Environmental Management (2022) 69:128–139
https://doi.org/10.1007/s00267-021-01499-2

The Possibility of Consensus Regarding Climate Change Adaptation Policies in Agriculture and Forestry among Stakeholder Groups in the Czech Republic

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Received: 25 July 2019 / Accepted: 30 June 2021 / Published online: 28 August 2021

Abstract

As ongoing research efforts contribute to elucidating the consequences of climate change as well as adaptation and mitigation options, aligning the current research knowledge with stakeholder opinions and perceptions remains critical for adopting effective climate change policies. This paper utilizes an interactive survey to (1) address the aforementioned gap in studies involving three groups of stakeholders and opinion makers and (2) perform a comparative primary study of the climate change assumptions, risk perceptions, policy preferences, observations, and knowledge of Czech farmers, governmental policy-makers and researchers. This study shows that the stakeholder groups agree that the climate is clearly changing, attribute this change mostly to man-made causes and expect the negative effects to either prevail or be unevenly geographically distributed. The large majority of all three groups consider unmitigated climate change a major threat even by 2050 and agree that preparing in advance is the best sectoral strategy. Importantly, while investment in adaptation measures is considered the most efficient tool for accelerating the implementation of adaptation measures, the CAP and EU rules (as valid in 2016) are believed to hinder such measures. The results of this study have ramifications for the wider region of Central Europe.

Keywords Climate change impacts · Climate adaptation · Climate policy · Stakeholder involvement · Cluster analysis

Introduction

The impacts of climate change on the agriculture and forestry sectors have received considerable attention (Bojovic et al. 2015, Prokopy et al. 2012, Smith et al. 2014), and the challenges associated with effective adaptation action and translation of knowledge into climate change adaptation policies have been widely recognized (e.g., Havlík et al. 2015a, Nelson et al. 2014, Leclére et al. 2014, EEA 2019). The translation of knowledge into policy and practice requires approaches addressing complexity, uncertainty, and controversy for scientific knowledge to become legitimate. Knowledge co-production has been recognized as a fundamental aspect in decision-making and policy design regarding climate change adaptation (Olazabal et al. 2018). Knowledge co-production can be characterized as a collaborative and collective process in which scientists and all stakeholders, including institutions, jointly define a problem and its potential solutions for climate change adaptation. The effective and legitimate implementation

Supplementary information The online version contains supplementary material available at https://doi.org/10.1007/s00267-021-01499-2.

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(mainstreaming) of climate adaptation policies and measures requires mutual understanding, dialog, support, and deliberation among the involved stakeholders (Van Buuren et al. 2014).

The political discourse and, to some extent, media coverage have long stressed the uncertainty in climate change projections, and public debates frequently feature politicians questioning the need for and relevance of mitigation and adaptation to climate change (Meah 2019). The Czech Republic has a relatively extensive record of climate change research (see review in Supplement), but the uptake of climate change policies has been rather hesitant and slow. This situation is illustrated by the time it took for the Paris Agreement to be ratified by the members of the Parliament, involving five rounds of voting and heated debate (e.g., Parliament's Report 2017). While the planned adaptation to climate change is already described in the governmental white papers and action plans (e.g., Ministry of the Environment 2017), the mitigation road map has yet to be decided.

Despite the relatively slow action regarding climate change, the Czech government has made progress in the preparation of adaptation strategies. The National Strategy on Adaptation to Climate Change in the Czech Republic was endorsed along with the action plan in 2015, followed by the National Action Plan on Adaptation to Climate Change (Ministry of Environment, 2017). The lack of will to address climate change as a critical societal issue and political debates focusing on challenging the basic facts rather than formulating adaptation and mitigation strategies in the 1990s and early 2000s led to a hiatus in the adaptation efforts that have only recently been renewed. The attitudes of critical groups of decision-makers (i.e., governmental agencies, the research sector, and business representatives) have not been transparently analyzed, communicated, and compared. The majority of the Czech population shows a high level of concern about climate change in line with that shown in other European countries, believing that climate change exists and is at least partly influenced by human activity (Poortinga et al. 2019). However, skepticism is higher in Central and Eastern European countries than in Northern or Western Europe, and this effect translates into the lagging efforts to fight climate change in this region (Climate Action Network Europe 2018). Some recent surveys show increasing climate change concerns in the context of landscape conservation and management as 87% of people think that without reducing emissions, we will be unable to protect our landscape from drought, smog, and the desiccation of forests (STEM 2019). As nearly 40% of the Czech Republic´s population of approximately 10 million lives in rural or semirural areas or uses landscape for recreational activities, agricultural and forestry management is of high concern in the Czech population.

The key of the Czech agriculture economics is crop production, which is dominated by small grain cereals (winter wheat and spring barley), maize for biomass (for either silage or bioenergy), and winter oilseed rape. A considerable proportion of agricultural land is also occupied by field crops, such as sugar beet and potatoes, complemented by minor crops, such as hops and grapes (Czech Statistical Office 2018). In the case of forestry, 34% of forested land is covered by predominantly coniferous trees (60%, mostly dominated by spruce), 12% by deciduous, and 28% mixed. The farm structure is diverse, with a number of large companies (over 10,000 ha) as well as small- and medium-sized farms. The total number of farms is approximately 22,000 (Czech Statistical Office 2010), with an average size of 150 ha, but less than 15% of the farms cultivate approximately 70% of the area. The proportion of irrigated land is relatively small (65,000 ha, i.e., 1.5%), representing a decline from approximately 160,000 ha shortly after 1990 (e.g., Trnka et al. 2016a).

Stakeholders' participation, level of knowledge, and attitudes are critical components for the successful planning of climate change adaptation. Given the onset of climate change and the impacts on the managed ecosystems, the implementation of endorsed strategies will require strong action. The aim of this article is to map the level of consensus or disagreement among key stakeholder groups with regard to the effective management of land and ecosystems in the Czech Republic.

Materials and Methods

Deliberative Participatory Approach

Here, we explore the perceptions, knowledge, and preferences regarding climate change of three groups of actors influencing the agricultural and forestry landscape of the Czech Republic. We, therefore, conducted a survey to (i) map the current level of knowledge about climate change among key stakeholders; (ii) identify what is perceived as the highest risk posed by climate change; (iii) determine which adaptation/mitigation options are seen as realistic and how willing stakeholder groups are to implement them; and (iv) identify what is seen as the principal barrier to the introduction of adaptation measures. We applied the deliberative direct opinion polling method among important stakeholders and interest groups related to agriculture, forestry, and water management in the Czech Republic. The participants were attendants of a national conference presenting a system for the exchange of information on the impacts, vulnerability, and adaptation measures associated with climate change in the Czech Republic (Czechadapt 2019).

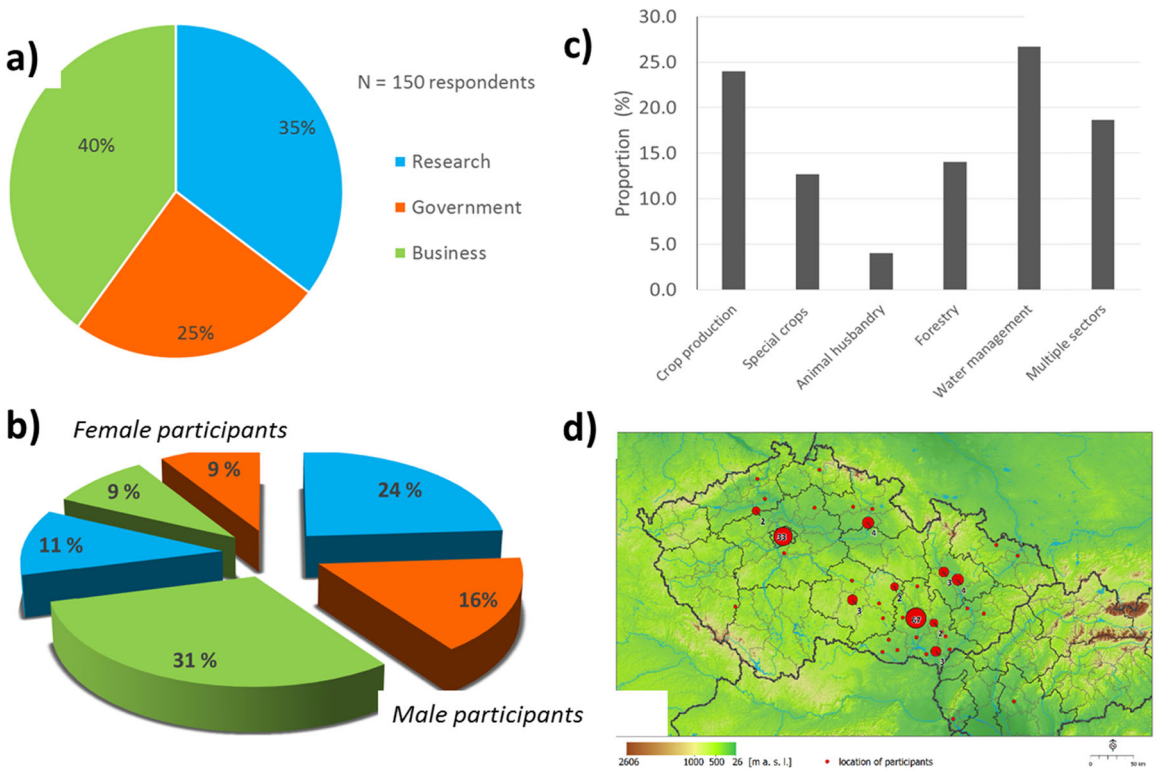

Fig. 1 The proportion of participants by group (**a**); by gender (**b**) and by field of expertise (**c**). The geographical locations of the primary addresses of the companies, research organizations, and governmental agencies are plotted on the map (**d**)

The total sample comprised 150 experts present at a one-day meeting on climate change impacts, adaptation, and mitigation. According to their role in agricultural and climate change research and policy, the participants were found to represent three stakeholder groups: the central and regional governments ($n = 37$), farm- and forest-based businesses and their associations ($n = 60$), and researchers associated with climate change impacts and adaptation ($n = 53$). The respondents were assigned to groups based on her or his preferences at the conference registration and checked for consistency based on the invitation list. The groups were typically male-dominated (Fig. 1b). Of the sectors, agriculture clearly prevailed, accounting for nearly 41% of the respondents, followed by water management (~26%) and forestry (14%). Figure 1d shows that 65% of the respondents were primarily based in the eastern part of the country (Moravia), while the western part of the county had lower coverage.

The sample is a convenient non-probabilistic sample of representatives of key institutions relevant to climate change adaptation in the agricultural and forestry sector and academia. The deliberation consisted of audience interaction with speakers introducing key topics outlined below. Each member of the audience received a wireless electronic voting device that allowed synchronized real-time responses and response evaluation. The responses were provided individually by each audience member from a selected list of possible answers. Responses were required from all members of the audience, and the data acquisition was monitored in real-time. The complete list of questions is presented in Supplement Table 1.

The voting was organized based on the following four major themes (for a detailed description of the related questions and responses, see Supplemental Table 1):

- Theme A: Knowledge regarding climate change.
- Theme B: Perceptions of future impacts on agriculture.
- Theme C: Perceptions of adaptation and mitigation challenges.
- Theme D: Perceptions of adaptation measures and governance.

We performed a descriptive analysis of the responses that the actor groups submitted regarding themes A to D. In all themes, the questions were formed in a closed-ended format (see Supplemental Table 1). The respondents had to choose one answer per question. All answers were equally weighted.

We expected the heterogeneity of responses to be largely explained by the background of the participants, i.e.,

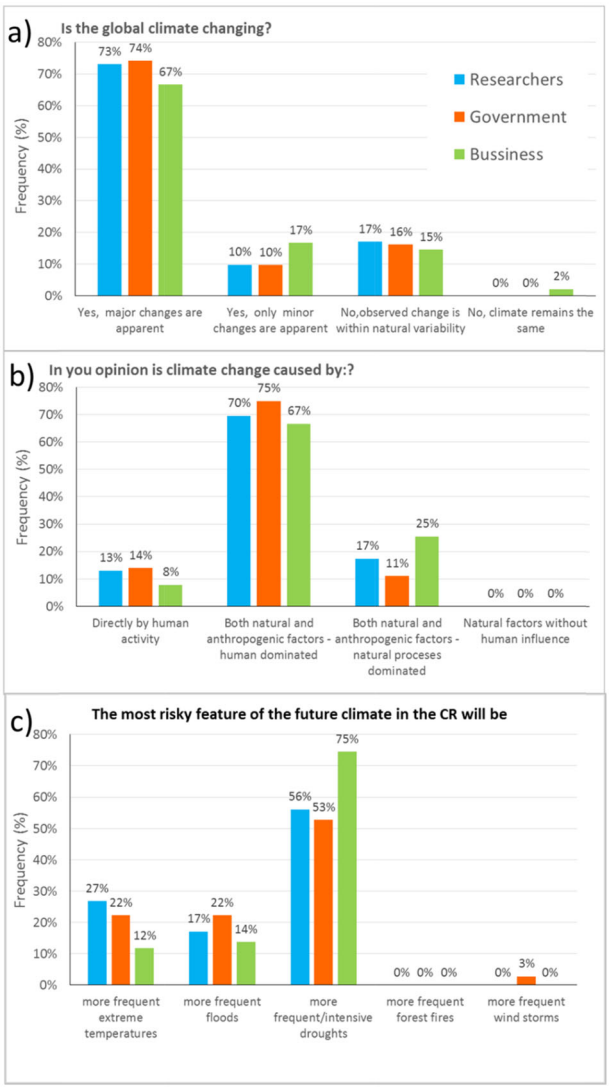

Fig. 2 Proportion of respondents by their perception of climate change as a proven phenomenon (**a**), its likely cause (**b**), and the riskiest features of the changing climate in the Czech Republic (**c**)

association with the research, business, or government sectors. To explore whether the responses to each question in each theme statistically differed among the different groups, we performed a cross-tabulation analysis. The cross-tabulation analysis tests and measures the association using two-way tables. In our analysis, the columns of the table corresponded to the profile of the respondents, while the rows corresponded to their responses (per question per theme). Pearson chi-square was employed as the measure of association.

In addition, we employed a two-step cluster analysis (TSCA) to further explore how the responses would differ if all questions under the same theme were simultaneously considered and determine whether the heterogeneity in the views presented was due to deviations in the group or personal/individual level. TSCA is an explanatory tool that reveals natural grouping or clusters within a dataset that otherwise would not be apparent. It was developed by Chiu et al. (2001) and is provided by the statistical package SPSS (SPSS Inc. 2001). The main aim of TSCA is to group data in a series of clusters (e.g., two clusters, three clusters) by maximizing the similarity among the observations within a cluster and maximizing the differences between the clusters. The analysis can be performed using both continuous and categorical variables. In our case, we used categorical variables only. The cases correspond to the objects to be clustered, while the variables reflect the attributes upon which the clustering is based. The number of clusters is determined based on information criteria, i.e., Bayesian information criterion (BIC) or the Akaike information criterion (AIC).

By employing TSCA, we aimed to investigate the participants' responses considering the themes of the questions. We expected to find similar views within clusters and variations between clusters. To determine whether the variation is explained by the type of respondent, each cluster profile was examined by performing a cross-tabulation analysis.

Results

Results by Theme

Theme A: knowledge about climate change

The general attitude toward the existence of climate change was surveyed by questions focusing on climate change and its causes. Despite the reluctance among policy-makers described in the introduction, the acceptance of climate change as a real issue with a major impact is quite clear, as shown in Fig. 2a. Interestingly, a higher proportion of the business group perceived the observed changes as minor compared with the government and research groups. Nevertheless, a fairly significant group (15–17%) across all groups attributed the observed changes to natural variability. Human activity was seen as the dominating (but not single) cause by a significant majority (67–75%) of the respondents (Fig. 2b). One-quarter of the business group and 17% of the research group considered natural processes the driving force of the change, with only a minor contribution from human activities. All three groups shared the view that in the Czech Republic, the increased frequency of drought was the most serious issue associated with climate change, outweighing even the concerns of more frequent heatwaves and floods (Fig. 2c).

Theme B: perceptions of future impacts on agriculture

The next questions assessed the expected impacts on global crop and livestock production. Figure 3a shows marked

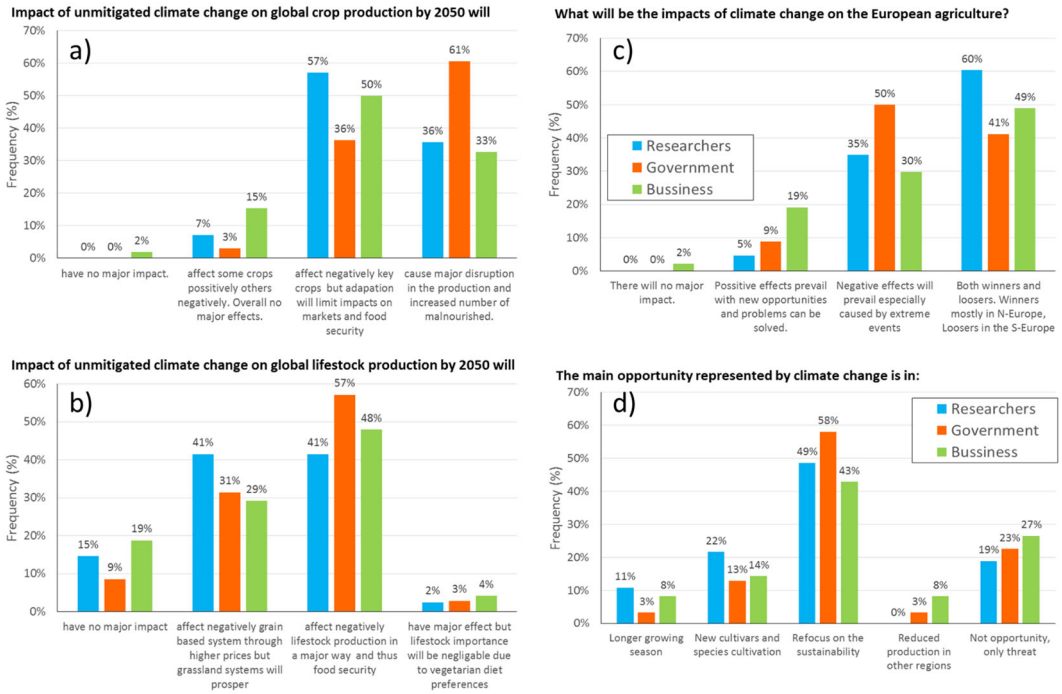

Fig. 3 View of respondents on the impacts of climate change on crop production (**a**) and on livestock (**b**); expected impacts on European agriculture as a whole (**c**) and opportunities presented by climate change (**d**)

differences in opinion among the groups. While the majority of the respondents expected major impacts on the key crops, both researchers (57%) and business respondents (50%) believed that the impacts would be managed through adaptation, thus minimizing the impacts on markets and food security. Only approximately 1/3 of the respondents from each group considered major disruptions in production to be likely by 2050. However, the government representatives were clearly more skeptical. This negative outlook by government officials also held in the case of livestock production, where major disruption was expected by 57% of government respondents but by "only" 41% of the researchers and 48% of the business representatives. The second most widely held view was that cereal-based livestock farming would face major problems due to the increasing grain prices, while the grazing-based systems would prosper (Fig. 3b).

However, major changes in the alimentary habits of the global population were not considered likely (Fig. 3b). On the European level, the responses of the business representatives seemed to at least partially reflect a more entrepreneurial approach, with 1/5 of these respondents expecting positive effects to prevail (representing a proportion three times larger than the proportion of researchers with the same opinion). The most widely held view is mixed, with losers in southern Europe and winners in northern Europe, which is a view held by 60% of researchers, 49% of business representatives, and only 41% of government experts. The last group sticks to the more negative outlook (Fig. 3c). The highest proportion of respondents from all three groups considered the climate change-driven focus on sustainability (Fig. 3d) to be the largest opportunity represented by climate change, with almost 3/5 of the government officials and over 2/5 of the business experts sharing this view. On the other hand, 27% of business representatives, 23% of government officials, and 19% of researchers did not see climate change as an opportunity at all. The new cultivars/crops that could be planted and grown over a longer growing season because of climate change were given markedly lower approval by businesses (14% and 8%, respectively) and government representatives (13% and 3%). The idea that the productivity drop in some regions caused by climate change would represent an opportunity was shared by 8% of businesses and 3% of government respondents.

Theme C: perceptions of the challenges for adaptation and mitigation

The responses with regard to adaptation focused first on which climate factors are perceived as posing the highest risk. Figure 4a shows that only a fairly small proportion of the audience (less than 23%) in all groups considered changes in temperature and precipitation to be threatening and/or key drivers of adaptation. Researchers and businesspeople attributed the highest weight (67 and 57%) to

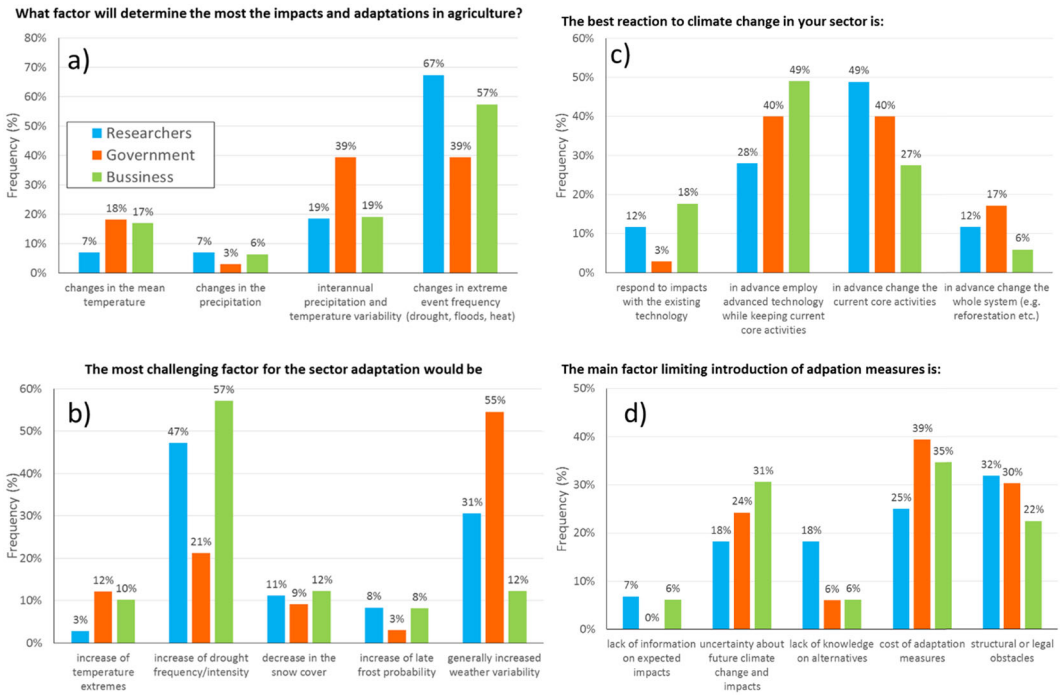

Fig. 4 The weight of climate factors assigned to key climate variables that will most affect the impacts and adaptation response (**a**) and the factors that will pose the largest challenges to adaptation (**b**); the best-perceived adaptation options (**c**) and factors most limiting their implementation (**d**)

changes in the frequency of extreme events, followed by the increased interannual variability in temperature and precipitation (19% both groups). On the other hand, the government representatives considered these to be equally important.

The respondents generally hoped that the adaptation to weather changes during the winter season would be less problematic or at least manageable, as a decrease in the snow cover and an increase in the probability of late frost were seen as major challenges by less than 20% across all groups (Fig. 4b). Similarly, the higher temperature was not seen as a major problem. The business people (57%) and researchers (47%) were most concerned about the increasing frequency and intensity of drought, followed by general increases in weather variability (12 and 31%, respectively). The government group again differed, seeing drought as much less important (21%) and rather considering the weather variability (55%) a challenge for adaptation.

The different stakeholder groups differed greatly in their responses in regard to the best options for adaptation (Fig. 4c). The researchers had relatively little preference for a response based on current technology or for radical change affecting the whole system (12% to both responses; e.g., reforestation instead of farming), while they preferred to change the focus of core business activities before climate change took effect (49%) or to take measures in advance and maintain the current core activities (28%). Not surprisingly, the business respondents showed much less eagerness to change the core activities in advance (27%) or to change the whole system (6%), while they preferred to change the use of technologies to maintain the core activities (49%) or only to respond to changes as they happen using the existing technology (18%); these responses indicate that 2/3 of the business representatives strongly preferred to stay within the current core business activities rather than switching them in response to changing climate. The government experts presented views between the other groups, preferring advance actions to either maintain (40%) or alter (40%) the core business functions, but a fairly high number (17%) considered an advance change of the whole system to be the best option.

The business respondents considered the cost of adaptation (35%) and uncertainty about future impacts (31%), followed only by structural or legal obstacles (22%), as major factors limiting the introduction of adaptation measures. The researchers listed structural or legal obstacles as the key factor (32%), followed by the cost of the measures (25%) and then uncertainty about the impacts (18%), and unlike other groups, they also perceived a lack of knowledge about the available adaptation options as important (18%). The response of the government experts could be characterized as something in between, seeing the cost of adaptive response (39%) as the key factor limiting the adaptation efforts, with legal obstacles in the second place (30%). The groups differed markedly in the main barriers for adopting adaptation measures identified (Fig. 4d).

With regard to climate mitigation (Fig. 5), the two most extreme answers available to the respondents, i.e., that agriculture is too important to be "burdened" with mitigation efforts and that agriculture should be replaced by forestry or bioenergy production, were given by only a small fraction of researchers and governmental representatives. However, one-fifth of the business representatives thought that agriculture should not be constrained by mitigation efforts. This group (36%) was also much less ready than the other two to accept the role of agriculture in reducing N_2O emissions and in sequestering carbon (56 and 58%). However, 41% of the business representatives and well over one-third of the governmental officials think that a continued and more efficient farming intemperate zone would allow the reforestation of the tropics and, therefore, contribute to emissions reductions.

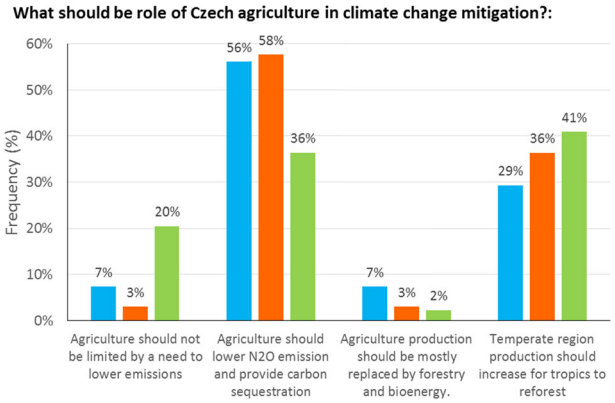

Fig. 5 Views on the role of agriculture in mitigation efforts

Theme D: perceptions of adaptation measures and governance

The responsibility for adaptation differs by sector, but when the responses were pooled (Fig. 4d), interesting differences were noted. In general, the researchers strongly favored (63%) the notion that adaptation is the responsibility of the public sector with support from the business sector. On the other hand, 69% of business-related experts thought that adaptation should be the responsibility of private business, with direct support from public funds. The government representatives were split but generally favored the primary responsibility of the private sector. However, the idea that either the state or the private sector held sole responsibility for the adaptions was widely shared. Perhaps surprisingly, a lack of information was not considered an obstacle to adaptation (Fig. 6a). While business representatives worried most about the uncertainty in the estimates of climate change impact (implying uncertainty in adaptation), the government perceived financial and legal obstacles as the greatest challenge.

Although the meeting participants stated that they considered an adaptation to climate change as an issue relevant to private companies and the public, and all but one government expert did not consider climate change in strategic planning (Fig. 6b). For business and government experts alike, climate change was one of many priorities (73 and 74%, respectively) in strategic planning, while approximately 1/10 of the respondents considered it a key priority.

Concerning the most efficient means for adapting the European agricultural/forestry sector to climate change (Fig. 6c), more than half of the respondents from all three

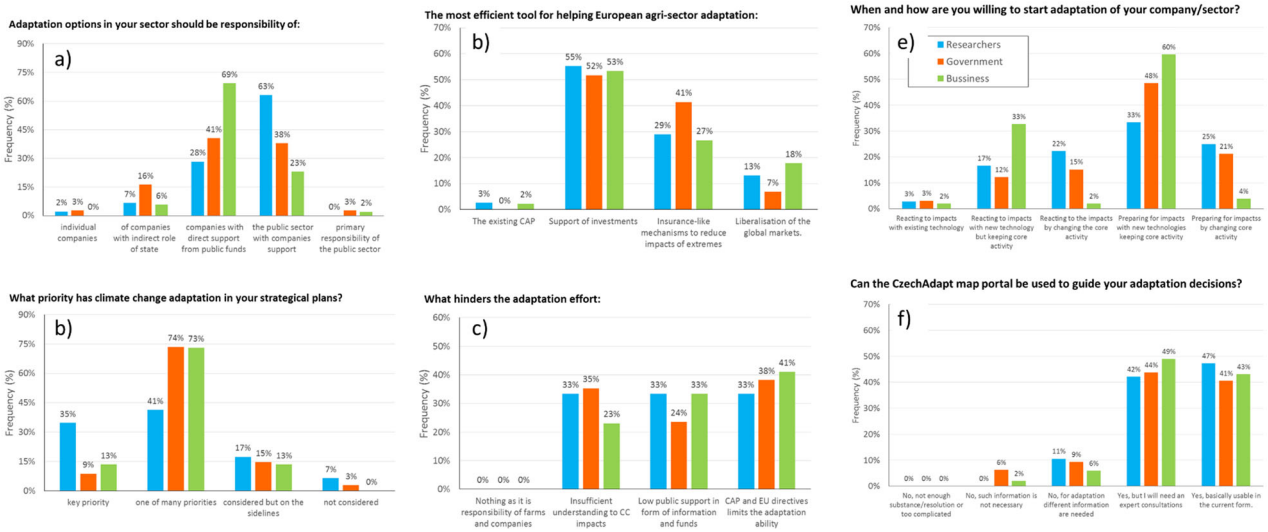

Fig. 6 View of the responsibility for the implementation of adaptation measures (**a**) and the priority status of climate change adaptation in the strategic planning of the particular company/sector (**b**); the most efficient tools for helping the European agriculture sector adapt to climate change (**c**) and major obstacles slowing down the adaptation efforts (**d**); how the climate change portal can aid in adaptation (**e**) and the helpfulness of the portal in guiding such measures (**f**)

groups favored the support of investment in structural changes of the whole sector. This was followed by the introduction of insurance and insurance-like mechanisms that would help reduce the economic impacts of the expected increase in the weather variability. This measure was particularly favored by government representatives (41%) and less by businesspeople (27%) and researchers (29%). The suggestion that global agricultural market liberalization would be beneficial by allowing European agriculture to take advantage of improved competitiveness on the global market was noted by a small minority of respondents (7–18%).

Only two members of the audience considered the existing common agricultural policy (CAP) to be an efficient tool for adaptation to the expected climate conditions. The CAP and other EU directives were considered major hindrances limiting adaptation efforts by the largest proportions of the business (41%) and government respondents (38%, Fig. 6d). While the business respondents considered the low public support in terms of the information and funds dedicated to adaptation efforts to be the second major limiting factor (33%), the government representatives considered the greatest obstacle to be the insufficient understanding of climate change impacts (35%). The researchers were equally divided among all three presented options. The view that adaptation is unhindered received no support from the audience.

The final set of questions concerning when and how actors are willing to make decisions about adaptations and to a certain degree which information they consider useful. There were significant differences between the responses of business actors and of the government representatives and researchers (Fig. 6e).

As there seems to be a significant group of respondents who would consider early or "pre-emptive" adaptation instead of a wait-and-see approach, it is also worth understanding which information would be required for such adaptation to occur. At the start of the meeting, we used the only portal dedicated to climate change in the Czech language (Czechadapt 2019), which was generally well known to the audience, to introduce the projection of climate change. The audience was invited to explore its functionalities via smartphones and detailed printouts presenting its functionality (Fig. 6f). The most skeptical group regarding the usefulness of such information was government stakeholders, with 15% considering such information either as unnecessary or in the wrong form. The same opinion was shared by 11% of researchers but by only 8% of business stakeholders. The overwhelming majority (92%) of business actors considered such information to be helpful, with approximately half requiring expert consultation to use it for decision making. The same positive opinion about the usefulness of such a product was shared by 85% of the government representatives and 89% of the researchers (Fig. 6f).

Cross-Tabulation and TSCA

The cross-tabulation revealed statistically significant differences in the stakeholders' views of certain questions in themes A to D, which are summarized in Supplemental Tables 2–4, and a more detailed description of the results is provided in the Supplement. TSCA revealed the presence of heterogeneity in climate change issues, which is described by grouping respondents into several clusters (Supplemental Table 5). The analysis highlighted diverse standpoints in regard to climate change knowledge, the future impacts on agriculture, and the adaptation and mitigation challenges, which mostly originated in the different perceptions at the individual rather than the group level. Hence, for these subjects, the stakeholder's role is not very determinant, and any forecast concerning policy consensus is ambiguous. For the subjects related to adaptation measures and governance, the heterogeneity was found to be stronger since the heterogeneity at the individual and group levels was significantly related. Nonetheless, researchers were the actors with the most homogenous views according to the share they represented in a given cluster, highlighting that it would be mainly business and government stakeholders who would have to take great effort to find common ground and reach consensus in matters related to the implementation and governance of adaptation.

Discussion

Stakeholder Involvement in Climate Change Adaptation

Our article presents an analysis highlighting the potential disagreements or consensus regarding selected aspects of knowledge co-production in climate change adaptation planning among stakeholders in agriculture, which could present barriers to adopting effective adaptation policies and measures. The study participants included members of the key groups influencing climate adaptation and mitigation policies in the agriculture, forestry, and water sectors. The engagement of stakeholders has been suggested to be a crucial factor ensuring the effectiveness of climate change adaptation strategies (Bohensky et al. 2016; Himanen et al. 2016; Wamsler 2017). We did not aim to perform a complete process of adaptation planning based on an analytical framework for strategic adaptation planning (Wamsler 2017). However, we aimed to elicit stakeholders' perceptions of recent knowledge regarding climate change and some emerging topics in climate change adaptation, notably future impacts of climate change on agriculture, perceptions of the most important adaptation and mitigation challenges, and perceptions of the suitability of adaptation measures and governance.

The first group considered in the present analysis comprised representatives of the central and regional governments responsible for shaping, executing, and evaluating government involvement in the agricultural and forestry sectors, including ensuring the long-term sustainability of production and other key ecosystem services. As Fig. 3 indicates, this group of stakeholders was particularly concerned (twice as much as the other groups) with unmitigated climate change causing major disruption to global production. Interestingly, this group had a favorable view of public support of the adaptation efforts with only ¼ thinking that it is inadequate (Fig. 6c).

The second group represented the farm- and forest-based businesses and their associations. As farmers directly manage more than 51% of the national territory and forest companies more than 34%, their involvement and interest in climate change adaptation are obviously critical in shaping the future landscape. Systematically, the group responses leaned towards not only a lesser overall impact but also the lowest perception of future opportunities (Fig. 3) This group shows a generally significantly larger concern regarding drought as a major future challenge (Fig. 4) and the lowest willingness to play a role in mitigation. However, at the front of adaptation (Fig. 6a), this group strongly believes that business companies are primarily responsible for climate change adaptation.

The third "reference" group consisted of researchers associated with climate change impacts and adaptation research. Interestingly, this group expects the public sector to play a much greater role in adaptation measures than businesses (Fig. 6). In the case of many questions, this group's responses were in the middle between the responses of the previous two groups.

Since the group of researchers also constitutes significant opinion-makers and educates the future generation of farmers and foresters, the influence of its members should not be underestimated. While the first two groups are certainly influential within the agricultural and forestry sector, their bargaining power at the governmental level is sometimes perceived as fairly small. Compared to areas such as the automotive industry, only small proportions of the country workforce (2.8%) and tax revenues are generated by the agriculture and forestry sectors. Although primary agriculture, forestry, and fisheries production directly provide only a fraction of jobs on the labor market, other related sectors, e.g., the machinery and chemical industries and services, need to be considered. (Czech Statistical Office 2018). Furthermore, Czech society is sensitive to events that seem to threaten the landscape and provided ecosystems services during the 2015–2020 drought period. Farmers and foresters work relentlessly through their associations to gain importance and the attention of the media and policymakers, and working with the government to craft responsible adaptation policies is critical. Our results (Figs. 2–6) show that there is important common ground between both groups in general as both groups

(i) believe that the climate is clearly changing and attribute such changes mostly to man-made causes;
(ii) consider unmitigated climate change a major threat even by 2050, especially through a higher frequency of adverse/extreme events and drought in particular;
(iii) expect the negative effects to either prevail or be unevenly geographically distributed;
(iv) agree that preparing in advance would be the best sectoral strategy and claim that such advanced preparation is hindered more by the cost of the measures and adaptation obstacles than uncertainty regarding the impacts of climate change;
(v) find investment for adaptation measures as the most efficient tool for accelerating the implementation of adaptation measures, while the CAP and EU rules (as valid in 2016) are believed to hinder adaptation; and
(vi) consider the climate change adaptation strategy only one of many priorities.

However, the cluster analysis highlighted relatively large differences within the government and agro/forestry business groups in climate change knowledge, the future impacts on agriculture, and adaptation and mitigation challenges. These differences originate from the individual rather than the group level, and therefore, despite an agreement between the groups in some critical questions, major opinion shifts among some business and government stakeholders are required to reach a consensus regarding issues related to the implementation and governance of adaptation.

The results presented in the series of Supplemental Tables 2–5 clearly show that the depth of the knowledge not only about ongoing climate change but also its expected impacts are important determinants of views concerning the adaptation strategy. The results show that the researcher group is a potentially important facilitator of opinion shifts given their relatively homogenous views according to the share they represent. All three stakeholder groups were generally in favor of the purpose-built portal that should facilitate autonomous adaptation efforts, indicating interest and a need for such systems even though 10% of the researchers and 15% of the government stakeholders were skeptical regarding its need and/or merit.

However, comparing the opinions of three different stakeholder groups was beneficial as this analysis mapped real-time responses that were preprocessed and visualized already during the meeting. Knowledge co-production as an interaction among science, policy, and practice is receiving increasing attention in climate change adaptation

(Olazabal et al. 2018; Boon et al. 2019). Knowledge co-production opens new opportunities for collaborative engagement among various actors to effectively design climate change adaptation policies (Hegger and Dieperink 2014). Our study expands the existing literature by involving decision-makers influencing adaptation policies and knowledge transfer in the agricultural, forestry, and water management sectors. Several studies explored the perception of climate change and adaptation behavior of farmers and found that the adaptation response depends on risk perception (Arbuckle et al. 2015, Mitter et al. 2019). While previous studies mainly addressed individual farmers´ perceptions and behavior, our study compares the responsiveness of different stakeholder groups based on a deliberative participatory approach and compared and contrasted individual versus group-level perceptions of the impacts and challenges of adaptation.

The findings concerning stakeholder engagement in climate change adaptation differ across studies. Participatory approaches can entail stakeholder interviews (Wiréhn et al. 2020), surveys and questionnaires (Piwowarczyk et al. 2012), case study analyses (Hegger and Dieperink 2014; Boon et al. 2019), advanced methods, such as Fuzzy Cognitive Mapping (Olazabal et al. 2018) or a combination of these methods. We applied an approach involving deliberative polling, which is an effective tool for involving various actors in a discussion regarding important topics in a limited time frame. To ensure the deliberative elicitation of opinions, an interactive workshop is required, where participants have the opportunity to share and exchange views and build consensus (McCrum et al. 2009). Bartels et al. (2013) applied participatory approaches to build an agricultural learning network, supporting the development of adaptation tools, and emphasized that networking and participation contributed to relationship building among researchers and practitioners. Several studies have engaged farmers in the design and implementation of adaptation measures, as illustrated in studies in Finland and the Netherlands (Himanen et al. 2016; Schaap et al. 2013).

Adaptation to climate change imposes additional costs on production. Overall, the analysis concluded that approximately 8% of the surveyed business people, i.e., the highest share among the stakeholders, considered the reduced production in other regions the greatest opportunity potentially represented by climate change. However, almost 1/3 of the business respondents still considered climate change only a threat. This may represent a large heterogeneity in climate change impacts, even over a relatively small region such as the Czech Republic, where particular regions have suffered from several years of droughts without yielding any obvious alternatives to the current production orientation.

Overall, 80% of the business representatives recognized that agriculture and forestry play a role in climate change mitigation. While approximately half of them saw a major opportunity for reducing domestic emissions and potentially providing a carbon sink and biomass for energy through afforestation, the other half considered it most important to increase the production in temperate regions to allow production reduction and afforestation in tropical regions. The latter strategy would indeed be in line with the scientific findings by Johnson et al. (2014), who highlighted that while temperate regions have relatively high crop yields, the carbon storage in soil and vegetation is relatively low, while in the tropics, there are relatively low crop yields but very high potential for the storage of carbon. Similarly, Herrero et al. (2013) demonstrated that, for instance, ruminant production is far more GHG efficient in Europe than in Latin America. Hence, reducing beef production in Europe and substituting it by beef imports from Latin America would lead to a net increase in global GHG emissions. Surprisingly, this strategy was favored by only 29% of scientists. Indeed, if climate change mitigation can provide new business opportunities for the sector, its acceptance may improve.

Reducing agricultural GHG emissions is currently a concern mostly under the European climate policy rather than under the CAP. However, the current policies will likely have little effect on agricultural GHG emissions since member states of the EU can substitute emission reductions in agriculture for reductions in other sectors, and agricultural emissions are often more difficult and expensive to reduce than emissions in other sectors (Fellmann et al. 2018). Rather, there is an ongoing concern in the food industry for reducing the carbon footprint of food products as part of the marketing strategy (Elofsson et al. 2016). The stakeholders in the meeting considered it a priority to reduce these emissions, although the business representatives had a higher focus on enhancing production in Europe than on reducing emissions (Fig. 5).

Overall, our findings complement the literature regarding how climate change can be studied as a "relational phenomenon" and understood on a local level (Brace and Geoghegan 2011; Smith et al. 2014) and show that key stakeholders might hold similar views despite having very different mindsets. While our research revealed that 67–75% believed that human activity plays a significant role in climate change, this is an achievement given the highly skeptical view of the top government officials between the late 1990s and 2010. This high figure has certainly been helped by actual weather events, with major floods in 1997, 2002, and less in 2006 and 2012 and droughts in 2000, 2003, 2007, 2010, 2012, and 2015. Drought was considered the most dangerous outcome of climate change for the Czech Republic´s agricultural, forestry, and water management sectors.

Conclusions

Decision-making regarding adaptation responses and strategies is not only influenced by the level of knowledge of the impacts of climate change but also involves multiple trade-offs (Wiréhn et al. 2020). Our analysis showed that the stakeholder groups differed in their views of the causes of climate change and the factors that challenge sector adoption and the best reaction to climate change. The groups significantly differed particularly in the case of adaptation policy governance. However, clearly, a consensus among the stakeholder groups must be formulated; otherwise, the discrepancy in priorities will affect policies and their implementation and inevitably cause frictions. The study findings also indicated the importance of the level of understanding of climate change causes and likely impacts in affecting the views and potential actions of stakeholders. Based on the results, we can conclude that improving and increasing knowledge regarding climate change may potentially lower the differences in views among individual stakeholders and stakeholder groups.

The analysis presents the results of a national deliberative workshop, enables a comparison of the inter-group preferences of national stakeholders based on deliberative polling, and complements other research in this area that demonstrates the effects of the involvement of stakeholders in decision-making concerning agricultural adaptation policies (Prokopy et al. 2012, Bartels et al. 2013, André and Jonsson 2015). Our study addressed the linkages between stakeholders' knowledge and beliefs regarding climate change, its impacts, and the perception of the most appropriate adaptation measures and governance responses. As highlighted in this study, differences in the adaptation response could arise in the business sector and public sector. The business sector had a greater preference to use existing assets than the government representatives or researchers. Obviously, this opinion needs to be considered when drafting national adaptation strategies and action plans. Perhaps not surprisingly, the business representatives strongly preferred not to change their core activities. However, keeping these activities unchanged was not considered the best strategy by almost 80% of the government representatives and researchers, who are perhaps more objectively able to consider the question while not having major vested interests. It is also important to recognize the positive attitude of the business and manifestation of autonomous capacity in making strategic decisions and need to influence these decisions by positive incentives rather than through regulations. Both national and EU-level policymakers should take note of the perception of the current CAP rules as hindering rather than assisting adaptation efforts. While this might be due to CAP communication rather than a genuine problem of the policy, it needs to be discussed and explained to the stakeholders.

Finally, there seemed to be a consensus that climate change adaptation efforts are a public–private issue and that the key stakeholders consider partnering to be critical for achieving successful adaptation. This should help modify the existing set of regulations, which are seen as negatively influencing the exploration of adaptation opportunities by the business sector.

Data Availability

Anonymized responses to the questions and the presentations provided at the conference are available upon request by the authors and (notably, the entire survey and most presentations were conducted in the Czech language).

Acknowledgements As authors, we would like to pay tribute to the life-long work of our friend and research associate prof. Arne Skjelvåg sadly passed away in June 2021. Dr. Daniela Semerádová is acknowledged for her help in drafting Fig. 1. We thank the two anonymous reviewers for their helpful comments and challenging remarks, which greatly improved the original version of the study.

Funding The study was supported by the project SustES - Adaptation strategies for sustainable ecosystem services and food security under adverse environmental conditions (CZ.02.1.01/0.0/0.0/16_019/0000797). The funding source had no involvement in or influence on the design, collection, analysis, and interpretation of the data or the writing and submission process.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

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