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INVESTIGATION OF FOOD WASTE GENERATION

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Abstract

According to the Food and Agriculture Organization of the United Nations (FAO), up to one third of all food is lost or wasted worldwide throughout the supply chain. It must be investigated how much food waste is generated in the whole food chain in reality, are consumers really responsible for the majority of food lavish, what are the main reasons for food waste and how can we minimize spoilage. In this review article a wide outlook of papers is given, published about food waste in last two years. It has been concluded, that additional data are needed to get a clear picture about the real quantities of wasted foods, because the available data are inconsistent.

In the reviewed papers, a lot of action have been published about how to reduce food wastage, starting from innovation in the industry, logistics, through creation by-product exchanges, development of demand forecast and product packaging, etc. up to substantial improvement of food literacy of the population. It is evident, that these actions will have some effect. In this case, the quantity and proportion of food waste will change, thus, the generation of waste is

dynamic. If it is dynamic, it can be modelled and forecasted on the basis of models created in future. In this way the research question can be answered.

Keywords: food waste, waste in food supply chain,

Összefoglalás

A FAO adatok szerint a világon az élelmiszerek harmada hulladékká válik az ellátási láncban. Meg kell vizsgálni, hogy valójában mennyi hulladék képződik a teljes élelmiszerellátási lánc egyes szakaszaiban, valóban a fogyasztók felelősek-e túlnyomórészt az élelmiszerveszteségért, illetve melyek az élelmiszer veszteség fő okai és hogyan lehet minimalizálni a pazarlást. E referatív cikk áttekinti az utóbbi két évben megjelent tudományos cikkeket. Megállapítást nyert, hogy további adatokra van szükség az elpazarolt élelmiszerek pontos mennyiségének meghatározásához, mert inkonzisztensek a rendelkezésre álló adatok.

E cikkben sok élelmiszerhulladék csökkentési akcióról olvasható az ipari és logisztikai innovációtól a melléktermék tőzsdén, igény-előrejelzés modell, valamint a csomagolás fejlesztésen át a lakosság élelmiszertudatosságának növeléséig. Evidens, hogy ezek nem maradnak hatás nélkül. Ebben az esetben viszont az élelmiszerhulladék mennyisége és a képződés helye szerinti aránya is változik. Ha pedig ez dinamikus, akkor modellezhető és a mennyisége és mennyiségi arányai előre jelezhetőek a jövőben. Így a kutatási kérdés megválaszolható.

Kulcsszavak: élelmiszer hulladék, hulladék az élelmiszerláncban

Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), up to one third of all food is lost or wasted worldwide throughout the supply chain. This corresponds to about 1.3 billion tons per year and represents a waste of resources, water, energy, land, and other inputs used for producing that food, including labour (Gustavsson et al. 2011). For Europe, different estimates are highly uncertain, mostly due to: different methods for quantifying food waste exist, different databases for the calculation are used (e.g. FAOSTAT and EUROSTAT), and a lack of harmonization in the nomenclature (Cristóbal et al. 2018).

Thanks to the recent Circular Economy (CE) package (EC 2018), food waste prevention has gained prominence in the European political debate. In fact, the CE Action Plan (EC 2015) included food waste within the so-called ‘‘priority areas”, i.e. areas that should be carefully considered to strengthen the circularity of the European economy.

The EU policy can, and has, led to significant amounts of avoidable wastage of fresh fruit and vegetables. However, the reforms of policy, even of those not specifically focused on food waste, such as the CAP, can have a positive impact on reducing the volumes of such loss and waste (Porter et al. 2018).

The subject of food loss and waste prevention recently gained much attention and priority among governments and international organizations, as a major means to achieve global food security and sustainability; this led to the very ambitious UN goal SDG12.3, which aims to halve global food losses by 2030 (Rosa 2017).

The target of this article is to review scientific literature about current results, used methods and further research proposals which must be considered in answering the research question.

How much food waste is generated in the whole food chain in reality, are consumers really responsible for the majority of food lavish, what are the main reasons for food waste and how can we minimize spoilage.

a) There is a notable inconsistency in data about food waste available from different sources,

b) The quantity and proportions of waste is not static, the dynamics can be modelled.

Results and Discussion

General factors

The research question and hypothesises are in accordance with conclusion of earlier studies, for example must be investigated (Muriana 2017): (1) Forecasting the food waste and loss by means of holistic-adaptive models, (2) Defining the analytical conditions responsible for the food waste and loss generation, (3) Redesigning the supply chain management models, (4) Verifying the affordability of food waste and loss management systems.

Food waste definitions and system boundaries need to be carefully selected and communicated in a transparent manner, as the chosen definition and system boundaries will impact the final results and conclusions (Hartikainenet al. 2018).

Both consumer behaviour and production practices play crucial roles in the efficiency of the food system. The substantial losses occurring during livestock production, and reveals the magnitude of losses from consumption of food in excess of human nutritional requirements. The greatest rates of loss can substantially affect the overall efficiency of the food system, and associated environmental impacts (e.g. greenhouse gas emissions) (Alexander et al. 2017). An

integrated metropolitan food systems and corresponding food policy and planning are gaining ground in the wake of growing urban populations, changing diets and consumption patterns, and with sustainable agriculture and food supply chain innovations and solutions to potentially reduce urban footprints and vulnerability to global changes. Thus, quantitative estimates about the relationship between food demand and regional production conditions are required to inform and support the design of food policy (Zasada et al. 2017).

A waste reducing plan needs to question the unlimited right to produce waste and orient waste producing actors toward waste prevention. A hard way could be to regulate through environmental permits the amount of waste that every business is allowed to generate. A softer way could be to financially promote waste prevention initiatives with a high effect on waste generation. However, this requires tools for evaluating the waste prevention effect of initiatives and balancing the three disparate parameters of waste prevention – quantity, impact, or hazardousness (Johansson et al. 2018).

A range of recurrent organizational factors may have an impact on reducing food waste in a causal sense, including: food market competition; impact of food imports upon customers; standardized food regulations; easy, open, low cost food market entry (easiness of market access); level of bureaucracy; working with local charities; one unified food authority; time to market; collaboration between food authorities and supply chain stakeholders (Irani et al. 2018).

The challenges food characteristics, supply chain uncertainty, food policy and regulation, and market infrastructure were determined to be the ‘key’ challenges inhibiting the reduction of food waste in Indian agri-food supply chain (Gokarnet al. 2017).

Food industry

A nontrivial amount of food loss is being attributed to the industrial/production level. An advantage of industrial food waste is that it is generally a more homogeneous resource that can be more readily converted into higher value products (RedCorn et al. 2018).

Industrial/production level was mentioned earlier. One possible way of reducing wastes is the developing of By-product Exchange Networks. They can transform the existing system - to sell waste as by-product, which will be used as raw material - into a much more effective one (Raabe et al. 2017).

Others (Raak et al. 2017), on the basis of case studies, made in Germany, concluded, that the causes of food waste generated during food processing are underrepresented in the scientific literature. They intend to fill these gaps by interviewing representatives from the food industry. The identified causes may be categorized as follows: (i) Losses resulting from processing operations and quality assurance; and (ii) Products not fulfilling quality demands from trade.

The innovation is most important in food industry. One example is described by (Matar et al. 2018), as shelf life modelling. Other example for innovation, in milk industry, less waste is generated from one product, if it has a longer shelf time (Spadaet al. 2018). Another example concerns the waste reducing effect of intelligent packaging (Poyatos-Racionero et al. 2018, Ahmed et al. 2017). Packaging has an effect too. The shape of box determines, how much product will be left unused, simply it will remain in box (Meurer et al. 2017). Innovation should prevail be in technology of production process too, because this can lead to less waste generation (Mustafa et al. 2017). Nonthermal plasma technology as an innovative procedure,

that can be used with a some favourable effect on packed food, reducing waste generation (Hati et al. 2018).

As the labelling (including date printing and electronical label reading solutions) has an important effect on food waste generation, the actors of food industry are stakeholders too, they bear a big responsibility (Wilson et al. 2017, Thompson et al. 2018, Chen et al. 2017).

The farming conditions and slaughtering technology have an effect on the meat industry waste generation, through confiscating (Jaja et al. 2018).

Food supply chain

Food loss is an issue in the upstream stages of the supply chain, with rates varying from 3 to 12%, depending on the sector (Broekmeulen et al. 2017, Ju et al. 2017). Food waste can be reduced, for example, with the Dynamic Industry Resource Efficiency Calculation Tool (Verghese et al. 2018). Other researchers found inconsistency in data regarding the generated wastes in supply chain (Cicatiello et al. 2017; Chaboud 2017). On the basis of 26 German case study initiatives tackling consumer food waste, these can be categorized into three main categories: (i) information and capacity building initiatives aimed at supporting consumer motivation and ability to avoid food wastage. (ii) redistribution initiatives as 'classical' foodbanks or consumer led actions (iii) supply chain initiatives, as actions by conventional retailers or other established or new actors in the supply chain, that tackle food waste through altering retail sale or the supply chain functioning (Aschemann-Witzel et al. 2017). The root causes of food waste generation are well known yet (Teller et al. 2018).

Innovation plays an important role in supply chain too. For example, the ultrasonic humidification can reduce the post-harvest losses of selected fruits and vegetables in Europe

by up to 23% compared to conventional supply chains. (Fabbri et al. 2018) The controlled atmosphere of storage, with increased CO_2 content in air, leads to longer shelf life (Alamar et al. 2017). Other waste reducing innovations are the using of wireless technics and RFID solutions (Badia-Melis et al. 2018, Lorite et al. 2017). The demand forecast with modelling is a good up-to-date tool to reduce leftovers (Birisci et al. 2018). Waste likelihood is higher when food items are purchased via online (vs. in-store) grocery channels, (Ilyuk 2018) and in delivery system too (Fikar 2018). Waste could be reduced in shops with lowering storage temperature (Erikssonet al. 2016) and in whole supply chain (Zhao et al. 2018). The computer assisted ordering (CAO) or automated order systems (ASO) can be evaluated as innovative solutions too (Haijema et al. 2018).

New business models (for example social co-op project, Fruta Feia, developed in Portugal) change the paradigm in society regarding the consumption of fruits and vegetables following aesthetic rules, because the food waste due to aesthetic reasons is a problem in most developed countries (Ribeiro et al. 2018, de Hooge et al. 2018). In this paragraph reprocessing must be mentioned the, e.g. frying the fresh meat leftover in meat shop (Kawata et al. 2018). Food bank activity becomes wider and wider (Sewald et al. 2018).

Expiration date-based pricing as a food marketing approach for foods currently wasted at the retail stage should become a practice perceived favorably by consumers. In consequence, it can become more efficient and widespread, allowing to save greater quantities of food from wastage with less resource use and effort. As an implication for consumer behaviour research literature, the findings do not confirm a negative quality inference of price reduced suboptimal food nor the counteraction provided by the positive quality inferences tested, but in turn underline the relative role of familiarity (Aschemann-Witzel 2018). Expiration date based pricing was mentioned by other authors too, using "dynamic pricing" expression

(Adenso-Díaz et al. 2017, Buisman et al. 2017). But in other cases several marketing actions, as promotion can lead to the increasing of food wastes (Le Borgne et al. 2018, Swaffield et al. 2018). Bigger On Shelf Availability may be evaluated as marketing activity and leads to more waste (Broekmeulen et al. 2017).

Developed logistics solutions can reduce food wastes in the whole agri-food chains by taking back the leftover (Fancello et al. 2017). Other authors state it as preferences of take-back agreements (Eriksson et al. 2017). The route optimization in emergency and everyday cases is another logistics possibility to reduce wastes (Mejjaouli et al. 2018, Mercier et al. 2018).

In several countries administrative policies lead to reducing of food waste. Tax credit and disposal fee are substitute mechanisms for inducing food donation (Lee et al. 2017). In Sweden, on the basis of cost-benefit analysis, it is suggested to include promotion of food waste reducing investments into policies (Mattsson et al. 2018).

HORECA

School Lunch Policies must content time and duration of lunch, because they effect on quantity of food waste (Chapman et al. 2017), because more structured lunch breaks lead to less plate waste (Steen et al. 2018). It must be promoted by awareness campaigns to reduce food (and inorganic) waste in canteens (Pinto et al. 2018). Others found key food waste determinants (i) top management standpoint towards food waste and sustainability in general (ii) relevant differences among the catering business models, (iii) diverse resource availability among the schools. The human factor arose as the most relevant one when aiming to minimize food waste (Derqui et al. 2018). The environmental and personal determinants are

interrelated and that the impact of different determinants is relative to perceived time constraints during a visit of the university canteen (Lorenz et al. 2017).

Restaurant food waste per capita per meal varies considerably by cities, consumer groups, restaurant categories, and purposes of meals (Ling-en et al. 2017, Lingen Wang et al. 2018). At EU level, restaurants occupy the second highest position in the classification of bodies responsible for food waste generation and a significant share of restaurant costs "goes" to waste (Principato et al. 2018). But majority of people were not aware of the environmental impacts of restaurant operations (Sarmiento et al. 2018). The personal characteristics, together with situational factors, are determinants in workplace cafeterias too (Sebbane et al. 2018). In particular, food waste generation per meal can likely be limited by: promoting and using local, fresh, and quality food; standardizing and limiting daily menu items; basing food recipes on consolidated cooking knowledge and experience; and limiting plate sizes. The monthly variation can be explained by high working pressure of consumers and the closing of a seasonal business - typical for restaurants in tourist areas (Tatàno et al. 2017). Three-quarters of restaurants avoided food donation because of unfounded fear of the legal liability (Sakaguchi et al. 2018). Bulk of research exist on food donation, that studied the phenomenon from the perspective of food donors. The perception of recipients, especially their willingness to accept donated food, remains under-examined, and yet there is anecdotal evidence that people have the tendency to assist, rather than to accept social assistance (Filimonau et al. 2019). There is a double paradox between conflicting norms and emotions: personal norms encourage not to waste while salient social norms encourage leaving leftovers; asking for a doggy bag generates immediate shame while leaving leftovers produces anticipated regret and guilt (Sirieix et al. 2017). In several cases food is taken away to workplaces or delivered to there. Management of take-away waste in workplaces has become a serious problem in

Chinese cities while the separation of the mixed waste is regarded as a promising solution (Liao et al. 2018).

In hospital the room service improves nutritional intake and increases patient satisfaction while decreasing food waste and cost (McCray et al. 2018). It was concluded by other authors too, completed with changing 3-meals per day to 6-meals (Ijmker-Hemink et al. 2017).

Households

A lot of articles were published about food waste generated in households. It is regulated by quite other interactions. Earlier research works started from Theory of Planned Behaviour (Ajzen 1991). The short essence of it is, that the intention will not be rejected by attitudes or subjective norms or perceived behavioural control, then it will be carried out, for example: not to waste.

This model defined, that attitudes and other norms determines the food wastage up to 35%. So, food-related routines (i.e. planning, shopping and leftovers reuse) are main drivers of food waste in addition to perceived behavioural control. Among the routines, the leftovers reuse routines are the most important contributors to food waste but are closely followed by shopping routines. Planning routines contributed only indirectly through shopping routines. These routines were closely associated with households' perceived skills. Nevertheless, the psycho-social factors included play a role as well (Stancu et al. 2016).

In another article (Diaz-Ruiz et al. 2018) a combined approach was mentioned, assembling current evidences on the relevance of food and environmental behaviours as well as selected consumer values to explain consumers' food waste generation. The results, obtained from their model, confirmed the hypothesis, that food waste behaviour is a complex issue that

needs to be analysed with an integrative approach. Overall, the main results suggest that consumers' purchasing discipline, waste prevention behaviours and materialism values are useful direct predictors of food waste behaviour. Specifically, high and committed waste prevention behaviour influences to declare low food waste generation. But others include strong latent factors too (Ponis et al. 2017).

Particularly, in Hungary, it was also confirmed that income has an effect on food waste production that varies by foodstuff categories: bakery product waste was mainly dominant for middle income consumers and fresh fruits were typically wasted by more affluent households. Apart from that, higher income resulted in higher food waste production in general (Szabó-Bódi et al. 2018).

Conclusion

This review article has achieved its own target, it gives a wide outlook of papers, published about food waste in last two years. The research question is confirmed at the necessary level. Both hypothesises were confirmed. Additional data are needed to get a clear picture about the real quantities of wasted foods.

In the reviewed papers, a lot of action have been published about how to reduce food wastage, starting from innovation in the industry, logistics, through creation by-product exchanges, development of demand forecast and product packaging, etc. up to substantial improvement of food literacy of the population. It is evident, that these actions will have some effect. In this case, the quantity and proportion of food waste will change, thus, the generation of waste is

dynamic. If it is dynamic, it can be modelled and forecasted on the basis of models created in future. In this way the research question can be answered.

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ENVIRONMENTAL AWARENESS OF INTERNATIONAL STUDENTS STUDYING AT UNIVERSITY OF PANNONIA

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Abstract

Climate change is a worldwide phenomenon which needs a plenty amount of publicity and measures in order to alleviate its significant impacts on climate, built environment and on the society. There are many factors that will be affected by climate change including rising sea levels, drought and loss of agricultural land. Nowadays and in the near future mankind has to face to the biggest environmental challenge what they ever seen. Therefore, environmental education plays a crucial role. Thus, well-educated and informed public will be able to make more sensible and precise decisions and reaction to climate change concerns.

In this study the degree of consciousness about climate change was examined by questionnaire between the International students of University of Pannonia in Veszprem city. Questionnaire titled as “Climate Change in view of you” contain 15 questions. Study allows us to determine the climate change perception of the young generation from all over the world. During the examination climate change awareness of different age groups and gender were compared. Regarding of the obtained results, it is estimated to make events at University of Pannonia for international students with the intention of providing more detailed information on climate change.

Keywords: climate change, environmental education, environmental awareness, environmental knowledge

Összefoglalás

Az éghajlatváltozás olyan világméretű jelenség, amely rengeteg nyilvánosságot és intézkedést igényel annak érdekében, hogy enyhíthetőek legyenek az éghajlatra, az épített környezetre és a társadalomra gyakorolt jelentős hatásai. Az éghajlatváltozás számos szektort fog érinteni, különös tekintettel a mezőgazdaságra, ahol az aszály és a mezőgazdasági területek elvesztése jelentős mértékű lehet. Az emberiségnek szembe kell néznie a legnagyobb környezeti kihívással, amivel valaha találkozott, ezért a környezeti nevelés döntő szerepet játszik. A jól képzett és tájékozott lakosság képes lesz ésszerűbb és pontosabb döntéseket hozni, és reagálni az éghajlatváltozással kapcsolatos aggályokra. Tanulmányunkban egy kérdőív segítségével mértük fel az éghajlatváltozással kapcsolatos tudatosság mértékét a Pannon Egyetemen tanuló nemzetközi diákok körében. Az „Éghajlatváltozás a te szemedben” című kérdőív 15 kérdést tartalmazott. A tanulmány

lehetővé tette számunkra, hogy meghatározzuk az éghajlatváltozáshoz való hozzáállást a fiatal generációk esetében akik a világ minden tájáról érkeztek.

Introduction

The word ‘climate’ is defined as fundamental weather conditions of the certain area, such as a change in wind flows, atmospheric pressure, patterns of rainfall, index of humidity, diversifications of temperature, increasing smog and during the particular time interval whichever statistical transformation in that weather arrangement can be characterized as “climate change” (Hussain, et al. 2018). The term climate change described in the scientific literature earlier than the term global warming. Even though these terms are used compatible in media, they have distinctive technical explanations (Leiserowitz, et al. 2004). One of the earliest investigations is proclaimed by the French physicist Joseph Fourier who showed that the Earth temperature would be colder. In 1975 the phrase “global warming” invented by the US scientist Wallace Broecker and at that time concentration was shifting to the unfavourable effects of climate change which was caused by humans (Frost, et al. 2017). As regards adjacent connection of climate change to the normal life of people and improvement of the ecosystem, during the last decades it has been progressively in the centre of people’s awareness (Zhong et al. 2017).

Climate change is undeniable fact of life and today we can obviously see the evidence of it. To take a particular example, levels of the sea are rising, glaciers are retreating, transformations in precipitation patterns and the temperature of the world is increasing gradually (Adedeji, Reuben and Olatoye 2014). According to the Third Assessment Report of IPCC in 2001, it is predicted that by 2100 global mean temperature of the surface would

increase from 1.4 to 5.8° C. By cause of this significant modification, it could have extensive disastrous results (Schneider and Lane 2006). During the last two decades, possible impacts of climate change have been inspected on the Antarctic ecosystem and this regional climate changes detected by the examination of microflora (Singh, P.Singh and Khare 2018). Beginning from the 1940s effect of climate on soil erosion also recorded and the reason for this is variations in the quantity of rainfall (Li and Fang 2016).

The major reason for global climate change is greenhouse gas (GHG) and as a consequence our planet faces with global warming (Hussain, et al. 2018). Beginning from pre-industrial level, the anthropogenic greenhouse GHG have risen continuously and has powered greatly by the growth of population and improvement of the economy (Uitto, Puri and Berg 2017). As a result of the burning fossil fuels, the concentration of GHG in the atmosphere has risen considerably (Seidenkrantz 2017). In 2008 the food production process, has delivered approximately 17 000 mega tonnes of carbon-dioxide equivalents (CO_2e) into the atmosphere that constituted to tierce of all anthropogenic GHG (Gabriella and Ferranti 2016). Rice cultivation, cattle farming, and deforestation also effected deliberately to rising GHG during the last centuries. Thus, nowadays, the amount of GHG emissions has reached the highest historical climax point (Uitto, Puri and Berg 2017).

The 21st century is distinguished by the prominent level of technical and scientific intricacy of environmental problems such as climate change (Awusi and Asare 2016). In European strategies, plenty number of directives, regulations, and discussion papers are published in order to promote the reduction of GHG emissions and to assimilate climate change (Reis and C.Ballinger 2018). Regardless great amount of studies conducted, immense part of the world population, specifically in developing countries, are still unfamiliar about climate change (Ochieng and Koske 2013). With the aim of raising the

alertness in public predominantly, education on climate change is considering one of the most crucial appliances (Paul, J and Gale 2015). The research was also designed to examine the knowledge of students mainly from developing countries at University of Pannonia on this subject.

Methodology

According to the statistical data from the Tempus Public Foundation, in the academic year 2017-2018 there were more than 15000 Stipendium Hungaricum applicants from 55 different countries all over the world. Regarding chosen study level of the applicants there were 3634 for Bachelor programme, 7004 for Master programmes, 3021 for Doctoral degree, moreover 999 for One-tier master's degree programmes and 337 candidates for Preparatory courses. The number of the students who come from Pakistan (1885), Jordan (1194), Azerbaijan (1052) and Syria (1057) remarkably higher than other countries. Statistical information also shows that almost 80% of the students give high preferences to study in English (Tempus Public Foundation 2017).

Since 2015 at the University of Pannonia continuously increasing number of international students are studying by the help of the Stipendium Hungaricum program. The university have 5 faculties, namely Georgikon Faculty (GF), Faculty of Information Technology (MIK), Faculty of Business and Economics (GTK), Faculty of Modern Philology and Social Sciences (MFTK) and Faculty of Engineering (MK). Within the framework of the program applicants are able to choose from 4 BSc/BA and 9 MSc/MA programs. They also have the opportunity to continue their studies in one of the 6 Doctoral Schools.

The questionnaire was organized in English language and it contains 6 sections and 15 questions. The research assessed international students' general understanding of climate change. The first section of the survey gives a short description to inform participants about the reason for the questionnaire, the time they will spend to fill it and keeping anonymity. The second section is about personal data, such as the participants' gender, age, origin as well as the highest level of education. The third section is named "Climate change as a phenomenon" and contains three questions. The questions investigated that whether the participants are familiar about climate change or not, from which source they have heard about it and what could be its potential dangers to our society. In the fourth section the causes and consequences of climate change was examined (e.g. activities and major gases which are responsible). The fifth section analysed the perspective of participants about activities which can mitigate climate change, who is responsible for it and individually how they can protect themselves from the effects. Apart from the first section, almost all the questions were offered a multi-response kind and fields for supplementary comments. The survey was mainly introduced to participants through email, however, some students were reached through Facebook too.

Results

The survey was sent around 80 international students of the University of Pannonia and 44 students filled it in during the given two weeks. From the first section it is visible, that the number of the females (54.5%) who filled the survey is higher than males (45.5%). Regarding age distribution, even though, almost all age groups participated in the survey, but the number of the students whose age was between 24 and 26 are significantly higher than other age groups.

Figure 1 shows the origin of the students. Most of the students who participated in the survey was from South-East Asia (23%) and from Western Asia and the Middle East (23%). The largest student groups are from India (5 students), Indonesia (5 students), Russia (4 students), Syria (4 students) and Jordan (4 students). Furthermore, participants from Cambodia and Mongolia accounted for the similar number, 3 students from each country. In comparison to the above-mentioned countries number of the participants from China, South Africa and Iraq are marginally lower and counted for 2 students for each country. Finally, there is only one participant from Tunisia, Algeria, Kazakhstan and the Philippines, Egypt, South Africa, Laos, Ecuador, Algeria and Kenya.

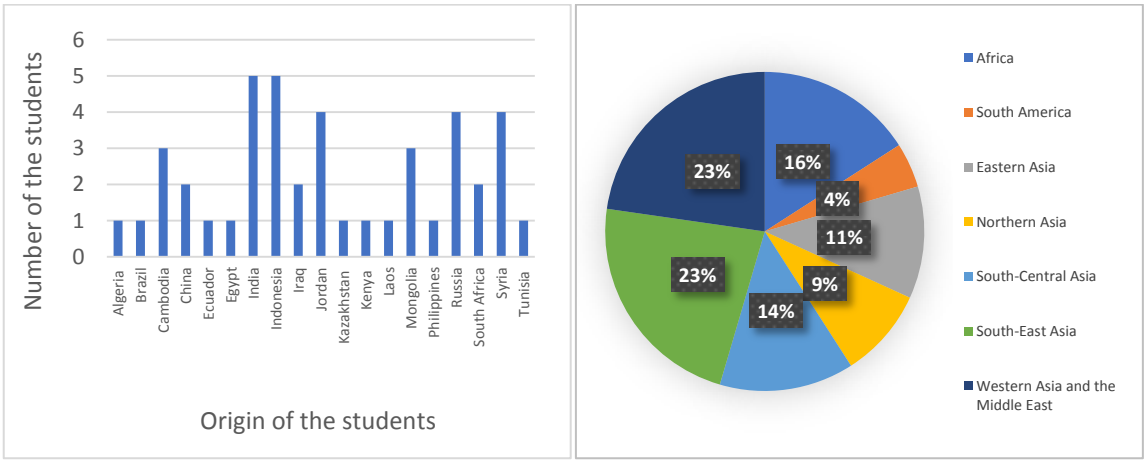

Figure 1: *Origin of the students*

More than 80% of the respondents live in a city with more than half a million inhabitants (43.2% in the capital city, 38.6% in other cities), whereas 15.9% of the responders were from small towns and only 2.3% were from villages.

The highest level of education was investigated also, but because of some misunderstanding in the question the results cannot be used. The research also analysed the majors of the participants who filled the survey and the distribution of students between different

disciplines was as follows: 36.4% economics, 22.7% social sciences and nature sciences, 11.4% technical sciences and 6.8% IT.

From the second part of the questionnaire - called “Climate change as a phenomenon” – the results indicate that all the students have learned about climate change and as it is seen on Figure 2 most them heard about it from the internet or from the television during their studies. It is also visible on Figure 2 that 77% of the students consider that climate change is an essential issue and requires to be solved. Whereas, 21% of them think that there are more critical problems which needs to be addressed.

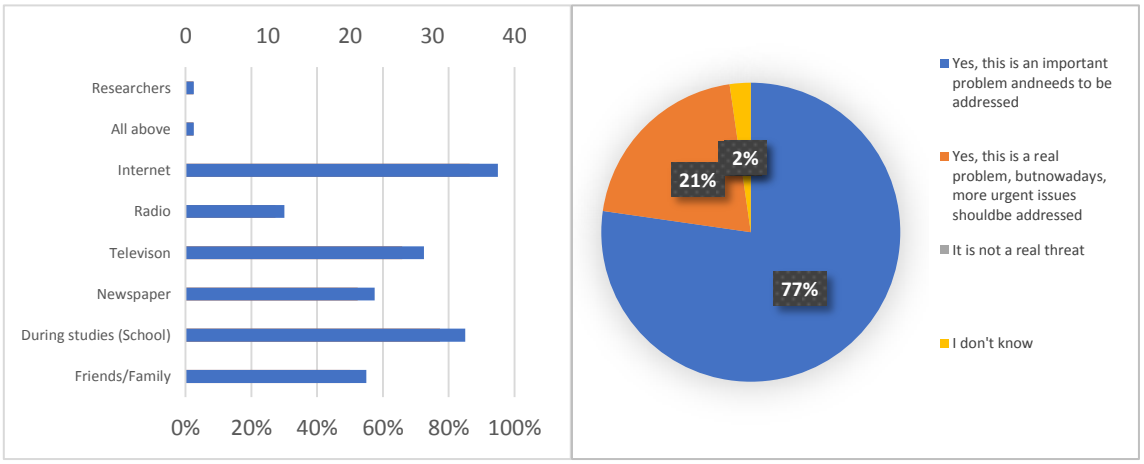

Figure 2: Climate change as a phenomenon

In the third part of the survey the causes and the possible consequences of climate change were investigated. Figure 3 shows, that more than half of the participants consider GHG emissions is one of the main causes of climate change, whilst 32% voted for deforestation, decreasing of green areas. However, the minority of participants believe that climate changes because of overpopulation (7%), changing the Earth rotational properties (4%) and volcanic activities (2%).

The gases in the atmosphere which are responsible for the greenhouse effect were examined too. According to the respondents, carbon-dioxide, methane and sulphur-dioxide are three-

main gases contributing the greenhouse effect. The respondents consider water vapor ozone and freons as less important gases for greenhouse effect.

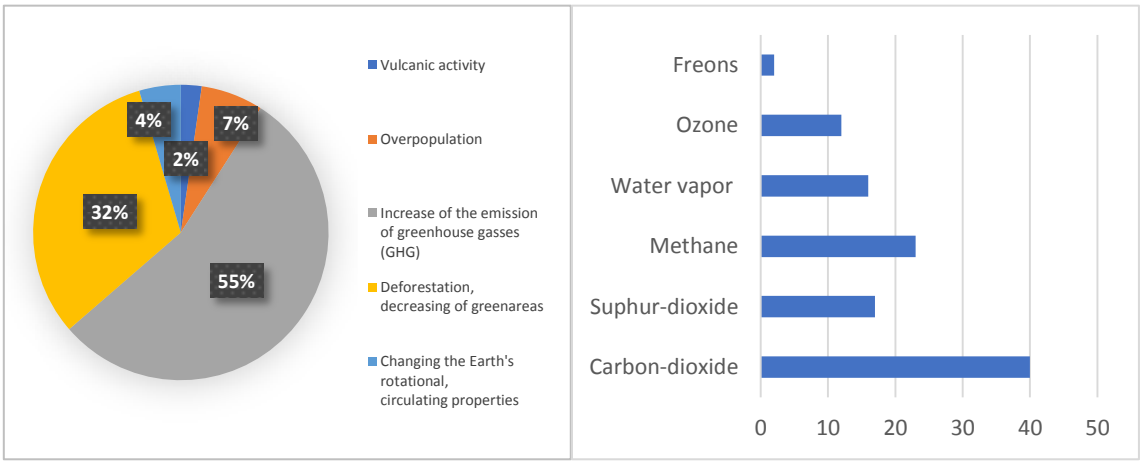

Figure 3: *Causes of climate change and GHG emissions*

For the question about what they think what could be the consequences of global climate change (Figure 4), 33 students consider that extreme weather conditions could become more frequent. Moreover, 31 students think that global climate change will cause to the melting glaciers and polar ice sheets and rise of world sea level. The number of the students who believe that climate change could lead to the decline in biodiversity and deforestation accounted for 20. However, fewer consider that it could result in degradation of agriculture productivity (15 students), acceleration of spread of diseases (14 students), migration (10 students), war (8 students) and termination of Gulf stream (6 students).

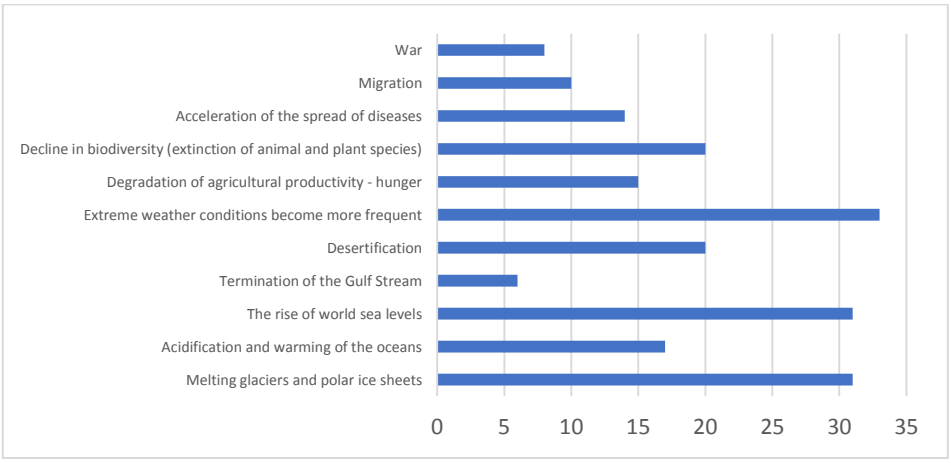

Figure 4: *What could be the consequences of global climate change*

According to the Figure 5, 63% of the participants think that each person individually should be responsible to mitigate climate change. Whereas, only the small number of the students consider that it is responsibility of government (16%), factories and companies (14%) and politicians (7%).

Regarding the type of activities which could mitigate the climate change, the great number of students say that "I turn off the lights when I am not in the room" (33 students), "Walking or biking to university" (32 students) and "I collect waste separately" (25 students). However, only fewer say that "I am buying energy saving equipment" (12 students) and "I am buying bio and organic food" (4 students).

Figure 5: *Actions to mitigate climate change*

The last question in the survey was about protection against climate change impacts (Figure 6). Two in three students protecting themselves from impacts of climate change through reducing energy consumption and more than half of the participants do it through reducing car use and reducing water consumption. Moreover, about 6 of the students protect themselves through isolation of flat or house, however, 3 participants say that climate change does not affect them. In the "other" section, one student wrote that educating people could be solution.

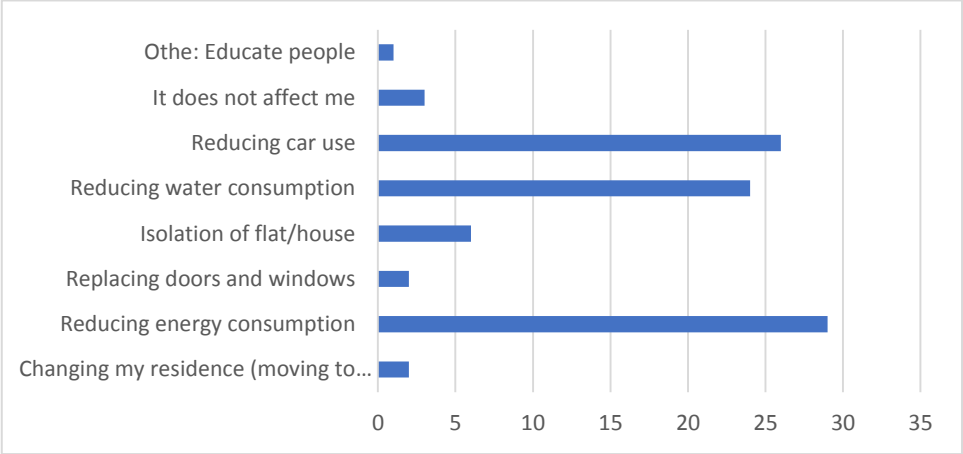

Figure 6: *How are you protecting yourself against climate change impacts*

Discussion

From the described results of the survey, we can obviously see that majority of students have knowledge and awareness about climate change and data statistics also demonstrated that female participants showed more interests then males. Similar outcomes also can be observed in a survey which was conducted in Nebraska and for Vietnamese Coastal Residents' in Ha Tinh province (Abdel-Monem, et al. 2014) (Nguyen, King and Boon

2016). Gender has a remarkable influence on climate change topics. To take a example in the survey called "Australians' views of climate change" it was investigated that women more likely to believe that anthropogenic activities are the reason for climate change (Leviston, et al. 2011).

Even though all the students come from developing countries, we can see that the majority of them have appreciable knowledge of climate change and issues related to it. For example, even though China is a developing country (Jing Gu and Messner 2008), 91.4% participants in the similar survey which was conducted in China, approve that climate change is happening and they also aware of sustainable development (Lia, et al. 2016). Survey studied that majority of participants live in the capital city in their hometown. Cities are considering especially resistless to climate change. The reason is that intense weather events are possible to be uncontrollable for compound urban systems (Gurría 2014). Probably the relatively high understanding level of most students on climate change is based on their origin and they have already experienced one of these changes. In this study, most of the participants say that they have heard about climate change from the internet, during their studies and from television. These outcomes almost reflect the results of the survey in Nigeria and the Republic of Macedonia where electronic media is one of the most ruling ways of receiving data on climate change (Awusi and Asare 2016) (Bojovic 2014). The study which is conducted in Ghana shows that television is the main source that they obtained information about climate change (Barimah, Kwadwo and David 2015).

It is noteworthy that most students consider climate change as a real threat to our society and need to be addressed. However, there were still some students who consider this problem as not urgent and 1 student out of 44 participants have no information about the danger of climate change. In respect to the knowledge about causes of climate change, we

can see from the results that most participants agree that it happens as a consequence of increasing GHG and deforestation. In Cambodia, during the survey, 67% of respondents said that they have experienced deforestation. Thus, it causes the transformations in weather patterns and all the clue informants create a connection between climate change and deforestation (Department 2011).

Survey results show that majority see the carbon dioxide and methane as major gases which causes greenhouse effect in the atmosphere. However, students have very low knowledge of ozone, freons and water vapor as GHG. This limited knowledge of participants about GHG also can be observed in similar questionnaires which are studied for climate change awareness (Paul, J and Gale 2015). According to the conducted survey in Oman, most of the respondents said that reduction of GHG has an essential role in decreasing consequences of climate change (Buloshi and Ramadan 2015).

Nevertheless, outcomes for parts which analyzed students on their knowledge of climate change impacts and climate change mitigation/ adaptation were positive, there were few students who think climate change does not affect them. Moreover, the number of students who consider through education they can protect themselves from climate change is only 2.3%. It means there is still a gap in the knowledge about climate change.

As regards, the cause of climate change, large majorities of students think that climate change can cause extreme weather conditions and an increase of sea level. According to the similar survey in Nigeria and Tanzania showed that participants think the sea level rising as major climate change impact (Paul, J and Gale 2015). The survey conducted in the USA about two in three Americans believe global warming is impacting weather in the United States (Leiserowitz, Maibach, et al. 2017).

Finally, with regard to the activities to mitigate climate change, the majority of students do it through reducing energy consumption, car use, and water consumption. Roughly same result noticed in an online survey of the citizens of the Republic of Macedonia (Bojovic 2014). In comparison to the above-mentioned survey results, in the similar survey which is conducted Oman, most of the respondents said that reduction of GHG is one the most essential solution to decrease consequences of climate change (Buloshi and Ramadan 2015).

Conclusion

Climate change awareness questionnaire tilted as "Climate Change in view of you" was conducted between the International students of University of Pannonia. Questionnaire contained 15 questions and it allowed us to determine the climate change perception of young generation from all over the world. Regarding the findings of the survey, the result was that the level of the climate change alertness between international students in Veszprem at the University of Pannonia is significantly high. It is also worth to mention that most students consider climate change as a serious issue and say it needs to be addressed. Additionally, participants approve that each person is individually responsible for mitigating climate change and the most part of participants protect themselves through reducing energy consumption and car use. Even though mainly outcomes of the research are positive, there are still considerable gaps in the student's knowledge about GHG. Understanding the importance of environmental education needs to be addressed as well. To deepen the knowledge of the international students, work-shops are recommended to

organise in the topic of climate change and GHG (types, sources, and effects to the atmospheric weather). Round-table discussion could help also, where the students can share their experiences.

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POSSIBILITIES OF IOT BASED MANAGEMENT SYSTEM IN GREENHOUSES

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Abstract

The widespread use of information technologies provides new opportunities for agriculture to achieve optimal results. The IoT (Internet of Things) and Big Data, parts of the Industry 4.0 concept, provide methods to establish primary databases adjusted to the needs of the specific farm. Previously, several modular, multifunctional data acquisition systems have been developed, to measure factors at multiple spatial points. In the following, an experimental, cost-effective greenhouse management system will be presented, based on the 5th generation reference system. During the first test, the system provided multi-point environmental data to discover the characteristics of the greenhouse, to meet the decision-makers requirements and to use it as basis for controlling, thereby ensuring optimal environment during the production. To store measurement and additional data, describing the farm for management purposes, databases and a module for the web-based application was developed to ensure data integrity. The application provides functions to manage the system and to analyze as well as visualize data through ETL processes. In the paper, the initial steps

of the experiment have been presented, including the opportunities, the sensor network, the management application and a test to gather real-time experience to support the development of further features.

Keywords: internet of things, sensor networks, environmental data acquisition, greenhouse, decision support

Összefoglalás

A fejlett információs technológiák elterjedése új lehetőséget biztosít a mezőgazdaság számára az optimális eredmény elérése érdekében. Az IoT (tárgyak internete) és a Big Data, az Ipar 4.0 koncepció részeként új módszereket biztosítanak primer adatbázisok létrehozására az adott farm igényeinek megfelelően. Korábban több moduláris, multifunkcionális adatgyűjtő rendszer fejlesztésével foglalkoztam a különböző faktorok több ponton történő mérése érdekében. A következőkben egy költséghatékony fóliasátor menedzsment rendszer kerül bemutatásra, mely az 5. generációs referenciarendszer alapján készült. Az első teszt alatt a rendszer több ponton biztosított környezeti adatokat a fóliasátor karakterisztikájának megismerésére, a döntéshozók igényeinek kielégítésére és vezérlési módszerek alapjaként való alkalmazására, mely biztosítja a termelés alatt az optimális környezeti feltételeket. A mérések és a gazdaságot leíró, menedzsment célú további adatok tárolása érdekében adatbázisok és a web alkalmazás új modulját alkalmaztuk az integritás érdekében. Az alkalmazás lehetőséget biztosít a rendszer menedzselésére, az adatok elemzésére és vizualizálására ETL folyamatok segítségével. A cikkben a kísérlet kezdeti lépéseit mutatjuk be, beleértve a lehetőségeket, a szenzorhálózatot, a menedzsment alkalmazást és egy tesztet a

valós-idejű alkalmazással kapcsolatos tapasztalatok gyűjtése érekében, mely segíthet a további funkciók fejlesztések során.

Introduction

There are several new opportunities that arise through the development of the information technologies. The IoT (Internet of Things) concept and its technologies, defined also in the Industry 4.0 standard proves to be an effective method to provide measurable, quantifiable data in order to reveal previously unknown relationships between the measured data and other data sources, describing additional factors. Depending on the examined activity, the related data can influence the result directly or indirectly, which makes it important to collect and analyses them in order to optimize the process. Accordingly, more and more sectors try to adopt and use the technology to keep pace with the further development. This is no exception to the agricultural sector, which uses various methods described in the concept of precision agriculture in order to meet the expected doubling of crop demand from 2005 to 2050 (Tilman et al., 2011). In addition, there are other challenges of agricultural production in terms of environmental impact, food security and sustainability (Gebbers & Adamchuk, 2010). In case of precision agriculture, the first application area people think of are the machines, equipped with sensors and actuators, operating based on the measured data using a predefined algorithm. These are predominantly mobile devices however, there are activities in which the use of a local system is needed in order to achieve similar benefits. It can be a livestock farm, a processing plant, a warehouse, a transport vehicle or a greenhouse which will be discussed later. This paper is an introduction to a series of greenhouse experiments which I would intend to perform through multiple topics in the future. Several data acquisition and control systems were developed in the recent years to

perform similar tests mainly for personal use in agriculture and other activities. Accordingly, it is understandable to start experimenting by integrating a similar system and optimizing it to adapt to the characteristics of the production in greenhouses in order to see some of the potentials which can be achieved using this technology.

Industry 4.0 is a data exchange and automation approach to manufacturing technologies that embraces a wide range of current concepts, including the so-called smart factory, whereby manufacturing tools are equipped with sensors and actuators, thus forming an autonomous system (Lasi et al., 2014). Some of the included concepts and technologies are IoT, Big Data, cloud computing, process control methods, augmented reality, intelligent robotics, data security and additive manufacturing (3D printing) (Luque et al., 2017). Apart from analyzing the data, using M2M (machine-to-machine communication) is also advantageous for control purposes. In addition to the PID (proportional–integral–derivative controller) based controlling mechanism, the current model-based approaches, including the Fuzzy Logic and the neural network-based methods can also be supported with data, provided by the WSN (Wireless sensor network) devices, described as the part of the IoT concept (Huang, 2013). Because this paper predominantly builds on the IoT concept, we should describe the basic understanding behind the technology. The concept consists of four pillars. The first pillar is the WSN mentioned above, while the other pillars are M2M (machine-to-machine communication), RFID (unique identification and tracking based on radio frequency), and SCADA (monitoring and data collection) (Zhou, 2013). A sensor network consists of structured or unstructured nodes that collectively monitor or track determining factors of a particular area. The low-power nodes consist of a controller, one or more sensors and actuators detect, measure and collect sensory quantifiable environmental data, which

thereafter are transmitted to the user in order to support the local decision-making process (Yick et al., 2008).

In precision agriculture, data acquisition and control procedures range widely, from automatic steering to the determination of certain quality parameters via pattern recognition using machine vision and artificial intelligence (Patrício & Rieder 2018). This paper predominantly focuses on greenhouses; therefore, the later mentioned examples are also related to this. Multi-point data acquisition in greenhouses is a known topic, however, implementation is always different. Some experiment uses off the shelf component, like Arduino development board (Aiello et al., 2017) or MicaZ nodes (Akkaş & Sokullu, 2017), but some experiment utilizes custom developed systems (Park – Park, 2011) to adapt to the task. The measured parameters however are similar, including temperature and humidity sensors, soil moisture sensors (Balaji et al., 2018), illumination, CO_2 concentration, soil temperature (Lin & Liu, 2008), pH meter, as well as imaging sensors for machine vision algorithms to estimate leaf area (Liao et al., 2017), detect pest early (Boissard et al., 2008), or automate harvesting based on the classification of the visible quality parameters (Rajendra et al., 2009).

After the data acquisition, the next step is to utilize the collected data. The data can be used to control the environmental conditions or to discover new relationships by analysis in order to help the decision-making process. In terms of control methods, we have more options available to optimize the microclimate of a greenhouse, including Fuzzy Logic Control (FLC), Adaptive Neuro-Fuzzy control (ANFIS), Artificial Neural Network control (ANN) and PI control (Atia & El-madany, 2015). The quantity and structure of the data provided by the IoT conception require new methods in order to gain information. Data management can be facilitated by farm information systems which can handle the measured spatial data in

addition to modules, like operation management, reporting, finance, site-specific systems, inventory, machinery management, human resource management, traceability, quality assurance, sales and best practice in order to enhance the decision-support process (Fountas et al., 2015). As far as further analytics goes, there are several models which can be implemented to use sensory data as well in order to support the decision-making process, including probabilistic and optimization models, supervised learning models, Bayesian models, time series analysis and genetic programming, based on a paper describing the AgroDSS system (Rupnik et al., 2018).

Material and methods

In this chapter, we will be discussing the devices and methods used in the data acquisition process and the environment where the test has been implemented. This is the first test using some of the modules from a new reference design of a custom developed data acquisition system. Accordingly, the test provided a sample dataset containing real data, ready to be analyzed as well as valuable experiences with the new system.

The test in question took place in a greenhouse as they have always considered as a favorable environment for test processes because of their nature of a closed system. This helps to illustrate the possibilities of the multi-point data acquisition method and it provides a basis for developing and using various environmental control methods in the future. The environment, where the test was implemented has a relatively small scale with a height of 2.64 m, maximum width of 4 m, length of 6.5 m and accordingly, volume of roughly 62 m^3. The main difference of this greenhouse (Figure 1.) that it is located 1 meter under the ground which may show distinct characteristics compared to conventional greenhouses because of the

insulating effect of the soil. The main parameters, describing the shape of the greenhouse are stored in the database of the reference system in order to utilize the 3D data processing and visualization.

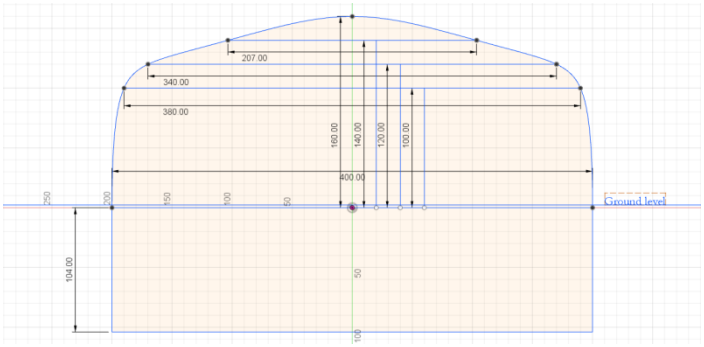

Figure 1.: Sketch about the greenhouse from a front view (values in centimetre)

Source: own figure

Before the test, multiple hardware and software development was needed in order to adapt to the circumstances. The following figure (Figure 2.) shows the logical structure of the system, including the modules from the reference system (blue), the modified modules, based on the reference system (red) and the modules developed specifically for this test (green).

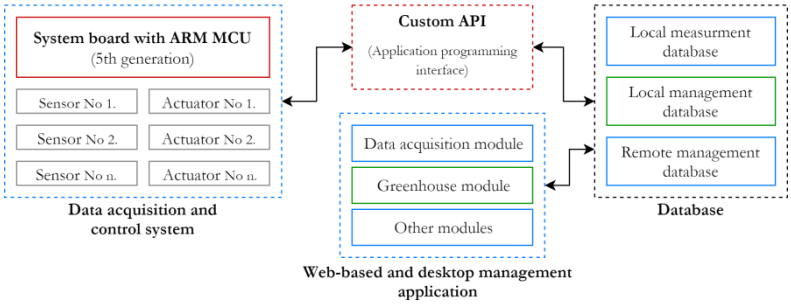

Figure 2.: Logical structure of the system

Source: own figure

Based on the figure we can distinguish between the data acquisition system (including hardware and its software) and the server-side supporting subsystems, including the API, databases, and management applications. The data acquisition system used in this test is based on the 5th generation, MCU independent (can be used with MCUs using ARM and AVR architecture as well) reference system which is still under development right now. It is developed considering the previous experiences and needs to be the successor of the 3rd and

4th generation reference system, used in various tests before in the field of multi-point data acquisition. The controller board includes all the basic components, necessary for the designed operation, like MCU socket, RTC (real-time clock), EEPROM, wireless network controller, LED driver, SD card socket, LED indicators (green for normal operation, yellow for measurement and red for error), expansion socket (for LCD, GSM and Ethernet controller) and the sensor connectors, supporting multiple communication protocols. The main purpose of the controller board is to provide a uniform interface for the devices providing the same connector and protocol for every sensor and additional component in order to optimize the installing procedure. Overall 16 sensors were used during the test which can provide 10 different data types, describing the environment where they reside. The data types include interior parameters such as temperature and humidity in 8 different positions, luminous intensity and UV radiation in 2 positions, soil moisture in multiple positions, as well as exterior parameters, like barometric pressure, rain, wind direction and speed in addition.

Results

The main goal was to perform the first test using modules from the new reference system in order to examine its functionality and usability on the long run as well as to produce a sample database which can be processed and analyzed further to discover relationships between the measurement points and data types. In order to store additional data in the existing database system other than the measurement data, a new rudimentary module was developed to extend the database system and the web-based management application.

Test measurements

Several preparations were needed before starting the test. This includes preparing a temporary IT infrastructure and determining the optimal locations of the sensors. The

reference system normally uses TCP/IP protocol to transfer data (measurements, events, time and date, identifier) to the API, but for test purposes, it is not cost-effective to use a local server. To solve this issue, the main software on the Atmel SAM3X8E MCU was modified in order to use serial (SPI) connection with an external SD card to save the same messages in the same structure as it would be in case of an active network connection. After powering on the controller board, an initialization process begins, which configures the MCU and its peripherals, including the communication controllers, external network controller, LED driver and real-time clock. The software of the reference system was written with the presence of the API and local server in mind. Accordingly, after the initialization process the MCU tries to communicate with the API in order to query the time and date as well as the identifiers of the connected sensors. In order to make the least modification in the software, a tablet was used as a server during the boot process. In order to use the SD card as storage instead of sending the messages to the network controller, a flag, stored in the EEPROM ensures that the relevant program functions are used, developed for the test. Finally, the MCU initializes the connected sensors according to their protocol. In case of an error (timeout or error response) the MCU sends a message in a defined structure, including the identifier of the sensor and the error. Thereafter, the measuring cycle begins which consists of reading the sensors, check their status, concatenating the measurement data according to the message protocol and writing it to the SD card or in in general case, transmitting it to the API via the network controller. The message, based on modified JSON format, contains sensor identifiers, associated values, errors, the device identifier, and a timestamp. Subsequently, the device enters a low-power mode that is interrupted by a timer after 3 minutes, repeating the measurement cycle. After the measurement session, a new module of the API, written in C++, developed for this test was responsible to process the saved messages line by line as in the

case of a real-time connection and add them to the table of a database, identified by the additional parameters in the message. This includes the measurement data as well as other events. The database tables used for storing the measurement data have a transaction-oriented structure. To support the visualization methods, an ETL (Extraction, Transformation, and Loading) algorithm was developed to merge the various data types according to the time and date, creating a single record for every sampling cycle with the spatial coordinates of the devices. The ETL process reads structured or unstructured data from multiple sources and includes data only in case of meeting the established criteria (Geng, 2017).

Because of the temporary nature of the system, some components were mounted just like as is was on a production system (custom PCB-s and 3D printed enclosures for the sensors) but some sensors were operated using breadboard connections. A home-made PCB for the DHT22 temperature and humidity sensor was developed, driven by a separate MCU with AVR architecture in order to work optimally with the existing, custom developed reference controller board using the same connector and communication protocols. The unified RJ45 connector includes a one-wire, I^2C, analog, output and status LED channels as well as the power lines. The PCB of the sensor also provides direct connection to the sensor with a jumper setting. In case of direct connection, the controller board is able to handle 16 sensors (considering the one-wire protocol). When using the MCU on the PCB of the sensors, this number increases according to the characteristics of the I^2C bus. The concept of the homogeneous sensor network was followed which means that the sensors were located along an equal-sized grid. In general, this method requires a high number of sensors in case of the need of high resolution, but because of the good experience from a previous test (Tóth et al., 2018), the temperature and humidity sensors were placed along the grid in crossing positions near to the sides. There are three additional sensors of the same type, two of which are located

in the middle of the greenhouse in a row and one is located outside of the greenhouse as a reference. Two luminous intensity and UV intensity sensors are located at either side of the greenhouse. The other sensors, measuring datatypes less influenced on the location are located near to the controller board from the reference system using breadboard connection. Later, similar PCBs will also be available for these sensors as well to create a unified system.

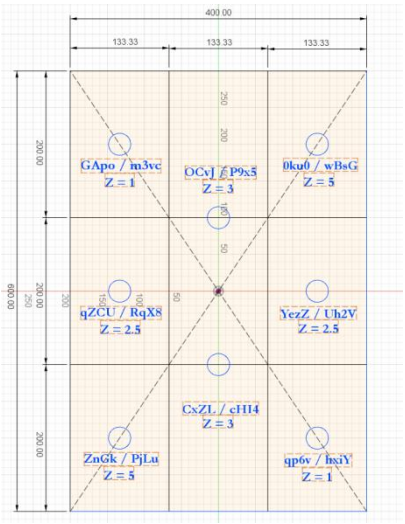

Figure 3.: The placement of the temperature and humidity sensors from top view

Source: own figure

The greenhouse was divided into multiple zones to utilize the location-specific data. The devices are placed along the X, Y and Z axis. The origin is located near to the entrance, at the lower left corner. Accordingly, there are 3 zones along the X-axis (width), 3 zones along the Y-axis (length) and finally 5 zones along the Z axis (height). The dividers are defining roughly equal sized zones. The sensors are located in the centre of the specified zone, defined by the intersection of the coordinates (Figure 3.). The main points are recorded to the database of the reference system to provide data for the 3D visualization. Some sensors are able to measure more than one data type. In order to distinguish them, the database routine used by the reference system creates unique identifiers. Some of the identifiers of the main sensors used during the test can be interpreted using the following table (Table 1.).

Table 1.: Sensor identifiers

Identifier	Sensor (X Y Z zone)	Identifier	Sensor (X Y Z zone)	Identifier	Sensor (X Y Z zone)
GApo	Temperature (1 3 1)	m3vc	Humidity (1 3 1)	0ku0	Temperature (3 3 5)
wBsG	Humidity (3 3 5)	qp6v	Temperature (3 1 1)	hxiY	Humidity (3 1 1)
OCvJ	Temperature (2 2.5 3)	P9x5	Humidity (2 2.5 3)	CxZL	Temperature (2 1.5 3)
cHI4	Humidity (2 1.5 3)	qZCU	Temperature (1 2 2.5)	RqX8	Humidity (1 2 2.5)
YezZ	Temperature (3 2 2.5)	Uh2V	Humidity (3 2 2.5)	ZnGk	Temperature (1 1 5)
PjLu	Humidity (1 1 5)	xU4U	Luminous int. (2 3 3)	6OfU	Luminous int. (2 1 3)
gYgi	CO_2 conc. (-)	iA2K	UV (2 3 3)	a3z8	UV (2 1 3)
rWjd	Soil moisture (-)	HY3y	Bar. pressure (-)	L93D	Ext. temp. (-)

Source: own data

In order to demonstrate some sample of the measurement data, including temperature, humidity, atmospheric pressure, luminous and UV intensity, a dataset, containing measurement data describing a randomly chosen time period is visualized using the 4th and 5th figure below.

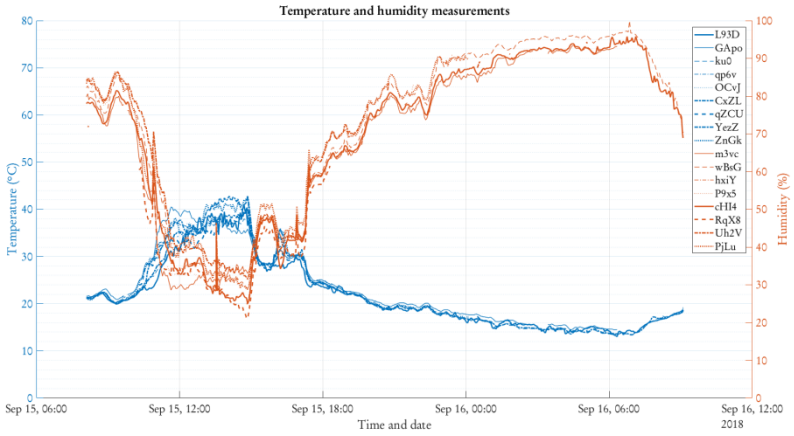

Figure 4.: Temperature and humidity data, measured by multiple sensors

Source: own figure

As we can see, the measured temperature and humidity data converge with the same datatype, measured in different locations, but we can experience a visible increase in standard deviation comparing the measurement points during a cloudy time period with a rainfall (in the early afternoon), which was also predicted before using atmospheric pressure measurements. The largest difference experienced in temperature was 12.9 °C whereas in

humidity it was 12.5% examining the same timestamp. This difference would not have been detected using a single sensor, which is typical for many systems in use for data acquisition and controlling purpose. Unfortunately, in the evening the high humidity caused connection error at some sensor nodes, which resulted in data loss. The multi-sensor design, in addition to the location-specific data may help in similar cases with redundancy. In this test, the data loss was not a critical factor due to this property.

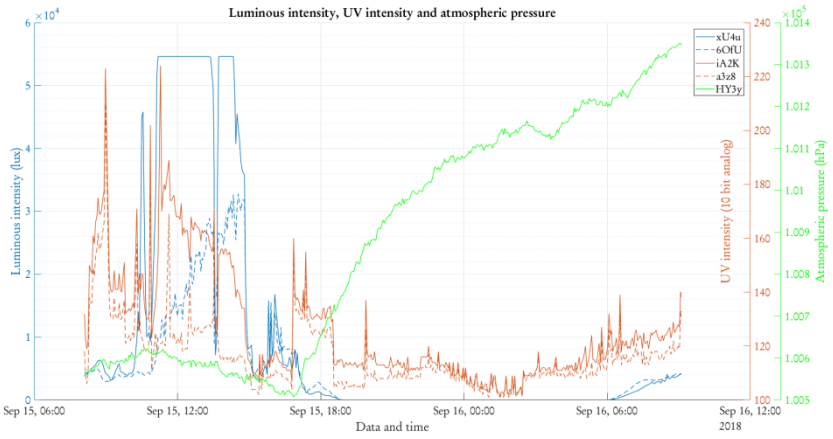

Figure 5.: Luminous intensity, UV intensity and atmospheric pressure

Source: own figure

The luminous intensity, as well as the UV intensity drops at the time period mentioned above. The luminous intensity sensor has a measurement range of 1 lx to 65535 lx which led to overflow at direct sunlight, can be seen at the chart as well observing the data, measured by the sensor with "xU4u" identifier. The UV intensity measurements were executed using a sensor with analogue output. As we can see, the luminous intensity data shows correlation with the UV intensity data, but the latter tends to show noise because of the ADC (analogue to digital conversion) process. This characteristic can be solved using post-processing or hardware modification.

In order to visualize the spatial distribution using a single record from a specific time, interpolation was needed. The arrangement of the temperature and humidity sensors ensures that the smallest number of sensors represent the reality relatively precisely. The interpolation

was done with a custom application developed for the test, written in C++ based on the INPAINTN iterative algorithm (Garcia, 2010). A three-dimensional data visualization may help the management in the optimal production site for the specific plant and may help in tool placement as well. In addition, it provides a basis for process control methods which can work more accurately using multiple sensors if conditions are given, including multiple, controllable actuators and an algorithm, which is able to take advantage of the multi-point data acquisition.

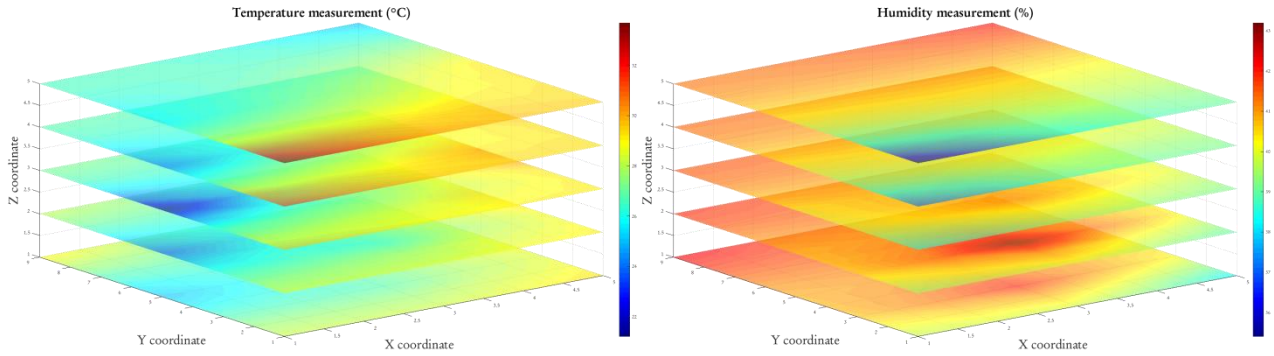

Figure 6.: 3D data visualization of temperature and humidity

Source: own figure

The temperature and humidity difference can be seen in the 3D data visualization as well at the mentioned time (Figure 6.). If we create a figure representing each measurement cycle, used them as an animation, we can discover the characteristics of the greenhouse at a changing period. Considering the environmental parameters measured outside, it can provide us with a sample dataset to use them in a simulation thus providing additional benefits in decision support and control methods.

Database and web application extension

The measurements are describing the primary production environment which may influence the result whether it is quantity or quality. We can relate them as production variables. But in order to cover the process in more detail, there is a need for further data describing the activity. This was implemented through the web application developed

originally for the reference system. Because of the modules from the reference system were used during the test, it provides compatibility with the existing software. Of course, it had to be modified as well to gain an advantage from the new data structure. The web application ensures platform independent operation, optimized for desktop and mobile devices as well via its responsive design. The interface is based on the Bootstrap 4 framework, while the logic is determined by custom PHP and JavaScript code. The management application for the reference system implements custom user right management, which ensures the accessibility of the module for the users.

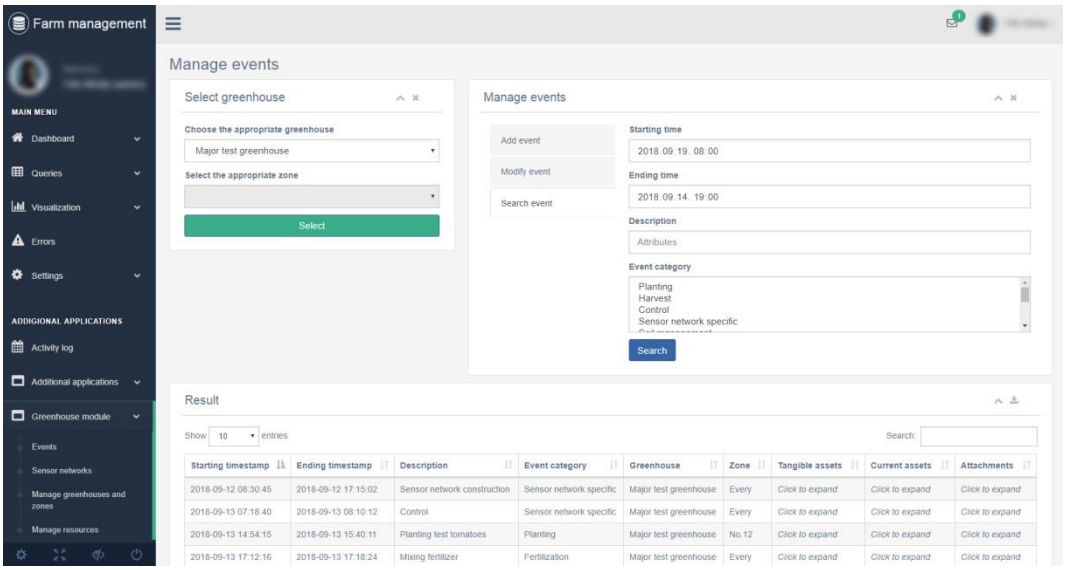

Figure 7.: The greenhouse module of the management application

Source: own figure

The greenhouse module utilizes an event-driven method which means, that every operation creates a new record (event) in a database table with parameters, like the timestamp of the beginning and ending of the event, the name and category, the location which is affected by the event as well as the zone inside of it, the transaction of tangible and current assets and other attachment, varying from scanned documents to individual datasets describing the event (Figure 7.). The event-driven method is an effective way (Paraforosa et al., 2017) to develop Farm Management Information Systems (FMIS) in order to store and

process data for the farm management (Fountas et al., 2015). The structure of the database ensures the scalability and that it can be analyzed in conjunction with the measurement data, which tells us the environmental parameters which were typical at the time of the event as well as the environmental parameters typical for the period between the events.

Discussion

In this paper the data acquisition and the management interface are distinguished. The data acquisition test provided valuable experiences which can be used as a starting point for future developments. However, to fully utilize the potential behind the technology, various developments of the tools and the methods are needed.

This data acquisition and control system was tested for the first time in a greenhouse, which raised several issues in weather resistance (temperature and humidity) and measurement resolution (sampling time and spatial resolution). The weather resistance can be solved by redesigning the 3D printed enclosure and using proper cooling solutions along with sealing, but the optimal measurement resolution, which is unique for every greenhouse, can only be determined via a long-term test and statistical analysis of the channels. As a first test, the homogenous grid was an appropriate decision, but in case of a large dataset, we may be able to find critical zones which require higher resolution, as well as zones, which tend to have homogenous parameters, accordingly, lower resolution is also sufficient. The resolution is an important factor not just because of the cost-reduction, but also because of the data quantity which highly influences the manageability. The management application, used by the reference system was extended with a rudimentary greenhouse module, providing application-specific functions, in addition to the former data acquisition module. The functions were

developed without determining the demands of the potential users. As a person, with a profile of arable crop production, I have no proper view of the needs of a greenhouse management. In order to make the application useful in practice, there is a need for additional research among professionals in this field. Definition of the functions could be supported by questionnaire research.

In order to use the data acquisition and farm management in conjunction effectively, we must find a connection between the environment variables and the management data whether it's a greenhouse or other closed system to utilize their usefulness in decision support. To realize these connections, there is a need for statistical analysis which will be the next step in the experiments when the testing period succeeds.

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THE TAXONOMIC PROBLEMS OF THE FESTUCA VAGINATA AGG. AND THEIR COENOSYSTEMATIC ASPECTS

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Abstract

We studied the vegetation of the sandy areas along the Danube. The most important dominant species of these grasslands is *Festuca vaginata*. Besides *Festuca vaginata,* an other taxon, *Festuca pseudovaginata* was also discovered (Penksza 2003). According to Borhidi (2003) *F. dominii* is a dominant species on acidic grasslands. Taxonomical judgement of *Festuca dominii* Krajina taxon changed remarkably. Soó (1973a), Šmarda and Kočí (2003) and Šmarda et al. (2007) registered it as *F. vaginata* subsp. *dominii* (Krajina) P. Šmarda. Šmarda et al. (2007) clarified the taxon, and named it as a subspecies of *F. psammophila* (Čelak.) Fritsch (which taxon occurs only in pine forests in North Europe), therefore the accepted

name is *F. psammophila* subsp. *dominii* (Krajina) P. Šmarda.

In 20 Hungarian areas, we examined individuals belonging to *F. vaginata*. On the basis of the results, we found the *F. vaginata* taxon was the typical without awn. In addition, we have collected short or longer awn from the tip of the lemma, which have short fibers under the tip of the lemma. Clarification of taxa also means clarifying the name and dominant species of sandy vegetation, and the overriding and correction of the associations and coenotaxa described above is also necessary.

Keywords: *Festuca dominii,* inflorescens, spikelet, awn

Összefoglalás

A Duna menti homoki területek növényzetében, irodalmi közlések és ismerteink alapján, a nyílt gyep legfontosabb domináns és egyben egyedüli faja a homoki vagy magyar csenkesz (*Festuca vaginata*). Új fajként a tecei csenkeszt (*Festuca pseudovaginata*) Penksza (2003) írta le. Az új faj levélszöveti felépítése hasonló a *F. vaginata* fajhoz, de a színe zöld és nem hamvaszöld. A virágzatában jelentős az eltérés, a külső toklászokon hosszú szálka található és tetraploid, szemben a *F. vaginata* diploid fajjal. A tipikus *F. vaginata* taxon külső toklásza rendszerint szálkátlan. A homoki gyepekben irodalmi adatok alapján olyan fajok is előfordulnak, amelyek rövidebb, hosszabb szálkával rendelkeznek. Ebbe a csoportba tartozik a *Festuca dominii*, amit Krajina fajként írt le (Domin 1930) és a taxonómiai megítélésén túl a vegetációben betöltött szerepe miatt is jelentős. Borhidi (2003) szerint a *F. dominii* egyeduralkodó a savanyú homoki területeken. Soó (1973), Šmarda és Kočí (2003) és Šmarda et al. (2007) szerint a faj neve *F. vaginata* subsp. *dominii* (Krajina) P. Šmarda, Šmarda et al.

(2007) szerint azonban *F. psammophila* subsp. *dominii* (Krajina) P. Šmarda, amely rövid szálkával rendelkezik (0,1-0,2 mm), valamint a valamivel hosszabb szálkás (0,2-0,4 mm) *F. psammophila* (Čelak.) Fritsch, ami jelenleg csak az északibb területek erdei fenyveseiben található. 20 hazai mintaterületen vizsgáltuk a *F. vaginata* alakkörbe tartozó egyedeket. Az eredmények alapján minden mintaterületen megtaláltuk a tipikus szálka nélküli *F. vaginata* taxont. Ezen túl a külső toklász csúcsa alatt eredő rövid szálkával rendelkező és a külső toklász csúcsából induló rövidebb vagy hosszabb szálkás egyedeket is gyűjtöttünk. A kérdés, hogy ezek a taxonok igazolhatók-e *F. dominii*-ként és a *F. psammophila*-ként. A taxonok tisztázása egyben a hazai homoki vegetáció névadó és domináns fajainak a tisztázását is jelenti, és az ezek alapján leírt társulások, cönotaxonok felülbírálása, korrekciója is szükségessé válik.

Introduction

Open sandy vegetation of the Pannonian Region can be split into two association groups. In calcareous areas *Festuca vaginata* forms associations (*Festucion vaginatae* Soó 1929) that occur from the western coasts of the Black Sea to the Carpathian Basin through the valley of the Danube (Borhidi 2007). This group contains six association types from which the most frequent is *Festucetum vaginatae* Rapaics ex Soó 1929 em. Borhidi 1996. On acidic sandy areas 3 associations of *Corynephorion canescentis* Klika 1931 group can be found, from which the most widespread is *Festuco dominii-Corynephoretum* Borhidi (1958) 1996. According to Borhidi (1957, 2003), Borhidi et al. (2012) and Soó (1973b) the dominant and characteristic species of these acidic sandy areas is *F. dominii*. However, in the eastern part of

the Pannonian Region (Nyírség) this association (*Festuco vaginatae-Corynephoretum* Soó in Aszód 1935) can be characterised by the dominance of *Festuca vaginata* (Soó 1973b, Borhidi et al. 2012). Besides *F. vaginata*, a newly described species, *Festuca pseudovaginata* (Penksza 2003) can be also dominant in sandy grasslands.

Festuca dominii was described for the first time as a species by Krajina (1930) and its taxonomical status have been defined differently by various authors. According to Soó (1955) it was a varietas named *Festuca vaginata* var. *dominii*, however Soó and Jávorka (1951), Soó (1973a) referred to this species as *Festuca vaginata* subsp. *dominii*, also did Dostal (1989) and Schwarzová (1967). Some databases does not emphasize the taxonomical importance of subspecies, *F. dominii* is considered as a subspecies of either *F. vaginata* or *F. psammophila* as a synonym (hppt1).

Domin (1930) compared the 3 taxons (*F. vaginata*, *F. dominii* and *F. psammophila*) and stated the number of flowers in the spikelet is lower in *F. vaginata* (3–6) than in *F. psammophila* (3–8) and *F. dominii* (3–7). Besides this, the spikelets are longer in *F. psammophila* (5.6–9 mm) and in *F. dominii* (5.2–9 mm) compared to *F. vaginata* (4.3–7.5 mm). Lemma is also longer in two other species (3.6–4.5 mm and 3.9–4.5 mm) than in *F. vaginata* (3–4.2 mm). Domin (1930) classified only individuals without awn as *F. vaginata*. Detailed taxonomical overview was performed by Šmarda et al. (2007). Based on their results, *F. dominii* is a subspecies of *F. psammophila* in which the lemma of second flower in the spikelet is longer [(3.4)3.7–4.9(5.2)], while it is shorter in case of *F. vaginata* [(2.7)3.2–4(4.3)]. The awn is (0.1)0.2–1.1(1.4) mm long in *F. psammophila*, while it is shorter in *F. vaginata* [0.05–0.4(0.6) mm].

We addressed the following questions in our research: (1) Does *Festuca dominii* occur in sandy grasslands of the Pannonian Region? (2) If yes, can it be found only in acid grasslands or in calcareous ones either? (3) Does any other *Festuca* species occur in the studied grasslands besides *F. vaginata*?

Materials and Methods

We compared collected individuals and herbarium specimens of 3 taxa characteristics to open sandy grasslands (1. *Festuca vaginata*, 2. herbarium specimens determined as *F. dominii* and collected *F. vaginata* individuals with awn, 3. *Festuca pseudovaginata* individuals) and analysed their morphological data.

We had altogether 20 study sites in the western and central parts of Hungary (Little Hungarian Plain, Danube-Tisza Interfluve, Ipoly Valley, Inner Somogy, the Balaton Uplands, Bakony Mountains and North Hungarian Mid-Mountains), in South Slovakia (near Ćenkov) and in Serbia (Deliblato Sands). Living plants and herbarium specimens (*Festuca vaginata*, *F. pseudovaginata* and *F. vaginata* with awn) were collected in every study site. Besides field sampling we studied the Herbarium Carpato-Hungaricum and Herbarium Generale of the Hungarian Natural History Museum.

In our study we analyzed the following herbarium specimens determined as *F. dominii* (indicating the locality): Káposztásmegyer, Újpest, 1905.06.16.; Fülöpháza, 1979.05.22.; Bokod, 1935.05.27.; Felsőpeszér, 1935.06.02.; Klotildliget, 1943.06.11.; Pilisszentiván, 1910.05.28.; Somogyszob, 1926.05.29.; Nyírbakta, 1927.06.04.; Nagykanizsa, 1964.06.06. The analysed *F. pseudovaginata* individuals originated from Domony Valley, Kistece pasture

and sandy areas near Örkény and Tatárszentgyörgy.

The analysed parameters were the following, based on Verseczki and Wichmann (2003) and Penksza (2014) (Fig. 1.)

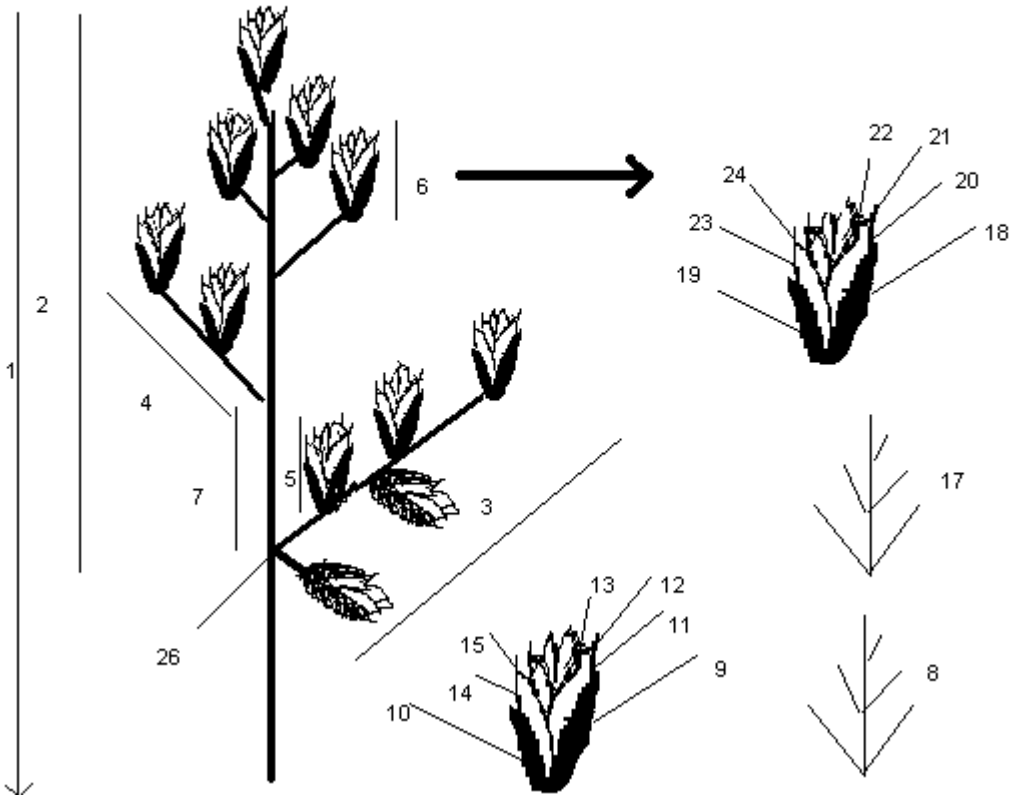

*Figure 1. Inflorescence parameters of investigated Festuca taxa (traits marked with * were not measured)*

1. Length of generative stem; 2. Length of inflorescence; 3. Length of the longest branch on the 1th node; 4. Length of the longest branch on the 2nd node*; 5. Length of the 4th spikelet from the top of branch; 6. Length of 4th spikelet from the top of inflorescence; 7. Length of the 1st internode of the inflorescence.

8-15: 4th spikelet from the top of branch: 8. Floral number of spikelet, 9. Length of upper glume, 10. Length of lower glume, 11. Length of the 2nd flower's lemma, 12. Length of the

2nd flower's awn, 13. Hair of spikelet*, 14. Length of the 1th flower's lemma, 15. Length of the 1th flower's awn.

16-24. 4th spikelet from the top of inflorescence: 16. Floral number of spikelet, 17. Length of upper glume, 18. Length of lower glume, 19. Length of the 2nd flower's lemma, 20. Length of the 2nd flower's awn, 21. Hair of spikelet*, 22. Length of the 1th flower's lemma, 23. Length of the 1th flower's awn; 24. Number of branches on the 1th node of inflorescence*.

We analysed 20 traits of 261 inflorescences altogether with ordination methods, for representation discriminant analysis was used. Statistical analyses was done with MINITAB (Minitab 17 Statistical Software, 2010), for multivariate analyses and graphical representations SYN-TAX program was used (Podani 1993).

Results

Measured morphological traits and data of the three taxa are summarized in Table 1.

According to the results of ordination analysis two groups were differentiated (Fig. 2). The group on the left side contains the data of two taxa: *Festuca vaginata* and *Festuca dominii,* while the other group is formed by *Festuca pseudovaginata.* In Fig. 3 isodensity circles of *Festuca vaginata* and *Festuca dominii* are almost completely overlapped, while the circle of *Festuca pseudovaginata* is separated from them.

Table 1. Mean values of the measured traits in the investigated taxa (numbering of traits is the same as in Fig. 1.).

Parameters	**Investigated taxa**

	Festuca vaginata subsp. *dominii*	*Festuca vaginata*	*Festuca pseudovaginata*
1. Length of generative stem (cm)	47.75	38.72	24.54
2. Length of inflorescence (cm)	12.44	10.91	6.58
3. Length of the longest branch on 1th node (cm)	4.62	4.06	2.58
7. Length of the 1th internode of the inflorescence (cm)	3.59	3.30	1.84
4th spikelet from the top of branch			
5. Length of 4th spikelet from the top of branch (mm)	5.58	6.40	5.72
8. Floral number of 4th spikelet from the top of branch (n.)	4.43	5.13	4.28
9. Length of upper glume (mm)	3.10	2.96	3.43
10. Length of lower glume (mm)	2.19	2.00	2.40
14. Length of the 1st flower's lemma	3.65	3.76	4.05
15. Length of the 1st flower's awn (mm)	0.18	0.00	0.85
11. Length of the 2nd flower's lemma (mm)	3.63	3.80	4.05
12. Length of the 2nd flower's awn (mm)	0.24	0.00	1.30
4th spikelet from the top of inflorescence			

6. Length of 4th spikelet from the top of inflorescence (mm)	5.35	5.39	5.64
16. Floral number of 4th spikelet from the top of inflorescence (mm)	4.22	4.84	4.23
17. Length of upper glume (mm)	3.00	3.09	3.56
18. Length of lower glume (mm)	2.09	2.08	2.52
22. Length of the 1th flower's lemma (mm)	3.66	3.78	4.19
23. Length of the 1th flower's awn (mm)	0.19	0.00	0.92
19. Length of the 2nd flower's lemma	3.70	3.84	4.12
20. Length of the 2nd flower's awn (mm)	0.26	0.00	1.42

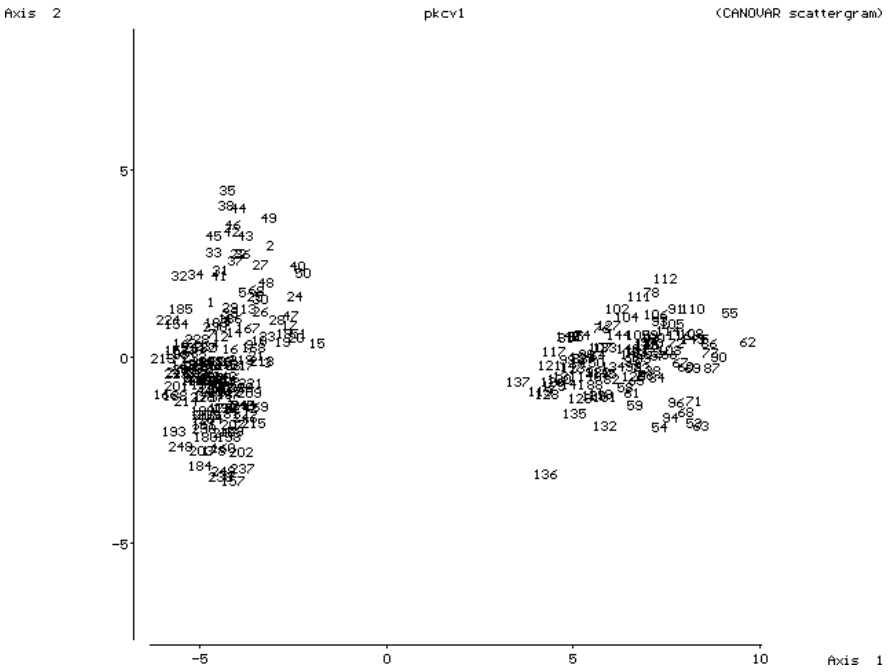

Figure 2. Results of CCA ordination on the measured data of the 261 inflorescences. Every number on the graph represent an individual inflorescence with all the measured data.

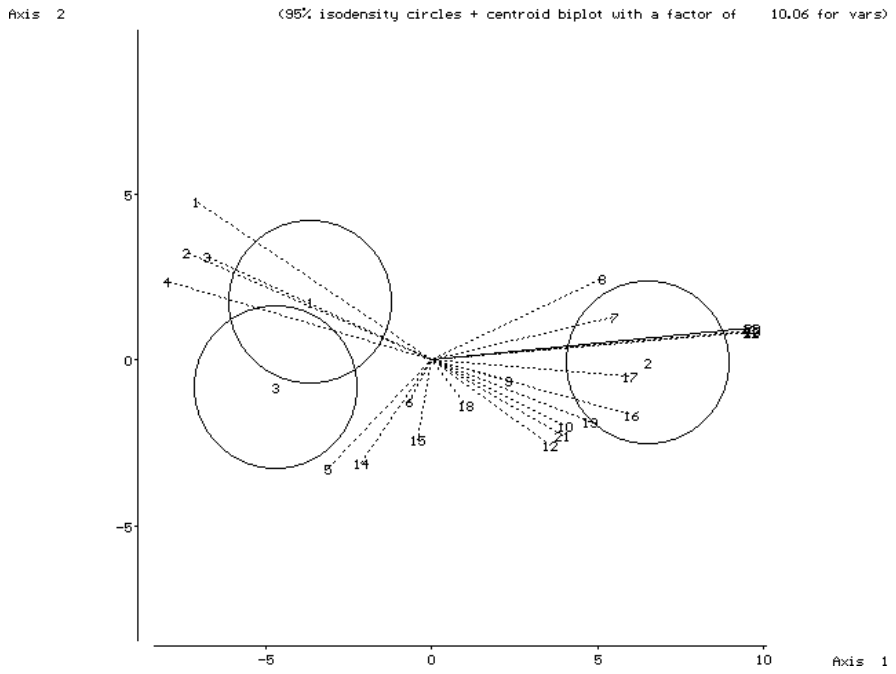

Figure 3. Differentiation of the three Festuca species based on discriminant analysis.

Discussion

Based on the analysis of morphological traits it can be clearly stated that *F. pseudovaginata* is different from the other two taxa. *F. vaginata* subsp. *dominii* not diverged obviously from *F. vaginata*. Lenght of the awn on the lemma was the determinative key to differentiate the taxa. Other important key traits were the length of the generative stem, the inflorescence, the lower branch, the first internode of the inflorescence and the length of the spikelets. These results confirm the comparative analysis of Domin (1930) where the lemmas are longer in case of *F. psammophila* and *F. dominii.* Šmarda et al. (2007) mentioned these traits, highlighted the importance of the length of the 2nd flower in the spikelet and the length of the lemma as a differential feature. In this case we can not accept the standpoint of The Plant List (hppt1), because *F. dominii* described as a species and the taxa registered as a subspecies or varietas can not belong to two different species. Therefore the results of Šmarda et al. (2007, 2008) are acceptable, accordingly, *F. dominii* became the subspecies of *F. psammophila* (*F. psammophila* subsp. *dominii* (Krajina) P. Šmarda) which is the currently accepted name of the taxon (Chytry et al 2017.).

Based on our results, we can answer the questions:

1-2. We could not verify the occurrence of *Festuca dominii* or *F. psammophila* subsp. *dominii* taxon in the Pannonian Region, confirmed by the examination of the collected living *Festuca* specimens. We found individuals with a 0.2-0.6 mm awn on the lemma among *Festuca vaginata* specimens, however, it can be classified as a varietas (Šmarda et al. 2007) with no independent occurrence. This morphological feature should be published in New Hungarian Herbal (Király 2009) and delete *F. dominii.* Because of the dominance of *F. vaginata* in Pannonian calcareous and acidic sandy grasslands, *Festuco dominii-Corynephoretum* Borhidi

(1958) 1996 association have to be classified in *Festucion vaginatae* Soó 1929 group with a new association name.

3. *Festuca vaginata* is the only dominant species both in calcareous and acid grasslands. In addition to this, *Festuca pseudovaginata* also occurred with relatively high cover.

Acknowledgements

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hppt1: The Plant List (www.theplantlist.org)

METHODOLOGICAL CHANGES OF AGRICULTURAL STATISTICS FROM THE BEGINNING OF THE 19th CENTURY

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Abstract

Due to the natural conditions agriculture played an important role in the Hungarian economy and the same can be said even today.

The history of independent Hungarian Statistics (including the Hungarian Agricultural Statistics as well) dates back to 1867, while the independent Hungarian Statistical Office was established in 1871 under Karoly Keleti's leadership. Among the first tasks of the independent Hungarian Statistical Office we needed to highlight the importance of surveying, analysing the state of the Hungarian Agricultural Sector, the establishment of the Hungarian Agricultural Statistics.

Over the decades the changing economic, social processes, the development of sciences and technology have been shaped the system of statistics as well as the system of Agricultural Statistics. The statisticians had to follow the changing life, they had to develop, establish new methodologies in Agricultural Statistics decades by decades.

In the case of the more than 150 years old Agricultural Statistics I have defined 5 – more or less homogeneous – periods of time, introducing the main feature of the single periods, introducing the changes of methodology applied in Agricultural Statistics.
Based on the historical experiences I have formulated a few thoughts that might be important even in the case of current Agricultural Statistics.

Key words: agricultural statistics, history, methodology of agricultural statistics, digital era

Összefoglalás

A természeti adottságoknak köszönhetően a mezőgazdaság az évszázadok során mindig fontos szerepet játszott a magyar gazdaság történetében. Ennek köszönhető, hogy az 1867-ben megalapított magyar statisztikai szolgálat az agrárstatisztika kidolgozását az elsők között tűzte zászlajára. Az évtizedek során a gazdasági-, társadalmi folyamatok, a környezet változásai, a tudomány és a technika fejlődése folyamatosan új kihívások elé állította, alakította az agrárstatisztikát. Az agrárstatisztika mintegy 150 éves történetének, módszertanának vizsgálatához öt – többé kevésbé homogén – időszakot különböztettem meg, melyeket az alkalmazott módszertan markáns különbségei különböztettek meg. Míg a kezdetektől az 1867-ig terjedő időszakot (a gyökereket) az államigazgatási adatforrásokból kialakított statisztikák jellemezték, a kiegyezéstől a 19. század végéig tartó időszakot a mai értelemben vett adatgyűjtések, agrárcenzusok megjelenése jellemezte. A 20. század első fele – többnyire a világháborúk miatt – csupán a korábbi gyakorlatok, módszertanok megőrzésére, szerény működtetésre adott lehetőséget. A 20. század második felében váltak rendszeressé a nemzetközi szervezetek (ENSZ, EU) javaslatai, előírásai alapján végrehajtott agrárcenzusok,

de ekkor alakult ki a magyar agrárstatisztika rendszeres adatgyűjtéseinek rendszere is. Az ötvenes, hatvanas, hetvenes évtizedek legfontosabb jellemzője az volt, hogy az adatgyűjtések csak a mezőgazdasági termelésben meghatározottnak tekintett gazdálkodási formákra terjedtek ki. Alapvető változást a kilencvenes évek hoztak, amikor a politikai, gazdasági, társadalmi körülmények változásával az adatgyűjtések egyre inkább kiterjedtek a magán szektorra, az agrárium esetében az egyéni gazdaságokra. Az agrárstatisztika fejlesztésében fontos szerepet játszott az informatika, technika megjelenése, fejlődése is. Az ezredfordulót követően az informatika gazdag eszköztára már nem csak az adatgyűjtések végrehajtásának módját, de az adatok feldolgozását, az adatok kommunikációját is alapjaiban változtatta meg, amiben az agrárstatisztika az esetek többségében élen járt (első reprezentatív összeírás, folttérképek kidolgozása, Egységes Adatfeldolgozási Rendszerbevezetése, térinformatikai ábrázolások alkalmazása, stb.). Vitathatatlan, hogy az agrárstatisztika módszertanának alakításában markáns változásokat hozott az Európai Unió statisztika rendszeréhez történő csatlakozás is.

Introduction

The history of agricultural statistics is the same age as the birth of statistics which aims at observing and presenting numerically the phenomena, processes of the economy and society. Statistics has been present in our everyday life since centuries, it plays an important role in the information activity of the media, serves as the basis of the decisions of decision makers, and there is no science that would not rely on the tools offered by statistics.

The term of statistics was first used in the publications of *Gottfried Achenvall* (1719-1772), German philosopher, historian, economist, jurist for the purpose of analysing the information,

data related to the activity of the state. Researches revealed nevertheless that the word was originally due to his professor, *Martin Schmeizel*, but it was Achenwall who used and published it for the first time. Martin *Schmeizel* (1679-1747) from Transylvania, of Hungarian origin had used the word for the first time in his paper presented at the University of Jena (*Collegium politico-statisticum*, 1723).

Statistics has changed during the decades, adapting itself to the changes of the phenomena, processes, the development of techniques and sciences. The second half of the 19th century was characterized by the emergence of the methodology of descriptive statistics, the propagation of branch statistics. The methodology of statistics in the current sense (micro-, macro- statistics) was developed in the first half of the 20th century. The introduction of the methodology of sample surveys (Andres Kiaer, Arthur Bowley), of the confidence interval (Jerzy Neyman) took also place in that period. The elaboration of the methodological manual of national accounts (System of National Accounts – SNA) corresponded also to that period. In the second half of the 20th century, information technology influenced fundamentally the functioning of statistics in the seventies, IT supported surveys were carried out, increasing number of registers for statistical purposes were developed from administrative registers. More decisive changes occurred in the past decade, the digital world, information boom, globalisation, the accelerated way of life posed new challenges to statistics, with all their advantages and disadvantages.

In the world of information technology, the role of statistics increases considerably, statisticians must help users of statistics to understand properly the data, to be aware of the possibilities and ways of using statistical data. Statistical data misused by the lack of knowledge, or intentionally can cause serious misunderstandings and damage.

Hungarian Agricultural Statistics

In the case of Hungary agriculture – due to the natural characteristics of the country – has always played an important role during the past centuries, and this is the case nowadays as well. Currently agriculture represents 3-4 per cent of GDP, which corresponds to the ratio of developed countries. On the other hand, nearly half of Hungarian households carry out some sort of agricultural activity, which has economic and social implications as well.

The independent Hungarian statistical service was created in 1867, followed by the establishment of the Hungarian Statistical Office in 1871. The Statistical Office lead by Károly Keleti was among the firsts to put on its agenda the elaboration of the system of agricultural statistics. The history of the more than 150 years old Hungarian agricultural statistics is the history of changes. If we examine carefully the history of Hungarian agricultural statistics, we can distinguish 5 – more or less homogeneous – periods, each having its own lessons, messages, even for today.

Milestones of independent Hungarian statistics

Birth of the independent Hungarian Statistical Service

The Hungarian statistical service was founded in 1867, the legal predecessor of the current statistical office was established at that time in the form of the Statistical Department of a Ministry. The Department was led by Károly Keleti, first president of the Hungarian Statistical Office. The Statistical Office established in 1871 was among the firsts to put on its agenda the development of the system of agricultural statistics. The Statistical Office contributed actively to international statistical work as well. Already in the first years of the operation of the Statistical Office, Károly Keleti worked on the elaboration of the European

methodology of vineyard and wine statistics, which served as the basis for the vineyard and wine census conducted in Hungary in 1872. The publication presenting and analysing the results of the census is still available to the readers in the Library of the Statistical Office, the abundance of information and data, the splendid language of the publication fascinate the reader (Keleti, 1875).

The periods of Hungarian Agricultural Statistics

On the basis of my assessments I have distinguished five periods related to the history of agricultural statistics, taking as guiding principle the changes of the methodologies applied.

- Roots of agricultural statistics (from the beginning to 1867)
- Birth of independent Hungarian agricultural statistics (from 1867 to the end of the 19th
- century)
- Further on the beaten path (first half of the 20th century)
- Changes in agricultural policy and the answers of Hungarian agricultural statistics (second half of the 20th century)
- Accession to the Statistical System of the European Union and the period following it (from 2000 till today)

Roots of agricultural statistics (from the beginning to 1867)

Users interested in data, information in agricultural statistics are in a better position than users dealing with the data of other branches. Surveys on crops – due to the recovery of tithes – had been carried out already in the 11th and 13th century. From the 16th century, when the state took on lease the tithe from the church, the royal chamber introduced – for taxation purposes -

accurate crop surveys, which later were complemented by national censuses. The surveys of the beginning of the 18th century which covered already the production area, the quantity of crop, livestock, and were supplemented in some cases with information on agricultural prices foreshadowed already the outline of a system of agricultural statistics. Although the lands (not being subject to any feudal duty) of the nobility were not included in the surveys mentioned, the problem was alleviated by the fact that at that time great part of agricultural production was carried out in the form of tenure.

The establishment of the Austrian Official Statistics in 1829 was a turning point, followed by the establishment in 1840 of the Austrian Administrative Statistical Directorate. The series of publications entitled „Tafeln zur Statistik der Österreichischen Monarchie" edited by the Austrian Statistical Office contained already data on agricultural production in Hungary (based on the estimates of Hungarian agricultural authorities).

The short period when the Statistical department created under the leadership of Károly Keleti in 1848 functioned allowed only the elaboration of the plans concerning the development of agricultural statistics. After some months of work, the collection of agricultural data was once again taken over by the Administrative Statistical Directorate in Vienna according to the previously established practice.

The most valuable data collection of the epoch was the temporary cadastre of 1850 which aimed at determining the net income per land use categories serving as the basis of land tax. The great merit of the survey was that it covered all the holdings of the country, but the data were based on estimations which was a shortcoming, although the accuracy of the data was far much better than that of previous data. The method of surveying the quantity of crop was also very interesting. The quantity of crop production was determined in the villages by an expert committee. While in the committee the board of the village aimed to define the lowest

possible crop production (yield) averages, the commissioner representing the interests of the treasury in charge of the estimation tried to define higher yields. According to the opinion of the experts of the epoch – due to the different interests reflected in the composition of the committee – the crop yields estimated were mostly near to reality.

From 1860, the Austrian Administrative Ministry ordered the preparation of two annual reports on the situation of the crop production. The data collected were compared with the data of the cadastre, and the corrected data were published in the series of publications „Tafeln zur Statistik der Österreichischen Monarchie". The data published in the series „Tafeln zur Statistik der Österreichischen Monarchie" had nevertheless the weakness to correspond less and less to reality because of the significant changes occurred in the agriculture of the country (Konkoly Thege, 1927).

The period was characterized by the fact that data collections were carried out by local agricultural authorities, data collected were fundamentally based on expert estimations, meaning that the data were not always accurate, in many cases they must be taken with reservation.

Birth of independent Hungarian agricultural statistics (from 1867 to the end of the 19th century)

The independent Hungarian Statistical Service dates back to 1867, when a Statistical Department was created in the Ministry of Agriculture, Trade and Industry. The Statistical department – through the local authorities – partly continued the data collections launched previously by the Austrians, but it also introduced new data collections. The Department put great emphasis on the establishment of international relations as well. It was a recognition of the work of the emerging independent Hungarian Statistical Service, that the statistical

congress held in Hague in 1869 mandated it to elaborate the methodology of European vineyard and vine statistics. (Kokoly Thege, 1927). It was also due to external support that in 1871 the Statistical department of the Ministry was transformed into the National Royal Statistical Office.

At the beginning the aim of the Statistical Office was not to increase the number of data collections, but to improve the quality of statistical data (the number of data collections raised only after 1880). At that time agricultural statistics collected only data on the sown area of holdings of 100 Hungarian acres or bigger. The surface of the sown area of smaller holdings was estimated by the village prefecture, the quantity of crop production was calculated on the basis of the crop yields provided by economic correspondents.

The first Agricultural Census of 1895

The Statistical Office had elaborated the programme of the first full scope agricultural census with the personal guidance of Károly Keleti, but – due to the lack of resources – the implementation of the census took place only after Károly Keleti's death. The great merit of the census was that it covered all the holdings. The questionnaires collected data on all the fields of agricultural production. It was a serious progress that the consistency checking, control figures incorporated in the system of questionnaires contributed considerably to the improvement of data quality. With a little exaggeration we can say that it foreshadowed the outline of a system of quality control. The data collection was performed by the enumerators – under the supervision of the officials of the municipality, - their work was controlled and assessed by the committees of the municipality.

Hungarian Agricultural Statistics have been modernized on the basis of the results of the Agricultural Census conducted in 1895. The law on the Agricultural Census stipulated also

the introduction of the annual livestock counting in spring, though at that time cattle counting was still based on estimations (Konkoly Thege, 1927, Oros, 1999).

Further on the beaten path (first half of the 20th century)

From the turn of the century to the outbreak of the 1st World War, the implementation of agricultural data collections did not undergo substantial changes, the outstanding event of the period was the livestock counting of 1911.

During the World War agricultural statistics faced also serious problems, the number of data collections decreased, the reliability of data deteriorated, the activity of the Statistical department of the Ministry decreased also to the minimum. 1919 was the worst year when the Statistical Office did not conduct any agricultural survey.

The „revival" of agricultural statistics took place in 1921 only, when the conduct of an Agricultural Census was also planned. Due to the limited resources – as in so many occasions – only the previous annual agricultural surveys were implemented.

Statisticians made efforts to decrease the number of estimations, they urged instead the implementation of questionnaire-based surveys. In 1921-1922 the data of holdings of 20 Hungarian acres and bigger were already collected with questionnaires, the data on smaller holdings were collected on registers.

Data on yields were collected twice a year, preliminary data were estimated at harvest time (by the agricultural supervisors). The final data on yields related to holdings of 20 Hungarian acres or bigger were also collected via questionnaires. Data on smaller holdings were still based on estimations. Statistics on thrashing were introduced among others for controlling the yields of cereals. The implementation of data collections, the preliminary data processing continued to be the task of the local agricultural authorities (Konkoly Thege, 1927).

Agricultural Census of 1935

At the beginning of the 20th century, a new Agricultural Census should already have been implemented decades ago, in fact the second full scope census was conducted in 1935 only. Hungary carried out the census upon the recommendation of the International Agricultural Institute of Rome, predecessor of the Food and Agricultural Organization of the United Nations (FAO). Although the implementation of the Agricultural Census was not as successful as the full scope Agricultural Census of 1895, nevertheless the results were useful in many respects. The census showed that between 1895 and 1935 agricultural production hardly developed (we could even say that it stagnated), basically due to the half feudal system of holdings.

Beyond the regular agricultural surveys, there was an attempt in 1942 to conduct a full scope survey on agricultural production (including the agriculture of the re-annexed areas), but even the most important results of the survey could only be published by the Statistical Office in the Statistical Yearbook of 1948 (Oros, 1999).

Changes in agricultural policy and answers of Hungarian agricultural statistics (second half of the 20th century)

The tasks and activity of the Statistical Office changed radically after the 2nd World War. The competence, tasks, staff number of the Hungarian Central Statistical Office (HCSO) increased with the introduction of the so called "planned economy". In 1952, the creation of the regional offices of the HCSO brought changes, the implementation of data collections became the task of the HCSO. Within the county directorates of the HCSO, local offices were established in each district. They had the task to implement data collections, agricultural

surveys, including the annual compilation of the farmers' register, the full scope livestock counting, survey' implementation on sown areas, crop estimation and the determination of yields.

In parallel with the Office, the Ministry of Agriculture collected also data on the state and cooperative sector (the surveys, data collections performed by the Ministry were mainly oversized and inaccurate). There was a year when state farms had to fill in and send to the Ministry of Agriculture a questionnaire containing 40 thousand data, 50 thousand in the case of forestry.

As Hungary joined FAO in 1945, the idea of conducting a full scope Agricultural Census emerged the same year, but the planning of the census ended when Hungary left the FAO in 1953. In the following years the Statistical Office carried out instead of the Agricultural Census a countrywide Orchard survey in 1959, a countrywide Vineyard survey, and the survey on machinery in 1960.

The 1960ies brought again significant changes. Domestic agricultural production began to spread among the population of the villages. While detailed and abundant information was available on big farms (state farms and cooperatives of production), hardly any data, information were available on the households' agricultural activities, on the small scale production that represented 30-35 per cent of agricultural production. [Oros, 1999, Laczka, 2004].

Agricultural Census of 1972

In the seventies, as a result of national and international requirements Hungary joined the World Agricultural Census of FAO in 1970, the first Agricultural Census in the current sense took place in 1972. For developing countries FAO recommended the implementation of a

minimum programme and for developed countries that of a maximum programme. In 1972 Hungary implemented the maximum programme. As for the big holdings the majority of the requested data were available (from the state reporting system and official statistics), the HCSO collected only supplementary data in their respect. On the other hand, basic production data had to be collected on the agricultural activity of households. A full scope survey and 8 representative surveys based on the full scope census were implemented concerning agricultural activity of households.

As the task was to assess the total output of Hungarian agriculture, Hungarian statisticians defined for the first time the holding concept (threshold) related to households (private holdings). The agricultural census of 1972 produced a lot of information that had been totally unknown previously. It revealed that nearly half of the population of the country participated in agricultural production, nearly all social strata were represented among small farmers (Oros, 1999). In the Hungarian agricultural profession, the notion of „small-scale production" was introduced by statisticians.

Agricultural Census of 1981

In 1980 Hungary joined the decennial World Census round of FAO without prior discussion (the census was implemented in 1981), striving nevertheless to implement a more cost-efficient, but limited census programme than in 1972. Beyond the survey on big holdings supplementing the state reporting system, a full scope survey and 5 representative surveys were carried out concerning small producers, households' agricultural activities. The fact that the time-use survey conducted in 1982 observed already the social characteristics of "small producers" illustrates the good professional cooperation that existed between the departments of the HCSO. It was also an important achievement that the office opted for conducting

quinquennial sample surveys (in 1976 and 1986) to follow the structural changes of small scale farming (Oros, 1999). With the purpose of ensuring the international comparability of time series, statisticians continued to use the definition of private holdings (threshold) defined in 1972.

Agricultural Census of 1991

Land privatisation following the change of the political, economic and social system caused structural changes for the third time, which were among the biggest changes occurred in fifty years in Hungarian agriculture. Many households acquired lands, but many of them did not endeavour or – in the lack of the necessary skills – could not undertake to cultivate the lands, thus important areas were not cultivated. Property and land use conditions changed, the structure of production and resources were transformed, which meant that Hungary took part in the 1990 World Agricultural Census of FAO without hesitation.

The objectives of 1991 agricultural census were realized with the coordinated implementation of several surveys. In 1991 the Agricultural Census used and complemented the state reporting system and the surveys of the HCSO for the data needs on big holdings. One full scope and 2 sample data collections were implemented for households dealing with small scale production (Oros, 1999). The concept of private holdings (their threshold) remained unchanged.

Agricultural Census of 1994

The agricultural census of 1991 could report only on the initial stage of the process of transformation, it was not yet possible to reflect structural changes. In 1994 the HCSO

attempted to present the changes in their complexity, but the census failed to achieve its goals as it did not cover the holdings of the (new) farmers living in towns. [Laczka, 2010].

Regular annual surveys in Agricultural Statistics (from 1950 to 2000)

Beyond full scope census, regular annual data collections must be mentioned as well. The annual, regular data collections were in each case based on the results of the previous census. Their most important characteristic was that the surveys covered only the forms of farming that were considered as decisive from the point of view of agricultural production. Accordingly, in the fifties, sixties, seventies only state farms and cooperatives of production were obliged to provide data on a regular basis. During these years, the holdings with small scale production provided data in the case of the Agricultural Census only, although data provided by the big farms contained some information related to small scale production as well.

As contrary to land use, animal husbandry was not limited at that time either, the increasing livestock of households has been included in the statistical surveys since 1950. In the initial stage data on livestock were collected annually in the form of full scope surveys. It was in the middle of the fifties (1957) that sample livestock surveys were introduced and became regular in relation to the livestock of small holdings as well.

Fundamental changes appeared in the nineties. The work of the statisticians working at that time deserves to be praised, as they were able to react quite quickly to social and economic changes. The sample surveys concerning private farms were gradually extended to crop production and later to land use (Oros, 1954, 1999).

Accession to the Statistical System of the European Union and the period following it (from 2000 till today)

Preparation for the Statistical System of the European Union

Negotiations for EU-accession began in the middle of the nineties, giving quite a lot of tasks to statisticians dealing with agricultural statistics (at that time, the expected date of accession was the turn of the millennium). In the case of agricultural statistics, the work accelerated at the end of the nineties. The EU legislation in vigour at the epoch represented 1200 pages, this huge amount of legal texts had to be compared with the practice of Hungarian Agricultural Statistics.

Statisticians examined all the legal texts related to the different fields of agricultural statistics in the light of the Hungarian practice and classified the fields into three groups. There were statistical fields where the Hungarian practice was fully compliant with the corresponding Acquis Communautaire. The second group contained statistics that needed modification and the third group covered tasks that were considered new tasks for Hungary. With some simplification we can say that in 1999 each group corresponded respectively to one third of Hungarian agricultural statistics. The examination of all the items made also possible for statisticians to define in detail the respective tasks of the Ministry of Agriculture and its background institutions, and those of the HCSO, which resulted in the signing of a cooperation agreement. The agreement of cooperation put an end to the previous discussions, tensions. The division of labour was based on the "concept" that estimations, and similar tasks belonged to the competence of the ministry, while the HCSO was responsible for the areas of Agricultural Statistics covered by statistical data collections (Laczka, 2010).

In the following part of the paper, I would like to present briefly some important tasks in agricultural statistics without being exhaustive.

Agricultural Census of 2000

The agricultural census 2000 had the peculiarity of being conform to FAO recommendations, but it also fulfilled the requirements of the European Union. The full scope survey (census) of the output of the Hungarian Agriculture and the conduct of a full scope Vineyard and Orchard survey were in a certain sense a condition for accession.

The Agricultural Census 2000 (AC 2000) covered natural and legal persons engaged in agricultural activity on the territory of Hungary and holdings without legal personality. According to the law holdings with legal personality and without legal personality performing agricultural activity were obliged to provide data independently of their branch classification. Holdings realizing agricultural activity fulfilled their obligation to provide data on the basis of the National Statistical Data Collection Programme (OSAP). In the case of natural persons, the basic unit of the survey was the household.

The census was implemented with the reference date of the 31st of March 2000, the HCSO collected data on demography, employment, land use, livestock, machinery and assets. The census served as the basis for the sample surveys carried out in August and December 2000 which focused on the yields of crop production, livestock, livestock production statistics and the important parameters of machinery. The Agricultural Census 2000 dealt already with the environmental implications of agricultural production.

The Council regulation (EEC) 571/88 on the organization of Community surveys on the structure of agricultural holdings prescribed a statistical coverage of 99 percent for the output of the agricultural production in the Member States. The threshold value of 1972 satisfied the requirements concerning private holdings. In order to inform users the earliest possible – in 2000 – the HCSO compiled and published the preliminary data of the census within six

months after census taking, on the basis of a 1% sample. This solution has become a tradition in the case of censuses. (Laczka, 2010).

Agricultural Census of 2010

At the beginning of 2010 a broad debate developed in the European Union concerning the Common Agricultural Policy (CAP). Three-four meetings about agricultural policy were held in Brussels every week. It was obvious for statisticians as well that the CAP reform would affect the information system of the European Union, the new agricultural policy generated new information needs. Regulation (EC) No 1166/2008 of the European Parliament and of the Council on farm structure surveys and the survey on agricultural production methods was adopted after two years of preparatory work. According to the new regulation the EU all Member States are obliged to carry out in 2010 a survey in the form of a census, and in 2013 and 2016 sample surveys, it also stipulated that data had to be provided on the location of the farm with geographical latitude and longitude coordinates. The regulation stipulated also that the statistical surveys had to cover 99 percent of the agricultural area and livestock of the country. The threshold value defined in 1972 proved to be acceptable this time also – with some minor modifications.

The questionnaire of some eight pages of the Agricultural Census 2010 made also possible for the HCSO to retrieve certain data (data on organic farming, production of quality wine, subsidies) from administrative sources. Data, information on environmental impacts were covered by the sample survey on agricultural production methods. In 2010, the HCSO made possible for the farmers of the bigger private holdings to provide data via the post office (instead of a personal interview at the holding). (Laczka, 2010).

The Vineyard and Orchards Census of 2001

Due to its climate conditions, in Europe Vineyard and Orchard plantations cover a greater proportion of agricultural area than in other parts of the world. The situation in Hungary is similar to that of the Mediterranean countries where compared to the size of the population a much greater quantity of grape is produced that in the countries in the Northern part of Europe. The difference in relation to other fruits (mainly apple) is not so significant. For this reason, around the turn of the millennium Mediterranean countries considered the Central European countries before EU accession as competitors, and consequently they were expected to provide a new, reliable picture, statistical data on the situation.

Due to the structural changes that had occurred in Hungary in the sectors of vine and fruit production, the conduct of the plantation census was a timely task to satisfy national needs as well (the previous plantations censuses had been carried out at the end of the 1950-ies and the beginning of the 1960-ies).

The two basic observation units of the plantation census of 2001 were the users of the vineyards and orchard plantations and the plantations themselves. During the first phase of the census, enumerators collected the data on users of plantations, in the second phase they surveyed (on the spot) plantation characteristics. The multi-level organisation of survey implementation made possible the linking of quality control tasks, the operation of a unified system ensuring statistical and professional data quality.

One of the peculiarities of the plantation census was the design and use of „spot maps" prepared by the Institute of Geodesy Cartography and Remote Sensing (FÖMI). On the basis of remote sensing data, the experts of the Institute marked on a topographical map the presumed location and size of holdings. The supplemented topographical maps prepared with a new technology supported the design, organisation, implementation of the survey, but also

the validation of the data collected. This was especially important, because at the turn of the millennium there were no updated vineyard and orchard registers. It was for the first time that geo-coordinates were used to present the data of the Vineyard and Orchards 2001, which has been called „ÜST". (Laczka, 2002).

Economic Accounts for Agriculture (EAA)

The purpose of the Economic Accounts for Agriculture (EAA) is to analyse the process of agricultural production and the primary income generated by it. The EAA are a satellite account of national accounts.

The legal basis for the annual compilation of the EEA is Regulation (EC) 138/2004 of the European Parliament and of the Council, the methodology has been developed by Eurostat, data are published since 1964. Concerning Hungary, data from 1998 are available. The EEA are composed of production, income and capital accounts, which allow to assess, present the internal relations of the agricultural sector, and prepare sectoral models. EEA accounts are compiled three times a year by the HCSO and the Research Institute of Agricultural Economics (AKI) jointly. The first estimates are calculated in November of the reporting year, the second estimates in January after the reporting year, the final, complete accounts are compiled by the HCSO and the Research Institute of Agricultural Economics in September after the reporting year. It is obvious that before the end of the reporting year (in November), only very few statistical data are available, the first, preliminary results of the EAA are essentially based on estimates. The situation is only slightly different in the case of the second preliminary results (in January after the reporting year), when estimates are still prevailing. This is the reason why the first and second estimates are the main responsibility of the Research Institute (AKI), while the compilation of the final data (in September after the

reporting year), are of the responsibility of the HCSO. In autumn after the reporting year, statistical data necessary for the compilation of the EAA are already fully available. The joint compilation of the EAA introduced during the first years of the new millennium is one of the most meaningful examples of the cooperation between the HCSO and the Research Institute (AKI) and of professional cooperation in general.

HOMBÁR and the Unified Data Processing System (EAR)

Finally, I would like to mention among methodological developments an innovation that data users perceive only indirectly. These are two systems of statistical data processing (HOMBÁR and the Unified Data Processing System – EAR). The concept of data processing is fundamentally different from the previous practice. The basic idea of HOMBÁR and EAR can be compared to the use of LEGO bricks. IT experts program „mathematical operations" according to the requirements of the statisticians, who use and reorder them during data processing which is led and managed by statisticians. The HOMBÁR concept was elaborated and introduced between 2000 and 2005 as a result of the dreams of agricultural statisticians. After 2010 - based on the good experiences of HOMBÁR – the HCSO extended the system to nearly all the fields of official statistics. The great advantage of HOMBÁR and EAR is that they provide statisticians with a new IT tool. The processing of statistical data is under the direct control of the statisticians, the system integrates statistical and IT work in line with the requirements of our epoch.

The contribution of Agricultural Statistics to the Hungarian Statistics

Agricultural statistics are one of the most multifaceted fields of statistics. On the one hand because from the use of administrative data, registers to traditional data collections and macro

statistics (satellite and national accounts), everything can be found in the agricultural system, and this applies to the use of the methodological tools as well. Due to the complexity of agricultural statistics we can say – with some exaggeration – that agricultural statistics reflect the statistical tasks of official statistics.

This should explain that during the decades, agricultural statistics have always been one of the flagships of statistical developments. The livestock counting in the form of a sample survey (1957) was one of the first sample surveys in the Statistical Office, the use of the concept „small scale production" was introduced in the agricultural literature by the Agricultural Census 1972. The solution elaborated at the time of the Agricultural Census 2000 ensuring the quick production and publication of preliminary data (processed and produced on one percent sample) is still applied. The „spot maps" elaborated and used during the Vineyard and Orchards Census 2001 were original and new, modern tools, similarly to the GIS application of the census results. The first census when two third of the data were based of administrative data sources (the Vineyard Census 2009) was also the result of the developments in agricultural statistics.

The HOMBÁR system elaborated 2000-2005 by the staff of the Department of Agricultural and Environmental Statistics (with the support of an EU project) was also the merit of agricultural statisticians.

Agricultural Statistics nowadays

The decade after the millennium brought again significant changes in the life of statisticians. Changes occurred again in land use, land ownership, it became indispensable to observe these changes. It is not an easy task neither for the owners of registers nor for statisticians to reflect (update) these changes, and it is not easy either to define accurately agricultural production,

the population of producers. The task is all the more challenging that the structure of Hungarian agriculture resembles in many respect that of the Mediterranean countries. There are many small production units engaged in agricultural activities, but due to their high number, the quantity of agricultural products they produce, the role of producers in the production of agricultural products cannot be neglected. The products produced can on the one hand influence the market, but it is also indispensable to examine the social conditions of producers. Consequently, statisticians have to determine the population observed in the more accurate way. It is necessary to differentiate the units of production considered as holdings „only" from the point of view of statistics and those which can be considered holdings in an economic sense. Numerous publications have been published since the millennium concerning the concept of holding in statistical and economic sense, calling the attention to the phenomenon and the usability of data.

It is the task of agricultural statistician to decide which data sources, which data collection methods should be used to observe the different economic groups. Obviously different data sources, different statistical procedures, methods should be used in the case of small and big units of production. It is also obvious that in the case of small units, estimations, modelling are more practical and cost efficient. Thanks to technical development, information explosion, the elaboration of new solutions is an exciting challenge for statisticians, good quality estimations should not be a problem nowadays at all.

Conclusion

Nowadays the life of statisticians is determined by the influence, the advantages and disadvantages of the digital world, information boom and globalisation. Changes are more

significant than ever, today it is not possible to give traditional answers to challenges, to use traditional solutions. In this situation statisticians can learn from the history of agricultural statistics as well, including the failures and successes. Let us just consider that – similarly to agricultural statistics in other countries too – agricultural statistics started with the use for statistical purposes of data collected by the state for taxation purposes. Huge amount of estimations used in agricultural statistics were later gradually replaced by (factual) data collected via questionnaires. Thanks to technical, IT, scientific development, IT has become in the seventies one of the most important tools in statistics, administrative and statistical registers have become part of the life of statisticians. The digital world requires once again a paradigm shift. Today the mass of data, information existing in official statistics, in the research and private spheres must be used for statistical purposes, they must be integrated and standardized. The role of estimations increases again in the work of statisticians, but nowadays estimations should be based on mathematical, statistical methods which together with modelling gain weight and their application requires a deeper, more thorough knowledge than before.

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GAMIFICATION AND AUGMENTED REALITY IN AGRICULTURE – EDUCATION AND PRACTICE POSSIBILITIES

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Abstract

By the widespread increase of new technologies, Internet has become an essential element for generation Z, however, this is not particularly surprising given the fact that over recent years different IoT solutions have become widely available, well-known and increasingly cheaper. As we know the new devices like tablets, phablets, other smart devices and new services like Cloud Computing, Augmented Reality, Blockchain and Gamification have great potential in agriculture. Gamification nowadays is a method that become more widely used depending on field of use, thus it may meet needs of businesses and also educational institutions. However, the business assessment of these technologies must not be done only on the basis of the technology and taken out of its environment randomly, since the whole area is very complex. Since we do not concentrate on learning during games, students

will find learning a pleasure rather than an imposition and it means many could improve their skills or receive information without realizing they are actually studying. In this article the authors show Augmented Reality and Gamification to highlight the possibilities in agriculture.

Keywords: gamification in agriculture, future possibilities in agriculture, AR and VR technologies, IoT, IT innovations, blockchain

Összefoglalás

Az új technológiák és az internet széles körű elterjedésével a Z generáció szinte lételemévé vált a mobil vagy más IKT eszköz használata. A kiterjesztett valóság (AR) használatával sok lehetőség merülhet fel, mind az oktatás, mind pedig a szórakoztatás területén. A játékosítás vagy gamifikáció egy olyan módszer, amely rendkívül jól kiegészíti korunk technológiai megoldásait, amely segítségével a vállalkozások és az oktatási intézmények igényeit is kielégíti. Az általa megszerzett tudást a hagyományos tanulási módszerrel szemben, hosszú időn keresztül tudják hasznosítani a diákok és a munkavállalók, melyet később a munkaerőpiacon is alkalmazni tudnak majd. A módszert használói hatékonyabban és kisebb erőfeszítéssel tanulhatnak meg egy-egy munkafolyamatot vagy tananyagot játékosítás révén. Ennek eredményeképpen a tanulás ezen innovatív megközelítése egyre inkább népszerűvé vált nemzetközi szinten. További előnye, hogy a motivációs problémákra is megoldást nyújthat. Ebben a tanulmányban a korszerű AR és VR megoldások által az agráriumban alkalmazható játékosítást igyekeztünk bemutatni gyakorlati példákon

keresztül. Emellett innovatív megoldásokat is gyűjtöttünk, amelyek a mezőgazdasági robotizációt és a mesterséges intelligenciát támogatják napjainkban.

Introduction

It is expected that the world's population will reach 9.6 billion by 2050. One of the main challenges for the future of agriculture is the proportion of food, feed and energy production on the land base. The population growth increasingly enhance the intensification in the sector, to produce larger yield of the highest possible quality on smaller area. It poses a number of challenges for farmers, moreover climate and extreme weather conditions and several negative effects on the environment make it more difficult (ENSZ, 2015).

Technological development following the turn of the millennium brought ground-breaking innovations which became part of everyday life. The way we communicate and obtain information has changed profoundly with the appearance of smart devices. Devices connected to the network, namely the Internet of Things (IoT) has a significant impact on the life of simple users and private sector but it also affects technological development of industry and agriculture. By these devices entered into production processes we are living in the era of Industry 4.0 since they connected in one network and can communicate to each other and in some cases Artificial Intelligence (AI) enables them to take decisions (Popp et al., 2018). By the expansion of IoT and the devices connected, our efficiency and productivity would improve and it represents a great potential for agricultural sector. Self-driving tractors and harvesters appeared over the last decade are used as part of the precision farming also in Hungary. New technological advances and innovative solutions are expected to be emerged

for the agriculture in the near future which could be built on gamification, augmented reality and continuous and sensor-based data collection. Simultaneously, a new approach is to be developed in line with the new technologies (Big Data, Cloud Computing, Artificial Intelligence, etc.) which is not based on the usual physical data storage and collection any more but with the possibilities offered by the internet, connect networks and systems. As a result of the digitalisation and technological development, agriculture has an opportunity to be a priority development area besides industrial development.

Agricultural opportunity of gamification as a method

In this study, we want to create a structured literature processing, through the AR and VR evolution. We have gathered examples of current technical solutions from the early phases to the most recent ones. First of all, we did a keyword search with the help of repositories, and then we have limited the well-known authors and methods which results are presented in detail in the next chapter. The term of gamification is described by Deterding et al. in 2011 and they defined it when a game element is used in a non-gaming environment (Deterding et al., 2011). First, the method was used as a marketing tool but through its efficiency it has soon appeared in the area of HR and education. It is important that this method is an excellent motivation tool and it is used to raise the interest of potential employees for current agricultural professions. Lee and Hummer published an article about the introduction of gamification in schools and besides the advantages they highlight also the potential risks (Lee and Hummer, 2011). It can be used both for education and further training depending on industrial development. Moreover, despite the traditional learning method, the

knowledge acquired this way can be used for a long time during seminars and later on labour market. Students may learn more effectively and with a lower effort using gamification. As a result, this innovative approach of learning has been becoming more and more popular internationally, furthermore, motivation shortage problems also could be solved by this method. Applications specifically written for AR devices (e.g. Oculus Rift, Samsung VR) allow in horticulture sector to practice pruning in virtual environment where a wrong pruning move do not cause crop loss. Positive feedback in gamification is important for employees therefore they can obtain scores, coins or brooches after learning the pruning methods of certain tree species.

During our previous research a gamification application, Koronakirály (CrownKing) has been developed. We made it partly for business purposes but at the same time it is a farm simulation application since the whole agribusiness included in it and strengthen the agricultural aspect. The name of the application, Koronakirály, refers to the Hungarian system for evaluating land quality (gold crown system). Our application contains production, processing, commerce, mission, questions, statistics and weather modules which seeks to strengthen the realistic nature of it.

The location of the app is Hungary and primary objectives are production and processing, then acquiring new areas. Users can learn the different agricultural techniques, plants, yields and the basic of commerce and market in different decision making conditions. The detailed description of our app is available in our previous article (Kovács et al., 2017).

Figure 1. The CrownKing user interface, services

Source: Own figure, 2017

As the figure above presents, users can process different raw materials and produce finished products in services modules. Left side of the page contains different services from which red wine production menu item is opened, where we can see the type and quantity of raw material needed, the production time, the price and the quantity of product to be prepared. We can produce brandies from different vine variety which can be sold at higher price because of the higher added value.

During use technology, raw materials, costs and revenues also can be learnt thus the transition from education to work will be easier and users could have the additional knowledge needed. Besides professional materials daily quiz questions give variety to the application which also ensure gamification and help students in learning. I mention here, as a further option, the installation of an online exam surface to help teachers and trainers in administration (Kovács et al., 2018).

Penetration of augmented and virtual reality

It is important to note that the term of virtual reality and augmented reality is not the same, however, several publication use them as synonyms (Azuma, 1997). The location means the difference between the two: when virtual headset (e.g. Oculus Rift) is used, we get into an artificial environment where the given game or application take place thus the reality is excluded, while in the case of augmented reality we stay in the same place and the different virtual items will be projected here. In augmented reality we watch some content through the camera of our smart phones or tablets and a specifically developed application projects images or information there (Szűts, 2011).

IKEA applied AR technology among the first. They developed an application which took much weight off the people's shoulders who intended to purchase furniture. This app shows furniture in that room where they would like to put in so they can match the new item to the wall colour and the existing furniture. For this, the camera have to be pointed where one would like to put the furniture and the application will paste it to scale anywhere in the scanned place.

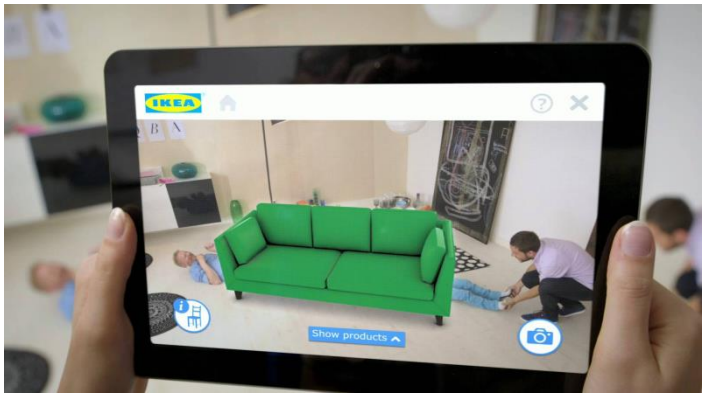

Figure 2. Ikea's AR application (IKEA place)

Source: I1, 2018

After this, Google developed a new Maps assistant which displays a fox when we use the GPS and it have to be followed to reach the destination. This development is an AR application and known as Visual Positioning System (VPS).

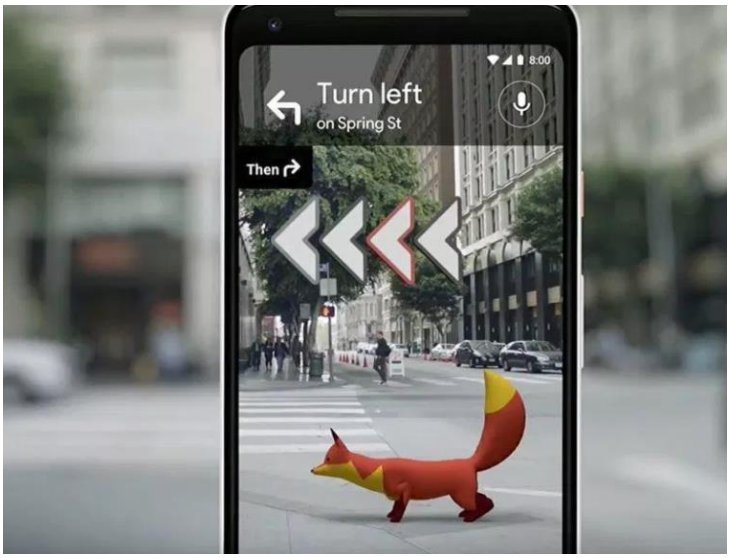

Figure 3. Google (VPS)

Source: I2, 2018

Microsoft's HoloLens is another tool as a displayer of augmented reality. Contrary to Ocolus Rift, which is one of the most well-known application, HoloLens displays virtual images and information as a hologram in real space and on real objects (Székely, 2015).

Among agricultural VR applications I highlight Bayer's development, Bayer VR farming. Gamification also plays a role in the application through games to solve and besides it, ecosystems and pests of certain soils also can be known (Figure 4). The application points out the possible reasons of the crop failures and makes various suggestions for prevention.

Augmented reality is now a relatively new technology, however, it has become more widespread, popular and available. Augmented reality, which was only used in scientific environment, has been involved in everyday life of simple users by the penetration of smart phones.

Figure 4. Bayer VR farming

Source: I3, 2018

Besides applications developed for educational purposes to help learning and provide practical knowledge, special dedicated software developer companies also have appeared with the aim of entertainment. It can be seen that both AR and VR technologies hold huge potential and they are present in everyday life when one plays, learns, uses GPS or plays sport. Furthermore, virtual tourist assistance services are also available today, an application presents tourist attractions and programs of Szolnok for visitors (Ráthonyi and Ráthonyi-Odor, 2017). This example demonstrates well the expansion and applicability of these innovative solutions both in scientific and daily life. Among agricultural VR games, Harvest Simulator is trying to make young people like farming through game. The weakness of the software that it is not platform neutral and in this way it is only available for Mac computers and PCs in single player mode. The software allows users to carry out different production tasks combined with missions in a virtual farm.

Innovative technologies and IT solutions for agriculture

As outlined in the previous chapter, AR, VR and gamification products have appeared not only on the market of everyday applications but it is used in different industrial sectors as specific software. The rapidly evolving informatics sector, the growing number and widespread usage of IoT devices with the decrease of their sales prices establish the possibility for innovative agriculture that could have been imagined only in the industrial sector a few years ago. Appearance of smart phones, smart bracelets and fitness tools in livestock farming and in sensor-based agriculture has begun as a result of the decrease in their price. This part presents briefly these innovative solutions. In Scotland, a smart collar developed by a start-up in Glasgow (Figure 5) has been applied for research and monitoring purposes since 2010. The concept of its operation is that the collar can sense when a cow is ready for mating since it indicates evidence entering oestrous (moves more, looks more restless), and the collar sends a message to the smart phone or laptop of the employee (King, 2017).

Figure 5. Smart neck Collar for Cows

Source: I4, 2018

Another system applied in another dairy farm has been examined by a research group of Osaka University. The method has been used to reduce lameness of cows which means 99 per cent of cow diseases. In this case movements of cows were studied in a farm monitored by video camera and their walk has been analysed. An artificial intelligence based algorithm was carried out for early detection of the disease and it can predict the cows affected by lameness at an early stage. The software has proved an effective tool for indicating lameness in moderate or severe stage in the experimental period (I5). A camera surveillance has also been carried out in Belgium where hatching and behaviour of broiler chickens were analysed by a research group and in 90 per cent of the problematic cases the system warned employees in time. Moreover in Beijing, AR was introduced with a special method of teaching students to implement virtual mapping of strawberries using the D'Fusion framework (Sheng et al., 2013). However, outstanding technology developments using IoT have taken place not only in livestock farming but crop production. German researchers are seeking to decrease the amount of fertilizer based on multispectral aerial images using drone technology. Infrared and near infrared spectral range allow them to assess the condition of the biomass in the area which indicate the supply of water and nutrient elements. In addition researchers may estimate production. Researchers found that in three years 34 kg nitrogen can be saved on average per hectares in the case of oilseed rape (Brassica napus). Various types of agricultural robots using sensors also appeared to help farmers measuring humidity, air pressure, soil compaction, water supply and collecting many other data on an ad hoc basis, in real time.

During an experiment carried out in England, given the name ‘Hands Free Hectare’, only robots were applied during the production of one hectare of spring barley (I6). In their experiment, Xiong and his colleagues carried out an algorithm and built an agricultural robot for weed detection using laser-based technology and in this way it could weed mechanically

in real time (Xiong et al., 2017). Image processing detected weeds with a precision of 97 per cent, in addition, it determined the shortest possible route for effective weeding. This solution is an excellent example for illustrating the potential of these environmentally friendly, AI based technologies and proving that they could have an essential role in the agriculture of the future instead of introducing new herbicides and chemicals and increasing their quantity.

As a new technique, blockchain is known from crypto-transforms. Of course, nowadays, the use of block chains appears as part of supply chain management at some companies. As food counterfeiting is stronger on the Far Eastern market than in Europe, the Kerchin cattle Industry has introduced the tracking of the production and transport of frozen beef, which already accounts for 10 percent of its online sales. The importance of technology is demonstrated by the fact that the European Union and China, within the framework of the EU-China-Safe project, have decided to start working together on the use of blockchain technology to raise food safety regulation between the two regions. The use of the block chain in the tracking of agricultural products is an excellent opportunity, as vertical integration can be developed with smaller farms and producers. Wolfert et al indicate the sharing of information as a key factor for effective smart farming, but do not write about trust among the chain actors. Two scenarios are outlined when the first is an open collaboration system, the second is closed (Wolfert et al., 2017) In our opinion, the spread and introduction of closed systems in the coming years is more likely due to GDPR.

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Conclusions and future prospects

The aim of this study to highlight current technological development in agriculture through some example and how these solutions got into the sector. We presented the opportunity of gamification, AR and VR technologies in education and employee retention and their application in IoT and robotisation. It is clear that agriculture has to face with the rapid population growth, the crop loss caused by natural disasters or damages, the weather variability and the adverse age composition. Almost 20 years ago Kapronczai described that agriculture profession is considered less attractive (Kapronczai, 2002). Popp described in 2014 that the better qualified a person working in agriculture, the more possible he will leave this profession in the short term (Popp, 2014). High level digitalisation and application of IoT devices could mean the solution for all these problems. The presented experimental examples from abroad define well the future possibilities, those trends which should be followed by the agricultural companies of the future. Sensor-based farming is not a new phenomenon and it can be considered the cornerstone of the precision agriculture and the reduction in the price of these devices allows farmers to use modern technology during production or processing. In addition, researchers try to take into account the issue of sustainability to reduce the environmental footprint of the agriculture (using less fertilizer, chemicals, etc.). However, not only hardware innovations diffuse into agriculture but different ISO standards also contribute to the spread of environmental management schemes (EMS) (Ridley, 2001).

In summary, the technological development in the agriculture slowly begun. Smart farms have appeared and in the near future robotics is also set to play an increasing role in production. Several studies point out that potential in livestock farming may be greater as the automation of horticulture and other intensive plant cultures is very difficult even with current

technologies. Thus, precision farming built on sensors and smart farms represent the future. However, prices of the presented devices are constantly falling, high investment costs mean barrier for domestic application. Although it is important to consider that despite long-term rate of return we can do a lot for our environment with the use of these technologies which will facilitate sustainability.

In addition, we cannot ignore the fact that the biggest limit in Hungary is the lack of capital for farmers, and the fragmented property structure is also hindering for the benefit of these innovative investments.

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THE POSSIBLE ROLE OF URBAN WASTEWATER TREATMENT PLANTS IN NUTRIENT- AND ENERGY MANAGEMENT

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Abstract

In our article, we deal with the potential role of wastewater plants in energy generation and nutrient management. We primarily deal with larger size plants, since in these plants there is a wider spectrum of energy and nutrient management options. This is due to, inter alia, economies of scale, higher amounts of homogeneous raw material and, consequently, easier utilization and qualification of different products.

In our estimates we have found that a purification plant using anaerobic technology for a population of 100,000 households can produce 2900 m^3 of biogas per day and from this about 1900 m^3 per day of biomethane. As regards the nutrient management of the site, the amount of the macro-element content of the incoming wastewater, which is approximately 13,000 m^3, is 281.000 HUF (~ EUR 900) of TKN (Total Nitrogen, 1.3 t/day) and 68.000 HUF (~ EUR 220) of TP (total phosphorus 0.2 t/day). In the outgoing purified water there is a TKN of HUF

42.000 (~ EUR 133), and a TP of HUF 4.400 (~ EUR 14). The methods and the values used in the calculations can serve as basic data for further comparative tests and potentials for different size plants.

Keywords: sludge, sewage plants, urban waste, biogas, biomethane

Összefoglalás

Cikkünkben a nagyvárosi szennyvíztelepek energiatermelésben és tápanyag-gazdálkodásban betöltött lehetséges szerepével foglalkozunk. A tisztító telepi kategóriák megemlítése mellett elsődlegesen a nagyobb méretű telepekkel foglalkozunk, ugyanis ezeken a telepeken szélesebb az energetikai és tápanyag-gazdálkodási lehetőségek spektruma. Ennek oka többek között a méretgazdaságosság, a nagyobb mennyiségű homogén alapanyag, és ebből adódóan a különböző termékek könnyebb hasznosítási lehetőségei, minősítése (pl. a homogén minőségű és mennyiségű rothasztott iszap termelése és hasznosítása).

Cikkünkben bemutatjuk, hogy nagy jelentősége van a rendszerszintű tervezésnek, és a körfolyamatok beépítésének, amely által az egyébként klasszikus értelemben vett hulladékból (szennyvízből) komoly értéket képviselő termék állítható elő. Éppen ezért a keletkező szennyvíziszap hasznosítása terén az esetleges égetés vagy hulladéklerakókba történő kihelyezés alternatívájaként minél teljesebb módon szükséges megvizsgálni a mezőgazdaságban történő hasznosítás lehetőségeit. Becsléseink során azt kaptuk, hogy egy 100.000 lakosegyenérték méretű, anaerob technológiát is alkalmazó tisztító telep gázvonalán napi szinten 2900 m^3 biogáz és ebből nagyságrendileg 1900 m^3/nap biometán termelhető. A

telep tápanyag-gazdálkodását illetően a telepre érkező – megközelítőleg 13.000 m^3 mennyiségű – szennyvíz makroelem-tartalmának értéke 281 ezer Ft TKN (összes Nitrogén; 1,3 t/nap), illetve 68 ezer Ft TP (összes foszfor; 0,2 t/nap). A kimenő tisztított vízben pedig 42 ezer Ft értékű TKN, illetve 4,4 ezer Ft értékű TP található. Az általunk a számítások során meghatározott értékek alapadatként szolgálhatnak további vizsgálataink, valamint eltérő méretű telepek potenciálbecslése céljából.

Introduction

Around the world, an increasing proportion of the population are moving to cities and producing increasingly large quantities of waste, the major (and difficult to handle) part of which is produced in liquid form. In contrast to smaller settlements, industrial plants operating in cities also emit large quantities of often hazardous organic matter, which should be managed together with household sewage, preferably in an automated and cost-effective way, with anaerobic fermentation and other technological solutions, to produce renewable energy. In addition, there is a great potential for utilizing the macro and

microelement content of the organic material in the wastewater from the plant. In our article, we deal with the potential role of these large city wastewater plants in energy generation and nutrient management. The role and potential of sewage in nutrient management are fundamentally determined by current environmental regulations and economic and financial conditions. At the same time, it can be stated that the raw materials, macro and microelements - generally used in agriculture - are present in large amounts in sewage and therefore,

depending on the different utilization methods, the measurement of their quantity and value is in any case justified.

Literature review

Today, due to increases in population and living standards, the amount of water used is constantly growing. Agriculture is responsible for 70% of global water use, 11% is for urban, residential use, and 19% for industrial water demands (UNESCO, 2017). By contrast, water scarcity is constantly increasing, driven by climate change and changing consumer habits ("water-intensive" foods, for example, meat consumption in the developing world, as well). In the 21st century, water scarcity is one of the biggest global problems: according to the FAO, by 2025 1.8 billion people will live in physical water scarcity (Internet1).

Another trend is that an increasing proportion of the population are moving to large cities; the share of urban population is over 50% globally, while in Hungary it is almost 70% (Kovács, 2017). The population flow to cities is very rapid: in global, their population is growing by about 200 thousand a day, and the area they occupy by 110 km2, and the proportion of the population living in cities of more than one million is over 27% (Internet2). The wastewater management problems of villages and cities, and the possibilities for applying technology differ greatly, not only because of the different size and the different regional roles of these settlements, but also because of the different income levels and wastewater quality. Villages are smaller and closer to nature, with more restricted purification efficiencies, while in large cities, due to the more concentrated and larger quantities of industrially polluted wastewater, large-scale automated, predominantly sludge-based sewage treatment plants are characteristic

(Bodáné Kendrovics, 2018). At the same time, there are other demands made on the large plants, and in addition to waste management tasks, in most places there is a need for anaerobic gasification, the production of heat and electricity, and occasionally (e.g. in Zalaegerszeg, Hungary) serving some local transport needs. In this context it can be stated that changing consumer/decision makers' attitudes in transport may help to promote the spreading of sludge based transport fuels, too (Jámbor - Mizik, 2008).

The three-stage water-energy-nutrient model is closely related to sewage treatment, so the efficiency, quality and other characteristics of the cleaning activity carried out have an impact on the environment, on society and on the economy, as well.

The amount, characteristics and value of the wastewater produced

According to FAO data, nearly three hundred billion m^3 of wastewater is generated over the course of a year on Earth. However, as regards cleaning it, it can be said that in the developed countries with a good economy the proportion of water purified is good (on average 70%), while in average and developing countries and poor countries, this proportion is on average only one third, or one quarter (Sato et al., 2013). Accordingly, around 80% of the wastewater produced around the world is estimated to be released into the environment without appropriate treatment, or purification (UNESCO, 2017).

According to McCarty et al. (2011), energy in wastewater is present in three forms. The specific theoretical amount of energy in sewage water considered average in the USA is as follows:

1. The energy of organic pollutants: ~ 1.93 kWh / m^3

2. The energy of plant nutrients 2 (N and P): ~ 0.79 kWh / m^3

3. Heat energy: ~ 7.0 kWh / m^3

The above values were measured by McCarty et al. (2011), calculated on the basis of the COD (Chemical Oxygen Demand) value for the organic components present in the wastewater (500 mg/l), assuming a theoretical power generation potential of 3.86 kWh/kg. In Hungary, this value is somewhat higher, and the wastewater is more concentrated due to the lower water consumption per capita. In addition, it is worth noting that the concentration of crude wastewater depends on several factors (depending on the country or region's economic situation, specific production activities, or water scarcity).

Types of cleaning plants, factors influencing their size

The size of the cleaning plant is fundamentally influenced by the energy and nutrient management potential. The purification technologies can be divided into two types, following Dittrich (2016): intensive and extensive technologies (Table 1).

Table 1. Categorization of sewage treatment technologies

1. Intensive technologies	2. Extensive technologies
1.1. Sludge processes: - Traditional - SBR - Oxidization ditch - etc. 1.2. Fixed-film procedures: - Drip bodies - Disc, etc.	- Sewage purifying lakes, built wetlands, flowing over the surface - built wetlands, flowing under the surface wetlands: root zone wastewater treatment - Soil filtration, soil spraying - Skimming - Pebbles and sand filters, etc.

(Source: authors' own editing, based on Internet3)

Among these technologies, the combination of intensive sludge effluent treatment and close-to-nature cleaning (plant and animal ecological community) is the so-called “living machines” cleaning technology. The purifier - which includes the classical anaerobic-anoxic-aerobic chain and plants on a lattice, as well as microorganisms and even higher-level animal organisms - is housed in a greenhouse-like building (Grant et al., 2012 IN: Veres, 2015). In this way it is partly possible to compensate for fluctuations in winter temperature and efficiency fluctuations, and the irritating smell can be reduced.

Based on TESZIR's records (Települési Szennyvíz Információs Rendszer / Urban Wastewater Information System), only 25 of the 574 plants in Hungary have a capacity of above 100,000 PE (population equivalent), while these plants account for more than half of the total cleaning capacity (Internet 3). Generally speaking, most of the wastewater is cleaned by larger size cleaners typically based on activated sludge technology. Sewage plant biogas production is carried out in 30 plants and - with one exception - is carried out in plants of at least 50,000 PE capacity. This is confirmed by Kárpáti (2016), who designates a 20-40 thousand PE capacity as the lower limit of the economic feasibility of biogas production.

Significant changes have been made in sewage sludge placement over the past decades. Prior to the millennium, sewage sludge was rendered harmless in seas or placed on agricultural land. Since 1998 the European regulations – the Urban Waste Water Treatment Directive (UWWTD) - have banned the disposal of sewage sludge in seas. As a result, a significant portion of sewage sludge (35-45%) has found its way to landfills (Rózsáné Szűcs, 2013). Changes in utilization ratios have moved in a favourable direction towards recycling in the last decade, and sewage sludge is considered a potential source of raw material (Gabnai – Gál, 2016).

Linkage of the circular economy to sewage treatment

In areas such as sewage treatment, where significant quantities of waste and by-products are processed, disposed of and possibly re-used or prepared, it is of the utmost importance to keep in mind sustainability and environmental awareness criteria. A wastewater treatment plant has the ability to "let through" the incoming material, which represents a

significant nutrient and energy content, without making use of any energy or material content, simply applying the mandatory cleaning function. In contrast, it is also possible to exploit the potential of either energy self-sufficiency or even surplus energy production and substantial nutrient re-utilization. The latter also includes the approach represented by the circular economy, where emphasis is placed on minimizing losses, reuse and recycling (Geissdoerfer et al., 2017 IN: Kiss T., 2018). We need to grow food on even less land and with less water, using less energy, in the future than today for feeding more and more people (Popp et al., 2014), so with the energy use of wastes (e.g. sewage) instead of plants we can save significant amount of land (Popp et al., 2018).

Methodology

In our article, in addition to mentioning the cleaning plant categories, we primarily deal with larger size plants, since in these plants there is a wider spectrum of energy and nutrient management options. This is due to, inter alia, economies of scale, higher amounts of homogeneous raw material and, consequently, easier utilization and qualification of different

products (e.g. production and utilization of homogeneous qualities and quantities of sifted sludge).

In our estimate - in the context of the circular economy concept - we determine the quantity and quality of product that can be produced for a unit-sized sewage plant (equivalent to the sewage produced by 100,000 adult inhabitants), as well as the value of the macro elements in wastewater. Our calculations include the following considerations:

• Biogas production and biomethane production potential

• The macro element content of the water arriving to the plant and the purified wastewater and its value

• The amount, nutrient content and utilization potential of matured sludge

Estimated basic data of a 100,000-inhabitant equivalent purification plant (based on data of Kárpáti, 2014):

• Amount of incoming, purified sewage: 13,000 m^3/day

• Biological oxygen demand: 6,000 kg/day

• Daily excess sludge yields: 0.7 kg MLSS/kg BOI

• MLVSS/MLSS ratio: 0.85

• COD (Chemical oxygen demand)/MLVSS ratio: 1.5 kg COD/kg MLVSS

• Specific methane content: 0.35 m^3 methane/kg of COD

Basic data used to calculate the value of (or monetary value of the) nutrient content of sewage:

• Nitrogen active ingredient: ~ 216 thousand HUF/tonne (~ EUR 690)

• Phosphorous active substance: ~ 339 thousand HUF/tonne (~ EUR 1,080)

Calculation: average data are taken from KSH (Central Statistical Office) (Internet 4).

The macro element content of the incoming and outgoing sewage, and wastewater sludge compost, taking into account Kárpáti's (2014) data:

• Incoming sewage TKN: 91-112 g TKN/m^3 (mg/l)

(TKN - Total Kjeldahl Nitrogen - Amount of Ammonium N and Organic N)

• Incoming sewage TP: 14-16 g TP/m^3 (mg/l) (total phosphorus)

• Outgoing sewage TKN: 15 g TKN/m^3 (mg/l)

• Outgoing sewage TP: 1 g TP/m^3 (mg/l)

• Compost TKN (in dry matter): 2.1%

• Compost TP (in dry matter): 1%

Results

Yield estimates for energy and nutrient management

Biogas Production Potential

On the basis of our calculations we can calculate the amount of biogas produced daily in anaerobic sewage sludge digestion process (based on technological parameters), as 2900 m^3, from which 1900 m^3/day biomethane can be produced. Based on these products, two main ways of utilization can be identified:

(1) Co-generation utilization: both heat and electricity are generated. The primary purpose of co-generation is to pursue energy self-sufficiency.

In the literature, several plants have been identified in which an energy self-sufficiency of more than 100% has been realized and where surplus commercial biogas is even sold (typically German, Austrian, Czech, British and American plants) (Shen et al., 2015). The cornerstone of economical operation is in this case the utilization of the waste heat generated in the process, which accounts for about 55-60% of the generated energy. The efficient and complete use of waste heat is made difficult by the fact that not only is the heat energy self-consumption reduced in the summer, but also the amount of biogas produced is higher than in the winter period, so it is rather problematic to plan continuous and complete heat utilization. Naturally, the fact that during the summer season the household heat demand decreases also contributes to this. During this period, it is possible to meet the technological heat demand of production plants.

(2) Biomethane purification and recovery: purification of biogas using a special method, followed by its use in the natural gas network or propellant.

In the developed EU Member States, biomethane has become relatively widespread in the natural gas network and as a fuel for transport. The latter is also considered to be significant in some developing countries (Argentina, Iran, India). When biomethane is used as a propellant, more economical results are achieved, while the production of marketable finished products means that in the case of co-generation it is partly impossible, and with biomethane production completely impossible, for a sewage plant to achieve energy self-sufficiency. Only two biogas production plants (Zalaegerszeg and Kaposvár) produce biomethane in Hungary, because most of the domestic wastewater plants tend to use biogas to meet their own technological heat and electricity needs.

The quantity and nutrient content of the incoming and outgoing water flow

In Table 2 it can be observed that the macro-element content of the 13,000 m^3 of waste water per day at the sewage plant is significant, for both incoming (HUF 281 thousand / EUR 900; and HUF 68 thousand / EUR 220) and outgoing (HUF 42 thousand / EUR 133; and HUF 4.4 thousand / EUR 14) wastewater.

Table 2. Quantity and nutrient content of the incoming and outgoing water flow

		Macro-element	
Description	Measure	TKN[1]	TP[2]
Amount in incoming sewage water	mg/l	100	15
Daily amount	t	1.3	0.2
Unit price	HUF/t	216	339
Value	thousand HUF/day	281	68
Amount left in output sewage water	mg/l	15	1
Daily amount	t	0.195	0.013
Unit price	HUF/t	216	339
Value	thousand HUF/day	42	4,4

(Source: authors' own calculation)

[1]*Total Kjeldahl Nitrogen - ammonium N and sum of organic N*

[2]*all Phosphorus content*

Volume, nutrient content and utilization potential of sludge

Taking into account that the resulting biological sludge yield is approximately half of the amount of matured sludge, according to our calculations, and assuming a 25% dry matter content, approximately 8.4 m^3 per day (~ 3060 t/yr) of rotted sludge is produced. For the composting of this quantity, based on Kárpáti's (2014) 2:1 structural material/sewage sludge ratio, it would be necessary to use 1500 t/year of wood cuttings (structural material). A part of the structural material is re-deposited for later use, and so according to our calculations, a

total volume of 1070 t/year of sieved compost is produced. The dry matter content of this composting material (40%) is 430 tonnes, of which the total

nitrogen content is approx. 9 tons. With 170 kilograms of active substance/ha/year, this is a total area of 53 hectares, which, however, can change according to the site conditions and other characteristics. The amount of phosphorus - assuming a 1% P content - is 4.3 tons of active substance per year.

Their theoretical monetary value:

• Nitrogen: HUF 1,947 million

• Phosphorus: HUF 1,456 million

Concerning the above calculations, it should be added that, in practice, the utilization of macro elements can be influenced by a number of production site conditions. According to Dulovics (2012), depending on soil conditions and farming practices, the N-supply of sludge or compost can be used over 3-10 years. According to the lessons learned from field and propagation experiments, N is only partially incorporated – and then only a proportion of it - into the persistent humus material of the soil.

Where the use of sewage sludge compost would cause concerns and risks (in areas producing crops for food), a good solution can be to apply it to energy plant production, where, as well as other nutrients, it is capable of significantly reducing the heavy metal content. In this regard, several attempts have been made to assess the extent to which a herbaceous energy plant can reduce the heavy metal content of soil or sewage sludge and, at the same time, the level of (excess) biomass it can yield. In this way it is possible to combine two advantages: on the one hand the plant reduces the harmful heavy metal content and on the other hand the resulting biomass can be used for energy purposes,

improving the efficiency of the cleaning operation. Sewage sludge can thus beunderstood as an alternative to fertilizers (Nabel et al., 2016). In the paper by Pszczółkowska et al (2012), the authors summarize the lessons learned from articles on using sewage or sewage sludge as a nutrient supply for various energy crops. According to the article, in addition to application of sewage - which in many cases improves the pH of the nutrient supply as well as replacing nutrients - the yield of the sida energy crop is on average 9-11 tonnes of dry biomass. The nutrients, micro and macro elements from the sludge are also efficiently utilized by willow species and 20 t/kg were found to have beneficial results for miscanthus (Chinese-reed), while in other research, amounts above 60 metric tons were used effectively as an alternative to conventional fertilizers. The fertilizer application (in an NPK mix of 90:70:90 kg/ha) increases the yield of miscanthus by 96%, while it is increased by 81% by the application of 63 t/ha of sewage sludge (Kurucz et al., 2014). With the use of digested affluent, Paulownia tomentosa (Vityi – Marosvölgyi, 2014) plantations also may support site remediation and biomass production.

In addition to materials and energy saving targets, significant emissions can be avoided, primarily through the replacement of the production and transportation costs of natural gas-based Nitrogen fertilizers, and the avoidance of the CO_2 emissions which accompany the use of fossil fuels (heat and electric energy, or fuels). Present agricultural GHG reduction projects in Hungary cannot contribute to achieving long term GHG reduction goals to the same degree as can be experienced in other sectors due to food market insecurities, production limitations and the decreasing exchange quotation of GHG emissions. Consequently, climate-friendly agricultural investments have more advantageous returns than in other sectors (Fogarassy – Nábrádi, 2015).

Good practices in sewage management

Below, we introduce a Swedish example that illustrates the possibilities well. The Swedish city of Hammarby Sjöstad (Stockholm, Sweden), often referred to as a model example of a sustainable city, is the result of a complex, well-designed, system-level plan that every year attracts the attention of more than ten thousand experts and decision-makers in sustainability and other areas. A precondition of the efficient operation of the system which – in addition to efficient implementation - embraces the concept of a circular economy, is the mapping of the exact features, characteristics and symbiotic connections of the elements of the system (waste management, energy, water management, agriculture and other areas). It is interesting that until 1998 the area was an industrial area where significant amounts of oil, heavy metals and other contaminants had accumulated. Accordingly, the development of the district had to be started by cleaning the area. The aim of the planners was to reduce the environmental load by half through an environmentally conscious and modern planning of land use, public transport, construction, energy and water and waste management, and maximizing cyclical processes, thus moving towards environmental and economic sustainability (Figure 1):

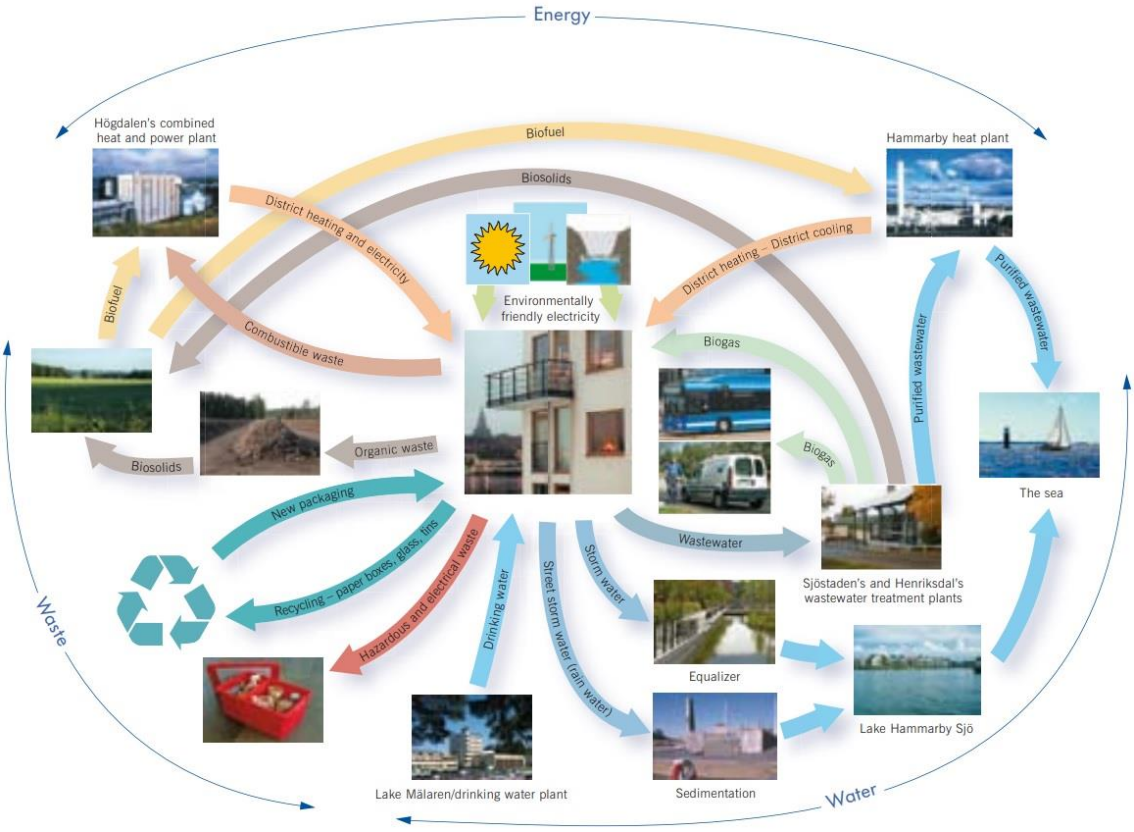

Figure 1. The complex system of Hammarby Sjöstad

(Source: Internet6)

An interesting example of soil management based on significant amounts of sewage sludge is the Carson Wastewater Treatment Plant (Los Angeles, California). The plant has been producing sewage sludge for sixty years now and has been operating an open prismatic composting system for thirty-five years. However, due to the increasingly stringent requirements, a modern composting plant has become necessary, for which 5900 hectares of property was selected in the central valley of California's agricultural zone, to create a composting capacity of one million tonnes per year. The plant produces a Class I sewage sludge that is used in surrounding agricultural areas to restore nutrient supply to the soil.

Summary

Nowadays, the use of energy and materials related to human activity, as well as the related environmental load, is taking on ever greater dimensions. All this places great emphasis on the need to use technologies and solutions that can contribute to making processes as sustainable as possible. In the case of cleaning plants, due to the requirement for good quality waste disposal and purification, the need for material and energy-saving operation is increasingly emphasized. Moreover, the above expectations can be seen in a significant amount of energy production processes, or even in terms of nutrient supply and reclamation. Naturally, in the field of water and waste management, the importance of extracting energy and nutrients from sewage has been evident from time to time, and serious endeavours and initiatives aim at achieving the most sustainable and environmentally conscious operation.

As we have seen in the article, system-level planning and the integration of cyclical processes is of great importance so that waste (sewage) as understood in a classical sense can produce a product of high value. With the advance of technology and the full exploration of the possibilities, energy can be produced in excess of the energy needed for cleaning, and a significant proportion of the nutrients can be utilized as part of the cycle. Macro nutrients in outgoing sewage and sewage sludge represent a significant value and can today contribute to generating enormous amounts of fertilizer and to reducing costs. Sewage sludge can be placed in a food-producing area in compliance with the relevant standards, but can also be utilized to great effect in energy crops in areas with less-favoured characteristics or excessive heavy metal content. All of these can also be recycled into the process, as wood shreddings can be an important raw material for composting. Therefore,

when considering the utilization of sewage sludge its possible use in agriculture should be investigated in the most comprehensive way as an alternative to possible incineration or landfilling. In our estimates we have found that a purification plant using anaerobic technology for a population of 100,000 households can produce 2900 m^3 of biogas per day and from this about 1900 m^3 per day of biomethane. As regards the nutrient management of the site, the amount of the macro-element content of the incoming wastewater, which is approximately 13,000 m^3, is 281 thousand HUF (~ EUR 900) of TKN (Total Nitrogen, 1.3 t/day) and 68 thousand HUF (~ EUR 220) of TP (total phosphorus 0.2 t/day). In the outgoing purified water there is a TKN of HUF 42 thousand (~ EUR 133), and a TP of HUF 4.4 thousand (~ EUR 14). The methods and the values used in the calculations can serve as basic data for further comparative tests and potentials for different size plants.

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DEMOGRAPHIC CRISIS AND RURAL DEVELOPMENT CHALLENGES OF MURALAND – CASE STUDY FROM SOUTH ZALA

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Abstract

As the United Nations points out, 66% of global population will live in urban areas by 2050. Even if the decisive part of this growth will be generated in Asia and Africa, the regional side effects of the global trend and the impact of the Hungarian demographic processes from the last decades cause serious challenges in the sustainability of rural areas in Hungary.

In this respect, one of the most affected area is South Zala (Muraland), where the fertility rate was the lowest in Hungary between the two national general census of 2001 and 2011 due to relatively high domestic migration and population-ageing. Thus, it is evident that the rural society of Muraland is coping with significant challenges in terms of competitiveness and sustainability.

This case study observes the underlying aspects of pro-urbanization factors such as labour and product markets, intermediate services, educational externality, agglomeration side effects, public services, or the stronger projection of self-interest. This way, we can identify the strategic factors that the rural policy must handle to decrease negative impacts of domestic migration.

Keywords: demographic crises, urbanisation, rural development, Muraland

Összefoglalás

Az Egyesült Nemzetek Szervezete statisztikai kimutatásai szerint 2050-re a világ népességének 66 százaléka városi területeken fog élni. Mindannak ellenére, hogy a demográfiai növekedés döntő része Ázsiában és Afrikában fog létrejönni, a globális trend mellékhatásai az európai és magyarországi vidéki területeken a korábbi évtizedekben kialakuló kedvezőtlen népesedési folyamatait fogják a továbbiakban is erősíteni.

E tekintetben hazánkban az egyik leginkább érintett vidéki területként Dél-Zala (Murafölde) azonosítható, ahol a viszonylag magas elvándorlási és elöregedési ráta miatt a 2001-es és 2011-es népszámlálás között Magyarországon a legalacsonyabb népességszaporulati ráta volt kimutatható. Mindebből megállapítható, hogy Murafölde vidéki társadalma a gazdasági versenyképesség és a demográfiai fenntarthatóság szempontjából jelentős kihívásokkal küzd.

A vidéki társadalmak gazdasági és demográfiai válságának perspektívájából esettanulmányunk a vidéki és városi területek közötti demográfiai térszerkezet átrendeződésének mögöttes tényezőit vizsgálja, mint például a munka- és termékpiacok

kiterjedtségét, a közbenső szolgáltatások fejlettségét, az oktatási externáliák szerepét, az agglomerációs szinergiák hatását, a közszolgáltatások versenyképességét vagy az önérdekérvényesítés hatékonyságát. Tekintettel arra, hogy ezek azon tényezők, melyek a vidéki lakosság urbanizált agglomerációk irányába történő elmozdulását eredményezik, így meglátásunk szerint a demográfiai térszerkezetben keletkezett anomáliák csökkentése érdekében a vidékfejlesztési szakpolitikának ezeket a területeket a jövőben szükségszerűen kiemelt módon kell kezelnie.

Introduction

According to the United Nations' statistical forecasts and demographic observations (United Nations, 2014: 7; United Nations, 2015: 38), it is likely that around 60% of the world's population by 2030, and 66% by 2050, will live in urban areas. In this regard, it will reverse the global demographic makeup of rural and urban population that prevailed in the 1950s. Therefore, the exchange of the global proportion of rural and urban population can be described as one of the most important demographic processes of the ongoing 100 years between 1950 and 2050. The scale of this robust transformation is well illustrated by the demographic prognosis that by 2025 the world's 600 largest cities will account for 60% of global economic growth, whilst their population will increase by 60% faster than the global average. As a consequence, 25% of the world's population will be concentrated in the top 600 cities by 2025 (Dobbs et al., 2011).

Due to the global demographic rearrangement, increasing urban concentration of economic functions is expected to escalate social tensions between depopulating rural and overpopulated urban areas. As a result of increasing urbanization pressure and the impact of urban accumulation of decisive economic, social and innovation potentials, a few

scientific analysis (Foley, Rider W et al., 2014; Jeffry L. Miekle, 2014; Moretti, 2014) predicts that social interactions of the future will be embedded in "city state" framework causing the eradication of existing nation state frameworks, where the social and economic role of the countryside will be reduced to a secondary position vis-à-vis the management and distribution functions of urban centers. Marketers are gradually more and more aware of the urgent need to react to this growing urbanisation with integrated marketing communications practices. Integrating communicational messages through several media channels is becoming a challenging task for companies and also for policy makers (Csordás – Gáti, 2013).

Despite the fact that 90 percent of the resources behind urbanization in the next decades will be fuelled by African and Asian societies (Moir et al., 2014: 9), the global demographic rearrangement phenomenon has significant impact also in Europe, thus in Hungary too. All these processes globally have an effect on buying and consumer behaviour, so economic consequences apply significantly (Malota, 2015). Consequently, in order to preserve and maintain the sustainability of the traditional functions of rural areas, it is explicitly necessary to examines the challenges of the Hungarian countryside and the opportunities to manage the obstacles in the domestic context.

In this respect, in Hungary, one of the most obvious research areas is Nagykanizsa and its surrounding South Zala (or Muraland, as it is called recently) proximity, consisting of 90,000 inhabitants, where the decline of rural population in the light of the 2001 and 2011 national censuses is particularly high comparing to national average. This phenomenon can be explained by the crucial consequences of the post-socialist political and economic transformation during the last 30 years. Namely, following the gradual economic downturn of the 1990s and the economic crisis of 2008, Muraland is showing a gradual deterioration

of its population retention power (KSH, 2012a, KSH, 2012b). Arguably, this challenge is directly provoking the marginalization of the region in the absence of appropriate policy responses. Thus, the evaluation and impact assessment of the region-level crisis management approach has a paramount importance to support policy decision making and also contributing to development efforts of rural areas with similar policy challenges.

Materials and Methods

Our study examines the factors that have led to the demographic equilibrium problems of Muraland (South Zala). During the analysis, we relied primarily on the statistics officially published by the Hungarian Central Statistical Office (KSH), the Territorial Information System (TeIR), the National Innovation Office, the National Employment Service (NFSZ) and the United Nations. From this comprehensive dataset – focusing on the past 20 years – we identified the most significant demographic challenges of the observed area and drew up conclusions based on the findings of the analysed statistical timelines. Beside the statistical observations, we also analysed the relevant professional literature – as secondary sources – examining the origins and causes of agglomeration/urbanisation that we consider one of the most crucial problem in the demographic crises of the Hungarian rural areas. In this regard, to understand the ongoing process of the population exchange from rural areas towards urban areas, we used *Moretti's 3+1 analytical framework* to describe the most important factors fuelling the upheaval of agglomerations and the demographic decline of rural societies. Moreover, based on Moretti's 3+1 framework and also using the mentioned statistical sources, we made a descriptive analysation about the actual demographic status of Muraland from the perspective of the 3+1 factors (labour and product market, advanced intermediary services, educational externalities, spillover effects). Therefore, pointing out

at empirical facts, we can better understand and explain the sources of challenges in the demographic crisis of Muraland.

Results

If we take into consideration the statistics of the Hungarian national censuses in 2001 and 2011 and the tendencies in between, it becomes clear that the Hungarian countryside faces significant challenges in terms of demographic sustainability (KSH, 2012a, KSH, 2012b). During the period under review, there was a persistent demographic slump in all counties, including the capital as well. However, in Győr-Moson-Sopron, Komárom-Esztergom, Fejér and Csongrád counties the demographic situation was mitigated by the domestic immigration surplus due to the "Budapest suburban agglomeration" in case of Pest County, and higher employment potentials in case of others (KSH, 2012a: 5). In addition, the migration gains of Pest and Győr-Moson-Sopron counties exceeded the population loss provoked by inner outmigration, so in these two counties the population increased by 15 and 4 percent in fact (KSH, 2012b: 7). But beside these positive exceptions, the remaining territories of Hungary are duelling with a significant loss of population. The most dramatic situation was identified in Békés, Borsod-Abaúj-Zemplén, Nógrád and Tolna counties, where low birth rates, high mortality and emigration reduced the population by 8-10 percent.

Although the population in Zala decreased by less than 10 percent in the observed 10 years (KSH, 2012b: 7), the demographic reserves of small villages in the typical rural settlements of South Zala region have been largely devastated by the decades of constant population decline and drastic aging, that threatens the total depopulation of certain small settlements. This fear is verified by the census data of the Hungarian Central Statistical

Office (KSH), which shows that between 2001 and 2011 the number of births per 1,000 inhabitants attained the highest negative deviation in Zala from the 9.5 national average, where the indicator reached only 7.5‰ (KSH, 2012: 10).

At the same time, the statistics of the Territorial Information System (TeIR) also show that demographic tendencies in Muraland – mainly covered by the Nagykanizsa and Letenye districts – have been significantly lagging behind the national average over the past 10 years. According to the latest figures, in 2015 the population decline of the Nagykanizsa district was 6.23‰, and 9,99‰ in the Letenye district, while this ratio was only 4.54‰ for the West Pannon region and 4.02‰ as national average. Moreover, if we observe the domestic migration rate beside population loss, we find that in the Nagykanizsa and Letenye districts the (out)migration rate – as the rate of officially announced change of address – was -2.58‰ and -6.89‰ in 2015, while the West Pannon region, an average migration surplus of 3.28‰ was identified. As a result, the population of South Zala – depending on the actual extent of the migration outflux – is facing with a 270-550 people loss on a yearly basis, that mainly concentrates on the loss of young people.

However, the demographic situation is further exacerbated by the fact that migration is coupled with critically high aging indicators, which is clearly demonstrated that based on 100 young people (under 14 year) we can count 224 old people (beyond 60 years) in South Zala in 2015 (compared to 162 in 2005) in line with a national average of 175 people. As a result of outmigration and drastic aging, crucial population decline has emerged and the population decline in Muraland accelerates itself well beyond the national rate. This is proved by that while the population of Hungary reached 4‰ of natural loss in 2015, this indicator increased to 8‰ in Muraland.

In the light of the population trends, it can be stated that, over the years since the 2011 census, the demographic outlook of South Zala has clearly deteriorated further, with the statistics of the KSH 2016 microcensus being most marked by the statistics of KSH 2016, as well as the above-described TeIR statistics. The statistical comparison of the 2016 microcensus and the 2001 census reveals that the number of population living in rural towns during the 15 years under review has undergone a major decline, therefore the population retention potential shrunk in these cases with some particular exceptions of economically more potent cities (e. g. Érd, Győr).

As it can be seen from the statistics, in Zala County, the number of inhabitants living in county rank towns (Zalaegerszeg and Nagykanizsa) decreased by 11.1 percent between 2001 and 2016, which is situated only 3.2 percentage points behind the worst result in Nógrád County (Salgótarján). In addition, with a deeper analysis of the data provided by the Central Statistical Office, we can further detail the worsening demographic situation in South Zala. Accordingly, between 2001 and 2016 the population of the Nagykanizsa district decreased by 11.76 percent, while the proportion of population decline in Zalaegerszeg was only 6.97 percent. From this perspective, it can be noted that Zala County, specifically Muraland, faces drastic demographic challenges, which can be considered the most important rural development concern of the region. Therefore, in order to understand the complexity of the situation, it is important in our paper to observe the factors that caused the demographic crisis of South Zala.

Discussion

In order to understand the reasons behind the challenges of South Zala and to develop an appropriate strategy to increase the commitment of inhabitants towards the rural regions

(Gyulavári, 2013), it is important to examine the factors influencing demographic processes that push the rural population towards urban centers. For this aim we can rely on Enrico Moretti's 3+1 framework that describes the potentials of urban areas with the following segments (economics of agglomeration) (Moretti, 2014: 8-15):

- labour and product market: One of the most important attractions of metropolitan centers is that higher level of population is generated in their territories due to the higher population concentration enables diversified product markets and advanced services through the benefits of economies of scale. In addition, due to the high population concentration, highly skilled labour is also accrued more easily, which means that the local economy can produce higher added value. Coupled with a high standard of living, it provides a significant attraction for the resettlement of the rural population.
    - In this area, the biggest challenge for South Zala is that due to the industrial decline of the 1990s and the highly skilled labour force and the outmigration of young people, income differences in the country increased. According to KSH, in Q1 2018, the monthly net average salary in Zala was 165.856 Forint against the national average of 210.318 Forint (KSH, 2018). Consequently, the market demand and consumption of the people living there is much more limited, which is one of the most significant obstacles to the development of stronger local economy (Péter et al., 2012: 23).

      After 2010, the accelerating production – as a result of national macroeconomic stabilization – soon made it clear that in Muraland the sectoral shortage of labour created by the former "brain drain" is also a major obstacle in the growth of local businesses. According to the statistics

of the National Employment Service, in April 2018 there were 3380 vacancies registered in Zala County, which is considered to be one of the worst results in Hungary (NFSZ, 2018). Consequently, due to the limited consumption potential and the unbalanced labour market conditions, in the present circumstances, no effective labour and product market can be identified that could significantly strengthen the population retention capacities of the area.

- advanced intermediary services: Another major advantage of urbanization centers is the large-scale creation of intermediary service providers (mainly in engineering and maintenance, financial advisory, legal aid, project management or marketing) in their territories, providing subcontracting secondary functions for large enterprises. By doing so, through exploiting the positive externalities brought about by specialization and diversification, companies save on significant HR and financial capacities, resulting in a more competitive economic structure and wider employment thanks to the high degree of flexibility.
    - In this category, the biggest challenge of Muraland is the lack of corporate and research backgrounds with high innovation efficiency. As the National Intelligent Specialization Strategy – developed by the National Innovation Agency in 2014 – points out, in case of Zala County we can identify a drastically low level of innovation spending, that did not reach 2.5 billion Forint in 2012 (NIH, 2014: 46). Thus, Zala County is situated among the low knowledge and technology intensive regions, that – due to the lack of corporate growth – doesn't leave room for advanced intermediary services in the region.

- educational externalities: At the centers of urbanization there is an extensive educational infrastructure having a flagship role in the maintenance and development of knowledge capital. Educational institutions have also the function of attracting people from nearby settlements (Szőke–Kovács, 2016). As a spill-over effect of education development, more human capital can be used to serve the labour market. All this allows higher living standards and more competitive economic output through greater added value, which indirectly motivates the further development of education. Research showed significant differences between the central and convergence regions among higher education institutes (Malota, 2014, 2016).
    - The most significant backbone of education in Muraland is the University of Pannonia Nagykanizsa Campus, where higher education and research activities are carried out to enhance co-operation between development stakeholder, to supply the market needs and serve the local innovation. This commitment is demonstrated by the training program of the University of Pannonia, based on the traditionally significant expertise of water management in Muraland, in cooperation with the local government of Nagykanizsa and with the Hidrofilt Ltd. Due to this alliance, founded the Soós Ernő Water Technology Research and Development Center was founded in 2014 which has been tailored to meet actual business needs, complemented by education and training program activities. The importance of the higher education focusing on water is further strengthened by the successful accreditation of the postgraduate water and

sewage system operator program in 2016, thus strengthening the market orientation of education at the Campus.

- spillover agglomeration: the combination of the three previous factors causes a self-generating efficiency process, which makes the development of urbanization centers virtually self-made. As the research results show, the doubling of the size of cities results in a 5-8% improvement in the efficiency of their economic production (Rosenthal-Strange, 2004). Due to the agglomeration effect, urbanization centers are able to create more competitive socio-economic structures, therefore the disintegration of rural areas with competitive disadvantages becomes permanent without any meaningful counteraction.

Apart from the economic, educational and market factors that have led to a profound transformation of the rural demographic structure, of course, there are a number of alternative background factors that can reinforce the process of urbanization (e.g. efficient local governments, user-friendly public services, more powerful self-reliance, stronger political relations, networks) (Christiansen-Loftsgarden, 2011: 8). At the same time, without the 3 + 1 basic factor, no other urbanization factor can reach significant effects, thus it is necessary to the focus on these underlying factors when analysing the triggers of urbanisation. It therefore becomes possible to interpret the impact of urbanization pulling forces in the demographic crisis of the countryside to ensure adequately planned and implemented policy responses from the rural development side.

After the examination of the demographic and rural development challenges in the Mura region, we believe that the reform-oriented treatment of the mentioned segments from Moretti's 3+1 model is the key element to ensure the long-term catch-up of Muraland in terms of demographic trends and economic competitiveness. In this engagement, our

geographic embeddedness provides us a meaningful advantage in the Mura Region where significant rural development best practices can be identified in Styria, Slovenia (Prekmurje and Pomurje) and in Croatia (Međimurje) that could be also implemented in Muraland through joint initiatives. In this regard, by relying on cross-border development cooperations and rural policy expertise, we can realize significant achievements in the rural development policy of Muraland. Accordingly, the internalization of regional experiences and good practices from the wider Mura region (from Styria to Međimurje) plays a strategic role in restoring the social and economic competitiveness of South Zala.

However, how to adapt the identified examples to local conditions raises a number of additional questions that may be subjects of new research papers in the near future in order to ensure that the empirical knowledge can be converted to the social and economic capital of the region. As a result, an emerging academic and policy dialogue can give further impetus to the rural development efforts of South Zala, so that we can find adequate solutions for our challenges through the experiences of our neighbours.

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