

**Theses for doctoral dissertation (PhD)**

**FUTURE PROSPECTS FOR FOOD SECURITY: THE ROLE OF  
KNOWLEDGE TRANSFER AND EDUCATION**

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Debrecen, 2021

# **1. THE BACKGROUND, OBJECTIVES AND HYPOTHESES OF THE RESEARCH**

I started my research in 2018, with the aim to address a topical issue that was of great public interest and would have a significant impact on future developments. My fundamental aim was to explore the challenges facing humanity and to examine them from a Hungarian perspective. Recognising that our future depends fundamentally on us and on the young generation, I included university students in my primary research sample, thus demonstrating their knowledge, attitudes, values and knowledge of the subject under study. Examining this target group is of exceptional importance, as it is from this group that future decision-makers are likely to emerge. It is also vital for Hungarian agricultural production and the domestic food processing industry that decision-makers with the necessary skills in this area take the necessary future measures. The results of the primary research of this doctoral thesis can be used to help decision-makers to develop action plans for the future.

The objective of my thesis is to examine the factors of global and domestic food security and to explore the structures of the interrelationships between these factors based on an evaluative analysis of international literature. Furthermore, I aim to analyse the available data and the data obtained from primary data collection using a multivariate data analysis approach. Based on the synthesis of the available literature, my thesis will provide relevant and practical results to explain the topic. The choice of topic was influenced by several factors, and research on the topic is especially relevant at the international level, and there are numerous literature sources and studies available from internationally. In writing this thesis, I have based my work on the assumption that by examining and analysing individual food insecurity events, I can contribute to the mitigation and possible reduction of factors that cause food insecurity.

## **Main objectives of the research**

1. Defining food security and related issues and describing their policy regulation.
2. Synthesising international and national literature to provide a complex picture of the global challenges facing agriculture.
3. Presentation of the most important historical milestones of sustainable development and the development of the process.
4. Assessing the information and knowledge of university students in the examined topic, and exploring the role of education (especially higher education) in the development of the idea of sustainability. This is important because global challenges are directly or indirectly present in the lives of all of us. The present generation is a key player in mitigating the processes expected in the future.

The main thrust of my research question was therefore to investigate the factors influencing food security and their interlinkages, and from this I formulated the following hypotheses:

- H1:** University students lack reliable knowledge and information on global challenges.
- H2:** University students can be clearly divided into distinct groups according to their level of education, based on their perception of the importance of environmental aspects, regulatory and institutional systems.
- H3:** University students can be divided into well-differentiated groups based on their knowledge of global issues and the observation of these events.
- H4:** University students blame agriculture as the main source of environmental problems.

## **2. LITERATURE REVIEW**

In the literature review, I first addressed the conceptual delineations of the topic. As a first step, I analyse the conceptual definitions of food security from different sources, and then focus on those closely related to this area. The analysis continues with the various policy changes, covering their international and Hungarian aspects. The Sustainable Development Goals (SDGs), which were established by the United Nations, play a crucial role in the course of the thesis. I will briefly present the impact of COVID-19 on the SDGs and Hungary's position in achieving some of the goals, based on the data available so far. In the literature review, I will analyse papers and databases closely related to the topic, mainly from abroad. The role of the education system is particularly important in addressing global agricultural challenges, as the literature review describes it. The next step is the change in the Earth's population, which is a key issue and the defining element of the thesis. The literature review also describes resource management, with a special focus on the issue of land and water. Energy and biodiversity are also key issues that have a major impact on global challenges. The final section of the literature review focuses on the impacts of climate change.

### **2.1. Conceptual definition**

Over the last three decades, a number of definitions and conceptual frameworks have been developed to explore and deepen the understanding of food safety, food security and related areas. The definition of food safety has evolved continuously since its introduction in the early 1940s. In the 1970s, the term was defined in terms of food supply to ensure that all people everywhere have access to sufficient food. In the 1980s, the importance of consumption and access was linked to the conceptual definition (FAO, 2017). The 1996 Food Summit proposed a new definition, which is the most complex, and I have taken it as the basis for my study: *'Food security is achieved at individual, household, national, regional and global levels when all people at all times have physical and economic access to sufficient, safe and nutritious food and to the dietary preferences necessary to meet their dietary needs and to lead active and healthy lives'* (FAO, 1996). This definition includes four dimensions of food security - availability, access, stability and utilisation.

## **2.2. Regulation, policy changes**

After an overview of the evolution of the conceptual framework, I will also describe the evolution of the relevant regulations, as this illustrates the important process of how food security has become an increasingly important policy area.

### ***2.2.1. The UN Sustainable Development Goals***

In September 2015, the United Nations adopted the Sustainable Development Framework and its backbone set of goals. Together they aim to eradicate poverty, tackle inequality and protect the Earth's environment. One of the main features of the new framework is that, unlike previous development cooperation plans, it takes a more comprehensive approach to sustainable development programmes, setting targets for individual countries and regions. At the heart of the agenda are the Sustainable Development Goals (SDGs), which apply to all nations and exclude no one from achieving them. Most countries in the world have agreed to work towards these goals. The 17 Sustainable Development Goals (SDGs) are set out in a list of 169 SDG targets, and progress towards these goals is measured by 232 specific indicators (ADAMS - JUDD, 2016).

### ***2.2.2. Impact of COVID-19 on the Sustainable Development Goals***

In the new decade beginning in 2020, humanity has a shared responsibility to collectively achieve the UN Sustainable Development Goals (SDGs). The already slow progress towards these goals has been severely set back by COVID-19 (e.g. Goal 2, eradicate hunger). However, the emergence of the COVID-19 pandemic worldwide has brought new challenges in all walks of life. Austerity measures, isolated economies and financial expenditure to contain the pandemic emergency resulted in a slowdown in socio-economic development. In the longer term, this poses a serious challenge to the achievement of the Sustainable Development Goals (SDGs), even on a decadal scale, and could in particular jeopardise the achievement of the UN Sustainable Development Goals (SDGs) by 2030. These negative impacts are already being felt in economically developed countries, despite the short timeframe, and are likely to be felt even more in developing countries.

### ***2.2.3. Sustainability aspects of the EU Common Agricultural Policy***

The Common Agricultural Policy (CAP), established at EU level in 1962, is an important policy that creates a partnership between agriculture and society, as well as between European farmers. The CAP is a policy of the EU Member States, managed and financed at EU level, using EU budget resources. The European Commission regularly consults with civil society groups and national agricultural committees to develop the best possible agricultural legislation and support policy. They are also advised by various expert groups (EUROPEAN COMMISSION, 2020). To ensure the future of European agriculture, policy-makers have over the years adapted the CAP to changing economic circumstances and the expectations and needs of citizens. A further objective is to promote a sustainable and competitive agricultural sector that can make a significant contribution to achieving the objectives of the European Green Deal, in particular the 'producer-consumer' strategy and the biodiversity strategy.

### ***2.2.4. The European Green deal***

The European Union is committed to addressing climate and environmental challenges. The Commission believes that action is crucial for this generation if we are to tackle the problems in time. The atmosphere is warming and the impact of climate change is being felt more and more every year. Forests and oceans are being destroyed by pollution. The European Green Deal responds to these challenges. As a new growth strategy, it aims to form the EU into a just and prosperous society, with a modern, resource-efficient and competitive economy, where net greenhouse gas emissions are eliminated by 2050 and where economic growth is not dependent on resources (EUROPEAN COMMISSION, 2021).

## **2.3. The current state of issues related to sustainable development**

### ***2.3.1. Population change and its consequences***

Population growth is arguably one of the most pressing global issues. In studying this phenomenon, it is essential to be aware of recent and expected demographic trends. A large body of national and international literature (CLARK, 1977, DURAND, 1977, MCEVEDY - JONES, 1978, DENEVAN, 1992, KREMER, 1993, MADDISON, 2001, HOFSTRA -

VERMEULEN, 2016, CRIST et al., 2017, DOOLEY, 2018, FUNABASHI, 2018, RIGGS et al., 2018, ROSER et al., 2020) deals with the analysis of the global population change and its impact. Researchers use international databases (EASAC, FAO, OECD, etc. ) to forecast projected population growth trends based on continuously updated data. Urbanisation is a parallel process to population growth, with more than 70% of the total population projected to live in urban areas by 2050 (FAO, 2019). Urbanisation will also lead to changes in lifestyles and living standards, which will induce changes in consumption patterns. Spendable income will rise as a result of urbanisation, accelerating changes in diets in developing countries. A strong increase in demand for semi-processed or ready-to-eat foods (high value-added products) is expected (POPP et al., 2014). Current global trends in food consumption are not sustainable, whether analysed in terms of public health, the environment or socio-economic costs (BLANCHARD et al., 2017). At different geographical scales, clear correlations are observed between socio-economic status and quality dietary intake and the resulting health outcomes. The change in the production structure is driven by an increase in the number of higher income earners in low- and middle-income countries. In particular, this induces a change in consumption patterns, with an increase in the consumption of meat, fruit and vegetables relative to cereals (COLE et al., 2018).

### ***2.3.2. Resource management***

#### ***Soil***

One of the main objectives of resource management research is to understand the impact of growing populations on agricultural land and the pressures on other resources, particularly water and arable land, which are already under threat from global warming (ARNELL - GOSLING, 2016). In recent decades, the growing demand for agricultural production has been partly met by increasing agricultural land (BOSERUP, 2017). However, various studies present an increasingly gloomy vision of the future, where increasing crop yields will not be able to meet the demand for raw materials (MCLAUGHLIN - KINZELBACH, 2015, DAVIS et al., 2016, CRIST et al., 2017). For this reason, additional areas will have to be brought under agricultural production. Agricultural production needs to expand faster

than population growth and this needs to be achieved in a sustainable way without further damage to the environment.

### ***Water***

Climate change has a significant impact on water resources and thus on human livelihoods, especially in regions and countries affected by water scarcity. As the availability of freshwater is essential to ensure a sustainable future, there is a strong link between water management and policies addressing climate and climate change (KOUTROULIS et al., 2018). This is a major challenge, as rising global temperatures have a serious impact on hydrological resources. According to various research studies, pessimistic climate change scenarios are increasingly likely to become reality, as the projected warming rate is occurring much faster than expected. As a consequence, the availability and irreplaceability of water as a resource seems to be an unavoidable issue that policy makers should seriously consider (PAPADIMITRIOU et al., 2016). Water scarcity is one of the most serious dilemmas facing the planet and alternative water-saving solutions are needed. One such alternative is the reuse of treated wastewater in agriculture. Treated wastewater is one of the most important sources of water in particularly arid areas (FLÖRKE et al., 2013). Climate change is leading to increasingly frequent and extreme weather anomalies, of which agricultural production is one of the main sufferers (and a major cause). In line with diminishing water resources, the frequency of national and global conflicts (even wars) could increase (EASAC, 2017), as preliminary trends and data suggest that water demand will increase by 100% by 2050 (EASAC, 2017). This alarming increase can be attributed to population growth, the effects of urbanisation and the negative impacts of climate change. From a water management perspective, one clear negative impact of population growth is that domestic and industrial water use is expected to increase dramatically (ZUBAIDI et al., 2020). Climate change will lead to increasingly frequent and extreme weather anomalies, with agricultural production being one of the main sufferers.

### ***Energy***

The food economy is responsible for about 30% of energy consumption, and 1/3 of greenhouse gas emissions are also linked to agricultural activities (GOTHANDAM et al., 2018). Agricultural productivity must be sustainably increased to meet growing demand.

One of the pressing challenges of global development is to ensure that everyone has adequate access to energy. Of all fossil fuels, natural gas will have the largest share of the increase compared to 2019. Demand for natural gas will increase by 3.2% in 2021, driven by growing demand from Asia, the Middle East and the Russian Federation (Russia). This is expected to exceed global demand by more than 1% compared to 2019. The United States remains the world's largest natural gas market. In 2021, nearly three quarters of global demand growth will come from the industrial and construction sectors, while electricity generation from natural gas will remain below 2019 levels (IEA, 2021). Demand for electricity has grown rapidly over the past 10 years. Electricity demand will increase by 4.5% in 2021, almost five times the decline in 2020, which pushed electricity's share of final energy demand to over 20%. Almost 80% of the projected demand growth in 2021 is in emerging markets and developing economies, with the People's Republic of China (PRC) alone accounting for half of the global increase. In developed economies, demand remains below 2019 levels (IEA, 2021). Renewable energy demand grew by 3% in 2020 and will increase by 8% in 2021 across all key sectors - energy, heating, industry and transport - to reach 8 300 TWh, the highest annual growth in absolute terms (IEA, 2021). Renewables are expected to provide more than half of global electricity supply growth in 2021. Solar and wind are expected to contribute two-thirds of renewable energy growth. The share of renewables in electricity generation is projected to rise to almost 30% in 2021, the highest since the start of the industrial revolution. Solar electricity generation is expected to grow by 145 TWh, or almost 18%, to reach nearly 1000 TWh in 2021 (IEA, 2021). China is likely to account for almost half of global growth in renewable electricity generation, followed by the United States, the European Union and India. China is expected to generate more than 900 TWh from solar and wind in 2021, the European Union 580 TWh and the United States 550 TWh. Together, these represent almost three quarters of global solar and wind production (IEA, 2021). The COVID-19 pandemic will continue to impact global energy demand as the third wave of the pandemic extends curfews and continues to curb global energy demand.

### ***Biodiversity***

Biodiversity refers to the diversity of genes, species, ecosystems, i.e. living organisms. It includes all living organisms from humans, plants and animals to the most primitive viruses

(PRETTY et al., 2018). Biodiversity has a significant impact on both pollination and the nutrient cycle, and thus plays a key role in human health and the economy. Agriculture is a major driver of biodiversity loss (MEHRABI et al., 2018). Agricultural expansion is one of the most damaging impacts on biodiversity. These negative impacts can be reduced either through dietary changes, by replacing part of meat consumption with plant-based alternatives, or through technological innovation (RITCHIE - ROSER, 2020). Although biodiversity is essential for agriculture and human well-being, it is declining at an unprecedented rate (PEREIRA et al., 2012, FAO, 2020a). Agriculture (especially livestock production) and biodiversity have a special relationship. Biodiversity and related areas can only be analysed in a broad context. Appropriate adaptation and conservation strategies are needed to reduce the negative impacts of climate change. Henle et al (2008) show that there is a strong link between biodiversity conservation and agricultural activities. The main driver of biodiversity conflicts is the intensification of agriculture (HENLE et al., 2008). The Common Agricultural Policy (CAP) is placing increasing emphasis on environmental issues. Pereira et al (2012) noted that biodiversity loss is mostly driven by habitat change and overexploitation, but pollution, invasive species and disease have also been important factors. Climate change is considered a new driver of biodiversity loss (PEREIRA et al., 2012). Research on pests and diseases is important for biodiversity conservation, as they are also important risk factors for yield differences while mitigating the effects of climate change (LAMBERTH et al., 2013).

### ***Climate change***

Mitigating the effects of climate change and minimising biodiversity loss remains a key priority. Increasingly extreme climate change is making production risks rise and placing an increasing burden on farmers' livelihoods (DOBÓ et al., 2006). Climate change poses a threat to the food supply of both rural and urban populations. Extreme climate events also have a negative long-term impact, as risk exposure and increased uncertainty affect the introduction of effective economic innovations. As a result, the number of low-risk but low-return activities starts to increase (LESK et al., 2016). Some recently published studies (MÜLLER et al., 2010, SCIALABBA - MÜLLER-LINDENLAUF, 2010, CHALLINOR et al., 2014, MÜLLER - ROBERTSON, 2014, ASSENG et al., 2015) discuss the impact of climate change on yields, especially for major crops such as wheat, maize, rice and soybean,

i.e. the scientific processing of the topic and the development of solutions are ongoing. In a number of studies published in relevant scientific journals, climate scientists agree that the climate anomalies of the last century are most likely due to human activities (ORESKENS, 2004, DORAN - ZIMMERMAN, 2009, ANDEREGG et al., 2010, COOK et al., 2016).

#### **2.4. The link between sustainability and education**

From the 21st century onwards, the idea of sustainability will permeate agriculture as a whole. The issue of sustainability is inevitable and unavoidable in the face of a growing population and increasing demand caused by rising global living standards, which will lead to further environmental pressures. In the long term, activities that are resource-efficient, i.e. do not use more resources than necessary, must survive. The dissemination of sustainability ideas to graduates should be a priority, with a strong emphasis on this issue at all levels of education. Sustainability issues can be taught either as a stand-alone subject or integrated into specific subjects, thus deepening students' knowledge. Most conscious people are expected to be aware of the requirements of sustainability. It is important to note, however, that some disciplines have a key role to play in enforcing these requirements. In addition to the development and implementation of educational and methodological reforms, further action is needed to ensure that the key message of sustainability is communicated to students in higher education.

### **3. DATABASE AND DESCRIPTION OF THE METHODS USED**

During the writing of the dissertation I conducted both primary and secondary research. In the initial phase of my research I only focused on sustainable forest management. During the analysis of the secondary research and studies, I decided to focus on the global situation of food security and sustainability and the related interrelationships, as the original choice of topic would have limited the complex analysis of global issues too much. The research was preceded by a synthesis of the relevant literature on the subject. This involved identifying papers, studies, publications and databases in the international and Hungarian literature. My primary research began following the evaluative analysis of these resources. My fundamental objective was to identify the challenges facing humanity and to examine them from a domestic perspective. Recognising that our future depends fundamentally on us and on the young generation, I included university students in my primary research sample, thus presenting their knowledge, attitudes, values and knowledge of the topic under study. The study of this target group is of exceptional importance, as it is from this group that future decision-makers are likely to emerge.

#### **3.1. Presentation of secondary research**

Secondary data used in the writing of this thesis are from the United Nations (UN), Food and Agriculture Organization (FAO), International Energy Agency (IEA), Our world in data and Google Scholar databases. In my study of the literature on global challenges, I relied on secondary data in the first phase of research on this topic. During the research, however, I was confronted with the fact that the international literature is the most important source of studies presenting extensive and complex analyses, while the domestic sources are currently scarce. The literature search was mainly carried out with the help of Google Scholar. I used the keywords *food security, food availability, climate change, climate change and agriculture, water scarcity, biodiversity, biodiversity and agriculture, population growth, land use, sustainable higher education, sustainable development* and the combinations of them. For Google Scholar, I first sorted by relevance, then by the number of citations and their location. I aimed to cite the most relevant, yet recent articles. Following the literature analysis, I developed my hypotheses and formulated my main objectives for the primary research.

### **3.2. Presentation of the primary research**

The primary research method I used was a questionnaire survey, based on classical descriptive statistics, supplemented by complex analyses. Over the last decade, we have observed an increasing use of multivariate methods in the field of food security. The tools used to interpret and analyse the results of my thesis included, in addition to traditional descriptive statistics, principal component analysis, two-stage cluster analysis and discrete choice experiment (DCE).

Overall, based on the sociodemographic characteristics of the sample, I found that the vast majority of respondents were female, with the highest level of education being a high school diploma and currently studying at bachelor level. The average respondent lives in a city in his/her own home, mostly with his/her family. The majority of respondents are generally in a sufficient income situation to live on, and are not necessarily able to save on their income, which they earn either as a wage or on a grant. However, it should also be pointed out that a very significant proportion of respondents do not have an independent income.

The comparison of independent groups was performed with the Wilcoxon rank sum test, which belongs to the family of non-parametric mean comparison tests. The test is known by several names, such as Mann-Whitney U-test or Mann-Whitney-Wilcoxon rank sum test. Like classical t-tests, it is used to compare a variable between two independent groups. In practice, it tests whether the distribution of the dependent variable is the same in the two groups. If so, they are assumed to come from the same population. The test assigns ranks to the values and uses the sum of the ranks in the calculation. This has two advantages: firstly, it eliminates the problem of outliers, the test does not assume a normal distribution of the data, and secondly, it can be used for ordinal scale comparisons (MANN - WHITNEY, 1947a, MANN - WHITNEY, 1947b, FIELD, 2013).

Both principal component analysis and factor analysis are used to reduce the sample dimension. The two methods give relatively similar results, but they start from different basic ideas. An important point to note about the calculated principal components is that, by default, orthogonal vectors are obtained in the calculation (which in practice means that the two vectors are not correlated). This avoids the negative effect of multicollinearity. In

summary, principal component analysis provides information not only about the patterns of variation in each variable, but also about the relationships between variables.

In the next part of the analysis, I performed a two-step cluster analysis, partly using the existing principal components. Cluster analysis is the process of clustering the data, i.e. sorting the data into homogeneous subgroups, taking into account certain criterion values for each respondent. The analysis does not distinguish between dependent and independent variables, but examines the relationships within variables. The number of groups is not known in advance, and they are formed on the basis of the data or on the basis of preliminary assumptions. Within the cluster analysis method there are several trends, such as hierarchical procedures and k-means cluster analysis (EVERITT et al., 2011). SPSS allows for the two-step cluster analysis method. Some problems of widely used clustering algorithms can be well avoided by using two-step cluster analysis. In particular, mixed type attributes can be handled well and the number of clusters can be determined automatically (BACHER et al., 2004).

In the last part of my questionnaire survey, I conducted a discrete choice experiment (DCE) in order to find out what preferences my respondents had in relation to the global challenges theme of the questionnaire. The discrete choice experiment is a preference assessment procedure that can also be used to handle so-called "Stated Preference" (SP) data. The properties of this data type include the fact that it examines the choices of individuals in a hypothetical situation (designed by the researcher). The method is based on the utility-maximising behaviour of decision-makers, decomposes total utility into a systematic (observable by the researcher) and a random (everything that does not belong to the systematic part) component (*Equation 1*), and assumes a discrete decision situation.

$$U_{n,i,t} = V_{n,i,t} + \varepsilon_{n,i,t}, \quad (1)$$

where  $n$  denotes the decision maker,  $i$  the alternative,  $t$  the decision situation,  $U$  the total utility,  $V$  the systematic part of the utility, and  $\varepsilon$  the random component of the utility (LOUVIERE et al., 2010).

To process data from discrete choice experiments, researchers now have a number of model specifications at their disposal. One of the oldest and most widely used of these is the

conditional logit (CL), named after McFadden. In this model, the systematic part of the utility can be written according to *equation 2*.

$$V_{n,i,t} = \beta_k X_{n,i,t}, \quad (2)$$

where  $k$  is the property under consideration and  $\beta$  is the parameter vector estimated for the property under consideration (MCFADDEN, 1974).

In the case of my research, the utility for the  $i$ -th alternative can be written according to *equation 3*.

$$\begin{aligned}
U_i = & ASC_i + \beta_{\text{Élelmiszerell. köz. font.}} \text{Élelmiszerell. köz. font.}_i + \\
& \beta_{\text{Élelmiszerell. nagy. font.}} \text{Élelmiszerell. nagy. font.}_i + \\
& \beta_{\text{Vízszüks. köz. font.}} \text{Vízszüks. köz. font.}_i + \\
& \beta_{\text{Vízszüks. nagy. font.}} \text{Vízszüks. nagy. font.}_i + \\
& \beta_{\text{Termőföld köz. font.}} \text{Termőföld köz. font.}_i + \\
& \beta_{\text{Termőföld nagy. font.}} \text{Termőföld nagy. font.}_i + \\
& \beta_{\text{Időjárás köz. font.}} \text{Időjárás köz. font.}_i + \\
& \beta_{\text{Időjárás nagy. font.}} \text{Időjárás nagy. font.}_i + \\
& \beta_{\text{Biodiverzitás köz. font.}} \text{Biodiverzitás köz. font.}_i + \\
& \beta_{\text{Biodiverzitás nagy. font.}} \text{Biodiverzitás nagy. font.}_i + \\
& \beta_{\text{Energia köz. font.}} \text{Energia köz. font.}_i + \\
& \beta_{\text{Energia nagy. font.}} \text{Energia nagy. font.}_i,
\end{aligned} \quad (3)$$

where  $ASC_i$  denotes the alternative-specific constant term estimated for the  $i$ th alternative.

From the different attributes, I constructed alternatives and decision positions using a D-efficient experimental design. This was implemented using Ngene 1.2 software (CHOICEMETRICS, 2018). The final design consisted of 16 decision situations, which I organized in 2 blocks, so that the completers were confronted with only a subset of the choice situations (8 decision situations). The decision situations in my questionnaire contained three options, none of which included a "no response" option. I therefore presented my sample of respondents with a so-called "forced choice". I conducted my CL model estimation, presented in the results section, using the R Apollo package (HESS - PALMA, 2019b, HESS - PALMA, 2019a).

## **4. MAIN FINDINGS OF THE THESIS**

### **4.1. Testing the knowledge of the respondents on the topic**

I started my primary research with a descriptive statistical analysis to test the validity of my first hypothesis. The statement of my first hypothesis is "H1: *The university-age population lacks reliable knowledge and information about global challenges.* " I consider my first hypothesis, that the university-age population does not have reliable knowledge and information about global challenges, as semi-accepted. Based on their answers, the respondents have knowledge about most of the factors I have asked about, but this knowledge is not always reliable, which is supported by some of the analyses.

I was able to test my fourth hypothesis precisely from one of the questions in the questionnaire. Statement H4 states that "*University students mainly blame agriculture as a source of environmental problems.* " I do not accept this hypothesis, as other factors such as waste production, industry, wasteful human consumption, energy production and transport were ranked higher than agriculture as the sector responsible for global environmental problems.

### **4.2. Principal component and cluster analysis of each set of questions**

With regard to the second hypothesis, principal component and cluster analysis provided clear answers. My second hypothesis was formulated as follows: '*University students can be divided into well-defined groups according to their level of education, based on their perception of importance of environmental aspects, regulatory and institutional systems.* "' The answer to this hypothesis is partially addressed in the *Main component and cluster analysis of each question group* chapter and the *Results of the conditional logit model estimation* chapter of the dissertation. I accept this hypothesis, and the proof of the hypothesis is briefly presented in sections 3.2 and 3.3 of the thesis statement.

My third hypothesis was that "H3: *University students can be divided into well-differentiated groups based on their knowledge of global issues and their monitoring of these events.*" This hypothesis was answered in detail in the chapter on *Principal Component and Cluster Analysis of each group of questions* in my thesis, and can be found in section 3.2 of my thesis booklet.

In order to continue testing the hypotheses, I conducted a principal component analysis in order to reduce the number of variables in the set of questions. The analysis was based on the question on the concepts of food security and the question on the role of the factors of most concern to the respondents.

In the next step, homogeneous groups (clusters) were formed in the sample. As the clustering algorithm is less efficient when the number of variables is high, I used the results of the principal component analysis for the group of questions 2.11. instead of the original variables, as this analysis best fits my research objectives. In the analysis, principal component 1 is mostly loaded with weather, climate and climate change, hence the name ÖKE (ecological-environmental balance). For Principal Component 2, food security, food safety and biodiversity were strongly dominant, hence the name EKE (human-environmental balance). Based on these results, a two-step cluster analysis was performed using the principal component result. To design the clusters, I tested the effect of several interactions - created from my variables - to find the best fit. These variables were chosen to be related to traditional sociodemographic characteristics (gender of respondent, permanent address, education level) on the one hand, and to sustainability issues (e.g. whether they monitor global challenges) on the other (*Table 1*).

**Table 1: Results of principal component analysis on conceptual knowledge (N=689)**

| <b>Claim</b>         | <b>Component 1<br/>(ÖKE)<br/>Cronbach's <math>\alpha</math> = 0.926</b> | <b>Component 2<br/>(EKE)<br/>Cronbach's <math>\alpha</math> = 0.839</b> |
|----------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Weather              | <b>0,931</b>                                                            | 0,214                                                                   |
| Climate              | <b>0,929</b>                                                            | 0,208                                                                   |
| Climate change       | <b>0,895</b>                                                            | 0,291                                                                   |
| Land use             | <b>0,673</b>                                                            | <b>0,469</b>                                                            |
| Food security        | 0,164                                                                   | <b>0,904</b>                                                            |
| Food safety          | 0,204                                                                   | <b>0,872</b>                                                            |
| Environmental safety | <b>0,532</b>                                                            | <b>0,622</b>                                                            |
| Biodiversity         | 0,244                                                                   | <b>0,590</b>                                                            |
| Energy dependence    | <b>0,515</b>                                                            | <b>0,558</b>                                                            |

*Note: Selection method: principal component analysis (PCA); Total explained variance: 74.187%, Bartlett's test for sphericity:  $\chi^2 = 5280.499$ ,  $p < 0.001$ ; Kaiser-Meyer-Olkin criterion = 0.873; Cronbach  $\alpha$  value = 0.907; Question 2.11. Are you familiar with the following concepts (Please mark answers 1 to 7, where 1 is not at all, 7 is maximally informed, 0 do not know/do not want to answer)? For the purposes of this comparison, 0 respondents have been excluded.*

*Source: own data (2021)*

Of the 4 clusters formed, cluster 1 had the highest mean value of 0.28 for principal component 1, which means that the respondents in this cluster are self-reported to be aware of the definitions of the ÖKE factors of the conceptual definitions I interviewed. For principal component 2, we see a negative mean sign, i.e. they were less familiar with the delimitations of the factors I listed for the EKE part of the questionnaire (Table 16). Cluster 1 includes only women (164), the majority (34.3%) live in cities, 29.7% in villages, 26.8% in county seats, and none in the capital. The respondents in cluster 1 are all (164) following up on global challenges, all (164) are studying at FOSZ or BSc level. Therefore the cluster's name is Attentive University Women.

**Table 2: Cluster characteristics (main, N=689)**

|                                                     | <b>Attentive University Women</b> | <b>Neutral Graduate Students</b> | <b>Postgraduate Interests</b> | <b>Attentive University Men</b> |
|-----------------------------------------------------|-----------------------------------|----------------------------------|-------------------------------|---------------------------------|
| <b>Your gender:</b>                                 |                                   |                                  |                               |                                 |
| Male                                                | 0                                 | 52                               | 41                            | 121                             |
| Female                                              | 164                               | 109                              | 69                            | 0                               |
| <b>Type of municipality of permanent residence:</b> |                                   |                                  |                               |                                 |
| Village                                             | 38                                | 45                               | 19                            | 26                              |
| City                                                | 92                                | 83                               | 34                            | 59                              |
| County seat                                         | 34                                | 33                               | 24                            | 36                              |
| Capital                                             | 0                                 | 0                                | 33                            | 0                               |
| <b>Do you monitor any of the global challenges?</b> |                                   |                                  |                               |                                 |
| Yes                                                 | 164                               | 0                                | 88                            | 121                             |
| No                                                  | 0                                 | 161                              | 22                            | 0                               |
| <b>Completing training level</b>                    |                                   |                                  |                               |                                 |
| BSc                                                 | 164                               | 161                              | 16                            | 121                             |
| MSc                                                 | 0                                 | 0                                | 94                            | 0                               |

*Note: 0 fillers were not included in the comparison.*

*Source: own data (2021)*

Based on the characteristics of cluster 2, the respondents belonging to this cluster were less informed about environmental factors (ÖKE), (mean value: -0.22), meaning that the

respondents belonging to this cluster were less familiar with the definitions I asked. On the other hand, the EKE section (Principal Component 2) was dominant with a mean value of 0.18, i.e. respondents in this cluster could be considered more familiar with the factors covered (Table 16). In terms of gender, there is a difference here compared to cluster 1, with 52 respondents being male and 109 female. Of the cluster respondents, 83 had a city, 45 a village and 33 a county as their type of permanent address, with no respondents from the capital city in this cluster. It is interesting to note that none of the cluster 2 respondents (161 respondents) follow the issue of global challenges. All cluster respondents are currently studying at FOSZ or BSc level (161 respondents) (Table 2), the name of the cluster is Neutral Graduate Students.

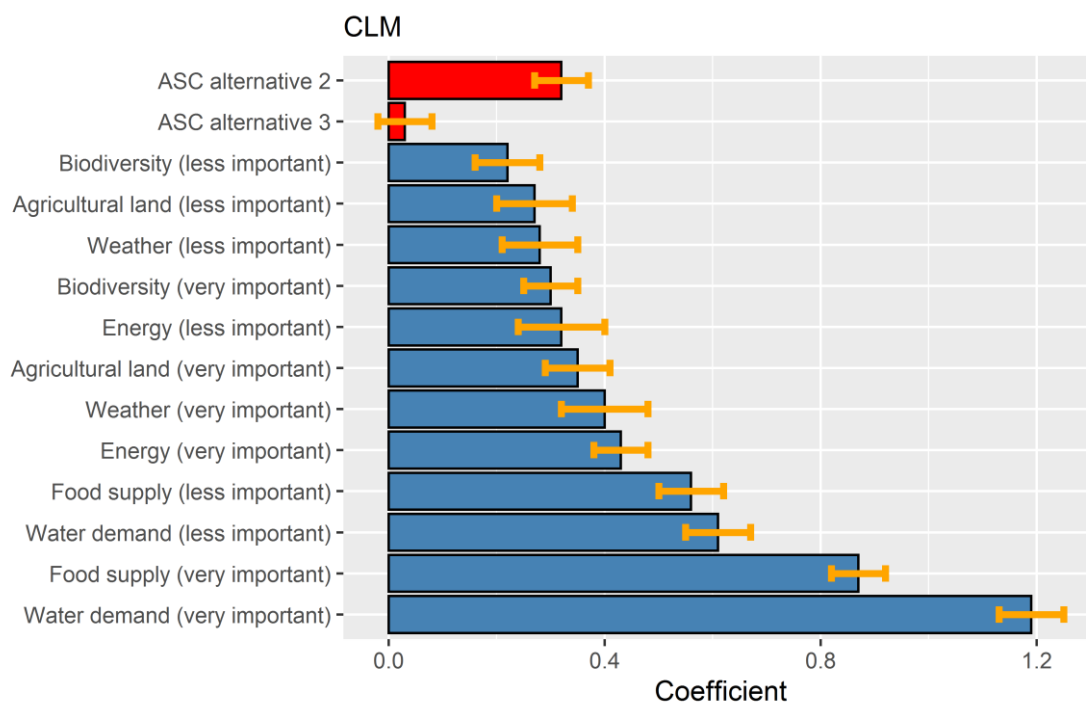
Cluster 3 students had a more important first principal component (ÖKE), based on the mean value of centroids (0.21), so it can be said that students belonging to this cluster were mostly aware of the definitions according to their own perception. Students belonging to this category were less aware of principal component 2 (EKE), as the mean was negative. This suggests that students in this cluster were less familiar with most of the EKE concepts (Table 1). Of the students in cluster 3, 41 were male and 69 were female. Here we find fillers from all types of municipalities, with the highest proportion of fillers from the capital city, 33. In addition, 34 live in cities, 24 in county towns and 19 in villages. In the cluster, 88 respondents follow the events of the cluster under study, while 22 do not. In terms of educational level, there is already a difference with the previous two clusters, as the majority of the respondents are studying for an MSc/PhD (85% of the cluster, 94 people), with the remaining 16 studying for a bachelor's degree (Table 2). The cluster name is Postgraduate Interests.

For cluster 4, the ÖKE factors were less important, as the mean value was negative (-0.21), indicating that the respondents in this cluster were less familiar with the definitions I asked about. However, in the case of the EKE, they are aware of the definitions included here, as the mean value was 0.23 and had a positive sign, indicating in this case that the respondents in this cluster are very aware of the factors I listed (e.g. food security, food safety, biodiversity) (Table 1). 100% of the respondents in this cluster are male, which represents 121 respondents. As regards the distribution by type of municipality of residence, 59 of the cluster members live in cities, 36 in county towns and 26 in villages. 100% of the cluster

follows global challenges. There is also no difference in terms of educational level, as all 121 people have studied at BSc/FOSZ level (*Table 2*). Therefore the name of the group is Attentive University Men.

### 4.3. Results of the conditional logit model estimation

The results of my conditional logit (CL) model estimation based on the utility function presented in *Equation 3* are presented in *Figure 2*. It is important to mention that, in order to maintain a balance between the two blocks and to eliminate incomplete responses, I worked further with a reduced sample ( $N=521$ ).



**Figure 2: CL model estimation results (N=521)**

*Note: The column size is the estimated coefficient value, the error bar is the standard error of the coefficient. In the estimation process, ASC alternative 1 and the "not important" level of the attributes tested were used as the base; \*\*\* significant at 1% level; AIC: Akaike information criterion; BIC: Bayesian information criterion.*

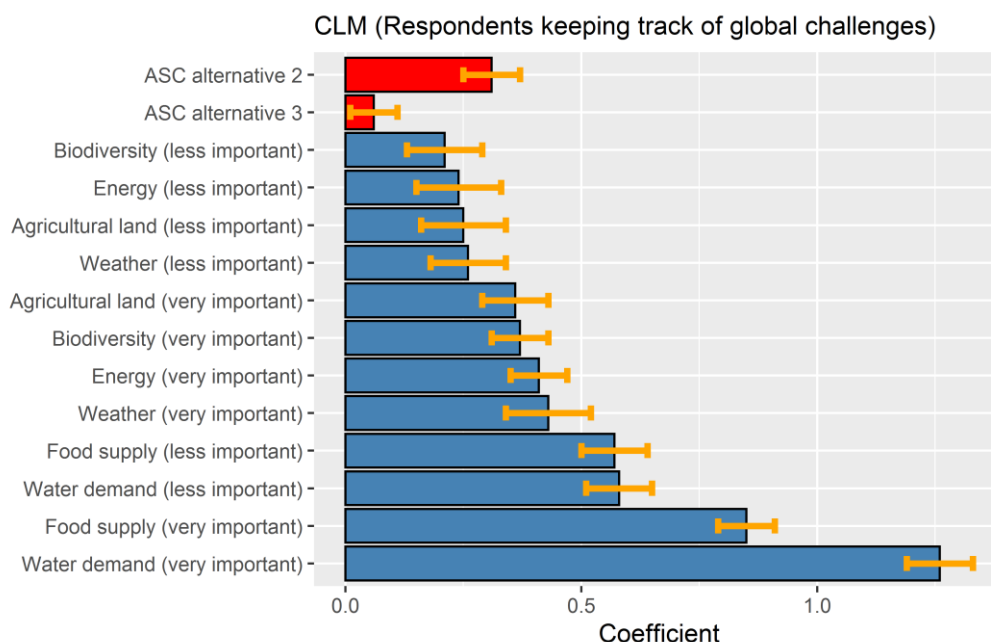
*Source: own construction, 2021*

I estimated a positive and significant value for the alternative-specific constant of the second option (ASC alternative 2). From this I can conclude that some decision regularity (the second alternative was significantly more preferred than the first one) prevailed among the completers (*Figure 2*). For the attributes examined, it can be seen that they all have a positive sign and a significant effect. Water and food supply have the greatest impact on the "sense of importance" of the respondents. The issue of water availability has been dominant throughout our history, along with the stability of food supply. The issue of the importance

of water has been discussed in detail in the literature section. Furthermore, the water issue is also a frequent element in the media, so it is likely to have influenced respondents' preferences. It can also be seen that the other attributes are ranked at about the same level in the respondents' value judgements. The least important aspect is biodiversity (*Figure 2*). Biodiversity enhances ecosystem productivity, where each species, however small, plays an important role. As discussed in the previous chapters, this section shows that fillers attach little importance to the healthy existence of biodiversity. We know that the main causes behind biodiversity loss are land-use change (deforestation, intensive monoculture, urbanisation), direct exploitation such as hunting and overfishing, climate change, pollution, invasive alien species.

#### 4.3.1. Model estimation results (respondents following global challenges)

Also based on the utility function formula presented in *Equation 3*, I performed CL model estimation, with the difference that in this case I worked with only a subset of respondents ( $N=358$ ). I restricted my analysis to the choices of respondents who were monitoring any of the global challenges issues (question 2.1) (*Figure 3*).



**Figure 3: CL model estimation results (respondents following global challenges)**  
( $N=358$ )

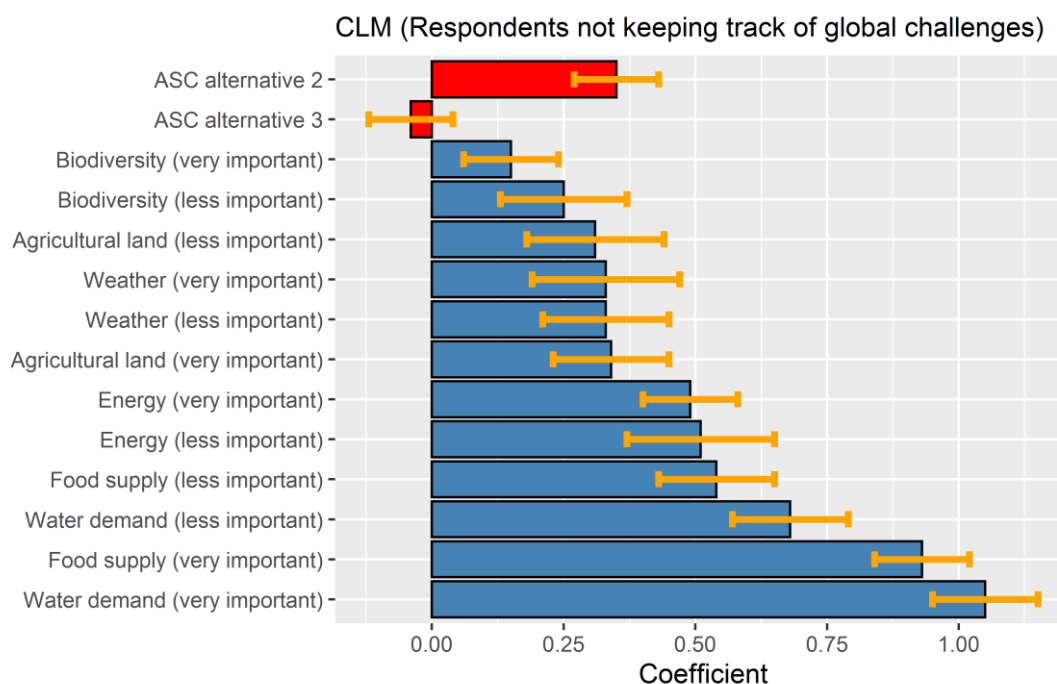
*Note: The column size is the estimated coefficient value, the error bar is the standard error of the coefficient. In the estimation process, ASC alternative 1 and the "not important" level of the attributes tested were used as the base; \*\*\* significant at 1% level; AIC: Akaike information criterion; BIC: Bayesian information criterion.*

*Source: own editing (2021)*

In the present case, I also estimated a positive and significant alternative-specific constant parameter for the second option, from which I can also conclude that there was a certain degree of regularity in the choices (the second option was chosen significantly more often than the first option, which represents the base level) (*Figure 3*). Based on the estimated coefficients for the attributes, it can be seen that for the sample monitoring one of the global challenges issues, the most important element is the issue of water needs, followed by food supply (similar to the overall sample). The least important attributes are land and biodiversity.

#### 4.3.2. Model estimation results (respondents not following global challenges)

In the next step, model estimation was also carried out for the other subgroup ( $N=163$ ), which does not follow any of the global challenges. The results are presented in *Figure 4*.



*Note: The column size is the estimated coefficient value, the error bar is the standard error of the coefficient. In the estimation process, ASC alternative 1 and the "not important" level of the attributes under consideration were used as the base; \*\*\* significant at 1% level, \*\* significant at 5% level, \* significant at 10% level; AIC: Akaike information criterion; BIC: Bayesian information criterion.*

**Figure 4: CL model estimation results (respondents not following global challenges) (N=163)**

*Source: own editing (2021)*

As in the two previous model estimations, the conclusion that there is a regularity of choice was confirmed (the second alternative was chosen significantly more often than the first

option) (*Figure 4*). Based on the estimated coefficients for the attributes considered, it can be concluded that for this subgroup, water needs and food supply are also the most important. However, weather is the least important factor besides biodiversity, which is slightly different from the results obtained in the previous subgroups. Consequently, it can be observed that no significant differences were found between the DCE model estimates for the full sample and the two subsamples.

According to *my second hypothesis*, university students can be divided into distinct groups according to their level of education, based on their sense of importance for environmental aspects, regulatory and institutional systems. Respondents can be clearly divided into groups according to their level of education and their sense of importance and their responses can be well separated on the basis of the analyses, and I therefore accept this hypothesis as well.

*My third hypothesis*, that university students can be divided into well-differentiated groups based on their knowledge of global issues and their monitoring of these events is accepted. The cluster analysis clearly shows the different groups by level of education, gender and age. Furthermore, the groups can be distinguished in terms of whether they keep track of global challenges.

## 5. CONCLUSIONS AND RECOMMENDATIONS

The forward-looking nature of my primary results allows for future practical applications. Due to the methodology of the study and the significance of the research carried out, my conclusions and recommendations also provide new impulses for the scientific community. My results and the conclusions drawn from them are summarised below.

In the course of the secondary research and literature synthesis, I found that the significance of global sustainability challenges is no longer in question. The international and Hungarian research community is paying attention to this issue in line with the importance of the topic, but practical surveys of university students in Hungary have not yet been widespread. By conducting my primary research, I therefore aimed to survey this unstudied community.

While the majority of the students surveyed follow events related to global challenges, it is important to highlight that, despite this fact, there was often confusion among respondents. The respondents' self-reported familiarity with the conceptual difference between weather and climate is, in my view, a positive development, as my experience so far has shown that the two terms are often confused and used as synonyms by lay people, which is not technically correct. After synthesising some studies in the literature, I found similar research to my own findings. The studies presented in my thesis deal in detail with sustainable consumption as a vital tool that can improve quality of life by reducing environmental pressures, improving resource efficiency and helping to meet future resource needs. The studies also highlighted that students' information about the environment comes mostly from social media, followed by television and a minority of print media. This finding highlights the importance of the role of the internet as a primary source of 21st century news. A study of the literature has revealed that it is not only students who display a lack of knowledge or an occasional conceptual confusion, but also teachers. Most of the teachers' associations with sustainability came from environmental issues, with the interaction of ecological, economic and social dimensions, which is prevalent in all modern concepts of sustainability, rarely mentioned.

Education is an important pillar in ensuring sustainable development, because through education people understand and learn how to become more responsible and humble towards the environment. Studies in the 21st century show a direct link between investment

in education and economic, social and human development. Achieving the Sustainable Development Goals requires a broad and focused effort by actors in all sectors, including higher education. Given that higher education is one of the key drivers of intellectual development in a country, it provides an opportunity for universities to play a greater role in the transfer of sustainability knowledge. My results show that students first acquired their knowledge of global challenges during their primary and secondary school education. My research has shown that the subjects taught in higher education have not been able to deepen students' knowledge enough, and that a greater role should be given to teaching this topic in higher education. It may be appropriate to include subjects specifically dealing with the topic in curricula and training plans.

In my view, the knowledge acquired at different levels of the education system is the result of the fact that respondents gave clearly high scores for the seriousness of the problems under examination. I also looked at the role that each factor might play in solving or mitigating the impact of global problems. In addition to the responsibility of individuals, respondents also stressed the role of institutions and decision-makers.

According to respondents, increased unsustainable food production has a major impact on the environment, particularly in terms of water supply problems and extreme weather. Respondents blame waste production and industrial activities for sustainability problems in particular. This again supports the role of the media, where images of "environmental pollution" are mainly associated with high levels of waste and industry. In relation to the issue of responsibility, the individual, consumer side came to the fore, suggesting that respondents were consistent in their answers.

My research showed that respondents' main barriers to adopting a sustainable lifestyle are lack of financial resources and lack of opportunities. I also found a correlation with this result based on the literature presented in the previous chapters. Lack of financial resources has emerged in the results of several studies as a major barrier to the sustainable development of higher education. In addition to financial reasons, I also found similarities with my own results in the literature, which can be attributed to accessibility and lack of opportunities. From the results of the principal component analysis and my cluster analysis, I separated my students filling out the questionnaire into four distinct groups, which can be helpful in developing a strategy for future sustainability education.

The already slow progress towards the UN Sustainable Development Goals has been severely set back by COVID-19. The emergence of the COVID-19 pandemic has brought new challenges to all walks of life worldwide. Austere measures, shut down economies and financial expenditure to contain the pandemic emergency have resulted in a slowdown in socio-economic development. These austerity economic measures are already being felt in economically developed countries despite the short timeframe, i.e. developing countries are likely to be more affected by these measures. The impact of the coronavirus will not only affect Objective 1 (eradicate poverty) and 2 (eradicate hunger). In many countries, the shutdown has prevented people from going to work for an unforeseen period of time, thus setting back economic recovery. In many cases, the difficult economic conditions have led to people losing their livelihoods (thus affecting Goal 8, Decent Work and Economic Growth). The situation may increase the likelihood of conflict (within and across borders) and therefore threatens the goal of global peace (Goal 16: Peace, Justice and Strong Institutions). Schools and universities in many countries have been closed down, leaving educational institutions to try to sustain themselves through online education programmes. Many students in developing countries do not have access to the Internet or computers, and therefore do not have access to online learning. The epidemic is therefore also causing problems in the field of education (Goal 4: Quality Education). The COVID-19 epidemic also highlights the link between clean water and health, especially as a large percentage of the world's population does not have access to adequate sanitation and drinking water, which is an additional risk factor in pandemic times.

The key to achieving sustainability is to prepare the next generation. But this preparation requires a further reinterpretation of education. The education of sustainability seeks answers to a number of challenges that require a transdisciplinary and complex approach. Given the complexity of the problems to be addressed, it is crucial to recognise the interlinkages and to respond rapidly and in a targeted manner. The main aim of sustainability education is to help the rising generation to develop a mindset that does not approach a challenging problem from a static, single direction or starting point, but also seeks cross-cutting solutions to the complexity of each problem. The dissemination of ideas around sustainability should be a priority for graduates, with a strong focus on this issue in education at all levels of education. In practice, sustainability issues can be taught as a stand-

alone subject or integrated into specific subjects, thus deepening students' knowledge. The role of the education system in addressing global agricultural challenges is twofold. On the one hand, there is a strong need to communicate sustainability at all levels of education and, on the other hand, the education system needs to raise awareness of global problems and challenges. There is a great need to educate students about their individual consumption habits and responsibilities, highlighting how they themselves can mitigate or exacerbate global problems. In addition to the development and implementation of educational and methodological reforms, further action is needed to ensure that the key message of sustainability is communicated to students in higher education.

## 6. NEW OR NOVEL RESULTS OF THE THESIS

1. I have carried out an extensive source analysis on the topic of global challenges, mainly by synthesising relevant international literature. In this context, in addition to the literature, I have also provided a complex overview of the various regulatory and policy frameworks and their major developments over the last almost 80 years. In addition to today's population, the responsibility of the future generation is inescapable in addressing the issues under study, and I have also presented the relationship between global challenges, sustainability and education in a complex way using a synthesis chart. Based on the literature synthesis, I have concluded that the teaching of sustainability in higher education needs to be strengthened at all levels of education. Based on the results of the primary research, there is a clear need to put this into practice in Hungary.
2. In the field of management and organisation sciences, no research has been conducted in Hungary that has examined the knowledge and opinions of university students on global challenges in such detail.
3. As a result of the analysis of the responses in the survey sample, I found that the university age group does not have a full knowledge and awareness of global challenges. Based on the responses, I conclude that some elements of the topic are given higher importance by the respondents, while others are given lower importance.
4. Based on my primary results, the hypothesis that the university students in the sample hold the environmental pressures of agriculture, which is a key element of environmental problems according to the literature, responsible for the development of global problems, was not confirmed. In the light of the results, respondents attribute greater responsibility to waste production, industry and wasteful human consumption.
5. Using the results of the factor analysis, I was able to classify the students in the sample into four clusters in a two-step cluster analysis. Of these, students form well-defined clusters according to whether or not they follow the global challenges event cycle, and each cluster is well characterised by differences in gender, age, permanent address and current education level.

6. I was the first to apply the discrete choice experiment (DCE) as a novel methodological approach in the field of management and organization sciences in Hungary, among university students, and thus demonstrated the applicability of the method in this field. On the basis of the study, I found that water needs and food supply have the greatest impact on the "sense of importance" of the respondents, while biodiversity has the least impact.

## **7. PRACTICAL USE OF THE OBTAINED RESULTS**

The results of the dissertation can be used in a complex way in several areas. Due to the multi-faceted nature of the study, the outputs of both secondary data analysis and resource synthesis and primary data collection and analysis can be used by policy makers, institutions at different levels of education, and consumers and their communities.

Among decision-makers, there are a number of potential stakeholders who could benefit from the results of the research in their operations. The outputs of primary research can be used by decision-makers active in agriculture, environment, water management, energy, climate, food, education and trade. This may include departments of the various sectoral line ministries (notably the Ministry of Agriculture, the Ministry of Human Resources, the Ministry of Innovation and Technology, and the Ministry of Foreign Affairs and Trade, given the global nature of the issue), legislative and decision-making bodies (notably the National Assembly and its committees), and regional and local governments), professional organisations (such as the National Chamber of Agriculture, the Hungarian Chamber of Commerce and Industry, the National Trade Association, the National Association of Employers and Industrialists), higher education institutions, public education institutions, education management organisations, research institutes and NGOs. Among these same groups, it is primarily organisations and decision-makers in the field of education and research that can use the results of secondary research and data analysis in their operations.

I would particularly like to highlight the relevance of my findings to pedagogy and teaching methodology. As a result of the study, I found that the global challenges of sustainability are a topical issue of great public interest, but that there are wide differences in the opinions on the importance of the different sub-areas. In view of possible gaps in knowledge and misconceptions, it is essential to strengthen the teaching of these issues at various levels of public and higher education.

Among the findings of the study, I consider it a strong indicator that the students in the sample are aware of their individual responsibility for global sustainability challenges. This means that, even if their knowledge may be incomplete, they typically care about the vision of sustainability. As a result, the outputs of the study are also well placed to be used by organisations that are in contact with individual consumers as end-points in supply chains,

as traders. However, it is also important to underline the role and responsibility of the media: influencing individual awareness and promoting sustainable lifestyles is already an important task for opinion leaders today.

## 8. SUMMARY

The population of every other species on Earth (except humans) may reach a maximum number of individuals over a certain period of time that is no longer sustainable with natural resources. Beyond its limits, the human population has increased dramatically in recent decades and we continue to use the majority of our finite resources unsustainably. Changing current trends will require all generations and social groups to act. Students are a group of people who have a greater responsibility than the average, i.e. whose address is of strategic importance. This is particularly important because today's higher education graduates will soon be entering the labour market, where they will have a good chance of finding higher positions as a result of the knowledge and qualifications they have acquired. As potential leaders, they will have the opportunity to bring sustainability to the forefront of the decision-making process. Agriculture and food security are closely linked. Providing a growing population with sufficient food in sufficient quantity and quality must be done sustainably and with scarce natural resources. The importance of the young generation is an inescapable key to achieving sustainability.

A wide range of definitions and conceptual frameworks can be found in the literature exploring food security and related areas. In addition to the day-to-day relevance of the topic and the conceptual delineation, the changes in regulation are also very important as they indicate the elementary process of how food security has become a vital policy area. The framework of the UN Sustainable Development Goals (SDGs) is used throughout the paper to provide a framework. It has played a fundamental role in the final formulation of the literature or even primary research. As an EU Member State, the role of the CAP is prominent, both at EU and national level. A key objective for the future of the CAP is to better prepare EU agricultural policy for current and future challenges, while continuing to support European farmers in their current needs.

In addition to agricultural land, the growing population also has a major impact on resource use. The issue of water is one of the most serious dilemmas facing the planet, and solutions are becoming increasingly urgent. Climate change has a significant impact on water resources and thus on human livelihoods, especially in regions and countries affected by water scarcity. There is a close link between climate and climate change policies and water

management, as the availability of freshwater is essential to ensure a sustainable future. In addition to water, the availability of arable land is a pressing issue. Much of the land that is suitable for agriculture but not yet cultivated can be acquired at the cost of deforestation, and its growth is limited mainly by the lack of infrastructure, which makes some land difficult to access. While current technologies can increase yields up to a certain level, it will be increasingly difficult to increase efficiency without adapting new technologies. Simple and advanced solutions can be combined to produce more food from less land. We can produce food in new places, even inside buildings, in cities, even in places where there is no soil. These practices reverse the process of land acquisition that humanity has practiced since the beginning of agriculture.

The food economy alone consumes around 30% of energy on a global scale. As the population grows, so does the demand for agricultural products, especially for higher value-added foods (meat, dairy products). Increasing agricultural productivity to meet this growing demand is not enough: it must be done in a sustainable way, using as few resources and energy as possible. Ensuring access to adequate energy for all is a pressing challenge for global development. But our energy systems also have important environmental impacts. If we could eliminate fossil fuels and harness nature's infinite resources (sunlight, wind, water and geothermal energy) instead of fossil fuels, we would already be solving some of the important elements of the global challenge.

Biodiversity refers to the diversity of species, ecosystems and living things, including all living things, from humans, plants and animals to the most primitive viruses. Biodiversity is an extremely important element in food production, but it also has a significant impact on pollination and the nutrient cycle. It is an interesting contrast that biodiversity is an essential requirement of agriculture, yet inappropriate agricultural activity is a major driver of biodiversity loss. Much of the new land under cultivation mentioned earlier begins with deforestation, but forests are an essential element in the 'healing' of our planet. They provide nature's best technology for carbon sequestration and are also centres of biodiversity. Again, these two attributes serve to justify the importance of forests. Tighter legislation can help stop the global spread of deforestation.

Mitigating the negative impacts of climate change and minimising biodiversity loss remains a key priority. Increasingly extreme climate change is making production risks higher,

which is also placing an increasing burden on farmers. Climate change can pose risks to food security stability for both rural and urban populations. Thus, negative changes in the environment due to instability may exacerbate the phenomenon of malnutrition (hunger) by limiting the availability and accessibility of food products. Extreme weather events can contribute to volatile food prices, which in extreme cases can lead to additional social problems such as riots or further increases in hunger, in addition to severe economic problems.



Registry number: DEENK/416/2021.PL  
Subject: PhD Publication List

Candidate: Dániel Fróna  
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MTMT ID: 10061698

### List of publications related to the dissertation

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**Total IF of journals (all publications): 4,993**

**Total IF of journals (publications related to the dissertation): 4,993**

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

26 August, 2021

