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AKADÉMIAI KIADÓ

Effectiveness of higher education in Central European universities towards climate change adaptation in the agricultural sector: A comprehensive survey

JÓZSEF ZSEMBELI[1*], ELZA KOVÁCS[2], ENDRE HARSÁNYI[3], PÉTER BALOGH[4], PÉTER CZINE[4], LÁSZLÓ HUZSVAI[4], MARIA BIHUŇOVÁ[5], JÁN JOBBÁGY[6], HANA STŘEDOVÁ[7], MILAN SKALICKY[8], ANDRZEJ STRUŻYŃSKI[9], ROMAN ROLBIECKI[10] and CSABA JUHÁSZ[2]

[1] Research Institute of Karcag, Hungarian University of Agriculture and Life Sciences, Karcag, Hungary

[2] Faculty of Agricultural and Food Sciences, and Environmental Management, University of Debrecen, Debrecen, Hungary

[3] Institutes for Agricultural Research and Educational Farm, University of Debrecen, Debrecen, Hungary

[4] Faculty of Economics and Business, University of Debrecen, Debrecen, Hungary

[5] Faculty of Horticulture and Landscape Engineering, Slovak University of Agriculture in Nitra, Nitra Chrenová, Slovakia

[6] Faculty of Engineering, Slovak University of Agriculture in Nitra, Nitra Chrenová, Slovakia

[7] Faculty of AgriSciences, Mendel University in Brno, Brno-sever-Černá Pole, Czech Republic

[8] Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences, Prague, Czech Republic

[9] Faculty of Environmental Engineering and Land Surveying, University of Agriculture in Krakow, Kraków, Poland

[10] Faculty of Agriculture and Biotechnology, Bydgoszcz University of Science and Technology, Bydgoszcz, Poland

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* Corresponding author. E-mail: zsembeli.jozsef@uni-mate.hu

ABSTRACT

Similar to other regions, in East Central Europe, agriculture is the most vulnerable sector regarding the consequences of climate change through increasing variability in weather conditions, even on the short-term and local scales. Agricultural engineers make decisions; higher education has a crucial role in taking proper actions. Our survey aimed to get up-to-date information on the knowledge and attitude of graduating students completing agriculture-related studies at 6 universities located in Hungary, the Czech Republic, Poland, and Slovakia, with particular attention to weather projections, crop production, and soil protection issues. Analyses revealed adequate lexical knowledge of young engineers in each country. They are familiar with the agro-environmental actualities and future trends, issues to address at the right time, and the repertoire of tools and practices for taking efficient measures. A positive attitude toward proactive actions was proved. We report proof of a high level of preparedness resulting from the proper efficacy of agricultural higher education. The content of the curricula and the teaching methodologies meet well the receptiveness to learning in the V4 countries. Our findings confirm that frequent updating of the content of subjects as well as incorporating practical applications that promote active learning and engagement, are more critical today than ever, and it is possible to achieve a high level of preparedness for the challenges in the agricultural sector.

KEYWORDS

agro-environmental awareness, sustainable agriculture, adaptive crop production, agricultural engineers

INTRODUCTION

The severity and frequency of extreme weather events have been increasing unequally by region. Climate change should be slowed by global contribution. Its effects, however, can be managed at a country scale by adequate governmental decisions and their proper execution by professionals. Higher education has a significant role in taking sufficient actions (Cynk, 2017).

Many publications have related to graduates' preparedness for reacting adequately to climate issues in general. Interestingly, even though the United States of America and China are among the biggest greenhouse gas emitters, college students in the USA rated the economy higher than the environment as a political priority. In contrast, Chinese students rated them equally important, based on a study carried out in 2013 (Jamelske et al., 2013). In another study made in 2010, however, among 1,000 respondents in the USA, young Americans were reported to be more optimistic than the elders about the effectiveness and benefits of taking action on global warming (Feldman et al., 2010). When comparing the environmental commitment of 200 university students in Ethiopia and the USA, US students were marginally outperformed in environmental awareness and willingness to pay extra taxes to offset environmental damages (Emiru and Waktola, 2018). Based on a survey predicting engineering students' desire to address climate change in their carriers in the USA, the previously known factors to increase motivation for climate action like course topics, political affiliation, student organization participation, undergraduate research experience, and environmental volunteering, were not found strong predictors (Shealy et al., 2021). In a further study made in 2011 with the participation of 337 respondents, students aged 16–20 in China were found to possess low levels of environmental knowledge, especially in the less-developed regions. However, they demonstrated environmentally responsible behaviour (He et al., 2011). Similar conclusions were made based on a survey among 146 university students in Taiwan in 2021 who had completed a four-semester-long environmental course, including climate change issues. Their knowledge was poor, and their action-related perceptions were rather negative (Li and Liu, 2021). In 2017, a study conducted within Portuguese, Mexican and Mozambican universities to investigate the perceptions of students completing courses on subjects related to biodiversity, environment, and sustainability revealed that despite being familiarized with climate change, that knowledge did not necessarily translate into concrete mitigation practices and behaviours (Morgado et al., 2017). In a survey, geography students in the UK were interested in environmental issues but did not show pro-environmental behaviours in particular. Little change in their attitude over the seven-year course had been found except when influenced by changes to the infrastructure around them (Robinson, 2014). In Nigeria in 2022, new curricula of engineering courses were found necessary to better incorporate renewable energy technologies into the course contents (Eshiemogie et al., 2022). Students learning other disciplines, e.g., health sciences, kept the curriculum insufficient to fully understand even the impact of climate change (Nigatu et al., 2014). In the USA, students enrolling in general chemistry courses showed an improved perception of science relevancy. They altered their career aspirations after discussing nanotechnology in the context of environmental hazards and sustainability issues (Gulacar et al., 2022). On the contrary, engineering students in some regions of the USA with high technical potential were found to be too culturally backward and resistant to change to embrace new energy sources (Tidwell and Tidwell, 2022). In a study – as an extreme example – made in 2019, university students from 51 countries were addressed (in English); the 237 respondents among the 1,200 invited ones showed a lack of interest concerning climate change in general (Filho et al., 2019). A survey with more than 100,000 respondents from 192 countries, with the participation of Facebook users above 18, revealed that the majority had at least moderate knowledge about climate change. E.g., in Finland, 92%; in Hungary, 90%; in Germany, 84%; and in Croatia, 83% of the respondents were found familiar with the issue. Each is an EU member state. On the other hand, majorities in only 26 areas said climate change was mostly caused by human activities suggesting the risk of feeling responsible and having an enthusiastic attitude, especially in Africa and Southwest Asia. Respondents in Europe felt the most responsible (Leiserowitz et al., 2022). In a study, the relevance of the education received in terms of its capacity to influence students toward climate change was questioned when the knowledge of altogether 1,149 first and final-year Spanish students studying both natural and social sciences was compared. Though approximately 65% of the answers were correct, syllabuses were advised to be reviewed (Meira-Cartea et al., 2018). Similarly, other authors concluded that studying natural sciences did not contribute to a more dynamic development of environmental intelligence of students in Poland, Slovakia, the Czech Republic, and Ukraine when considering the faculties; however, students from a European Union member state had higher scores (Cynk, 2017). In a recent study, authors discussed the assessment tools, approaches, strategies, and good practices for teaching climate solutions at the university level. They highlighted that the curriculum should support students to develop a systemic perspective and make meaningful connections between ways of thinking about the climate and practicing relevant climate action (Molthan-Hill et al., 2022). Where programs in environmental and sustainability sciences are offered specifically, enrolling students attain a high level of motivation and satisfaction, reaching effective competencies and attitudes as found, e.g., in Portugal in 2015 (Azeiteiro et al., 2015). As another example but specifically related to agriculture, a survey carried out in Nigeria in 2017 with final year students of an agricultural faculty revealed that high knowledge and favourable attitude in 94.6% and 86%, respectively, could have been achieved when they had participated in an out-reach program on climate change (Dimelu et al., 2017). Authors of another agriculture-related paper published in 2009 proposed that manuals should be problem-based, allow for a broad range of geographic climates, and address a wide range of agricultural enterprises, including livestock production, horticulture and cropping (George et al., 2009). There is a lack of studies based on a detailed survey among agricultural university students worldwide. If any, conclusions are very much general. In a study conducted at a university specialized in agricultural science and natural resources in Iran in 2020 (Zobeidi et al., 2020), the only conclusion was that knowledge of causes and consequences was found to directly affect the environmental attitude and the indirect impact on risk perception. Environmental attitudes and beliefs were found to affect risk perception significantly positively. In another study conducted at a university specialized in physical and agricultural science in Jordan in 2021 (Gazzaz and Aldeseet, 2021), a similarly simple conclusion was made; namely, a comparable ratio of the students possessed knowledge of the effects, the nature, and the causes of climate change. This is insufficient for taking direct actions in education and having a clear idea about the new generation's preparedness.

Agricultural professionals should be ready to immediately and effectively act. Interestingly, researchers primarily deal with the attitude of farmers of a wide age range already taking part in the business, with country-level conclusions e.g., for Kenya (Mairura et al., 2021), Nigeria (Ayanlade et al., 2017), South Africa (Hawkins et al., 2022), Vietnam (Trinh et al., 2018), Denmark (Woods et al., 2017), a Chinese district (Jianjun et al., 2017), and a Pakistan province (Fahad et al., 2020) – most with the conclusion of the need for broadened training courses –, and the role of officials, NGO leaders, professional association executives (e.g., Gutiérrez et al., 2014). Universities play a crucial role in assuring preparedness. Although the field encompasses land use, crop production, crop protection, animal husbandry, food production and food management, all of which are highly exposed to the direct effects of climate change, there is limited research on the knowledge and attitudes of young agricultural engineers just before entering the business, and the studies typically focus on one university (e.g., Zobeidi et al., 2020; Gazzaz and Aldeseet, 2021). The country-scale survey provides information on the potential for efficient introduction of governmental decisions. At the same time, results at geographical, agro-meteorological regional scale may reveal differences in the priorities in actions and measures. A recent survey has revealed inequalities in university performance by continents, regions, and even neighbouring countries (Cynk, 2017).

For 2023–2027, the common agricultural policy is built around ten key objectives forming the basis of strategic plans of the EU countries. Among them, supporting generational renewal and fostering knowledge and innovation is directly linked to agricultural higher education (European Commission, 2022). The agricultural sector in East Central Europe, including the Czech Republic, Hungary, Poland, and Slovakia – the so-called Visegrád Group (V4), a cultural and political alliance – is particularly important, historically (European Environment Agency, 2022). In this region, considerable amounts of crops are produced. At the same time, according to the data published by the European Environmental Agency, adverse regional effects of climate change have been accelerating recently, resulting in increasing vulnerability of agricultural production as well as economic feasibility (European Environment Agency, 2022).

Based on the above, our objectives were (1) to evaluate the knowledge and the attitude of final-grade students studying at agricultural universities in the V4 countries regarding the regional effects of climate change, with particular attention to soil protection and crop production, and (2) to assess their preparedness for the challenges that the agricultural sector faces currently and soon in the given countries.

MATERIALS AND METHODS

Sampling strategy, data gathering

In Hungary, Czech Republic, Poland, and Slovakia, the agricultural land in use is the following: 3,530 (Czech Statistical Office, 2021), 4,922 (Hungarian Statistical Office, 2021), 10,742 (Polish Statistical Office, 2020), and 1,910 (Slovakian Statistical Office, 2020) thousand hectares, representing 44.76%, 53.91%, 33.30%, and 38.95% of the country areas, respectively. According to the Environmental Stratification of Europe (Metzger et al., 2005), Hungary represents the Pannonian, Slovakia, and Poland represent the continental, while the Czech Republic has regions of both environmental zones.

The study was carried out in six agricultural universities in Hungary, Slovakia, Czech Republic, and Poland, the University of Debrecen Faculty of Agricultural and Food Sciences and Environment formerly the agricultural university covering agricultural higher education of East Hungary, the Slovak University of Agriculture in Nitra with over 12 thousand students, the Czech University of Life Sciences originally founded as an agricultural university now with *cca*. 20 thousand students, and the University of Agriculture in Krakow, the largest agricultural university in Poland (Fig. 1), at the time of the survey.

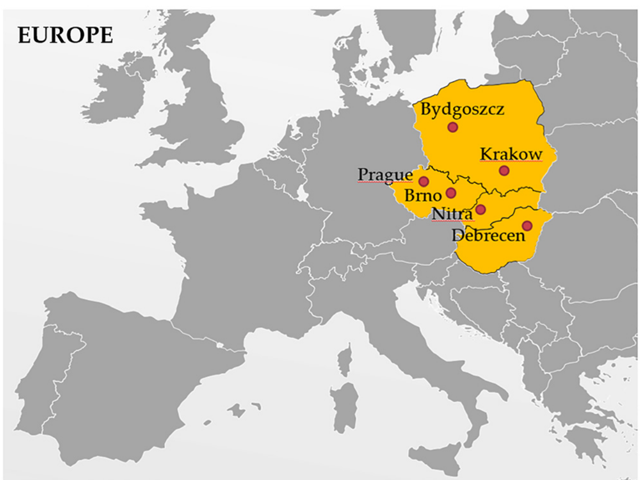

Fig. 1. East Central European cities of agricultural universities taking part in the survey are indicated red in the map

University students were recruited from bachelor and master courses related to agriculture, each completed last year before graduation. This focus group, including future agricultural experts, will potentially have the most critical influence on their countries' practical responses to climate change. The survey was administered over the Internet using the same questionnaire. Here we note that respondents were asked in their national language instead of English: the questionnaire was translated into each native language by university professors. The representativeness was between 20% and 90% by course. It must be noted, however, that the number of graduating students by courses and levels varied in a wide range. The numbers of respondents by country, subject, and course levels are summarized in Fig. 2.

The professional questions aimed to collect country-specific data about the level of knowledge of young agricultural candidates in the V4 region of Europe. Answers were evaluated relative to that of the authors as university professors regarding the linguistic part. They reviewed statements to eliminate both redundancy and lack of relevant aspects. The questionnaire was pre-tested by 10 students from each university. Based on a thorough preliminary review, country-specific facts, issues, and professional alternatives of solutions in agriculture related to climate change were assumed to be adequately incorporated into the curricula of the selected courses (Websites of the Universities, 2022). Answers were evaluated with the consideration of country-specific facts and future projections. Blocks of questions and statements evaluated by the final-grade students are summarized in Table 1.

Statistical methods for testing and evaluating survey questions

The comparative analyses aimed to describe the knowledge of the final grade students on climatic and related agricultural facts and predicted issues specific to their country and to get an insight into their attitude towards the particular challenges expected in their country. V4 region cannot be considered homogenous in any of the agro-environmental aspects in focus, i.e., young agricultural experts are expected to face different concerns with different sets of efficient solutions. Regional variances and contrasts in the environmental conditions and the expected future trends were analysed considering the country-specific findings. Differences in the responses were analysed using the Chi-square (χ^2) statistic, where the variables were measured at a nominal level. The study's sample sizes were unequal, ranging between 63 and 108 (Fig. 2). Where relevant, differences between universities within the same country were neglected; national higher education laws and policies are applied in each country. Bachelor and master courses were not differentiated except for questions Q6–Q8 regarding subject evaluation. The study's primary aim was not to assess the quality of education at different levels of higher education but to have a detailed overview of the preparedness of agricultural experts entering the labour market with a new university degree. Recommendations regarding the level and/or aspect of the need for incorporation of climate-related agricultural issues and solutions into the curricula were given accordingly.

Discrete choice analysis

We used a stated preference (SP) based preference valuation method, the discrete choice experiment (DCE) to evaluate the attitude related to climatic issues. DCE examines an individual's preferences for certain products/services in a hypothetical context (Louviere et al., 2010). DCE is based on random utility theory (RUT), i.e., it assumes utility maximization by the decision

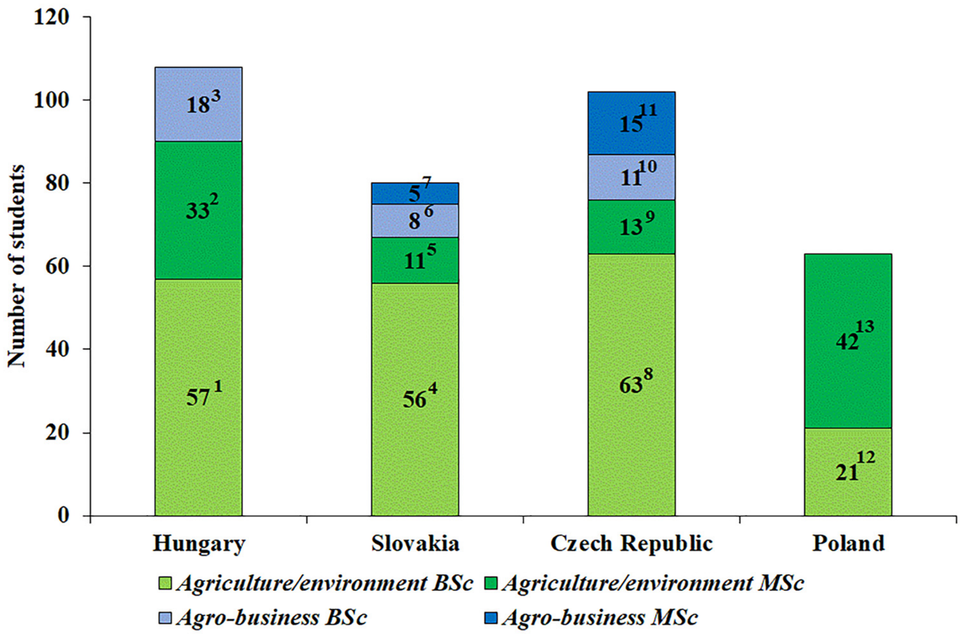

Fig. 2. Numbers of respondents taking part in the survey concerning agriculture-related graduates' knowledge and attitude toward climate change, by countries and subjects of courses

[1] Agricultural engineering, horticultural engineering, wildlife management engineering

[2] Plant protection engineering, horticultural engineering, agricultural water management engineering

[3] Rural development engineering

[4] Landscape architecture, landscape engineering, landscape consolidation and GIS, horticulture, environmental management, nutrition and society

[5] Landscape engineering, horticulture

[6,7] Regional development and EU policies, rural development and rural tourism

[8] Agricultural engineering, landscape management and soil protection, landscape and natural resources management, forestry, horticulture, crop production, animal breeding, horse breeding, aquaculture, agroecology, applied ecology, agrobiology, food quality and processing agricultural products

[9] Agricultural engineering, animal nutrition, phytotechnologies, crop production, agroecology

[10] Agro-business, rural development, regional development, public administration in agriculture

[11] Agro-business, rural development, regional development

[12] Biotechnology, hydrology and water management, environmental engineering, landscape architecture, agronomy and agro-business

[13] Agriculture, hydrology and water management, water management, hydrology, environmental engineering, hydrology

maker and decomposes total utility into an observable component (observable by the researcher) and a random component (unobservable by the researcher) according to Equation (1) (Ben-Akiva and Lerman, 2018):

Table 1. Questions and statements of selected general and agricultural aspects of climate change and alternatives of answers. Data were used to assess students' knowledge completing the final year of agriculture-related university-level courses. Results were expected to provide information for the preparedness of the new generation in the agriculture sector in East Central Europe

Subject	Question/Statement	Code	Alternatives of answer	Code
Climate change in general	How much is the carbon footprint for a citizen of the European Union?	Q1	*one right answer*	
	To what extent the carbon footprint of an EU citizen should be decreased to stop global warming?	Q2	*one right answer*	
	How much do you think you are familiar with the issues in relation to climate change (reasons, consequences, measures)?	Q3	– Quite well, in detail	*3a*
			– Generally, well	*3b*
			– There are some unclear aspects	*3c*
			– I think I should learn more about them	*3d*
			– I am more likely passive in such a conversation where this is discussed	*3e*
	Is human able to handle the climate change, efficiently?	Q4	– Yes, we can reduce the adverse effects of it	*4a*
			– Yes, we can even stop the negative trends	*4b*
			– Yes, we can at least slower the negative trends	*4c*
			– No, we are not able to handle it	*4d*
Regional effects of climate change on weather conditions	In *East Central Europe*, to what extent climate change will result in the following,			
	– the shift in the climate zones	A1	– already present	*1*
	– increasing frequency of floods along rivers	A2	– expected in a short term	*2*
	– increasing vulnerability of wetlands	A3	– could be in a long term	*3*
	– increasing frequency of		– not really probable	*4*
	■ heat waves	A4		
	■ tornadoes	A5		
	■ temporal water cover in arable lands	A6		
	– increasing vulnerability of water resources (regarding to quantity)	A7		
	– increasing frequency of forest fires	A8		

(continued)

Table 1. Continued

Subject	Question/Statement	Code	Alternatives of answer	Code
Dominant extremes resulting from climate change, by country	In *the area of the given country*, to what extent climate change will result in the following,			
	– the shift in the climate zones	B1	– already present	*1*
	– increasing frequency of floods along rivers	B2	– expected in a short term	*2*
	– increasing vulnerability of wetlands	B3	– could be in a long term	*3*
	– increasing frequency of		– not really probable	*4*
	▪ heat waves	B4		
	▪ tornadoes	B5		
	▪ temporal water cover in arable lands	B6		
	– increasing vulnerability of water resources (regarding to quantity)	B7		
	– increasing frequency of forest fires	B8		
Direct effects of climate change on weather conditions, by country	In *the area of the given country*, climate change will result directly in the followings,			
	– changing		– already present	*1*
	▪ annual mean temperature	C1	– expected in a short term	*2*
	▪ annual mean precipitation	C2	– could be in a long term	*3*
	▪ mean precipitation in the vegetation period	C3	– not really probable	*4*
	– increasing frequency in extreme events related to the annual number of			
	▪ hot days of >30 °C	C4		
	▪ hot days of >35 °C	C5		
	▪ frozen days (<0 °C)	C6		
		C7		
	▪ cold days (<−10 °C)			
	▪ drought days	C8		
	▪ days with high intensity precipitation	C9		
	– shift in the ratio in rain and snow/ice	C10		
	– increase in the probability of the			
	▪ late spring freeze	C11		
	▪ early autumn freeze	C12		

(continued)

Table 1. Continued

Subject	Question/Statement	Code	Alternatives of answer	Code
Indirect effects of climate change regarding crop production and soil protection, by country	In *the area of the given country*, climate change will result in the followings *in case of no measure*,			
	– change in the plant species repertoire	D1	– already present	*1*
	– depression in yield due to		– expected in a short term	*2*
	■ drought	D2	– could be in a long term	*3*
	■ freeze	D3	– not really probable	*4*
	■ pests	D4		
	■ temporal water cover in arable lands	D5		
	– adverse changes in salinity, acidity or alkalinity	D6		
	– worsening structural condition	D7		
	– compaction	D8		
	– loss of nutrients	D9		
	– water erosion	D10		
	– wind erosion	D11		
Knowledge in relation to climate change gained during the studies	To what extent the lexical knowledge on climate change is built into the subjects of your course?	Q5	– not really in focus – to some extent – in detail	*5a* *5b* *5c*
	To what extent the tools and techniques (i.e., measures, actions, management, technologies, research, etc.) related to climate change are built into the subjects of your course?	Q6	– not really in focus – to some extent – in detail	*6a* *6b* *6c*
	Is climate change discussed in case of all relevant subjects properly, in your opinion?	Q7	– not really in focus – to some extent – in detail	*7a* *7b* *7c*
Prevention, protection measures in crop production, against weather anomalies, by country	Select, which prevention or protection measures can be the most relevant against the weather anomalies that decrease the crop yield, *in the given country*,			
	– intensified irrigation	E1	– not true	*e1*
	– ice net in case of fruit trees	E2	– true	*e2*
	– introduction of			
	■ freeze tolerant plant species	E3		
	■ drought tolerant plant species	E4		
	■ pest resistant plant species	E5		
	– integrated pest management	E6		
	– simple repertoire of crops in use	E7		
	– (re)introduction of local varieties	E8		

(continued)

Table 1. Continued

Subject	Question/Statement	Code	Alternatives of answer	Code
	– extensive crop production	E9		
	– intensive crop production	E10		
	– flexible sowing date	E11		
	– to keep high crop yield, there is no need to consider any of the above	E12		
Agro-techniques for efficient crop production and soil protection, by country	Select, which agro-technical methods can be the most relevant for efficient protection against *drought*,			
	– drought is not relevant at all	F1	– not true	*f1*
	– introduction of drought resistant species	F2	– true	*f2*
	– more balanced nutrition	F3		
	– improving soil structure	F4		
	– eliminating compaction	F5		
	– applying crop rotation	F6		
	– using crops with deep root zone (ameliorating crops)	F7		
	– alternating cultivation depth	F8		
	– regular deep loosening	F9		
	– compacting with roller after shallow stubble cultivation	F10		
	– mulching	F11		
	– mellowing after basic cultivation	F12		
	– direct seeding	F13		
	– irrigation	F14		
Use of sources of professional news	Sources preferred by the respondent to get relevant, up-to-date information about the agriculture-related climate change issues, mitigation, and adaptation,			
	– printed professional papers	G1	– yes	*g1*
	– online professional websites	G2	– no	*g2*
	– professional radio and television programmes	G3		
	– competent professional bodies, organizations	G4		
	– the national agricultural chamber	G5		
	– consultant	G6		
	– exhibitions, fairs	G7		
	– educational institutes	G8		
	– other farmers nearby	G9		
	– experienced senior farmers	G10		
	– integrators, input distributors	G11		
	– Facebook	G12		
	– blogs	G13		

(continued)

Table 1. Continued

Subject	Question/Statement	Code	Alternatives of answer	Code
Additional personal attitudes	When choosing from different transportation options (flight, train, car, ship), it comes up that the respondent's choice has effect on the trends in climate change.	H	– yes – no	*h1* *h2*
	Assume that the respondent leads an economically prosperous company, where the environmental protection regulations are fully applied. The respondent would consider further actions to make the company "greener", i.e., to reach higher environmental performance, not necessarily resulting in direct extra financial income.	I	– yes – no	*i1* *i2*

$$U_{n,i} = V_{n,i} + \varepsilon_{n,i} \tag{1}$$

where U denotes the total utility, V is the systematic part of the utility, ε the random part of the utility, n is the decision maker, and i is the alternative. In most cases, the conditional logit (CL) is the starting point for modelling the data of the procedure. CL has the advantage of being easy to estimate and interpret, but several drawbacks are widely known, which means that it is not often the last step in the modelling phase. For the CL model, the systematic part of the utility (V) can be defined according to Equation (2) (McFadden, 1973):

$$V_{n,i} = \beta X_{n,i} \tag{2}$$

where β is the parameter vector representing the effect of the product/service attributes under analysis on the systematic part and $X_{n,i}$ is the vector of observed attributes for the *i-th* alternative viewed by the nth decision maker. One limitation of CL most often addressed is the assumption of homogeneous preferences. An alternative to capture preference heterogeneity is latent class (LC) modelling, where a discrete number of groups with different priorities can be defined. Members' preferences are now managed homogeneously within groups, as in CL. For LC, the formula presented in Equation (2) is modified according to Equation (3) (Boxall and Adamowicz, 2002):

$$V_{n,i} = \beta_q X_{n,i} \tag{3}$$

where β_q is a parameter vector estimated for the *q-th* class.

A difficult question for LC modelling is the determination of the optimal number of classes to be estimated. In most cases, researchers answer this question by using several information criteria. Among these, the Akaike information criterion (AIC) (Equation (4)) and the Bayesian information criterion (BIC) (Equation (5)) are commonly used (Mariel et al., 2021):

$$\text{AIC} = -2\ \text{LL} + 2\ \text{P} \tag{4}$$

LL is the log-likelihood function's converged value, and *P* is the number of estimated parameters.

$$\text{BIC} = -2\ \text{LL} + \text{P}\ \ln \text{O} \tag{5}$$

where O is the number of observations.

The LC model requires the definition of a class allocation equation for its estimation. In addition to the constant term, explanatory variables can also be included in the equation, which can be used (through the estimated parameters) to determine whether respondents with specific characteristics are significantly less/more likely to be in each class (Hess, 2014). In our class allocation equation, we included an explanatory variable, nationality, as defined by Equation (6):

$$OAE_{n,q} = \delta_q + \gamma_{Czech\ Republic} Czech\ Republic + \gamma_{Poland} Poland + \gamma_{Slovakia} Slovakia + \gamma_{Hungary} Hungary \tag{6}$$

where δ_q is the estimated constant for the q-th class, and γ is the parameter vector estimated for the explanatory variables of the class allocation equation.

Our model estimations were performed with the Apollo package of the R program, utility function was determined according to Equation (7) (Hess and Palma, 2019, 2021; R Core, 2020):

$$\begin{aligned} U_i = {} & \beta_{mean\ temperature\ actual\ q} Mean\ temperature_{actual_i} \\ & + \beta_{mean\ temperature\ expected_q} Mean\ temperature_{expected_i} + \beta_{precipitation\ actual_q} Precipitation_{actual_i} \\ & + \beta_{precipitation\ expected_q} Precipitation_{expected_i} \\ & + \beta_{extreme\ weather\ conditions\ actual_q} Extreme\ weather\ conditions_{actual_i} \\ & + \beta_{extreme\ weather\ conditions\ expected_q} Extreme\ weather\ conditions_{expected_i} \\ & + \beta_{water\ resources\ actual_q} Water\ resources_{actual_i} + \beta_{water\ resources\ expected_q} Water\ resources_{expected_i} + \varepsilon_i \end{aligned} \tag{7}$$

where β_q is the estimated parameter vector of q-th class, while mean temperature, precipitation, extreme weather conditions, and water resources are the investigated issues in relation to climate change.

The issues shown in Equation (7) were identified by the professors with relevant expertise working for the universities involved. The number of decision situations that could be formed from the problems and their levels was considered too large when using a full factorial design type, so a fractional factorial design was used. We used a D-efficient experimental design using Ngene 1.2 (Rose and Bliemer, 2009; Choicemetrics, 2018). It included 12 decision situations, each including four scenarios. In many cases, blocking was used, with only a subset (six problems) being presented to our respondents. Respondents were asked to choose one of the four scenarios which they considered most realistic. An example of a decision situation is shown in Table 2.

RESULTS AND DISCUSSION

Knowledge of the expert candidates in the agricultural sector in the V4 countries regarding climate change

Carbon footprint is a commonly used term in the context of human contribution to climate change. Considering its extent by the European Union citizens, three times more Czech and

Table 2. An example of the decision situations

Issue	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Increase in the annual mean temperature	already present	not really probable in the future	not really possible in the future	expected in the future
Increase in the annual precipitation	not really probable in the future	already present	expected in the future	already present
Increase in the frequency of extreme weather events	already present	already present	not really probable in the future	expected in the future
Decrease in the utilizable water resources	not really probable in the future	already present	already present	expected in the future

Polish students gave good answers suggesting more realistic ideas compared to the Hungarian and Slovakian respondents. Regarding the need to decrease carbon footprint, opinions collected from the countries as part of the survey showed the same order but with less difference (Table 3). Hungarian and Polish students felt somewhat confident in their knowledge of the reasons, consequences and measures concerning climate change. One-third of the Czech and Slovakian students declared to have generally good knowledge; however, the answers given by the latter showed more platykurtic distribution; more than one-third thought they needed to learn more (Table 3). Hungarian respondents were found to be the most optimistic regarding humans' ability to handle climate change efficiently (40%). In contrast, the majority of Czech students (61%) believe that the negative trends can be at least slowed. More than half of the Polish and Slovakian respondents had the same opinion (52% and 54%, respectively) (Table 3).

Young agricultural engineers need to have strong professional knowledge of climate change's most probable adverse effects on weather conditions. As reported by (Ceglar et al., 2019), the major part of Europe will be affected by further northward climate zone migration. Approximately half of Hungary, two-thirds of Poland, one-third of Slovakia, and one-third of the Czech Republic were classified as regions with relatively low and increasing potential yield in the period of 2000–2050. However, the regional agro-environmental conditions are different and should be addressed appropriately. In the V4 countries, 70–84% of the students consider the shift in climate zones already present or expected in the short term (Table 4). Regarding the increasing frequency of floods in the V4 region, most respondents were of similar opinion (69–92%) regardless of the country. 66% of Hungarians and more than 73% of Polish considered it already present or expected in the short term. A significant portion of Hungary is on protected floodplain, thus the flood risk is considerable, however, flood protection infrastructure and management are efficient. In contrary, in the Czech Republic, floods in 1997, 2002, 2006, and 2013 have caused serious crises. In Slovakia, between 1996 and 2002, 80 major damaging floods occurred. Similarly, wetlands were considered vulnerable currently or in the near future by the former three groups (75–87%), while 26% in Poland thought it was not probable. As a comparison, 0.9–2.5% of the respondents in the other three countries chose the same answer. The increasing frequency of heat waves was considered an already existing or near-future issue in the region by all in ≥90%. Over one-third of Hungarians and Czechs felt the increase in the frequency of

Table 3. Percentage of respondents by answers and countries regarding their knowledge of selected facts related to climate change. Values are given in %. The numbers of respondents by country are given in Fig. 1. Questions Q1–Q4, and explanation of codes 3a–3e, and 4a–4d are listed in Table 1

Questions	Q1	Q2	Q3***					Q4***			
Answers	*right one*	*right one*	3a	3b	3c	3d	3e	4a	4b	4c	4d
Hungary	7.3	19.3	8.3	60.6+	22.9−	8.3	0.0	44.0+	9.2	41.3−	5.5
Czech Republic	29.9	24.3	8.4	35.5−	43.9+	12.1	0.0	19.6−	11.2	60.7+	8.4
Poland	32.3	27.4	3.2	60.3+	31.7	4.8−	0.0	27.0	17.5	52.4	3.2
Slovakia	11.3	18.8	6.3	37.5−	32.5	23.8+	0.0	16.5−	21.5+	54.4	7.6

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively.
*** indicate coefficients statistically significant at the level 1%. Q3: $\chi^2 = 33.054$, df = 9; Q4: $\chi^2 = 28.896$, df = 9.

tornadoes was not probable in the V4 region; on the contrary, more than 40% of Polish students believe it is already present. Regarding the possibility of increasing temporal water cover in arable lands, Hungarians were the most sensitive; 90% said it was confirmed. The vulnerability of water resources regarding their shortage was considered existing by approximately half of the Polish and the Czech students; adding short-term expectations, close to 90% of the students gave a positive answer. On the contrary, while one-third of the Hungarian and Slovakian respondents considered the problem verified, 23% of both groups expected it only in the long-term showing a wide range in distribution. An increase in the frequency of forest fires was considered existing by the Polish in 64% and 95% when the answer of short-term relevance was added. Responses of the three other groups were similarly dispersed. It is essential to highlight that the subject of the questions was the same, the East Central European region.

When respondents were asked about the country-specific relevance that they would face as professionals after graduation, shifts in climate zones were considered existing or expected in the short term by the same percentage (65–84%); however, the ratio of substantial and short-term effect was systematically lower in each country (Table 4). Based on statistical analysis, the migration of agro-climatic zones in Eastern Europe may reach twice the velocity in the next decades as observed from 1975 to 2016 (Ceglar et al., 2019). Threat of floods only in the long term was expected systematically lower at the country scale compared to the results given for the V4 region. In Poland and Slovakia, 27% and 23% of the respondents expected country-specific flood issues only in the long-term or not at all, which are 8% and 15% for East Central Europe, respectively. Considering the facts, in the Czech Republic, floods in 1997, 2002, 2006, and 2013 caused serious crises; in Slovakia, between 1996 and 2002, 80 major damaging floods occurred. Wetland vulnerability as well as increasing frequency of heat waves by country was also considered systematically lower; distribution by answers remained similar in each country compared to the solutions for V4. More students in each country expected a lower risk of tornadoes in their country. Students did not expect a country-specific deviation from what was scheduled for the V4 region concerning the increasing occurrence of temporary water cover in arable lands. The quantity of surface water in the Carpathian basin decreases, resulting from increased storage

Table 4. Percentage of respondents by answers and countries regarding their knowledge of the dominant extremes in East Central Europe resulting from climate change, by country regarding statements A1–A8. Values are given in %. The numbers of respondents by country are shown in Fig. 2. Statements A1–A8 and explanation of codes 1–4 are listed in Table 1

Statements	A1*				A2**				A3***				A4				A5***				A6				A7***				A8***			
Answers*	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hungary	38.5	42.2	13.8	5.5	24.8−	44.0	27.5+	3.7	50.9	36.1	12.0	0.9−	62.4	27.5	7.3	2.8	6.4−	22.0	37.6	33.9+	45.0	34.9	16.5	3.7	30.3−	38.5	22.9+	8.3+	33.9	30.3	26.6+	9.2+
Czech Republic	29.9−	41.1	18.7	10.3+	40.2	35.5−	16.8	7.5	57.0+	29.0	12.1	1.9−	76.6	17.8	4.7	0.9	10.3−	28.0	29.9	31.8	27.1	37.4	29.9	5.6	54.3+	36.2	8.6−	1.0−	40.2	38.3	18.7	2.8
Poland	42.9	41.3	11.1	4.8	43.5	48.4	3.2−	4.8	23.0−	26.2	24.6	26.2+	69.4	24.2	4.8	1.6	42.6+	23.0	23.0	11.5−	38.7	33.9	22.6	4.8	49.2	36.1	6.6−	8.2	63.9+	31.1	3.3−	1.6
Slovakia	50.0+	27.5−	20.0	2.5	33.8	51.3	11.3	3.8	35.0	40.0	22.5	2.5	64.6	25.3	7.6	2.5	19.0	31.6	31.6	17.7	26.3	46.3	21.3	6.3	24.7−	49.4	23.4+	2.6	36.3	35.0	22.5	6.3

Where adjusted residual ≥|2|, + and − indicate significant positive or negative differences, respectively. ***, **, and * indicate coefficients statistically significant at the level 1%, 5%, and 10%, respectively. A1: $\chi^2 = 15.705$, df = 9; A2: $\chi^2 = 26.391$, df = 9; A3: $\chi^2 = 74.097$, df = 9; A4: $\chi^2 = 6.353$, df = 9; A5: $\chi^2 = 50.513$, df = 9; A6: $\chi^2 = 14.166$, df = 9; A7: $\chi^2 = 37.397$, df = 9; A8: $\chi^2 = 28.240$, df = 9.

capacity in the neighbouring upstream countries, while increasing evapotranspiration and fluctuation in precipitation further aid vulnerability. The pattern regarding the quantitative vulnerability of water resources was similar for each country compared to what was expected at the regional scale. Lastly, forest fires were considered a less definite problem in Hungary and Poland, while higher in the other countries than in the V4 region.

In Hungary and the Czech Republic, the annual mean temperature increased, while precipitation did not within the last decades, resulting in decreased moisture certainty, suggesting an increase of potential evapotranspiration and, thus, higher susceptibility of agricultural areas to drought. On the contrary, the average atmospheric precipitation has decreased in Slovakia. In the Carpathian basin, the fluctuation of rainfall in time increases, and extremes are spatially and temporarily uneven. A clear idea is required about the most critical weather events that engineers in the agricultural sector should be able to handle. Most students in all the V4 countries consider the direct effects of the change in annual mean temperature in their country already present or expected in the short term (64–73% and 18–30%, respectively) (Table 5). Regarding the change in annual mean precipitation, independently from the country, half of the respondents believe that immediate responses should be given in agriculture, and an additional 29–37% think that solutions will be necessary, at least soon. In the vegetation period, the problem is considered systematically more acute; answers of already present or expected in the short term represent 88–97%. Among the extreme events of potentially increasing frequency, the absolute risk of the direct effect of the increase in the number of sweltering days (>35 °C) compared to that of hot (>30 °C) days is systematically considered lower. Long-term effects or no relevance of scorching days were believed by 16, 23, 30, and 32% of the Hungarian, Polish, Slovakian, and Czech students, respectively. Hot days as a direct source of risk in agriculture are considered already existing by most students, i.e., half of the Slovakians, two-thirds of the Hungarians, and the other two groups in between. An increase in the frequency of frozen days (<0 °C) in the given countries was considered to occur as a direct effect of climate change differently by the respondents by country. According to a recent study (Vanschoenwinkel et al., 2016), Eastern Europe has a lower adaptive capacity than Western Europe. However, if Eastern Europe considers the same adaptation options, it could attenuate the decrease in land value or even benefit from climate change, depending on the climate scenario (Table 6).

Respondents' attitude towards the environmental effects of climate change – results of the discrete choice analysis

The increase in annual mean temperature is a relevant issue for respondents concerning climate change (Table 7). In addition, the increase in the frequency of extreme weather events and the increase in annual precipitation are also perceived as existing problems. The only exception is the reduction in utilizable water resources, and respondents consider it to be a problem for the future. In the LC model estimation, we tested several scenarios to find the most optimal class number model. Our decision was based on the values of the information criteria shown in Table 8. The BIC value already increased in the three-class case, indicating a worse model fit, so for further analysis, we chose the two-class specification. Table 9 estimates show that Slovak students are significantly less likely to be in the LC model's first class than Hungarians in the second class. For the first group, significant parameter estimates were obtained for all the problems studied. This suggests substantial differences between the actuality levels (not probable

Table 5. Percentage of respondents by answers and countries regarding their knowledge of the country-specific dominant extremes resulting from climate change, by country regarding statements B1–B8. Values are given in %. The numbers of respondents by country are shown in Fig. 2. Statements B1–B8 and explanation of codes 1–4 are listed in Table 1

Statements	B1**				B2				B3***				B4				B5***				B6*				B7***				B8***			
Answers*	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hungary	30.3	43.1	19.3	7.3	21.1	45.0	31.2	2.8	45.4	38.0	14.8	1.9−	60.6	28.4	10.1	0.9	3.7−	12.8	27.5	56.0+	43.5+	36.1	18.5	1.9	25.7−	32.1	34.9+	7.3	9.2−	31.2	43.1+	16.5+
Czech Republic	20.8−	44.3	24.5+	10.4	31.4	43.8	20.0	4.8	52.4+	31.1	14.6	1.9−	67.0	24.5	8.5	0.0	3.8−	10.4	28.3	57.5+	29.5	33.3	30.5	6.7	59.0+	27.6−	11.4−	1.9	20.8	40.6	28.3	10.4
Poland	30.2	39.7	11.1	19.0+	34.9	38.1	20.6	6.3	23.3−	16.7−	33.3+	26.7+	63.5	28.6	4.8	3.2	31.1+	16.4	24.6	27.9−	30.2	38.1	25.4	6.3	47.6	36.5	7.9−	7.9	56.5+	38.7	3.2−	1.6−
Slovakia	41.8+	40.5	13.9	3.8−	31.6	45.6	20.3	2.5	26.9−	50.0+	19.2	3.8	57.7	28.2	10.3	3.8	7.7	28.2+	43.6+	20.5−	25.3	49.4+	22.8	2.5	28.6−	50.6+	18.2	2.6	25.3	45.6	20.3	8.9

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively. ***, **, and * indicate coefficients statistically significant at the level 1%, 5%, and 10%, respectively. B1: $\chi^2 = 21.241$, df = 9; B2: $\chi^2 = 9.823$, df = 9; B3: $\chi^2 = 77.132$, df = 9; B4: $\chi^2 = 7.862$, df = 9; B5: $\chi^2 = 75.562$, df = 9; B6: $\chi^2 = 16.264$, df = 9; B7: $\chi^2 = 52.110$, df = 9; B8: $\chi^2 = 73.516$, df = 9.

Table 6. Percentage of respondents by answers and countries regarding their knowledge of the direct effects of climate change on weather conditions, by country, regarding statements C1–12. Values are given in %. The numbers of respondents by country are shown in Fig. 2. Statements C1–12 and explanation of codes 1–4 are listed in Table 1

Statements	C1				C2				C3				C4*				C5***				C6***			
Answers*	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hungary	72.5	20.2	6.4	0.9	48.1	34.3	13.0	4.6	57.4	30.6	11.1	0.9	67.0	27.5	5.5	0.0	50.9+	33.3	13.0	2.8	43.1+	33.0	12.8−	11.0
Czech Republic	63.8	30.5	4.8	1.0	53.8	31.1	10.4	4.7	65.1	32.1	2.8	0.0	64.2	28.3	7.5	0.0	34.9	33.0	27.4+	4.7	17.0−	25.5	44.3+	13.2
Poland	73.0	17.5	4.8	4.8	52.4	28.6	15.9	3.2	56.5	33.9	6.5	3.2	72.6	22.6	3.2	1.6	45.2	32.3	9.7−	12.9+	35.5	32.3	27.4	4.8
Slovakia	68.8	23.8	6.3	1.3	54.4	36.7	6.3	2.5	48.1	40.5	8.9	2.5	51.9−	40.5+	3.8	3.8+	27.5−	42.5	22.5	7.5	30.0	31.3	30.0	8.8

Statements	C7***				C8				C9				C10				C11***				C12***			
Answers*	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hungary	24.1+	32.4	24.1−	19.4	67.9	29.4	2.8	0.0	46.8	29.4	14.7	9.2	63.3	27.5	8.3	0.9	83.5+	11.0−	4.6−	0.9−	34.9+	31.2	22.0−	11.9
Czech Republic	7.6−	14.3−	48.6+	29.5	76.4	20.8	0.9	1.9	46.2	35.8	16.0	1.9	43.4	40.6	15.1	0.9	43.3−	32.7+	16.3+	7.7	15.1−	25.5	47.2+	12.3
Poland	31.1+	19.7	24.6	24.6	77.4	16.1	4.8	1.6	55.7	32.8	8.2	3.3	54.8	32.3	9.7	3.2	56.5	21.0	9.7	12.9+	41.9+	16.1−	32.3	9.7
Slovakia	12.8	37.2+	26.9	23.1	66.3	26.3	6.3	1.3	49.4	29.1	19.0	2.5	53.8	32.5	10.0	3.8	62.5	21.3	11.3	5.0	21.3	41.3+	28.8	8.8

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively. *** and * indicate coefficients statistically significant at the level of 1% and 10%, respectively. C1: $\chi^2 = 9.164$, df = 9; C2: $\chi^2 = 5.374$, df = 9; C3: $\chi^2 = 12.961$, df = 9; C4: $\chi^2 = 16.494$, df = 9; C5: $\chi^2 = 25.640$, df = 9; C6: $\chi^2 = 35.159$, df = 9; C7: $\chi^2 = 42.660$, df = 9; C8: $\chi^2 = 11.000$, df = 9; C9: $\chi^2 = 12.376$, df = 9; C10: $\chi^2 = 12.306$, df = 9; C11: $\chi^2 = 43.486$, df = 9; C12: $\chi^2 = 34.006$, df = 9.

Table 7. Results of the conditional logit model calculations

Issues and model outputs	Factor	*t*-value	Standard error
annual mean temperature increase			
not really probable in the future		*baseline*	
expected in the future	1.04***	13.38	0.08
already present	1.41***	17.06	0.08
annual precipitation increase			
not really probable in the future		*baseline*	
expected in the future	0.31***	4.12	0.08
already present	0.58***	7.77	0.08
increase in the frequency of extreme weather events			
not really probable in the future		*baseline*	
expected in the future	0.64***	8.87	0.07
already present	0.85***	10.95	0.08
decrease in the utilizable water resources			
not really probable in the future		*baseline*	
expected in the future	0.84***	11.69	0.07
already present	0.55***	7.10	0.08
Information criteria of the model			
Log-likelihood (0)		−2,736.55	
Log-likelihood (final)		−2,290.20	
AIC		4,596.39	
BIC		4,641.10	

AIC denotes the Akaike information criterion, BIC denotes the Bayesian information criterion.
*** indicates the coefficient is statistically significant at the 1% level.

Table 8. Information criteria for models with different class numbers

Information criterion	Two-class model	Three-class model
Number of estimated parameters	20	32
Log-likelihood (final)	−2,155.96	−2,112.56
AIC	4,351.91	4,289.12
BIC	4,463.67	4,467.93

AIC denotes the Akaike information criterion, BIC denotes the Bayesian information criterion.

in the future, expected in the future, already present). The increase in the annual precipitation and the increase in the frequency of extreme weather events are perceived as essential.

In contrast, the increase in the mean annual temperature and the decrease in utilizable water resources are perceived as future issues to address. Like the respondents in the first group, the increase in the frequency of extreme weather events is a current problem for the members of the second group. In addition, the increase in the mean annual temperatures is already perceived as a current problem by the respondents in this class. Respondents in the second group do not consider an increase in annual precipitation in the future to be likely (compared to the “expected in the future” scenario). Like respondents in the first group, they consider the reduction in utilizable water resources to be a future problem.

Table 9. Results of the latent class model calculations

Issues and model outputs	Factor (*t*-value) (standard error)	
	Class 1	Class 2
annual mean temperature increase		
not really probable in the future	*baseline*	
expected in the future	2.40***	0.33***
	(9.21)	(2.94)
	(0.26)	(0.11)
already present	2.26***	1.11***
	(7.46)	(10.97)
	(0.30)	(0.10)
annual precipitation increase		
not really probable in the future	*baseline*	
expected in the future	1.69***	−0.14*
	(6.36)	(−1.38)
	(0.27)	(0.10)
already present	2.04***	0.12
	(7.29)	(1.09)
	(0.28)	(0.12)
increase in the frequency of extreme weather events		
not really probable in the future	*baseline*	
expected in the future	1.56***	0.15*
	(6.74)	(1.57)
	(0.23)	(0.10)
already present	1.78**	0.39***
	(6.93)	(3.77)
	(0.26)	(0.10)
increase in the utilizable water resources		
not really probable in the future	*baseline*	
expected in the future	1.66***	0.37***
	(8.68)	(3.86)
	(0.19)	(0.10)
already present	1.28***	0.07
	(5.85)	(0.68)
	(0.22)	(0.10)
Parameters of the class allocation equation		
Hungary	*baseline*	
Czech Republic	0.07	*baseline*
	(0.22)	
	(0.33)	
Poland	−0.48	
	(−1.24)	
	(0.39)	
class probability value	0.45	0.55

(continued)

Table 9. Continued

Issues and model outputs	Factor (*t*-value) (standard error) Class 1	Class 2
Information criteria of the model		
Log-likelihood (0)		−2,736.55
Log-likelihood (final)		−2,155.96
AIC		4,351.91
BIC		4,463.67

AIC denotes the Akaike information criterion, BIC denotes the Bayesian information criterion. ***, **, and * indicate the coefficient is statistically significant at the levels 1%, 5%, and 10%, respectively.

Respondents' knowledge of the effects of climate change on crop production safety

Climate change is projected to increase the potentially attainable yields of the currently-grown crops in the rest of the area of Slovakia, Poland, and the Czech Republic, classified as having relatively high and increasing potential yield. In contrast, Hungary is expected to have half of its area affected by an adverse change in the potential yield of the current crop mix (Debonne et al., 2022). Regarding the indirect effects of climate change on crop production in case of no measure, the need for changing plant species repertoire was considered dominantly already present or short-term in each country (75–85%), with the highest sensitivity of Poland (Table 10). Similar expectations for yield depression due to drought were expressed, but even with higher severity. Freeze, as a cause of lower yield, was considered critical by 75% of the Hungarian respondents.

In comparison, 26% of Czech university students think it would only become an issue in their country in the long term, while 36% believe it is already real. The contribution of pests to yield decrease was considered already present by 55% of the Hungarians and 40–41% of the respondents in the other three countries, but the sum of the ratios of the answers already present and short-term was consistently high, 75–91%. More than half of the Hungarians considered yield decrease due to temporal water covers a fundamental problem. In contrast, in the Czech Republic, it was expected only in the long-term by 32%. In Slovakia and the Czech Republic, answers showed a wide distribution between existing and not probable.

Regarding soil quality, adverse changes in salinity, acidity, or alkalinity were considered genuine by half of the Hungarian respondents as the highest. Though the range of giving answers, already present or short-term, was 64–80%, one-third of the Slovakian, one-fourth of the Czech, and approximately one-sixth of both the Hungarian and the Polish students expected the problem only in the long term. Students in each country consider worsening structural conditions of soil actual or relevant soon (80–89%). Thought in Slovakia, close to 45% of students expect it instead in the short term, and even one-fifth believe the issue arises only in a long time. Similar ratios were found regarding the actuality or short-term expectation of the compaction of the soil. One-third of the Slovakian respondents chose whether it was becoming long-term or not probable in the future. Climate change was expected to have a considerable adverse effect on the loss of nutrients in the soil already existing or occurring in the short term by 72–89% of the respondents in their countries. According to European

Table 10. Percentage of respondents by answers and countries regarding their knowledge of the indirect effects of climate change regarding crop production and soil protection, by country regarding statements D1–D11. Values are given in %. The numbers of respondents by country are shown in Fig. 2. Statements D1–D11 and explanation of codes 1–4 are listed in Table 1

Statements	D1				D2*				D3***				D4*				D5***				D6**			
Answers*	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hungary	35.5	40.2	19.6	4.7	62.6	29.9	7.5	0.0	75.2+	21.1	3.7−	0.0−	55.0+	35.8	9.2	0.0	55.0+	32.1	8.3−	4.6	50.5+	30.3	18.3	0.9
Czech Republic	21.7	54.7	18.9	4.7	50.0−	43.4+	6.6	0.0	35.8−	28.3	26.4+	9.4+	40.6	39.6	18.9	0.9	25.5−	34.9	32.1+	7.5	38.7	33.0	25.5	2.8
Poland	41.9	43.5	14.5	0.0	72.6+	19.4−	6.5	1.6	61.3	22.6	11.3	4.8	41.0	34.4	19.7	4.9+	39.0	37.3	15.3	8.5	40.3	37.1	16.1	6.5
Slovakia	26.3	48.8	22.5	2.5	51.3	38.8	8.8	1.3	48.8	33.8	13.8	3.8	40.0	45.0	12.5	2.5	28.8	38.8	26.3	6.3	25.0−	38.8	32.5+	3.8

Statements	D7				D8***				D9				D10				D11**			
Answers*	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hungary	45.9	39.4	13.8	0.9	49.1	38.0	10.2−	2.8	48.6	37.6	11.0	2.8	45.0	37.6	13.8	3.7	44.0	41.3	11.0−	3.7
Czech Republic	56.6	32.1	10.4	0.9	52.4+	32.4	14.3	1.0−	50.9	33.0	13.2	2.8	51.9	37.7	9.4	0.9	53.8+	29.2	15.1	1.9
Poland	43.5	43.5	9.7	3.2	38.7	35.5	16.1	9.7+	38.7	50.0	8.1	3.2	46.8	32.3	17.7	3.2	41.9	25.8	22.6	9.7
Slovakia	36.3	43.8	18.8	1.3	30.4−	34.2	27.8	7.6	35.0	37.5	23.8	3.8	31.6	46.8	16.5	5.1	25.3−	41.8	24.1	8.9

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively. ***, **, and * indicate coefficients statistically significant at the level 1%, 5%, and 10%, respectively. D1: $\chi^2 = 13.879$, df = 9; D2: $\chi^2 = 15.610$, df = 9; D3: $\chi^2 = 50.527$, df = 9; D4: $\chi^2 = 16.059$, df = 9; D5: $\chi^2 = 33.365$, df = 9; D6: $\chi^2 = 18.501$, df = 9; D7: $\chi^2 = 11.315$, df = 9; D8: $\chi^2 = 24.657$, df = 9; D9: $\chi^2 = 14.414$, df = 9; D10: $\chi^2 = 11.662$, df = 9; D11: $\chi^2 = 26.370$, df = 9.

statistical data (Eurostat, 2021), the Czech Republic is among the countries with a high input of mineral nitrogen fertilizers (4th in the EU), with the 2nd highest share of mineral nitrogen in the total nitrogen input and a high positive nitrogen balance (6th in the EU).

On the contrary, in Hungary, the fertilization level is low, and the nitrogen surplus is among the lowest in the EU. Based on the answers to questions D7–D9, soil degradation is considered or expected to be a relatively less critical issue that young agricultural engineers would face in Slovakia. More than half of the respondents regarded water and wind erosion as a real problem in the Czech Republic.

Respondents' opinion on the level of knowledge transfer at the agricultural universities

In the four countries, crop production and horticulture losses do not necessarily result from inadequate knowledge of the agricultural professionals but the lack of access to adequate tools, where solutions below a given field area are currently not economically feasible. Students evaluated their knowledge about climate change gained during their studies. The majority of all respondents in the V4 region reported that linguistic aspects were built into the subjects of the courses to some extent (Tables 11 and 12). Ratios were 54–67% and 56–69% at BSc and MSc

Table 11. Percentage of respondents by answers and countries regarding their knowledge on climate change gained during their BSc studies. Values are given in %. The numbers of respondents by country are given in Fig. 2. Questions Q5–Q7 and explanation of codes 5a–5c, 6a–6c, and 7a–7c are listed in Table 1

Questions	Q5***			Q6			Q7		
Answers	5a	5b	5c	6a	6b	6c	7a	7b	7c
Hungary	14.7	58.7	26.7+	23.0	60.8	16.2	29.3	54.7	16.0
Czech Republic	12.8−	66.7	20.5	23.1	64.1	12.8	20.5	53.8	25.6
Poland	33.3	66.7	0.0−	23.8	57.1	19.0	33.3	61.9	4.8
Slovakia	31.7+	54.0	14.3	38.7	41.9	19.4	37.1	43.5	19.4

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively.
*** displays coefficients statistically significant at the level 1%. Q5: $\chi^2 = 17.413$, df = 6; Q6: $\chi^2 = 8.479$, df = 6; Q7: $\chi^2 = 9.290$, df = 6.

Table 12. Percentage of respondents by answers and countries regarding their knowledge on climate change gained during their MSc studies. Values are given in %. The numbers of respondents by country are given in Fig. 2. Questions Q5–Q7 and explanation of codes 5a–5c, 6a–6c, and 7a–7c are listed in Table 1

Questions	Q5*			Q6			Q7		
Answers	5a	5b	5c	6a	6b	6c	7a	7b	7c
Hungary	14.7	55.9	29.4+	23.5	55.9	20.6	26.5	64.7	8.8
Czech Republic	6.9	69.0	24.1	20.7	69.0	10.3	10.3	69.0	20.7
Poland	26.2	69.0	4.8−	23.8	59.5	16.7	26.2	69.0	4.8
Slovakia	18.8	62.5	18.8	25.0	37.5	37.5	18.8	56.3	25.0

Where adjusted residual ≥|2|, + and – indicate significant positive or negative difference, respectively.
* displays coefficients statistically significant at the level 10%. Q5: $\chi^2 = 11.585$, df = 6; Q6: $\chi^2 = 6.106$, df = 6; Q7: $\chi^2 = 8.877$, df = 6

levels, respectively. Patterns by country were the same for both education groups; graduates in Hungary felt to get detailed knowledge with the highest ratio. At the BSc level, one-third of Polish and Slovakian respondents reported that the lexical aspect was not focused on during their studies. It was found lower at the MSc level, representing 26% and 19%, respectively. 39% of the Slovakian BSc students believed that tools and techniques (i.e., measures, actions, management, technologies, research, etc.) related to climate change were not built into the subjects, though one-fifth reported the opposite. 38% reported high focus at the MSc level, while 25% was low. In the other three countries, the ratios were quite comparable in the two education groups with the dominance of the answer “to some extent”; Czech respondents represented the highest ratio at both levels. Polish students represented the lowest ratio regarding detailed discussion of climate change in all relevant subjects. Considering the sum of the answers “not really in focus” and “to some extent”, 74%, 81%, 84%, and 95% of the Czech, Slovakian, Hungarian, and Polish students at the BSc level were represented, respectively. At the MSc level, 79%, 75%, 91%, and 95% gave one of these answers, respectively. Results did not reveal considerable differences by course level.

Based on the results, the country-specific relevance of the different environmental aspects is widely believed accurate at the V4 level. E.g., the shift in climate zones is discussed at the country scale, and students probably project their knowledge in general. This is likely a subjective extension based on objective knowledge. Regarding flood risk, respondents expose their expertise on local hydrography to the V4 level at all universities, too. E.g., in Hungary, the river regulation program was completed by the beginning of the last century; hence flood risk is negligible. Students are familiar with it; news in the media regularly informs about natural disasters but in far regions of the world. The vulnerability of wetlands is of public interest, where the media has a considerable role. Students show sensitivity to the protection of natural resources. Many types of weather extremes are experienced in the region, but specific ones by countries. Heat waves and temporary water cover of arable lands are discussed in many aspects; lecturers continuously update the related teaching materials. Underground water resources are quite different in quantity and availability for use, and a lack of detailed knowledge of the geography and hydrogeology of the V4 region as a whole result in local to regional scale projection. Forest fires in South Europe are reported in the media in the summer, sensitizing V4 students.

Respondents’ attitude towards the protection alternatives against the harmful effects of climate change in crop production

Adequate prevention or protection measures are needed to handle weather anomalies that can efficiently decrease crop yield. They can be different by regions within East Central Europe. Ideally, students should give coherent answers (E1–E12) for the dominant adverse changes in weather conditions (D2–D4). Intensified irrigation was prioritized by 32%, 51%, 57%, and 65% of the Czech, Slovakian, Hungarian, and Polish respondents, respectively (Table 13). The application of ice net to protect fruit trees was chosen as relevant by most Hungarians and approximately three-fourths of Slovakians, while slightly higher than half of the Czech and Polish students. It may be noted that in the Czech Republic, orchards and vineyards occupy a relatively small area of agricultural land. The introduction of species tolerating freeze better was considered necessary by 54–64%, with the highest ratio in Hungary. Drought-tolerant species to prevent high yield variation by years were chosen as an essential option by nearly 60% of Slovakian students, while

Table 13. Percentage of respondents by answers and countries regarding their knowledge of the prevention and protection measures in crop production, against weather anomalies, by country (E1–E12). Values are given in %. The numbers of respondents by country are shown in Fig. 2. Statements E1–E12 and explanation of codes e1 and e2 are listed in Table 1

Statements	E1***		E2***		E3		E4***		E5***		E6***	
Answers	e1	e2	e1	e2	e1	e2	e1	e2	e1	e2	e1	e2
Hungary	43.1	56.9	11.9−	88.1+	36.7	63.3	22.0	78.0	28.4−	71.6+	37.6−	62.4+
Czech Republic	68.2+	31.8−	48.6+	51.4−	41.1	58.9	22.4	77.6	46.7	53.3	56.1	43.9
Poland	34.9−	65.1+	46.0+	54.0+	46.0	54.0	19.0	81.0	49.2	50.8	61.9+	38.1−
Slovakia	48.8	51.3	28.8	71.3	38.8	61.3	41.3+	58.8−	52.5+	47.5−	47.5	52.5

Statements	E7***		E8***		E9***		E10***		E11***		E12***	
Answers	e1	e2	e1	e2	e1	e2	e1	e2	e1	e2	e1	e2
Hungary	79.8+	20.2−	67.0−	33.0+	80.7+	19.3−	62.4−	37.6+	47.7−	52.3+	100.0+	0.0−
Czech Republic	39.3−	60.7+	96.3+	3.7−	40.2−	59.8+	79.4	20.6	94.4+	5.6−	71.0−	29.0+
Poland	81.0+	19.0−	79.4	20.6	96.8+	3.2−	82.5	17.5	76.2	23.8	100.0+	0.0−
Slovakia	87.5+	12.5−	52.5−+	47.5+	86.3+	13.8−	86.3+	13.8−	73.8	26.3	97.5+	2.5−

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively. *** indicates coefficients statistically significant at the level 1%. E1: χ^2 = 22.036, df = 3; E2: χ^2 = 39.384, df = 3; E3: χ^2 = 1.555, df = 3; E4: χ^2 = 12.888, df = 3; E5: χ^2 = 13.977, df = 3; E6: χ^2 = 12.015, df = 3; E7: χ^2 = 67.952, df = 3; E8: χ^2 = 51.288, df = 3; E9: χ^2 = 86.415, df = 3; E10: χ^2 = 18.002, df = 3; E11: χ^2 = 59.718, df = 3; E12: χ^2 = 71.855, df = 3.

considerably higher (78–81%) of the rest. The application of species more resistant to pests was considered relevant by 72% of the Hungarians, while around half of the students were in the other three countries. Integrated pest management as a tool was chosen according to the same pattern. There were no changes in the crop repertoire in the four countries in the last three decades. There is no sign of adaptation to the effects of climate change, e.g., by increasing the diversity of crops, fulfilling the site-specific agroecological potential, considering flexible sowing dates, and/or preferring local varieties. Further simplification of the crop repertoire was thought not to be an adequate response to climate change by the majority (80–88%), except the Czech respondents (39%). The highest ratio for the relevance of the (re)introduction of local varieties was found in Slovakia (48%), while the lowest was in the Czech Republic (4%). Both the extensive and the intensive crop production as efficient protection measures were chosen as least relevant in Poland (3% and 18%, respectively), while having some relevance in Hungary (19% and 38%) and Slovakia (14–14%). Close to 60% of Czech students thought of considerable potential in comprehensive technologies. Adjusting the sowing date to the weather conditions was considered irrelevant by 94% in the Czech Republic, while only 48% in Hungary as the maximum and the minimum by ratio. Except for the 29% Czech respondents, all students (98–100%) prepare for the need for changing technologies to keep high crop yields.

Based on the reflection for the F1 statement (Table 14), all students (98–100%) rate drought as an issue in their country. New drought-resistant species and compacting with a roller after shallow stubble cultivation, however, are not considered an efficient option at all in the Czech Republic, but more balanced nutrition (70%), elimination of soil compaction (79%), using crops with deep root zone (highest, 72%), and alternating cultivation depth (65%), all with the highest ratio among the countries (Table 14). Drought-tolerant varieties may have been thought to have priority instead. Interestingly, only 16%, one-fourth of the respondents in the other countries, chose irrigation. In Poland, the highest relevance among the options was the introduction of drought-resistant species, irrigation, applying crop rotation, and improving soil structure (81% is the highest among the countries, 77%, and 60% that is comparable to the Czech and Slovakian ratios, and 59%, respectively), and compacting with a roller after shallow stubble cultivation was chosen by simple. In Slovakia, 73% chose irrigation, and 66% chose soil structure improvement as an efficient option against drought, while 59–59% found the use of drought-resistant species and applying crop rotation relevant. In Hungary, improving soil structure, irrigation, and introducing new drought-resistant species were selected in the highest ratio, 80% (highest among the countries), 77%, and 70%, respectively. In this country, developing irrigation capacities has limitations; political negotiation started about a decade ago but still has no implementation. In the V4 countries, similar proportions chosen as irrelevant were found for regular deep loosening (64–77%) and direct seeding (80–95%). Mellowing after primary cultivation was also considered insufficient by the majority in Poland and Slovakia (87% and 85%, respectively), while in Hungary and the Czech Republic, 43–43% were considered relevant. Mulching was preferred by 35–42% of the Polish, Slovakian, and Hungarian students, while 12% of the Czechs.

Respondents' preferences in information transfer and their attitude toward individual actions

The range of media tools used by the generation of age 20–25 years can be expected to be similar in European countries, in general. In this survey, differences and/or similarities in the preference

Table 14. Percentage of respondents by answers and countries regarding their knowledge of the agro-techniques for efficient crop production and soil protection by country. Values are given in %. The numbers of respondents by country are given in Fig. 2. Statements F1–F12, and explanation of codes f1 and f2 are listed in Table 1

Statements	F1		F2***		F3***		F4***		F5***		F6**		F7***	
Answers	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2
Hungary	98.2	1.8	30.3−	69.7+	46.8	53.2	20.2−	79.8+	59.6+	40.4−	57.8+	42.2−	72.5+	27.5−
Czech Republic	99.1	0.9	100.0+	0.0−	29.9−	70.1+	70.1+	29.9−	20.6−	79.4+	42.1	57.9	28.0−	72.0+
Poland	100.0	0.0	19.0−	81.0+	65.1+	34.9−	41.3	58.7	77.8+	22.2−	39.7	60.3	50.8	49.2
Slovakia	97.5	2.5	41.3−	58.8+	70.0+	30.0−	33.8	66.3	56.3	43.8	41.3	58.8	53.8	46.3

Statements	F8***		F9		F10***		F11***		F12***		F13***		F14***	
Answers	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2
Hungary	63.3	36.7	66.1	33.9	42.2−	57.8+	57.8−	42.2+	56.9−	43.1+	79.8−	20.2+	22.9−	77.1+
Czech Republic	35.5−	64.5+	76.6	23.4	66.4	33.6	87.9+	12.1−	57.0−	43.0+	95.3+	4.7−	84.1+	15.9−
Poland	81.0+	19.0−	63.5	36.5	100.0+	0.0−	65.1	34.9	87.3+	12.7−	90.5	9.5	22.2−	77.8+
Slovakia	72.5+	27.5−	70.0	30.0	90.0+	10.0−	61.3	38.8	85.0+	15.0−	87.5	12.5	27.5−	72.5+

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively. *** and ** indicate coefficients statistically significant at the levels of 1% and 5%, respectively. F1: $\chi^2 = 1.923$, df = 3; F2: $\chi^2 = 150.360$, df = 3; F3: $\chi^2 = 36.258$, df = 3; F4: $\chi^2 = 58.290$, df = 3; F5: $\chi^2 = 61.813$, df = 3; F6: $\chi^2 = 8.502$, df = 3; F7: $\chi^2 = 42.940$, df = 3; F8: $\chi^2 = 44.016$, df = 3; F9: $\chi^2 = 4.270$, df = 3; F10: $\chi^2 = 83.328$, df = 3; F11: $\chi^2 = 26.769$, df = 3; F12: $\chi^2 = 33.796$, df = 3; F13: $\chi^2 = 12.757$, df = 3; F14: $\chi^2 = 111.135$, df = 3.

Table 15. Percentage of respondents by answers and countries regarding professional news sources. Values are given in %. The numbers of respondents by country are shown in Fig. 2. Statements G1–G13 and explanation of codes g1 and g2 are listed in Table 1

Statements	G1*		G2***		G3		G4*		G5***		G6***		G7	
Answers	g1	g2	g1	g2	g1	g2	g1	g2	g1	g2	g1	g2	g1	g2
Hungary	60.6+	39.4−	15.6−	84.4+	61.5+	38.5−	67.0+	33.0−	35.8−	64.2+	57.8−	42.2+	75.2	24.8
Czech Republic	49.5	50.5	43.9+	56.1−	16.8−	83.2+	57.0	43.0	58.9	41.1	61.7	38.3	72.0	28.0
Poland	44.4	55.6	11.1−	88.9+	74.6+	25.4−	49.2	50.8	57.1	42.9	71.4	28.6	73.0	27.0
Slovakia	45.0	55.0	22.5	77.5	48.8	51.3	52.5	47.5	61.3	38.8	88.8+	11.3−	70.0	30.0

Statements	G8***		G9***		G10***		G11***		G12***		G13	
Answers	g1	g2	g1	g2	g1	g2	g1	g2	g1	g2	g1	g2
Hungary	32.1−	67.9+	71.6	28.4	79.8+	20.2−	86.2+	13.8−	60.6−	39.4+	84.4	15.6
Czech Republic	78.5+	21.5−	45.8−	54.2+	68.2	31.8	49.5−	50.5+	88.8+	11.2−	92.5+	7.5−
Poland	54.0	46.0	76.2+	23.8−	79.4	20.6	69.8	30.2	81.0	19.0	82.5	17.5
Slovakia	41.3−	58.8+	75.0+	25.0−	47.5−	52.5+	93.8+	6.3−	87.5+	12.5−	87.5	12.5

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively. *** and * indicate coefficients statistically significant at the levels of 1% and 10%, respectively. G1: $\chi^2 = 6.306$, df = 3; G2: $\chi^2 = 32.502$, df = 3; G3: $\chi^2 = 67.496$, df = 3; G4: $\chi^2 = 6.607$, df = 3; G5: $\chi^2 = 16.929$, df = 3; G6: $\chi^2 = 23.432$, df = 3; G7: $\chi^2 = 0.678$, df = 3; G8: $\chi^2 = 51.173$, df = 3; G9: $\chi^2 = 26.524$, df = 3; G10: $\chi^2 = 26.482$, df = 3; G11: $\chi^2 = 58.701$, df = 3; G12: $\chi^2 = 31.633$, df = 3; G13: $\chi^2 = 4.708$, df = 3.

of the sources among the graduates to gain relevant, up-to-date information about agriculture-related climate change issues, mitigation, and adaptation was studied. The majority of Hungarian respondents read printed professional papers (61%), while in the other three countries, it is 44–50% (Table 15). 44% of Czech students visit online professional websites, while only 11–15% of the Polish and Hungarians do. Radio and television are preferred sources in Poland and Hungary (75% and 62%, respectively), while only 17% of the Czech students chose them. 67% of the Hungarians, while approximately half of the students from other countries find competent bodies and organizations useful for asking professional questions. The lowest interest in the national agricultural chamber was found in the case of the Hungarian respondents (36%), while in the other countries, 57–61% of students gave a positive answer. Consultants have priority in Slovakia (89%). Exhibitions and fairs are engaging in the same ratio for all students in the region (70–75%). Based on the responses, educational institutes play an essential role in the Czech Republic as the highest. Contrary to the others, Czechs would not necessarily consider the experiences of other farmers nearby, while 72–76% would work in the other three countries. Only 48% of the Slovakian students think senior farmers are worth asking. The ratios in the different countries were found to be 68–80%. However, integrators and distributors are highly preferred in Slovakia. Facebook has the lowest role in Hungary while the highest in Slovakia (61% and 88%, respectively). Finally, most students would use blogs to share professional experiences (83–93%).

Transportation has a considerable contribution to climate change. On the other hand, time and comfort are prioritized in everyday life. Interestingly, students in all the V4 countries showed high sensitivity towards the environment's vulnerability and its relation to transport options (Table 16). 88% of the Czechs, while 60% of the Hungarians are the lowest, think of responsibility when traveling. Respondents were invited to play a situation when they would be leading an economically prosperous company, where the environmental protection regulations are fully applied. It was asked whether they would consider further actions to make the company "greener," i.e., to reach higher environmental performance, not necessarily resulting in direct extra financial income. The results reflected their increased responsibility, 84–96% of the students would make an extra effort towards environmentally sustainable agriculture (Table 16).

Table 16. Percentage of respondents by answers and countries regarding their additional personal attitudes. Values are given in %. The numbers of respondents by country are shown in Fig. 2. Statements H and I, and explanation of codes h1, h2, i1, and i2 are listed in Table 1

Statements	H***		I**	
Answers	h1	h2	i1	i2
Hungary	60.2−	39.8+	92.7	7.3
Czech Republic	87.6+	12.4−	96.2	3.8
Poland	74.6	25.4	84.1−	15.9+
Slovakia	68.4	31.6	93.7	6.3

Where adjusted residual ≥|2|, + and – indicate significant positive or negative differences, respectively. ***and ** indicate coefficients statistically significant at the levels of 1% and 5%, respectively. H: $\chi^2 = 21.153$, df = 3; I: $\chi^2 = 8.497$, df = 3.

CONCLUSIONS

Losses in agriculture, especially in crop production and horticulture, are experienced in the V4 countries, East Central Europe, and there are years in each country economically not feasible at all. There have not been any considerable efforts toward adaptation and flexibility to consider alternatives. Yields do not reach their potential, mainly resulting from improper plant protection practices and continuously narrowed chemicals' list in parallel, lack of flexibility in seeding date and tillage practice, and that of irrigation infrastructure. Experts are currently facing extraordinary challenges in balancing economic and environmental performance in the business sector.

The adaptive capacity of the regions significantly impacts agricultural climate response. E.g., when comparing Eastern and Western Europe combining climate, soil, geographic, socio-economic, and farm-level data, a quite different climate response was proved, with a higher potential to avoid the decrease in land value in the Eastern European countries if implementing the same adaptation options as of the Western European countries (Vanschoenwinkel, 2016). Though the European Environment Agency reported in 2021 that there were no immediate food security concerns in Europe related to climate change impacts (European Environment Agency), 2022 was a year of weather extremes with evidence of the vulnerability of agriculture. Based on the most recent reports published by the European Environment Agency and the European Parliamentary Research Service, food supply and food security in Europe are at risk more than ever (European Environment Agency, 2021; European Parliamentary Research Service, 2022).

We report here about the level of preparedness of the agricultural engineers' next generation in East Central Europe. This study is unique in terms of assessing four neighbouring countries located in the heart of Europe, forming a group with similar interests and joint reflections; for instance, in the field of agriculture within the EU, agriculture is a significant sector but poses relatively different environmental impacts, especially those of climate change. Here we note that respondents were asked in their national language instead of English.

Based on our results, students in the V4 countries definitely get objective information from the lecturers at the universities regarding, e.g., climate change concerning the Kyoto Protocol. Challenges are put into context, and facts such as weather extremes, achievements of international conferences, and European programs financing progress in actions in agriculture are explained. History of the protection of the environment is also a significant part of the subjects on environmental and water management. Solutions and tools appear in specific topics, e.g., soil management, plant physiology, crop production, agro-techniques, and agro-environmental technologies. In the agricultural courses of all the universities, water-related issues and technological as well as management solutions are discussed in subjects such as irrigation, drought management, water resource protection, and agrometeorology. Subjectivity and information from the media are additional factors when young agricultural experts take part in decision-making processes in any sense.

Regional and local aspects are relatively more important than general considerations. The ancient phrase "think globally, act locally" attributed to Patrick Geddes is more relevant than ever to be translated into practical knowledge and skills. In the V4 countries, agricultural performance, eco-efficiency, agro-environmental issues, and optional solutions are comparable, though differences in climatic zones make priorities different. EU scale knowledge is helpful because of the common labour market and commercial relationships. To improve it, there are several opportunities for the students to participate in EU-funded exchange programs such as ERASMUS, ERASMUS+, CEEPUS, CAMPUS MUNDI, and STIPENDIUM. Personal ambition and the level of English language skills determine individual decisions.

Country-specific questions show clear evidence of the quality of education in terms of the curricula expected to be up-to-date, the lecturers' attitudes, and the abilities of the students attending a course. The latter two, as individual attitudes, may show high variability within a university. Responses' statistics give information on the overall efficiency of agricultural higher education.

In the V4 countries, intensive development has been made recently, financed from both EU funds and the national budget. The curricula are kept updated, and lecturers have been trained in new teaching methodologies supporting professional and soft skills and lexical knowledge. However, lecturers have a high responsibility in the implementation; their performance and critical feedback to the students are the other pillars of the overall efficiency of higher education. This is well-reflected by the variability in the results. According to the students, the discussion of climate change in all relevant subjects should be more detailed at BSc and MSc levels. The need for adaptation to the regional effects of climate change is not a question in East Central Europe. Specific knowledge of weather conditions by countries is necessary to understand which extremes and how they need to be handled to have the lowest loss in agriculture. We have proved that students in the V4 countries are familiar with the vulnerability of agriculture resulting from the changes in the weather conditions and the problems they will face when starting their careers. At all the universities taking part in the survey, related facts, risks, trends, and options to mitigate adverse effects are discussed in relevant subjects.

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