iForest
Biogeosciences and Forestry

Research Article
doi: 10.3832/ifor3958-015
vol. 15, pp. 509-518

Seeing, believing, acting: climate change attitudes and adaptation of Hungarian forest managers

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Climate change attitudes, perceptions, and adaptation activities of Hungarian forestry managers have been examined in this study through a national questionnaire and interviews. The questionnaire results revealed that respondents are mainly concerned by the decrease in snow-covered days, but differences in opinions can be attributed to geographical location and forest composition. Forest management aimed at climate change adaptation in Hungary is still in the initial phase: only 16% of respondents reported the application of climate change adaptation measures. Many foresters claim legislative constraints frequently hinder their efforts to implement such measures; those who have implemented adaptation measures show an increased concern toward climate change, on average. They have been aware of climate change for a longer time and consider it a serious problem affecting their management activities. The questionnaire results indicate that the adaptations of state forest managers are at about the same level as private foresters. Moreover, a high level of concern combined with nature conservation factors does not hinder adaptation. Nevertheless, interview respondents reported that nature conservation factors are hindrances to adaptation processes.

Keywords: Climate Change, Forestry Management, Perception, Adaptation, Hungary

Introduction

Many factors, including climate-induced deforestation, land cover change feedback, climatic impacts on forests, and climate engineering proposals, make forests the focal point of climate change research (Bonan 2008, Lindner et al. 2014, Keenan 2015, Moomaw et al. 2020, Verkerk et al. 2020). Climate change perception and attitudes are a focal point in the human society. Beyond public polls, a well-founded focus on field practitioners in agriculture and forestry exists because these professionals experience firsthand natural phenomena such as climate change (Weber 2010, Geoghegan & Leyson 2012, Barkmann et al. 2017). Personal perception data can be compared to climate time series in much the same way other studies compare data series to laypeople's perceptions (Egan & Mullin 2012, Akerlof et al. 2013, Hamilton & Stampone 2013).

Nevertheless, such studies underscore various uncertainty factors inherent within such research. Theoretically, the perceptibility or imperceptibility of climate change is a contested issue (Rudiak-Gould 2013, Hulme 2014). Interpreting how non-professionals discern climate trends from daily weather observations is problematic due to personal bias, memories, cultural and local embeddedness (Brace & Geoghegan 2010, Hulme 2016), personal values or political attitudes (Egan & Mullin 2012, Akerlof et al. 2013). Furthermore, the effects of experiential learning – when personal experience increases belief certainty in anthropogenic climate change – differs from motivated reasoning when prior belief certainty determines personal experiences (Myers et al. 2013). However, the role of personal experiences in motivation and engagement in action against climate change deserves attention (Lorenzoni & Pidgeon 2006, Broomell et al. 2015).

The Hungarian forestry sector has long focused on climate change (Mátyás 1997, Somogyi 2000), which has also oriented research and forestry policy (NES 2016). Related research inclines mainly toward understanding and predicting the perceptible natural and ecological processes in forest areas and forecasting these in connection with climatic trends (Somogyi 2003, Mátyás 2006a, Führer et al. 2013, Mátyás et al. 2018). Hungarian research plays a significant role within an international context by studying the changes in the forest-steppe transition zone (Mátyás & Sun 2014). Research from social sciences is also notable, as forestry is a unique field with a potentially extreme time lag between adaptation measures taken today and future forests adaptation to a different climate (Sousa-Silva et al. 2018). The present study aims to assess the climate change attitudes of foresters, which is a critical endeavor. Our analysis seeks to explore the relationship between the understanding and percep-

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Received: Sep 01, 2021 - Accepted: Oct 11, 2022

Citation: Jankó F, Bertalan L, Pappné Vancsó J, Németh N, Hoschek M, Lakatos M, Móricz N (2022). Seeing, believing, acting: climate change attitudes and adaptation of Hungarian forest managers. iForest 15: 509-518. – doi: 10.3832/ifor3958-015 [online 2022-12-14]

Communicated by: Matteo Garbarino

tion of climate change and how the actors of Hungarian forestry sector adapt to these changes. The present study is novel research within this context and is of particular interest due to the potentially receding distribution borders of tree species in Hungary (Mátyás et al. 2018).

The literature on forestry, climate change perception, and adaptation is increasing worldwide (Halofsky et al. 2018, Sousa-Silva et al. 2018, Vilà-Cabrera et al. 2018). The case studies, mainly from Western Europe and North America, imply an increase in climate change concerns among forestry professionals. Nevertheless, adaptation measures remain rare. Various factors influence adaptation measures. These include political views (Ameztegui et al. 2018), information campaigns (Mostegl et al. 2017), education (Blennow et al. 2016), and sector traditions, personal habits or perceptions (Andersson et al. 2017). Previous research also provided evidence of varying forester attitudes about risk, perceived effects, related adaptation measures (Petr et al. 2014, Furness & Nelson 2012, Lenart & Jones 2014, Nelson et al. 2016), and species choice (Yousefpour & Hanewinkler 2015). On the other hand, small-scale owners may rely more on native diversity and related species, while commercial advisors prefer to use new exotics (Lawrence & Marzano 2014), implying that land ownership conditions could determine adaptation measures. Other studies elucidate the adaptation capacity of foresters (Johnston & Hesseln 2012, Andersson et al. 2017, Gameren & Zaccai 2015) or the acceptance of climate science among foresters (Blades et al. 2016, Blennow et al. 2016).

International comparative studies have emerged, but remarkable differences remain regarding the adaptation rate of foresters among the observed countries (Blennow et al. 2012, 2016, Sousa-Silva et al. 2018). These varying results could be dependent on the various methodological approaches employed by researchers in questionnaire surveys (Blennow 2012, Petr et al. 2014, Yousefpour & Hanewinkler 2015, Ameztegui et al. 2018) or in-depth interviews (Milad et al. 2013, Lawrence & Marzano 2014, Lakkonen et al. 2018), or both combined (Detten & Faber 2013). For example, repeated surveys in Sweden demonstrated that forestry adaptation measures developed and spread throughout the study periods and connected to the respondents' rate of risk evaluation, especially in the southern regions (Blennow 2012). Conversely, German studies reported that forester endeavors had few outcomes in the form of visible and implemented management strategies, although the foresters themselves considered climate change and even adaptation measures depending on the exposure of their region (Milad et al. 2013, Yousefpour & Hanewinkler 2015).

Blennow et al. (2012) presented the first interregional study, organized around the concepts of perception and action. This research group conducted questionnaire surveys in Sweden, Germany, and Portugal and reported that belief in climate change and experiences highly correlate with action against climate change. Moreover, regional differences in these aspects are remarkable. This study offered a methodological base for further studies analyzing the perception-adaptation link (Sousa-Silva et al. 2016), studying the role of forest-safety measures, or public awareness and fuel management in climate change adaptation (Raftoyannis et al. 2014).

By summarizing the relevant aspects of the literature in a Hungarian context, our study applied a combined methodology (questionnaire survey and interviews) to address the issues of belief and experiences. Our focus on detailed regional differences as drivers of perception and adaptation measures – together with forest composition, ownership, and conservation aspects – is unprecedented in the literature. We concentrated on two main questions and four related hypotheses. First, does the perception of climate change contrast with the observed climatic trends? Second, what are the detectable differences in adaptation measures and strategies among Hungarian forest managers?

For the first question, we hypothesized that the location, the forest composition, and the site-specific and mesoclimatic conditions all influence climate change perception. The second question aims to explore adaptation motives and factors. Three hypotheses were set for this purpose: (i) state forests are better prepared and more conscious of climate change; (ii) nature conservation of forests makes adaptation more difficult; (iii) excessive anxiety about the problem blocks adaptation and action.

Methods

Basic information

During 2016-2017, we contacted 22 state forest enterprises and numerous private foresters by email and telephone. We asked these organizations to have their operational-level forestry employees and forestry professionals complete a questionnaire including 22 questions (see Appendix 1 in Supplementary Material). After the survey, we obtained 186 evaluable answers to the questionnaire containing all the 22 questions. Five questions in the questionnaire addressed personal data (gender, date of birth, residence, etc.). Regarding the basic data, nine participants to the survey were women (5%), a little over 93% of the respondents were born between 1950 and 1989, and the most populated group (30%) was the 1970-79 age group. The next group was the 1960-69 group, which comprised 26% of respondents. Our survey is geographically representative because the respondents adequately represented all settlement levels and counties in the main forested areas of Hungary (Fig. 1).

Five questions within the questionnaire addressed forest management circumstances (location, forest composition, nature conservation categories, function of forests, and form of ownership). Based on the forest management location (settlement, forest micro-region), the respondents were divided into categories according to the elevation belts: plain (30% of the respondents), hilly (30%), and mountainous (40%). We also divided the area of Hungary, as well as the respondents, into four large regions, taking into account the forest-climate conditions, distinguishing the Great Plain (27%), Northern Hungary (23%), Southern Transdanubia (23%; including Zala) and Northern Transdanubia (27%).

Two-thirds of our interviewees worked in state forestry, and one-third worked in private forestry. Many respondents work in monoculture forest areas. With the stand-forming associations in mind, we formed the groups shown in Fig. 1.

Climate change perception

The next block of questions is concerning the problem of climate change perception (6 questions), aiming to obtain information related to climate change, the temporal dimension, the importance of experience, and problem topicality. Using a five-point Likert scale, we generated a series of six questions about fear or ignoring concern about the climatic future (with three positive and negative wordings each) that were properly aggregated to a fear index ideally ranging from 6 to 30, with observed values from 11 to 30 and an average of 23 (Appendix 1).

In particular, we considered the climatic or weather phenomena that foresters attribute to climate change in terms of residence or management location. Based on the responses, a "climate deterioration index" was developed (maximum: 12, average: 8.2) by summing up the answers for each respondent that pointed in the same direction (*e.g.*, blurring seasons, decreased number of days covered with snow, etc.). In the event of a reverse indicator, we rated the lack of change as one point and the change in the positive direction as two points (*e.g.*, unchanged and increasing annual precipitation), so the "climate improvement index" could reach 21 points in theory even though only values between 1 and 11 were obtained (with a mean of 3.2).

We made a spatial comparison using the perception questions and observed climatic trends of the past. The investigated five climatic dimensions were the following: changes in annual precipitation, annual temperature, drought frequency, heatwave occurrences, and current annual snow cover. The questions were related to five non-public climate maps provided by the Hungarian Meteorological Service at 1 km resolution. These maps are as follows: (1) annual precipitation change (%) for the period 1961-2018; (2) mean annual temperature change (°C); (3) mean summer tem-

perature change (°C); (4) change in the number of days with heatwave (days) for the period 1981-2018; and (5) the number of days with snow cover (days). The latter map presented only state conditions and not the trend in snow cover for the period 1981-2010 (Bihari et al. 2018).

The climate maps were georeferenced and masked for the area of Hungary using the software QGIS v. 3.4 (QGIS.org 2021). The questionnaire data was geo-located based on the spatial information of the management sites and was overlaid on the climate maps. We classified the data points according to the answers (reduced, increased, and not changed) for further analysis.

Climate change adaptation

The last block of questions in the questionnaire examined the impact on management, vulnerability, and adaptation (six questions). Concerning the latter, forest managers were divided into two groups based on open-ended questions on present adaptation actions and planned future actions: (1) those who have completed adaptation measures; and (2) those who have not completed any measures. The non-parametric Wilcoxon rank sum test statistically assessed the difference between the two groups (Haynes 2013). According to the research questions, we also analyzed the role of nature conservation in climate change adaptation by comparing the proportion of nature conservation areas in the managed forests with the vulnerability declared by the forest managers.

Interviews

A nationwide interview of 16 forest managers supplemented the questionnaire to obtain additional information and to collate the questionnaire results. Eleven participants to the interview represented state-owned forests, two represented private-owned forests, two represented both occupation types, and one expert represented UN-FAO. We ensured the respondents represented the major landscape units in terms of management location. Where possible, we applied the additional condition that each interviewee possessed several decades of professional and managerial experience. Thus, the interviewees were largely around 60 years of age. Some interviewees were retired forest managers, while one was a forest inspector. The questions aimed to inquire about climate change perception, the positive and negative effects of climate change, the applied adaptation strategies, and the main adaptation barriers.

Results and discussion

Perception of climate change

Regarding the basic data of our questionnaire survey, only one respondent claimed to be ignorant of climate change, while 13 rangers stated that they had not experienced the phenomenon. Approximately 90% of the respondents rely on traditional and online media as fundamental information sources on climate change and on professional journals and events, which echo the findings of Yousefpour & Hanewinkler (2015).

Concerning the general consideration of the respondents on climate change temporality, the majority (42%) cited the most recent 10 years as the climate change time frame. More specifically, this majority claimed to have been aware of the changing climate since roughly the mid-2000s. The interviews revealed here that severe drought was perceptible in this period. Thirty percent of respondents thought that climate change is perceivable over a longer period, while 22% reported a shorter period (Question no. 12). Some interviewees even highlighted the drought period occurred in the 1980s, which caused considerable damage to pine and beech stands, as the first sign of climate change. Some older respondents remembered as far back as the 1970s when sessile oak stands in Northeastern Hungary suffered major damage. Furthermore, the interviewees also mentioned other climatic changes regarding decreasing groundwater levels and extreme temperature fluctuations. Indeed, climate change effects have been visible for a longer period, such as drought and tree mortality that increased in Hungarian forests from the 1970s (Szabó et al. 2019). Our results show that Hungarian foresters are aware of the climate change problem in connection with the country's critical location in the forest-steppe transition zone (Mátyás & Sun 2014, Mátyás et al. 2018). Beyond the frames of the questionnaire, the interviewees mentioned further climatic changes regarding decreasing groundwater levels and extreme temperature fluctuations.

The questionnaire also addressed climate change topicality and skepticism. Fifty-seven percent of respondents reported, that "they feel the effects of climate change on their own skin, they see it with their own eyes". One-third chose the option that "climate will always influence humanity". This group, together with those who project climate change to the distant future (4%), could be considered skeptical about the importance of the issue. Yousefpour & Hanewinkler (2015) reported on the presence of a smaller group of climate skeptics, while Mostegl et al. (2017) estimated the rate of the skeptics in a sample of small private forest owners to be 20%.

The contrasting opinions were much more explicit during the interviews. Interviewees blamed anthropogenic factors for land-use changes, the expanding built environment, industrial and transport pollution, and the increased use of fossil fuels. However, many foresters were undecided about how human activity completes natural forcings like carbon-dioxide emissions from volcanos or silicates. Thus, most respondents (69%) considered climate change to be an outcome of intertwined processes of anthropogenic and natural forcings. This view can be considered scientifically wrong based on the present IPCC report, which cites human-caused emissions as the major cause of recent warming (IPCC 2021). Nevertheless, based on the questionnaire data, we can state that forestry actors believe their sector is the most exposed to climatic effects. They also consider these effects as mostly negative.

We included several questions addressing the changing climate with various weather variables and related phenomena. We

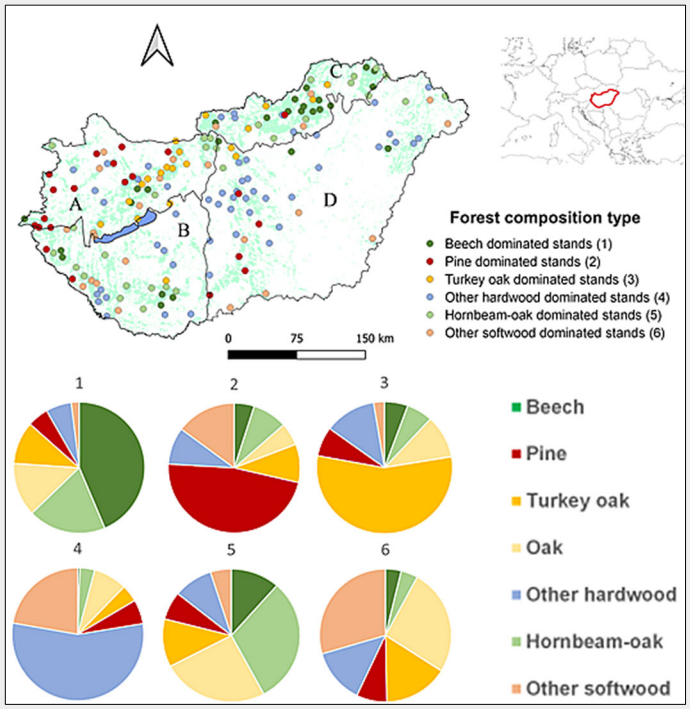

Fig. 1 - Location of the respondents according to the forest composition types (1-6) and the average mixing ratios of the tree species for each composition type. Green background color denotes the forested area, letters indicate the forest regions: (A) Northern Transdanubia; (B): Southern Transdanubia; (C): Northern Hungary; (D): Great Plain.

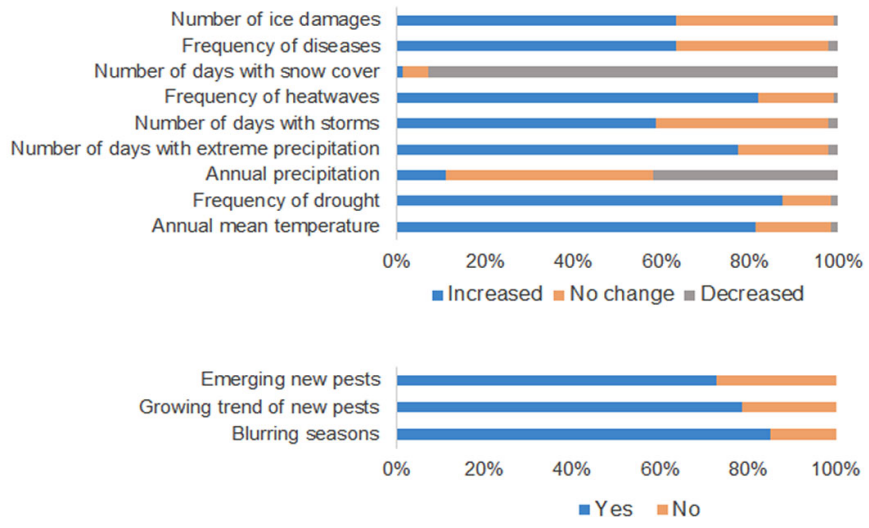

Fig. 2 - Climate and other variables attributed to climate change.

asked the respondents to identify any visible or perceivable effects in their environments or locations of daily practice. Our general data provided an unequivocal picture – major uncertainty appeared only in the case of annual precipitation. Many reported a precipitation decrease but far more reported no change in annual precipitation. The most consistent answers arose in questions about snow cover days and blurring seasons (Fig. 2). This result is country-specific; different results emerged in other regions (Furness & Nelson 2012, Detten & Faber 2013, Sousa-Silva et al. 2016).

Fig. 3 shows the result of the climate-deterioration index. The data indicate that significant differences exist between the elevation belts and forest regions categories; hence, there is a need to focus on these aspects when investigating the link between locality and perception. Namely, respondents from mountainous and plain regions perceive climatic problems to a lesser degree, in agreement with Hungarian research results (and with our expectations) that highlight the vulnerability along the xeric limit of forests in zonal hilly regions without surplus water from groundwater (Mátyás et al. 2018). These areas have experienced large-scale forest mortality events in the past that were related to severe drought periods (Lakatos & Molnár 2009).

In the categories of forest composition, some results also fit into the abovementioned picture. Group 3 (N=21), dominated by Turkey oak stands, reported the growing trend of drought periods, heat waves, ice damages, blurring seasons, and pests at the highest rate. Otherwise, group 2 (N=23), dominated by pine stands, had the highest rate in the other climatic variables like annual mean temperature, number of days with extreme rainfall, etc. Summing up, Group 1 (N=29) and Group 4 (N=56) reported unchanged climatic conditions at the highest ratio.

We obtained a clear picture of the regional categories. Respondents from Northern Hungary have the lowest grades regarding the perception of climate deterioration and the highest grades regarding no change in climatic conditions. However, these grades also reach 70% agreement in worsening trends. Of the 11 climatic variables, nine responses from Northern Transdanubia had the highest rates (three were extremely close to other regions), showing intensively blurring seasons, growing annual mean temperature, decreasing annual precipitation, and increases drought frequency and heatwaves, number of stormy days, ice damages and the presence of pests. Respondents from the Great Plain reported a decrease in snow cover days and increases in annual mean temperature and the frequency of drought periods. In Southern Transdanubia, the perception of extreme rainfall and the growing presence of pests were the highest.

Our data also showed that respondents (N=43) who perceived less deterioration in the local climate (*i.e.*, their climate improvement index was two times above the mean) were, to a larger extent, from the plains or the mountains. Alternatively, they were from groups 1, 4, and 6 and were younger on average. Half of these respondents only began perceiving climate change in recent years. In addition, these respondents reported a higher proportion of no change or improvement in business effectiveness due to climate change.

Thus, there should be some relationship between location and climate change perception. Our maps, contrasting the personal responses with observed data, exhibit some interesting evidences in this regard, where we expected some difference in the hilly, Southern Transdanubia (Fig. 4). The map of annual precipitation change indicates a significant precipitation decrease in SW Hungary; however, the respondents from this region mostly reported no change. Nevertheless, large areas with a remarkable increase in precipitation also included responses that perceived both decreases and increases in precipitation, which reveals the subjective nature of personal perception, which is affected by personal beliefs and the mediatized climate change effects. Concerning annual temperature, the trend is obvious in Hungary and the "no change" responses distribute evenly on the map with some slight concentrations in the mountains and along the southern border. The trend map of summer temperature days refers to drought frequency, which depicts a few "no change" responses in the mountainous areas. The change in the number of heatwaves shows a polarized map; the largest increase occurred in the southern plains. However, "no change" answers also occur in these areas, while some respondents also reported an increase in mountainous areas with only a very slight increase in this regard. Together with the snow cover map, these maps underscore the importance of locality, but other factors (media, local knowledge, etc.) also possibly affect the perception process at the individual level. However, the uncertainty of this analysis cannot be stressed enough, particularly regarding the observed data type and the related survey questions.

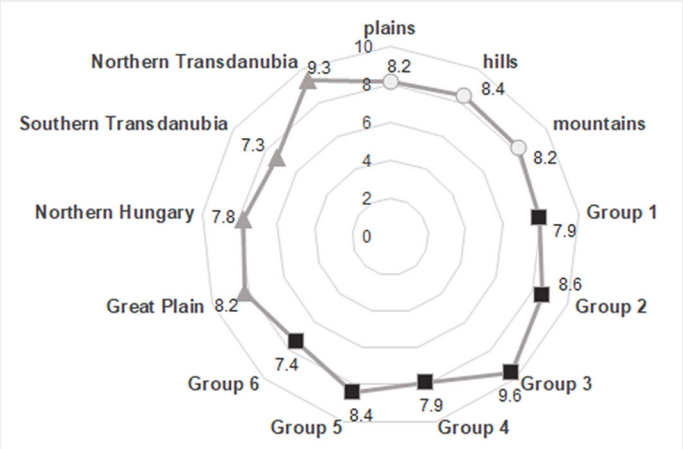

Fig. 3 – Average climate-deterioration index. Squares, triangles, and circles denote the groups of forest composition types, regions, and elevation belt, respectively.

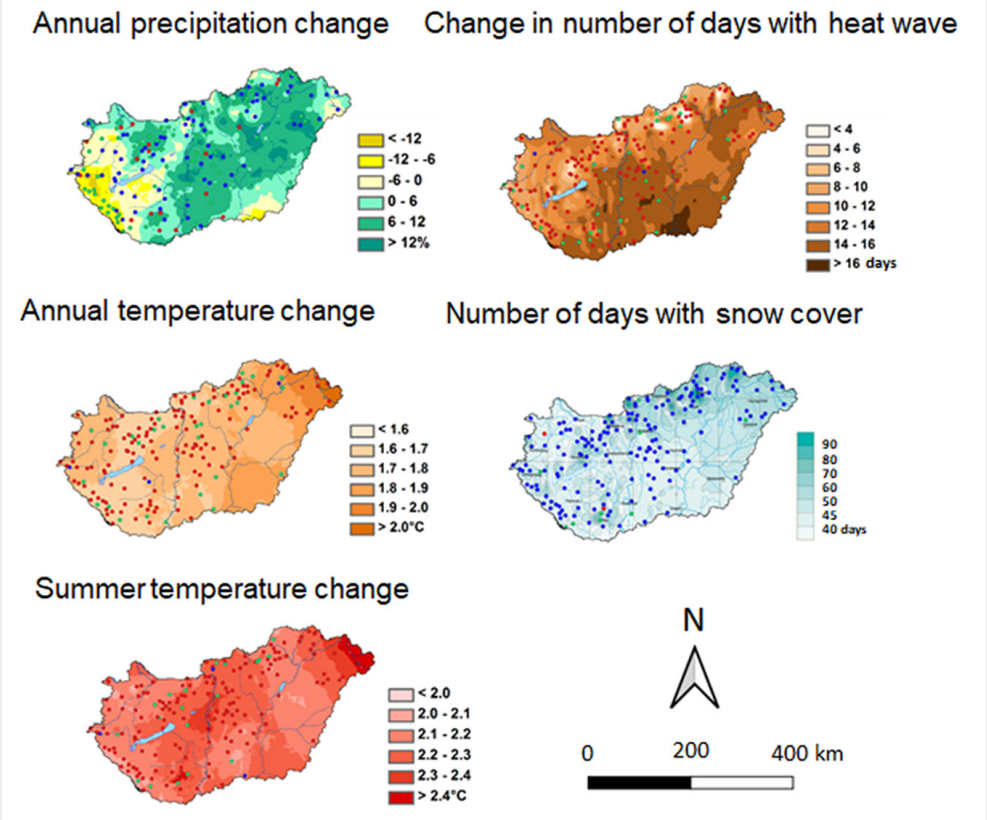

Fig. 4 - Comparison of respondent perceptions and observed climatic variables. (Red dots): respondents reported an increase; (green dots): no change; (blue dots): a decrease in the climatic variable. See also the in-text explanation.

Adapting to climate change

Most respondents hold a negative outlook concerning climate change effects on forestry. Two-thirds of the entire sample reported deteriorating results, while 13% reported heavily deteriorating results. Moreover, two-thirds of respondents considered themselves vulnerable in this regard, with 31% claiming they could overcome the difficulties at hand. Most respondents claimed available funds would influence their response (Bissonnette et al. 2017). The data indicates that knowledge, or a lack thereof, is considered a significant obstacle in connection with vulnerability, contrary to the numbers regarding perception or those found in preliminary research. Although the question was phrased differently, Nelson et al. (2016) reported much higher ratios in Canada.

Nevertheless, the majority of respondents are focusing on preparations. In all, 40-50% of respondents reported some form of professional preparation (discussions with colleagues, conferences, reading studies). However, only 16% of respondents have already initiated changes or adaptations (Fig. 5). This number is relatively low in an international comparison. More than 50% had adapted in Portugal, 48% in Germany, and 20% in Sweden (Blennow et al. 2012), while 32% in Belgium or 57% in neighboring Slovakia (Sousa-Silva et al. 2016, 2018).

Tab. 1 and Tab. 2 analyze the factors influencing decision-making in adaptation following the methodology used by Blennow et al. (2012).

In connection with adaption, settlement size was highlighted among personal characteristics, while locations in hills or Southern Transdanubia and an above-average ratio of Turkey oak or pine were noted as critical characteristics of forest areas. The Wilcoxon's rank sum test (see W and p in Tab. 1 and Tab. 2) underscores that those who have already adapted (somewhat) to climate change have significantly perceived its effects on a longer time frame, and view their forest management possibilities differently. Conversely, concern and anxiety are not significantly connected to adaptation. The two groups see and feel climate change similarly, while assessment of climate change on management efficiency as well as personal adaptation ability differs considerably (Tab. 2). As similar research results could not be recalled here for discussion, we can only stress that only a few local and personal characteristics influence adaptation measures in a small country like Hungary.

One research hypothesis noted that state-owned forests were managed at a higher professional level. This hypothesis was based on the fragmentation of the Hungarian private forest sector after the political transition: the number of private forest owners became very high and the average size of the management units became very low. Also, knowledge and institutional capacities were lacking in the first few decades after 1989 (Toth et al. 2001). A difference of only six-tenths can be observed between the anxiety indices of forest managers in private or cooperative forests and those in state-owned forests. In connection with this, 77.8% of employees

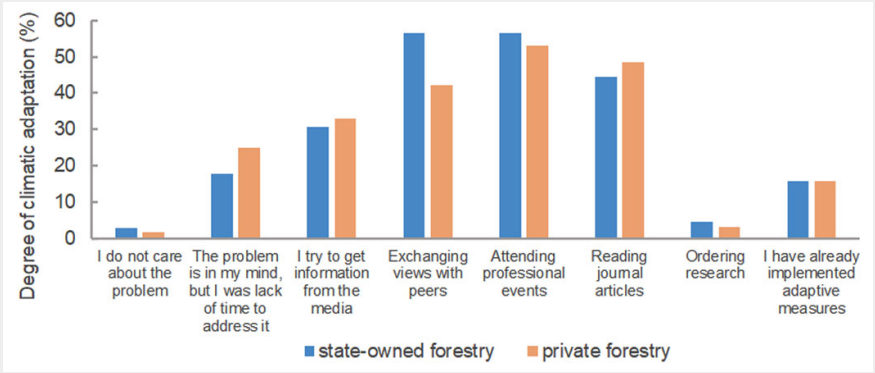

Fig. 5 - Respondents' attention to climate change.

Tab. 1 - Questions assessing the respondents' socio-demographic characteristics depending on the question "Have you adapted your forest management in response to climate change?" (N=186).

Group	Characteristic	% of respondents	
		Have not adapted (N = 159)	Have adapted (N = 27)
Personal Characteristics	Male	95.0	96.3
	Female	5.0	3.7
	Proportion of those over 50 (born before 1966)	32.7	59.3
	Proportion of Budapest residents	2.5	11.1
	Proportion of residents of settlements with populations < 5000	52.2	37.0
	University/college graduates	82.4	92.6
Characteristics of forest areas	Hill forests	25.8	37.0
	Mountain forests	40.9	37.0
	Lowland forests	33.3	25.9
	Forests on the Great Plain	27.7	25.9
	Forests in Northern Hungary	23.3	22.2
	South Transdanubian forests	21.4	29.6
	North Transdanubian forests	27.7	22.2
	Beech above average (10.6%)	32.7	25.9
	Hornbeam-oak above average (11.4%)	35.8	37.0
	Oak above average (14.2%)	38.4	25.9
	Turkey Oak above average (14.5%)	34.0	51.9
	Pine above average (11.4%)	25.2	33.3
	Other hardwood above average (23.5%)	37.1	33.3
	Other deciduous above average (14.4%)	28.3	25.9
	Over 50% protected forest	49.7	55.6
	Over 50% commercial forest	65.4	59.3
	State-owned forest	62.3	63.0
Have you experienced climate change? (W=14199 p=0.006)	No	8.8	0.0
	Yes, in the last few years	31.6	11.1
	Yes, in the past 10 years	39.9	55.6
	Yes, for an even longer time	20.3	33.3

Tab. 2 - Questions assessing the respondents' opinions on climate change (importance, anxiety, degradation, effects on management, ability to adapt) depending on the question "Have you adapted your forest management in response to climate change?" (N=186). All values represent the percent of respondents (%) except the anxiety and climate degradation index, where the average and range (in brackets) are reported.

Question	Answer	Not yet adapted (N = 159)	Already adapted (N = 27)
How important is the issue of climate change to you? (W=14742 p=0.585)	Climate change has affected humanity in the past, is affecting it in the present, and will affect it in the future	36.1	25.9
	Climate change will only have an impact on humanity in the distant future	3.8	3.7
	Climate change will only have a major impact on the lives of our children or grandchildren	4.4	7.4
	I can already feel the effects of climate change in my own life. I can see it with my own eyes	55.7	63.0
	Mean anxiety index (range) (W=14489 p=0.143)	*22.6 (11-30)*	*24.1 (17-30)*
	Mean climate degradation index (range) (W=14602.5 p=0.304)	*8.0 (0-12)*	*9.2 (5-12)*
Is climate change affecting the efficiency of your forest management? (W=1941 p=0.010)	Yes, performance has deteriorated significantly	11.7	22.2
	Yes, performance had deteriorated	64.8	66.7
	No, performance is unaffected	12.4	11.1
	Unknown, or performance improved	11.0	0.0
Assessment of personal ability to adapt (W=14276.5 p=0.009)	I feel completely vulnerable. I cannot do anything	3.4	7.4
	I feel vulnerable. There is little room to maneuver	70.3	37.0
	I know what to do to adapt successfully. Results depend on the financial resources available	18.6	55.6
	I can control problems and adapt to change	7.6	0.0

at state-owned forests and 79.7% at private forests reported deteriorating management options due to climate change. Those reporting a feeling of vulnerability reached 67.6% in the former group and 71.9% in the latter. This indicates that respondents who chose the "I know what to do" or "I can control problems" answers were more likely to work at state-owned forests. That is, there is slightly less pessimism among members of this group. If percentages are aggregated, then state forests are also somewhat ahead in terms of actual activity or intense preparations – from exchanging views with peers to ordering research. Nevertheless, the ratio of those already adapting is almost equal (Fig. 5). In conclusion, no remarkable difference can be identified between forests based on their ownership; thus, the hypothesis cannot be upheld.

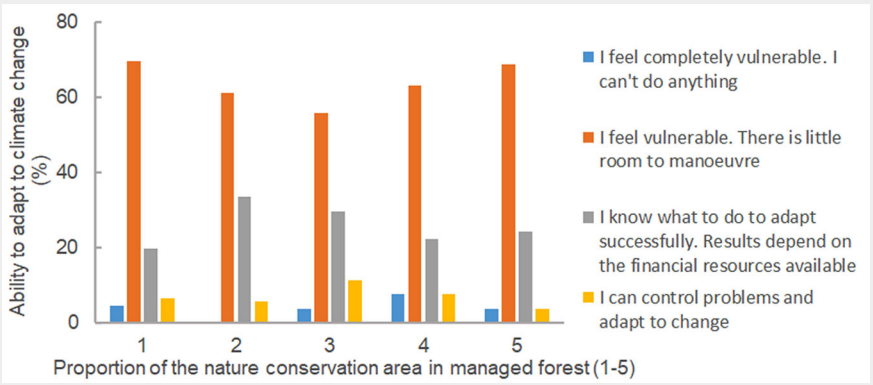

Fig. 6 - Assessment of ability to adapt to climate change. Proportion of nature conservation area in managed forests is denoted with numbers 1-5. (1): 0-10.00% (2): 10.01-33.33%; (3): 33.34-66.66%; (4): 66.67-90.00%; (5): 90.01-100.00% of nature conservation area ratio.

The second question and hypothesis in connection with adaption were tied to the conservation status of forests. While Tab. 2 suggests some correlation between the level of nature conservation and actions taken to adapt, the picture becomes less clear at a deeper level of analysis. Using a histogram, respondents were divided into groups of similar sizes based on how much of the forests they managed were nature conservation areas. The fourth group (66.7%-90.0% under nature conservation) perceived the biggest deterioration of efficiency. The fifth group came next, followed by the first group, both of which manage the least protected forests. The relationship is also more complex in terms of how respondents see their ability to adapt. A feeling of vulnerability is higher in forests with high or low conservation rates and lower among those in the middle of the range (Fig. 6).

Preparations for adaption reveal a similar picture: those in the middle of the range have done more to adapt to climate change and are at a higher level of preparedness. As a clear statistical link cannot be reported in forests under nature conservation, the hypotheses should not be upheld. However, the conducted interviews suggest that conservation makes adaptation more complex and that stricter regulations make the system rigid, leaving forest managers with little room to maneuver.

The final hypothesis addressed whether anxiety is connected to the ability to act. Does excessive pessimism block future action? Can the theorem that excessive anxiety causes the same negative effect on action as underestimating problems be observed? For this study, respondents were divided into six groups based on a histogram of their anxiety indices and their answers to two questions were compared. No correlation can be discerned between the ability to adapt and anxiety levels. A more visible but not significant correlation can be outlined between anxiety and preparation activities or operational changes. Those who are minimally concerned (category one) spend little time with the topic and preparation activity is low. These foresters have made no changes to their forest management. On the other end, foresters most concerned are very active in preparing and making changes (Tab. 2). Despite this, there is no clear connection between action and anxiety in the latter case. Notably, media as an information source plays an important role in anxiety levels. The group with the highest anxiety index relies on media as an information source twice as much as those listed in other groups. Could significant media consumption lead to increased levels of anxiety or does anxiety drive an increase in media consumption? The truth may lie somewhere in between the two extremes. There is no clear relationship between the methods of professional preparation – from asking colleagues to performing research. The most concerned group produced the highest value, but the order was muddled in the middle of the range. Ultimately, the hypotheses must be rejected. Rather than leading to inaction, a higher degree of anxiety results in increased active preparations among respondents.

Fulfilled and planned adaptation

In the case of the confident respondents, 26 have already initiated their adaptation. Fourteen changed their techniques connected to the applied species or the composition of the particular forest areas. Two mentioned the irrigation or cultivation of soils. Twenty-two intervened in maintenance, restoration, and protection.

Although adaptation is only in its initial phases and only a few foresters successfully fulfilled measures, 80% of the 159 remaining respondents claim to have plans. However, 10% mentioned only different forms of preparation (ordering research, reading scientific literature, installation of a meteorological station). Hence, 68.5% of respondents have concrete solutions in mind to prepare for the changing climatic circumstances.

The interviews revealed full agreement on the elimination of monoculture and the enhancement of forest diversity to support forest stability. There is also a relatively large agreement concerning the planting of saplings for high-quality production sites since saplings are more durable in case of unfavorable weather conditions, *e.g.*, uncertain precipitation amounts. There were several comments related to locally grown saplings that have already adapted to the local conditions of production sites. Local saplings are generally preferred over external ones. This poses a potential risk for successful afforestation. There was a controversy related to the preference of native or non-native species in the interviews. Foresters who argued for native species claim that these plants have already existed in the Carpathian Basin for hundreds of years and have successfully adapted to several climate anomalies during these periods. Although present-day changes are stronger, these foresters think that "nature" can adapt to these changes, albeit with higher stress levels. Foresters have to recognize and support the natural adaptation processes of the forests. On the other hand, foresters who argued for non-native species believe that vegetation zone boundaries will move according to the changing climate zones.

This raises the question of whether a successfully implemented, long-term afforestation could be fulfilled using only native species under the current tendencies of climate change. Thus, there is no consensus among foresters on the question of non-native tree species in the narrow sense, which is in line with the discussions in the Hungarian forestry literature (Gálhidy & Tímár 2011, Mátyás 2011, Bartha et al. 2018) and mirrored in the international literature (Pötzelsberger et al. 2020, Alizoti et al. 2022).

However, other problems also obstruct successful adaptation. The interviews and the questionnaires both emphasized a reconsideration of the current regulation system, an aim that is also palpable in the current national forestry strategy (NES 2016).

Our respondents claim that bureaucracy, legal regulations, and unreasonable nature conservation rules are the largest obstructions to the foresters in adaptation activities to face climate change. Such factors hinder fast reactions and deprive foresters of initiatives related to new and innovative methodologies.

In connection with the question of non-native species, the issue of the unsolved conflicts between forestry and nature conservation was strongly emphasized in the interviews. At the same time, the need for agreement is great. Within this context, dialogue and compromise between the two sides are required. In addition, stronger integration of the two areas into the decision-making system is also required because the optimal forest policy on tree species is essential to ecology, economy, and climate protection. However, the recent amendment of the Hungarian forest law points rather in the direction of growing economic interests over nature conservation (Gálhidy 2019).

Conversely, some foresters also mentioned that their innovation was successful in conjunction with nature conservation (*e.g.*, ecological water supplement, mini-lakes system). Several respondents mentioned that greater independence and trust should be given to those possessing local experience and knowledge while others highlighted the liability of science, the restructuring of the forestry education system, and the necessary changes to the current approaches. Relatedly, the dichotomy between forestry and nature conservation in the face of climate change is also reflected in the scientific literature. To sum it up, there is no consensus about the role of conservation in forest policy under the changing climate (Milad et al. 2011, Koning et al. 2014)

Ten percent of the confident respondents plan to improve the circumstances (climatic hydrological and soil conditions) of the production sites, 47% mentioned interventions in tree species composition or applying new species, and 20% plan to change forest maintenance, restoration, and protection. As far as the future is concerned, the need to change tree composition was considered greater than the needs within already implemented adaptation measures.

Conclusions

Our results indicate that Hungarian foresters possess notable awareness of climate change and are in the preparation phase when it comes to management adaptation. However, only 16% of the respondents reported having completed adaptations, which is a relatively low rate compared to the results of foreign research. Nevertheless, several foresters regarded the legal requirements as obstacles to adaptation. Based on this statement, it becomes clear that modifications to scientific communications, policies, and the regulatory environment would aid the forestry sector in implementing climate change preparations and adaptations (Mátyás 2006b, 2016). Within this context, our study revealed that more than half of the foresters who have already implemented adaptation measures have tried to make changes concerning the planted tree species. Others relied on changing management and restoration methods. Foresters planning adaptation consider the question of tree species first.

While climate change perception results have shown the influential role of forest area locations and tree species composition, our hypotheses, in terms of application, were only partially proved. Therefore, it should be underlined that public forestry cannot adapt at a higher level than private forestry. Further research is needed here to open up the possibility of international comparison. Contrary to our expectations, the environmental protection factor could not be statistically demonstrated as a hindering factor. In addition, a high degree of concern is not confirmed to hamper the adaptation to climate change. Forestry organizations that have already implemented changes in connection to adaptation showed greater concern and perceived climate change problems earlier because they considered it a significant issue in terms of the efficiency of their management.

Acknowledgements

This study was made in frame of the project TKP2021-NKTA-43 which has been supported by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme, and by the Agricultural Climate.2 - VKSZ_12-1-2013-0034 project. We would like to thank Attila Jagicza, Head of the Forest Planning and Supervision Department of Bakony Erdö Zrt. for his help in developing the questionnaires. We also thank Csaba Nagy, a teacher at the Gyula Roth Vocational High School and College, for his help in the analysis of the questionnaire and the foresters who filled in the questionnaire and provided information as interviewees.

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Supplementary Material

Appendix 1 - The questionnaire form (translated from Hungarian).

Link: Janko_3958@suppl001.pdf