DIGITIZATION OF THE METHODOLOGY FOR ASSESSING THE SUSTAINABILITY OF PLANT PRODUCTION SYSTEMS

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ABSTRACT

This contribution describes how a web application was created based on the given methodology for assessing the sustain-ability of plant production systems. The key indicators of this methodology are introduced. The way of transformation into digital form is shown. The outputs of the created application are presented.

Keywords: sustainability of plant production systems, digitization, web application

JEL Code: C88, Q59

1 INTRODUCTION

Sustainable agriculture is an issue that is important in many ways. El Chami et al. (2020) ask the question "How Can Sustainable Agriculture Increase Climate Resilience?" Celicourt et al. (2021) deal with sustainable water management in agrosystems. Arlauskienė and Šarūnaitė (2023) address the area of cover crop yield, nutrient storage, and release under different cropping technologies within sustainable agrosystems. A key factor for increasing soil fertility and promoting sustainable soil use in fruit orchard agrosystems is presented by Sofo et al. (2020). Bioinspired nanomodification strategies for sustainable agriculture are introduced by Xu et al. (2021).

Already in 2011, Professor Křen's team (2011) presented a methodology dealing with a comprehensive assessment of the sustainability of agricultural enterprises focused on plant production. The methodology contains three key groups of indicators, namely ecological, economic, and social indicators. Each of these groups contains even more specific and detailed indicators. Each of the indicators is calculated based on one or more input data. This methodology is described using a text document describing the sources of input data and calculations leading to individual indicators. The absence of a tool that would facilitate the calculation and automate it to a certain extent is almost incomprehensible in today's digitized age. Therefore, there was a request to facilitate the calculation process using a web application. This application was created as part of Krejsa's diploma thesis (2022).

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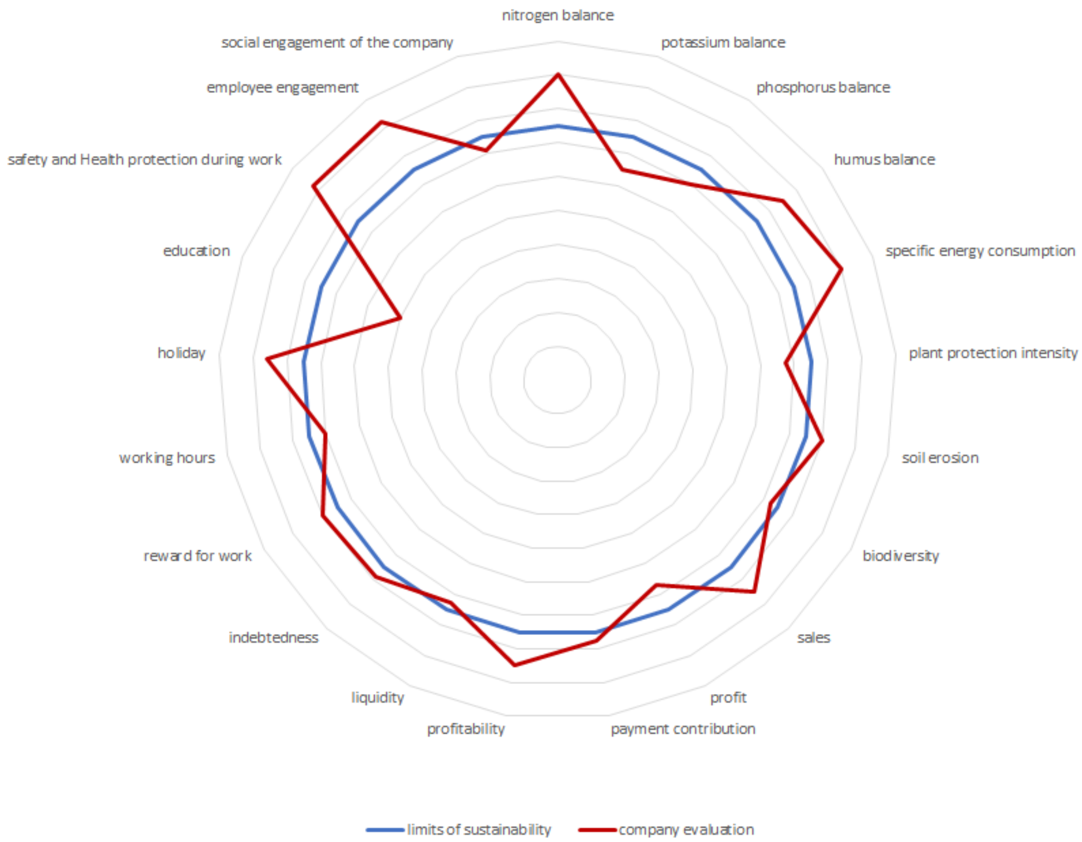

Fig. 1: Figure 1: Web graph for presentation of results
Source: Křen a kol., 2011

The purpose of this paper is to describe the created application that enables the mentioned evaluation of the sustainability of the agricultural enterprise to be carried out. The key is above all the clarity of the presented results. There is also a general emphasis on user-friendliness and speeding up the acquisition of inputs needed to achieve a rating.

2 METHODOLOGY FOR EVALUATING THE PERMANENT SUSTAINABILITY OF SYSTEMS FOR THE CONDITIONS OF THE CZECH REPUBLIC

The methodology dealing with the long-term sustainability of agricultural enterprises, according to which the evaluation will take place in the application, was described by Prof. Křen and his research team (2011). In the methodology, the name SAGROS system (sustainable agrosystems) appears, which was also used when creating the name of the web application. The output of the assessment according to the methodology is 21 indicators. These indicators can be divided into three main groups (ecological, economic, and social). Each of the indicators has its own evaluation function, which, based on the input value, can be used to obtain an output ranging from 0 to 1. A value of 0.75 was set as the limit of sustainability.

There is also a second document on the evaluation methodology, containing the methods of obtaining the data needed for the evaluation. This methodology was also created by the team of Prof. Křen (2012). Diverse data sources are mentioned here. This includes, for example, data from publicly available systems and authorities, but also data obtained from internal sources of the company.

As part of the methodology, the resulting evaluation of the company is usually presented using a graph. Due to the number of indicators and clarity, according to the methodology, the spider chart, shown in Figure 1, proved to be the most effective.

2.1 Ecological indicators

Within the ecological indicators, 8 output values are calculated:

- nitrogen balance,
- potassium balance,
- phosphorus balance,
- humus balance,
- specific energy consumption,
- plant protection intensity,
- soil erosion,
- biodiversity.

For the first six mentioned indicators, several scalar values are obtained from the user, with which basic mathematical operations are performed. The value obtained in this way is then transformed into the output value of the indicator using the evaluation function. For the last two indicators, in addition to loading other scalar inputs, data obtained from the public administration system is also needed. The last mentioned biodiversity indicator is the most complex of all indicators. It consists of 11 parts describing the land on which and in what way the farm operates.

2.2 Economic indicators

This group includes 6 output indicators. Particularly speaking about:

- sales,
- profit,
- payment contribution,
- profitability,
- liquidity,
- indebtedness.

It is possible to calculate the values of these indicators after collecting ten basic input values. As already mentioned, each of the indicators has its own evaluation function. An example evaluation function for the indebtedness indicator is illustrated in Figure 2.

2.3 Social indicators

As part of the social indicators, 7 resulting indicators will be calculated. It is about:

- reward for work,
- working hours,
- holiday,
- education,
- safety and Health protection during work,
- employee engagement,
- social engagement of the company.

Inputs for the evaluation of these indicators are obtained on the basis of interviews and questionnaires with company executives.

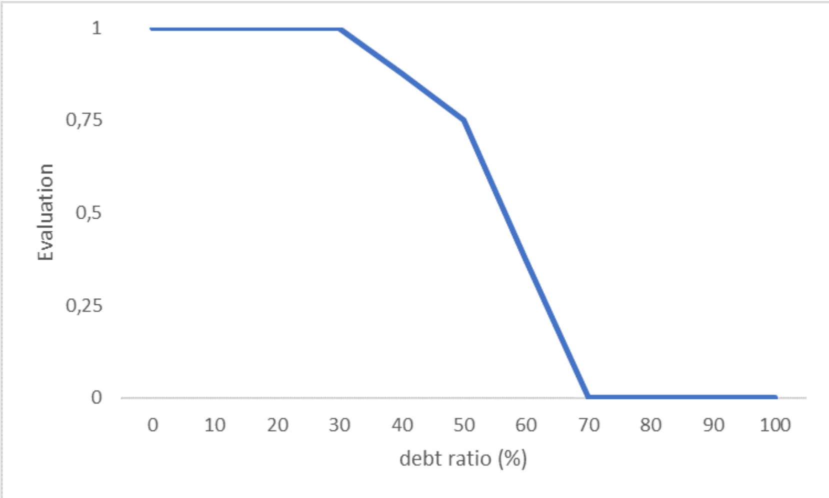

Fig. 2: Figure 2: Evaluation function of debt ratio
Source: Křen a kol., 2011

3 METHODOLOGY AND DATA

Currently, there is no software on the Czech market that would comprehensively assess the sustainability of an agricultural enterprise. According to an article on the Živá univerzita[1] (2022) website, the SustainAgri mobile application was recently published. It also deals with the sustainability of agricultural enterprises. In the application, it is possible to try out decision-making in an agricultural company within the scenarios. However, it is aimed at educating young or budding entrepreneurs in the field of agriculture and is therefore not suitable for the purpose of evaluating an existing agricultural enterprise.

Due to the absence of a suitable software solution for evaluating the sustainability of an agricultural enterprise, there was a request to create a web application that would enable this.

3.1 External data sources

As part of the evaluation of several indicators described in the methodology, data from external systems are used. As part of the design and creation of the application, this data will be downloaded and prepared in such a way that the user does not have to worry about obtaining it, thereby facilitating and speeding up the evaluation of the company.

3.1.1 LPIS

The first major data source used within the ecological indicators of soil erosion and biodiversity is data on parcels from the LPIS[2] system. As part of these indicators, the acreage and perimeter of the land block are used for evaluation. The parcels displayed in this system are publicly available. The procedure for downloading such data is described on the eAGRI (2022) web portal.

The obtained data can then be imported into a database with an extension to support geographic data. Parcels can be queried from the database for display in the interactive map in the web application. The downloaded information about the land blocks already contains the required area. The other characteristics of a given parcel can be calculated using the functions included in the database superstructure to support geographic objects.

1 Living University

2 LPIS is a geographic information system that primarily consists of records of agricultural land use.

3.1.2 Ministry of Labour and Social Affairs

The second external source in the application is data obtained from the website of Ministry of Labour and Social Affairs. These data are used to evaluate the social indicator remuneration for work. To evaluate the indicator, it is necessary to compare the entered wages with the average wage in the regional labor price statistics data set.

All data are available for download in JSON format on the Ministry‘s website. The obtained data can be serialized into objects and then inserted into the database.

3.2 Used technology

The application will be implemented according to the MVC design pattern. Technologies from three basic categories will be needed to implement the proposed application. These are frontend, backend, and database.

3.2.1 Frontend

The user interfaces of websites are usually handled using the HTML markup language. This page will be handled by a component of ASP.NET technology called Razor, which enables the creation of templates. A big advantage is the possibility of simple substitution of values from the backend. Another advantage is the possibility of linking to other pages registered in the project.

The frontend in the HTML markup language is often supplemented with styles in the CSS language. The interactivity of the front-end part can then be ensured using code written in JavaScript. The application will use a set of Bootstrap cascading styles. It is one of the most used and popular in this industry. Its main advantage is that the styles used in the application are consistent and clear. Another advantage is, from the point of view of implementation, ease of use and large quantity functionality.

It will also be necessary to use JavaScript libraries for working with the map, on which you can select soil blocks. The Leaflet library is suitable for this. This will allow the display and selection of loaded parcels. Another component needed for the application to run will be the jQuery library.

3.2.2 Backend

The C# language was chosen for the implementation of the proposed application. The latter is in second place in the presented graph under the name ASP.NET, which is a framework used in this language to implement web applications. The reason for this decision is the clarity of the created solutions, a large number of preset functions for the creation of the application, and, in addition, also quality documentation. In addition, the ASP.NET platform also directly offers the creation of a project structured according to the MVC architecture.

3.2.3 Database

As part of the implemented application, one of the most popular variants will be used, namely Microsoft SQL Server. The main reason was the possibility of using the SqlDataAdapter class in the C# language, which was chosen for the implementation of the backend. The class enables the intuitive assembly, execution, and processing of the results of database commands. The advantage is that when it is used correctly, user inputs are treated so that SQL injection cannot occur. Other reasons for choosing SQL Server are the clarity of the development environment, quality documentation, and extensive options for tuning the performance of database queries. This database will be used for storing downloaded or created code lists and also for storing data entered within the framework of individual solved projects.

A separate PostgreSQL database with the PostGIS extension will be used to store geographic objects. It will also contain a list of cadastral territories that will be used when downloading geodata. The reason for this choice was primarily the quality of PostGIS geographical extension. Compared to the geographic part of Microsoft SQL Server, this offers a greater number of intuitive and useful functions that facilitate work with geodata.

4 RESULTS

The resulting application significantly facilitates the evaluation of the sustainability of crop production systems. Using forms, users can easily enter the necessary values. Some data are obtained automatically or based on the selection of a specific plot of land.

Thanks to the import of data from publicly available sources, the user is offered a map from which he can select the corresponding plot, as can be seen in Figure 3.

In this way, all plots can be easily added. The indicators resulting from the information about the land are then automatically added, which saves a lot of work.

After entering any input value, a page presenting the evaluation of the company is made available to the user. Since the input values can be entered continuously, it is possible to display partial results on the page. All available obtained indicator values and a list of indicators for which the rating could not be calculated are presented.

For the presentation of the results of the indicators, a spider chart is recommended as part of the methodology. This display method was also used within the created application. A screenshot of the page with the resulting graph is in Figure 4.

Within the presented graph, two data sets are used, this is the limit of sustainability (0.75 for all indicators) and the calculated values of the indicators. The color and size of the displayed

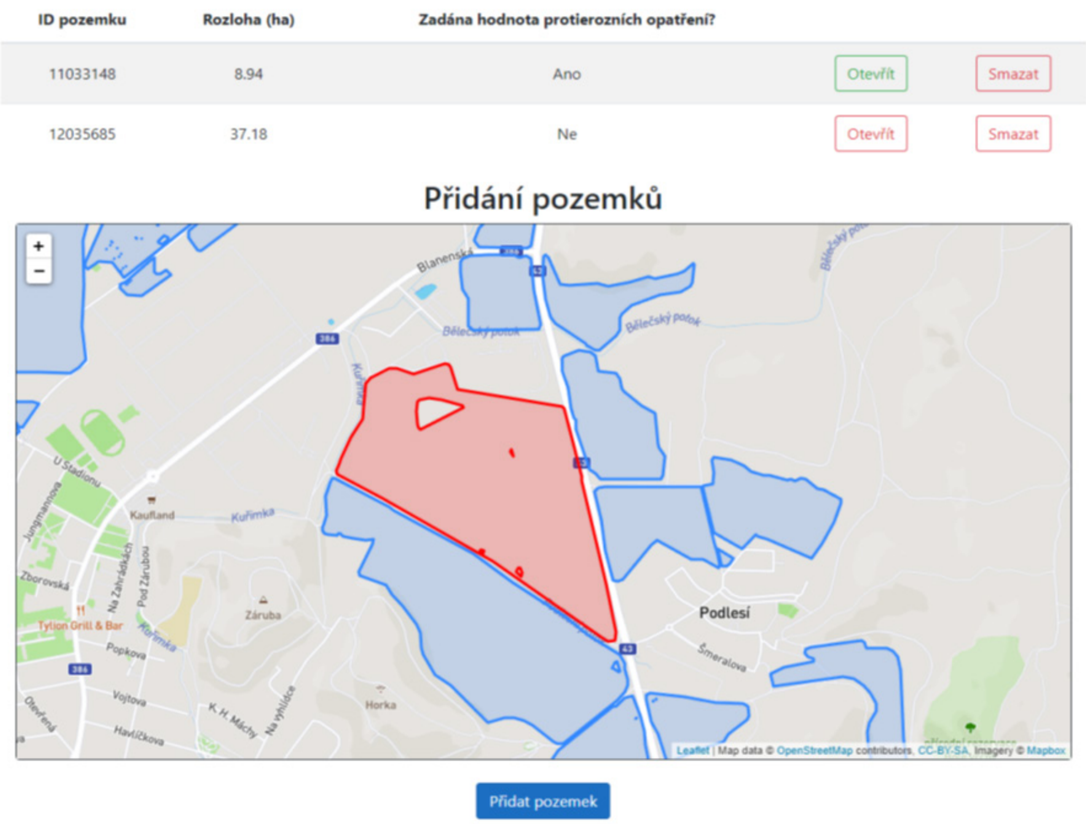

Fig. 3: Figure 3: Choosing plots in the web application
Source: Krejsa, 2022

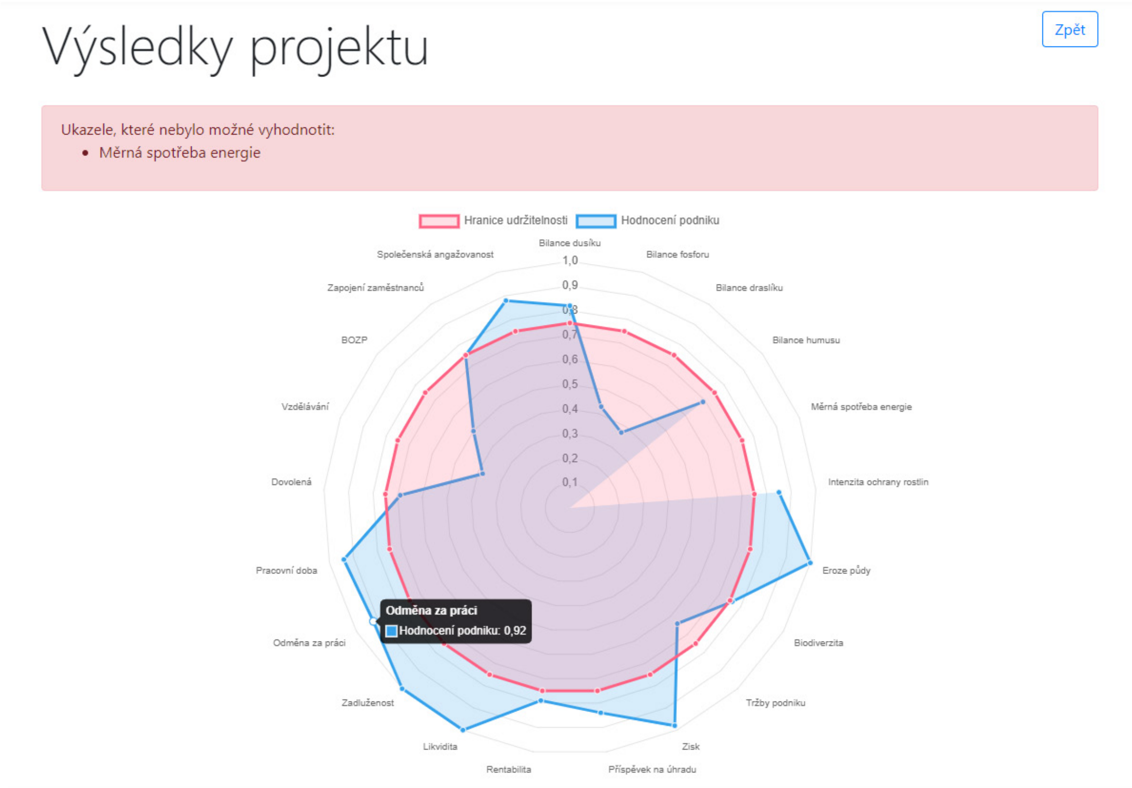

Fig. 4: Figure 4: Evaluation results
Source: Krejsa, 2022

elements in the chart can also be set within the data sets. A scale from 0 to 1, in increments of 0.1, is suitable for presenting the results. Incorrect values are omitted when plotting the business rating. The graph offers a degree of interactivity. When the cursor is placed on a point, the name of the indicator, the group of values, and the specific calculated value will be displayed.

5 DISCUSSION AND CONCLUSIONS

As part of the work, a web application was created that will enable the continuous loading of inputs for the calculation of the sustainability assessment of agricultural enterprises. The application can present results in a very similar format as mentioned in the methodology. The outputs of the application could be improved in the future. Specifically, this is the export of the specified input parameters. Whether it is an export in text form, which will be easy to read for ordinary users, or an export in JSON or XML format, which can be easily machine processed. The application is currently used mainly in education, if the application proves itself, it may also eventually be used commercially. This again could mean another set of feedback and possible modifications, according to the requirements of future users. It could be also beneficial to create a mobile application such as Prichystal (2016).

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