural Studies, 2017, 51, 28-36

Juhola S., Glaas E., Linnér B.O., and Neset T.S.S., Redefining maladaptation, Environmental Science & Policy, 2016, 55, 135-140

Juhola S., Goodsite M.E., Davis M., Klein R.J.T., Davídsdóttir B., Atlason R., Landauer M., Linnér B-O., Neset T.S.S., Glaas E., Eskeland G., and Gammelgaard Ballantyne A., Adaptation decision-making in the Nordic countries: assessing the potential for joint action, Environ Syst Decis, 2014, 34, 600–611

Juhola S., Driscoll P., de Suarez J. M., and Suarez P., Social strategy games in communicating trade-offs between mitigation and adaptation in cities, Urban Climate, 2013, 4, 102-116

Kitzinger J., The methodology of focus groups: The importance of interaction between research participants, Sociology of Health and Illness, 1994, 16(1), 103–121

Linell P., Transkription av tal och samtal: teori och praktik [Transcription of talk and conversation: theory and practice], report from Linköping University, Linköping, Sweden, 1994

Magnan A.K., Schipper E.L.F., Burkett M., Bharwani S., Burton I., Eriksen S., Gemenne F., Schaar J. and Ziervogel G., Addressing the risk of maladaptation to climate change, Wiley Interdisciplinary Reviews: Climate Change, 2016, 7(5), 646-665

Marková I., Linell P., Grossen M. and Salazar Orvig A., Dialogue in focus groups: exploring socially shared knowledge, Equinox, London, 2007

Marshall N.A., Park S., Howden S.M., Dowd A.B., and Jakku E.S., Climate change awareness is associated with enhanced adaptive capacity, Agricultural Systems, 2013, 117, 30-34

Mayer I.S., Carton L., de Jong M., Leijten M., and Dammers E., Gaming the future of an urban network, Futures, 2004, 36, 311-333

Moser S., Communicating climate change: history, challenges, process and future directions, Wiley Interdisciplinary Reviews: Climate Change, 2010, 1(1), 31–53

Moser S., Reflections on climate change communication research and practice in the second decade of the 21st century: what more is there to say?, Wiley Interdisciplinary Reviews: Climate Change, 2016, 7, 345-369

Neset T.S.S., Asplund T., Käyhkö J., and Juhola S. Making sense of Maladaptation: Nordic Agriculture stakeholders´perspectives Climatic Change, 2019 (Published online) https://doi.org/10.1007/s10584-019-02391-z

Neset T.S.S., Wiréhn L., Klein N., Käyhkö J., and Juhola S. Maladaptation in Nordic Agriculture, Climate Risk Management, 2018 (In press) https://doi.org/10.1016/j.crm.2018.12.003

Ouariachi T., Olvera-Lobo M.D., and Gutiérrez-Pérez J., Analyzing Climate Change Communication Through Online Games: Development and Application of Validated Criteria, Science Communication, 2017, 39(1), 10-44

Patt A.G., Peterson N., Carter M., Velez M., Hess U. and Suarez, P., Making index insurance attractive to farmers, Mitigation and Adaptation Strategies for Global Change, 2009, 14, 737-757

Poplin A., Playful public participation in urban planning: a case study for online serious games, Computers, Environment and Urban Systems, 2012, 36, 195-206

Reckien D. and Eisenack K., Climate change gaming on board and screen: A review, Simulation & Gaming, 2013, 44(2-3), 253-271

Rötter R.P., Höhn J.G. and Fronzek S., Projections of climate change impacts on crop production: a global and a Nordic perspective, Acta Agriculturae Scandinavica, Section A–Animal Science, 2012, 62(4),166-180

Snow D.A. and Benford R.D., Ideology, frame resonance, and participant mobilization, International Social Movement Research, 1988, 1, 197–218

Washington Ottombre C., Pijanowski B., Campbell D., Olson J., Maitima J., Musili A., Kibaki T., Kaburu H., Hayombe P., Owango E., Irigia B., Gichere S., and Mwangi A., Using a role-playing game to inform the development of land use models for the study of a complex socio-ecological system, Agricultural systems, 2010, 103, 117-126

Wibeck V., Fokusgrupper: om fokuserade gruppintervjuer som undersökningsmetod [Focus Groups. On focused group interviews as research method], Sweden, Studentlitteratur, 2010

Wibeck V., Enhancing learning, communication and public engagement about climate change – some lessons from recent literature, Environmental Education Research, 2014, 20(3), 387-411

Wiréhn L., Nordic agriculture under climate change: A systematic review of challenges, opportunities and adaptation strategies for crop production, Land Use Policy, 2018, 77, 63-74

Wärneryd O., Games for urban and regional planning: a pedagogical tool, Technological forecasting and social change, 1975, 7, 397-412