HUNGARIAN ACADEMY OF SCIENCES

Hungarian Agricultural Engineering

N° 35/2019

PERIODICAL OF THE COMMITTEE OF AGRICULTURAL ENGINEERING OF THE HUNGARIAN ACADEMY OF SCIENCES

Published by

Szent István University, Gödöllő
Faculty of Mechanical Engineering
H-2103 Gödöllő, Páter K. u. 1.

Gödöllő
2019

Published online: http://hae-journals.org
HU ISSN 0864-7410 (Print)
HU ISSN 2415-9751(Online)

PREFACE

In the name of the Committee of Agricultural and Biosystem Engineering of the Hungarian Academy of Sciences we would like to welcome everyone who is interested in reading our journal. The Hungarian Agricultural Engineering (HAE) journal was published 30 years ago for the very first time with an aim to introduce the most valuable and internationally recognized Hungarian studies about mechanization in the field of agriculture and environmental protection. In the year of 2014 the drafting committee decided to spread it also in electronic (on-line and DOI) edition and make it entirely international. From this year exclusively the Szent István University's Faculty of Mechanical Engineering took the responsibility to publish the paper twice a year in cooperation with the Hungarian Academy of Sciences. Our goal is to occasionally report the most recent researches regarding mechanization in agricultural sciences (agricultural and environmental technology and chemistry, livestock, crop production, feed and food processing, agricultural and environmental economics and energy production) with the help of several authors. The drafting committee has been established with the involvement of outstanding Hungarian researchers who are recognized on international level as well. All papers are selected by our editorial board and a triple blind review process by prominent experts which process could give the highest guarantee for the best scientific quality. We hope that our journal provides accurate information for the international scientific community and serves the aim of the Hungarian agricultural and environmental engineering research.

Gödöllő, 10.09.2019.

Dr. László KÁTAI
editor in chief

Dr. László TÓTH
editor in chief

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 5-12
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2019.35.5
Received: 2019.05.01. - Accepted: 2019.09.01.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
THE HUNGARIAN ACADEMY OF SCIENCES
and
SZENT ISTVÁN UNIVERSITY
Faculty of Mechanical Engineering

SMART ATTACHED WORKING EQUIPMENT IN PRECISION AGRICULTURE

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Abstract

Nowadays the increasing of the efficiency of agricultural production and the increasing of crop yields cannot be achieved without modern digital technology and smart machines that are a part of it. With the spread of precision agriculture and the digitalisation next to the power machines the attached equipment is becoming smarter and smarter. Through permanent technological and IT development, it became possible to thoroughly monitor and analyse operating functions and parameters not only for the most important power machines such as tractors, combines and other, but also there are existing solutions for measurement - and related to that a collection and an analyse of data - of specific utilisation parameters for other attached equipment. All of these processed data are essential for making well-considered actions related to the production technology and the machine operating. They help us to gain information about the quality of machine operations of the technology, the environmental factors, or even about the state of attached working equipment and machines.

In this work, the vibration control system as smart solutions on the fail movers will be presented which are effective tools for the utilization of machines, for the precision machine work as well as for prolonging the machine life cycle.

Keywords:

smart machines, Precision Agriculture, GPS, data analysing, Vibration Control

1. Introduction

Many authors have reached to the conclusion that development of digital technology and applications are regarded as an important factor in their economic growth and development in the agricultural production. The improvement of mechanization of field work, machinery and equipment is a continuous process. We are witnessing the spread and agricultural use of the more and more modern equipment, which reflects to the technical and technological level of the area [1].

Precision Farming did become a popular research field since the 1980s. Technologies have been developed all over the world to help the farmers raise crop yields and make agricultural production processes more efficient. This new developments steadily contribute to a higher productivity and show that this technology is very important. Electronic assistance systems, such as autonomous track guidance or section control are state of the art when investing in new machines on crop farms. [2]

Precision Agriculture is just a hypernym and can be divided into three major topics [3]: “Precision Pasturing”, “Precision Lifestock Farming” and “Precision (Crop) Farming”. While Precision Pasturing focuses on methods for e.g. managing feed supply and stocking rates on pastures [4], Precision Lifestock Farming addresses all kind of systems which correspond with animals in husbandry. The last topic, Precision Farming, is defined as technology-supported cultivation of agriculturally used areas [2, 5]

Precision Agriculture technologies are efficient tools to improve sustainability and productivity in farming. Precision Agriculture technologies offer solutions to produce more with less. It is one of the biggest revolution in agriculture [6]. Practically, Precision Agriculture technologies provide farmers with extra sensors which give them more information on how to manage natural variations. [7] It is technical, environmental and management innovation that has come out of the strategic product and technology innovation phase, while the whole management system is sharacterized by continuous renewal and new, higher added value added. [8]

The aim of precision, or site specific agriculture is to handle within field variability [9] with input materials to achieve the highest and sustainable profit. The approach mainly benefits from the development of technologies like GPS, GIS, computer technology, automatic control, remote sensing and advanced information processing [10].

The most popular precision agricultural technologies are the grid soil sampling, the variable rate fertilizer applications, the global positioning systems and yield mapping and the variable rate seeding [11, , 12, 13, 14, 15, 16].

2. Material and Method

2.1. Smart Farming in Agriculture 4.0.

"Smart Agriculture" and "Digital Farming" are based on the emergence of smart technology in agriculture. These technologies are using smart devices which consist of sensors, actuators and communication technology [1].

Digital systems, sensor techniques and technologies, remote sensing on different platforms, artificial intelligence including machine learning and deep learning, and in particular unmanned or quasi unmanned production systems are developing fast, and these are the tool for dynamic sustainability. In the future there will be the integration of these common players into smart transport, smart organisation, and smart landscape management by smart policy making. [17, 18, 19, 20]

The term Agriculture 4.0 should be logical upgrading of Smart and Digital Farming. There is some possibility about how will Agriculture 4.0 impact the supply chain by better using of IT:

- Optimize the inputs (Precision Farming).
- Manage mechanization more efficiently & use of energy resources.
- Enhance crop storage techniques & reduce crop losses.
- Provide better information about market demand & seasonal fluctuation.
- Improve transport & logistics services.
- Optimize retailer stocking & storage (less waste). [21]

The Smart Logistic System, integrated with the ERP (Enterprise Resource Planning), enables application of 4.0 industry approach. Its intention is to enable same application to agricultural machinery, e.g. for logging the seeding and fertilizing process (lot, operator, date, quantity) and remote diagnostic by using IoT ready systems. The advantages of own production applied utilization of digital information to trace the different materials and automate their handling, are listed following objectives:

- to reduce the material handling;
- to reduce the inventory failures;
- to implement flexibility with discipline;
- to find one place for everything and everything in its place;
- to set a FIFO (First In First Out) rule;
- to implement the material traceability. [22]

Automated data mining and -interpretation is becoming a critical element of agricultural industrial research. [23] Developments in agriculture which mine data and act almost autonomously on basis of these data can be summarized by the term "Agriculture 4.0" [24].

Some Precision Agriculture diagnostic technologies are already highly affordable and thus available to smaller farms thanks to smart phones or tablets and their applications, like in our presented study. Such applications can directly signal a problem on the field or connect to an online service for further probing. [7]

2.2. Devices for Precision Farming in grassland

In comparison to its widespread implementation on arable farms, Precision Farming in grassland is used rarely in practical farming. There was some efforts to measure the quantity of harvested grass to, amongst other things generate yield maps. Demmel et al. examined a weighing system in a conveyor belt, mounted at the rear part of a mower [25]. Kumhála et al. used methods to measure forage yield known from choppers or harvesters. They equipped a drum mower with a torque sensor and a curved impact plate (behind a mower conditioner) which was hit by the mowed grass. [26]

Some small smart applications already found their way into practice like a torque sensor for warning the driver if the rotation of the mower and the rotation of tractors power take off (PTO) distinguish too much to give him assistance for an optimum velocity and motor speed.

2.3. The Company INO Brezice d.o.o.

A Slovenian company INO Brežice produces a variety of mulching machines, vibrating subsoilers, fertilizer spreaders. Among the company's innovative products are so-called "Smart Solutions" which ensure a safe and efficient operating of their basic products:

- flail mowers by means of continuous measuring vibrations and detecting the outstanding ones,
- fertilizer spreaders and vibrating subsoilers by efficient specific electronic control of operating.

3. Results

INO VIBRATION CONTROL

3.1. Basic description

The Vibration Control System is a smart solution based on IoT principal, which consists of INO flail mower, sensor, smart mobile device and web application. It offers to the user an online information about working conditions for professional agricultural and communal machines. The main purpose for using INO Vibration Control is to control vibrations on the machine that means flail mower, arm mower or similar (Figure 1.). The sensor is measuring the level of vibrations which are sent to the mobile device. The mobile device stores GPS coordinates, a time stamp and x, y, z axe vibration levels and temperature through all working process for each second.

Figure 1. The position of the vibration sensors on the working machines, actually on the flail mower machine

3.2. Innovation character

The goal of this system is to control the level of vibrations on flail mowers and consequently also on other machines, used for public utilities and for agricultural land cultivation, where the level of vibration in allowed area is one of the key features for correct, safe and long-lasting operation.

Three level of vibrations, normal, marginal, and excessive could be measured and determined. (see Figure 2., 3., 4,)

In case of excessive vibrations the machine utilisation have to be stopped and the technical problem to be investigated and fixed.

Data compilation, collection of information is continued also in the direction of other telemetric information for the purpose of work control on cultivated land, data import from the phone, drawing-up of the surface in online graphic folders and keeping track of various attributes on an individual cultivation area, e.g. number of mowing, amounts of yield, fertilization, quantity, working temperature, speed of movement, location, etc. (Figure 5., 6.)

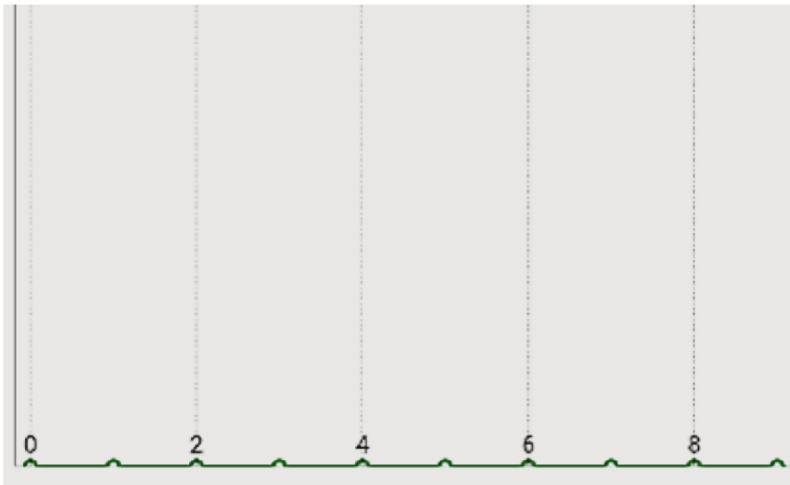

Figure 2. The machine is working in the expected level of vibrations (x axis: time [t], y axis: acceleration [m/s²])

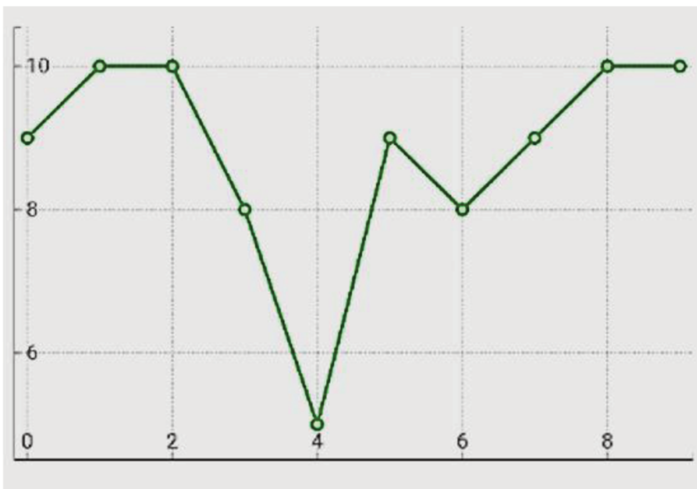

Figure 3. The machine has reached the margin value of vibration (x axis: time [t], y axis: acceleration [m/s²])

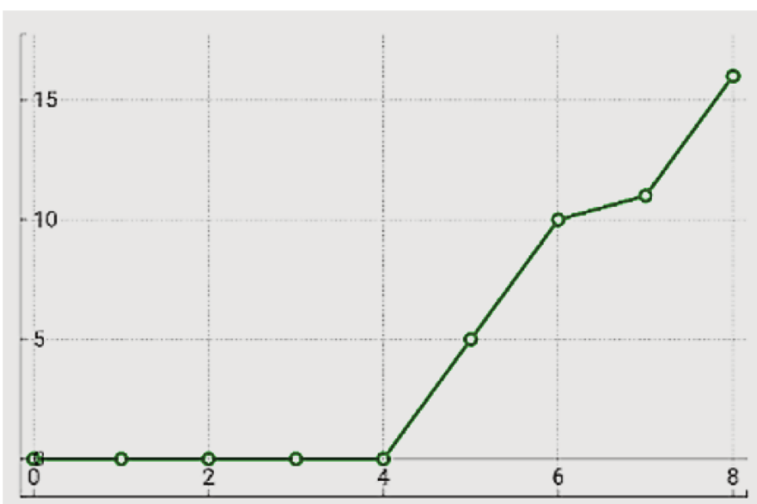

Figure 4. The vibration level of the machine has been exceeded (x axis: time [t], y axis: acceleration [m/s²])

Usability and advantages of system are globally as follows:

–control of machine operation,
–control of the operator's work,
–measuring productivity,
–communication between sensor and mobile device without vendor lock limitations
–online vibrations control level to enable safe, long-lasting operation and to decrease the maintenance costs
–mobile application for Android and iOS system
–telemetric data for determination of productivity level of the end user (tractor operator)
–simple Enterprise Resource Planning web based application
vuseful analytical synthesis data for the extension of the warranty
–independence from different payable systems,
–saving measured data.

Figure 5. Coordinates of GPS tracking on the strating screen of the mobile application

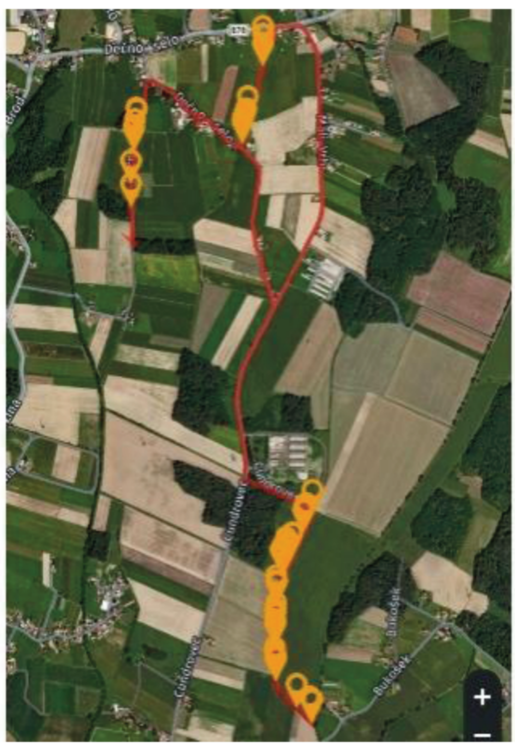

Figure 6. GPS tracking on the online map

The program package is developed for different users:

a) operators-tractor drivers

–alert if the engine hits something

–alert if too high vibrations are on the engine

–alert when low battery

b) supervisors at the desk:

–too high vibrations are on the engine

- engine is working in wrong time and/or on wrong area

–the exact place where the engine is working in the exact time

c) analysts-reporters:

–full report and analyse of working productivity including of working time and stops, working area, vibrations and alerts for each engine, details of surface covering, tracking and so on

–application with program package without use the sensor, adapted to the buyer's needs (possible all up-mentioned data except vibrations) [27]

The mobile application could provide the user with the next information:

–Emergency SMS service (send SMS with current location to selected contact)

–Send SMS for detection of machine stop (to selected contact)

–Send SMS for excessive vibrations (to selected contact)

–Option for use only as GPS tracking (no INO sensors needed)

–Show on Map for Log Files (with vibration data markers) [27]

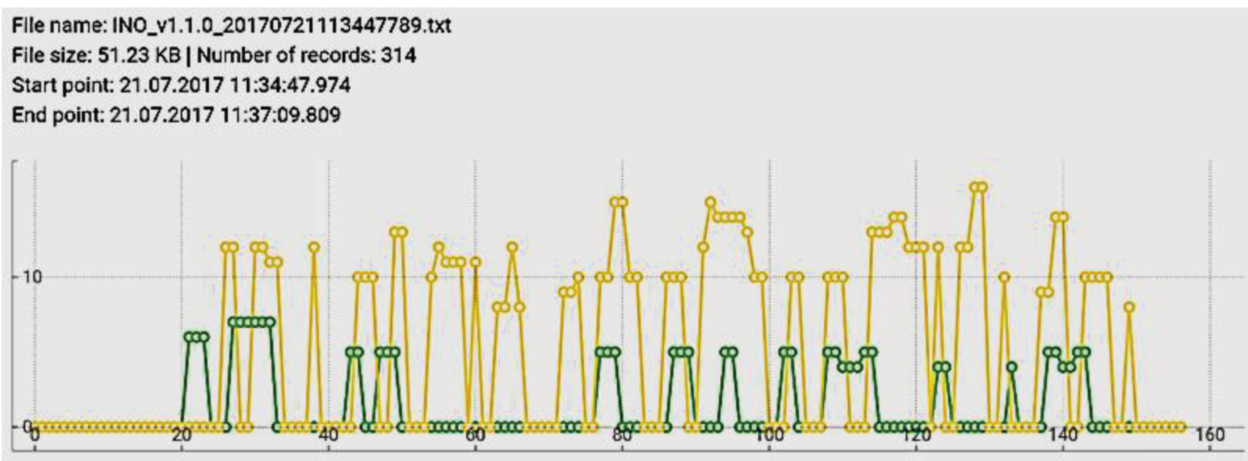

Figure 7. The history of the measured data on the Mobile Phone Screen
(x axis: time [t], y axis: acceleration [m/s²])

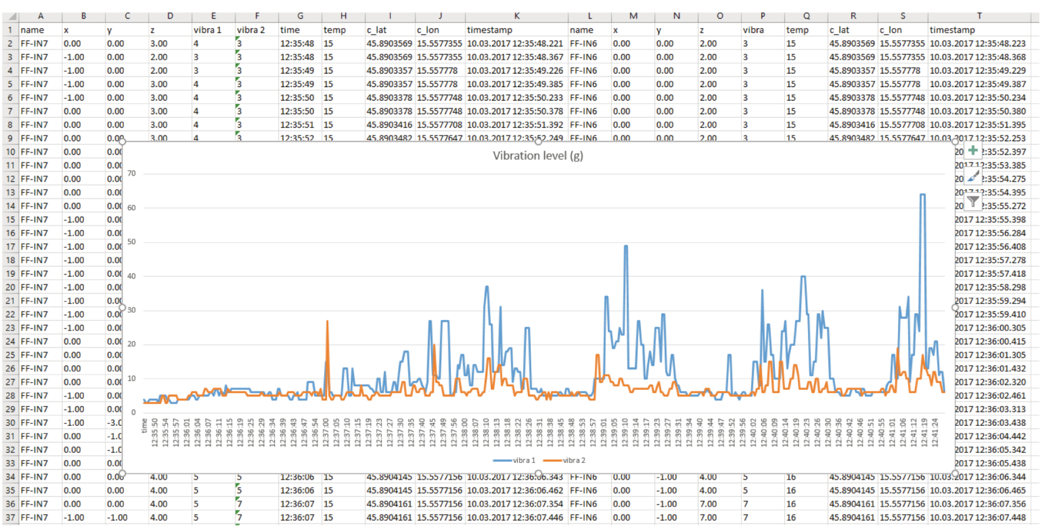

Figure 8. The history of the measured data on the Computer Screen

The measured sensor data can be stored to the mobile device. The user can read stored data for each second of recording: GPS coordinates, vibration levels by X, Y, and Z axis, temperature and exact time. Stored data can be exported to another device or computer and later analysed in one of the required applications (for example: MS Excel), or can be viewed directly on a mobile device. (Figures 7. and 8.)

Conclusion

For small, medium-sized, and for the large-scale farm machinery too, the above-mentioned Smart Solutions prove to be beneficial for efficient work, professional utilization of machines, and for minimizing the production and mechanization costs.

A common feature of systems described in this article is that they can be operated independently from the tractor's ISOBUS system. Both, the controller as well as the data collecting interface can be operated autonomously using their own system by means of a mobile phone or tablet device that can be controlled via wide spread accessible mobile application.

It is very important to mention that there are some advantages of IT, but some problems as well. Most significant are those related to putting systems into the operation and fighting with malfunctions. One of specific problem is coupling the tractors and implements by using different stages of ISOBUS. That means, full commercial maturity of compatibility of ISOBUS is still in front of us. [28]

The design of these electrical systems can also be realized by an individual, innovative medium-sized machine manufacturing company, as it is shown in the presented work.

References

[1] Kovács I., Husti I.: 2018. The Role of Digitalization in the Agricultural 4.0 – How to Connect the Industry 4.0 to Agriculture? Hungarian Agricultural Engineering, Periodical of the Committee of Agricultural and Biosystem Engineering of the Hungarian Academy of Sciences, Vol. 33. pp. 38-42.

[2] Bauerdick J., Piringer G., Kral I., Gronauer A., Bernhardt H.: (2017) Precision Grassland Farming – State of the Art and Future Research Topics. Proceedings of the 45th International Symposium Actual Tasks on Agricultural Engineering. Opatija, Croatia, 21 - 24 February 2017. p. 303 - 309.

[3] Auernhammer, H. (2002). Automatische Betriebsdatenerfassung im Ackerbau und seine Nutzenanwendung. In: "Ackerbau der Zukunft", Tagungsband zur Landtechnischen Jahrestagung am 04. Dezember 2002 in Deggendorf (G Wendl). Freising: Landtechn. Verein in Bayern (Landtechnik-Schrift, Nr. 14), pp. 45–58

[4] Schellberg, J.; Hill, M., Gerhards, R., Rothmund, M., Braun, M. (2008): Precision agriculture on grassland. Applications, perspectives and constraints. In European Journal of Agronomy 29 (2-3), pp. 59–71. DOI: 10.1016/j.eja.2008.05.005.

[5] Doluschitz, R., Morath, C., Pape, J. (2011): Agrarmanagement. Unternehmensführung in Landwirtschaft und Agribusiness. 1st ed. Stuttgart: UTB (Grundwissen Bachelor, 3587).

[6] Crookston K.: (2006) A Top 10 List of Developments and Issues Impacting Crop Management and Ecology During the Past 50 Years. Crop Science, 46, 2253-2262.

[7] Dryancour G.: (2017) Smart Agriculture for All Farms, CEMA - European Agricultural Machinery Association, Brussels, Belgium, 23 p.

[8] Takácsné Gy. K.: (2018) The Innovation Process of Precision Crop Production – Along with Economic Theories, in PREGA Science – Papers presented at the 2nd Sci. Conf. on Percision Agriculture and Agro-Informatics (Edited: Milics G.) p .17-19.

[9] Auernhammer H.: (2001) Precision Farming – the Environmental Challenge. Computers and Electronics in Agriculture. Vol 30. 1-3. pp 31-43.

[10] Gibbons G.: (2000) Turning a Farm Art into Science / an Overview of Precision Farming. http://www.precisionfarming.com

[11] Daberkow S. G., McBride W. D.: (1999) Adoption of Precision Agriculture by U.S. Corn producers, In Robert P. C., Rust R. H., Larson W. E. (editors), Precision Agriculture (pp. 1821-1831) Madison ASA/CSSA/SSSA

[12] Mackay D.: (1997) Precision Farming: Connecting the pieces. In D. A. Lobb (Ed.) Precision Farming. Challenges and Opportunities for Atlantic Canada. Charlottetown.

[13] Taylor J., Whelan B.: (2010) A General Introduction to Precision Agriculture. Grains Research and Development Corporation. http://www.agripecisione.it

[14] Bullock D. G., Bullock D. S., Nafziger E. D., Doerge T. A., Paszkiewicz S. R., Carter P. R. et al.: (1998) Does Variable Rate Seeding of Corn Pay? Agronomy Journal 90 (6), 830-836.

[15] Clark R. L., McGuckin R. L.: (1996) Variable Rate Application Technology: An Overview. In Robert P. C., Rust R. H., Larson W. E. (editors), Precision Agriculture (pp. 855-862) Madison ASA/CSSA/SSSA

[16] Nafziger E. D.: (2012) Corn in Illinois Agronomy Handbook. Champagne-Urbana. University of Illinois Extension and Outreach.

[17] Lundström Ch., Lindblom J.: (2016) Considering Farmers' Situated Expertise in Using AgriDSS to Foster Sustainable Farming Practices in Precision Agriculture. 13th International Conference on Precision Agriculture. July 31 – August 4. St Louis, USA.

[18] Urso L-M. et al.: (2017) Crop Production of the Future-possible with a New Approach. Proceeding of Advances in Animal Biosciences: Precision Agriculture. Edinburgh, UK. pp. 734-737.

[19] Kempenaar C. C. et al.: (2016) Towards Data-intensive, more Sustainable Farming: Advances in Predicting Crop Growth and Use of Variable Rate in Prediction Crop Growth and Use of Variable Rate Technology in Arable Crops in the Netherland. 13th International Conference on Precision Agriculture. July 31 – August 4. St Louis, USA.

[20] Neményi M.: (2018) Research Activity in PA in the Last Decade in Terms of Sustainability (Thoughts about the Future). in PREGA Science – Papers presented at the 2nd Sci. Conf. on Percision Agriculture and Agro-Informatics (Edited: Milics G.) p. 12-16.

[21] Adam U.: (2017) Agriculture 4.0 – the Challenges Ahead and What to Do about Them - 27th Club of Bologna Meeting, Hannover, 12-13 Nov 2017. 31 p.

[22] Oliaro F.: (2017) Smart Logistic for Effective Process - 27th Club of Bologna Meeting, Hannover, 12-13 Nov 2017, 14 p.

[23] Horstmann, J. (2016): Kommunikationssysteme und Farming 4.0 in der Landtechnik. In: Jahrbuch Agrartechnik 2015 (L. Frerichs). Braunschweig, pp. 1–7. Available online at http://www.jahrbuch-agrartechnik.de/index.php/artikelansicht/items/230.html, checked on 4/12/2019.

[24] Clasen M.: (2016). Farming 4.0 und andere anwendungen des internet der dinge. In Ruckelshausen, A. et al. (Eds.), Proceedings of GIL annual meeting 2016. Informatik in der Land-, Forst- und Ernahrungs-wirtschaft. Fokus: Intelligente Systeme-Stand der Technik und neue Möglichkeiten (pp. 15–18). Bonn: Koellen.

[25] Demmel, M., Schwenke, T., Heuwinkel, H., Locher, F., Rottmeier, J. (2002): Ertragsermittlung von Grünland – erste Ergebnisse. In: LANDTECHNIK – Agricultural Engineering 57 (3), pp. 146–147.

[26] Kumhála, F., Kroulík, M., Prošek, V. (2007): Development and evaluation of forage yield measure sensors in a mowing-conditioning machine. In Computers and Electronics in Agriculture 58 (2), pp. 154–163. DOI: 10.1016/j.compag.2007.03.013.

[27] Vučinić Z.: (2018) INO Vibration Control Presentation, Some Useful Data. INO Brežice, Slovenia, Krška vas, 2. p.

[28] Bosch J.: (2018) Farmer's Experiences with New Technologies in Agriculture - 28th Club of Bologna Meeting, Bologna 10 Nov 2018, 16 p.

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 13-17
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2017.35.13
Received: 2019.05.10. - Accepted: 2019.07.01.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
THE HUNGARIAN ACADEMY OF SCIENCES
and
SZENT ISTVÁN UNIVERSITY
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INVESTIGATING THE SOCIAL RETURN ON TECHNICAL INVESTMENTS

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Abstract

In this paper, we examine the importance of the use of the social Return of Investment (SROI) method by investors, company managers in the evaluation of a particular technical investment or activity. The SROI analysis method differs from other financial valuation methods because it collects and analyses information about the social value of the resources used by the activities. In most cases, the economic analysis of investments does not contain such information, and neither such that would examine the impact of these resources on society. As a result of the SROI analysis, qualitative, quantitative and financial data are available on the project, providing the end-user with information on the social values of the examined investment. This issue is particularly important for environmental investments financed by the European Union.

Keywords

Technical investments, measuring external effects, social return, SROI, cost-benefit analysis

1. Introduction

The result of an investment or activity is that the users of the project or service benefit directly from it. For most investments, such external economic effects that do not directly manifest at the users of the project and do not involve direct financial compensation. These are the external effects of investments [1].

Several methods can be used to estimate user benefits. On the one hand, the benefits can be approached by quantifying the resource savings achieved by the project. On the other hand, by estimating financial revenues if it adequately reflects the benefit to the users of the infrastructure created by the project. During the analysis it is necessary to examine the method of estimating the revenues, which can be used to conclude what external effects do not appear in the financial revenues [2].

The main purpose of the research is to quantify the effects that cannot be described by conventional financial methods. In the case of estimating external benefits, the methods for quantifying the effects may vary with each project. It may not be possible to quantify all the effects, so the impact should be described qualitatively in the analysis.

2. Cost-benefit analysis of external effects

External effect means that the economic activity in question also involves a participant (third party) who is not involved in the activity [3].

In the case of external effects, the welfare of such persons who do not participate in the transaction as either producers or buyers grows or declines. This effect does not appear in the course of corporate activity, so the price of the product or service does not include its benefits and costs. A further feature is that external effects are „uncompensated welfare changes" [4].

„The decisive feature of external economic effects is that there are goods that people appreciate, but are not the subject of market sales" [5]. In the framework of a research program [6] it was investigated that in case of agricultural cultivation and good farming strategy a significant reduction of CO2 emissions can be achieved, which can have a positive external effect on society and the environment.

The external economic impact is nothing else but an unintentional, unconscious impact on the level of welfare of one or more economic players. External economic impacts can be positive or negative and can affect producers and consumers alike.

–An adverse external effect is when the party concerned has suffered damage as a result of the external impact. This can be a financial loss, loss that can be directly or indirectly determined or not measured in currency. Such effects are negative externalities.

–In the case of a favorable external effect, the given externalities have a positive effect on the stakeholders and their environment. When it comes to a business, it affects its profit favorably as long as it affects the consumer; it increases its level of welfare. These are the so-called positive externalities.

Within negative externalities, a distinction can be made between technological and financial impacts. Environmental protection mainly deals with technological impacts.

A common method of dealing with negative externalities of activities that affect a large part of society is that the state tries to limit them with regulations. In these cases the objective is to prevent the development of externalities.

The state can intervene effectively in the case of such negative externalities that affect many people. Tax is levied on activities that result in negative externalities to be suppressed, or stimulate the activity in case of positive externalities. The abovementioned instruments for reducing or eliminating negative externalities are not applicable to all economic sectors. For example, in the case of biomass production, the use of these instruments is very complicated [7].

In the socio-economic analysis, the benefits and costs of cash flows are interpreted broadly. Not only are the revenues and expenditures of private projects that can be captured in the relevant financial and financial sense, but also the secondary effects of the project. What are the costs and benefits for the community and society? The project may have an impact on the environment, human health, employment, etc. The secondary effects of the project can be relatively well defined its quantification is difficult, however. The cash flows calculated in the socio-economic assessment take the benefits for the community that private projects do not calculate with into account. These are the external effects that are incorporated as separate points into the cash flow of the projects. The purpose of this amendment is to determine what other cash flow, profit or cost there is compared to private projects at a social level.

3. Method and indicator of social return on investments (SROI)

Social return on investments (SROI) is an analytical method for measuring social, economic and environmental values that do not appear in the traditional financial analysis of an investment.

While in financial analyses the ROI (Return on Investment) is a single indicator, SROI is not just a single indicator, but also an analysis method. The SROI method of analysis is based on seven principles and consists of six sections, which were also published in the „Guide for calculating the social return on investment" [8].

The calculation and analysis of the SROI indicator deals with the fifth stage of the method. Thus there is a difference between „SROI" as an indicator and the „SROI method".

The SROI method is a consistent quantitative approach to analyzing and managing the effects of a project or the activities of an enterprise or social organization.

The SROI shows the monetary value of social, economic and environmental changes resulting from these effects and activities, which generally do not have market value [8]. This approach demonstrates how effectively an enterprise can use its resources to create value for society. The SROI method attempts to make the less obvious effects of projects, developments, institutions and services, the correctness of the direction of interventions visible, or further developments using the results of an already implemented project [9].

The SROI analysis can be prepared in many forms. It is possible to analyze the social effects of all activities generated by an organization or of a specific project. There are two types of SROI analysis:

–Evaluation SROI method, which is a retrospective assessment of events and results that have already occurred.

–Forecasting SROI method that predicts how much social value is generated when activities meet expectations and the planned results are realized.

An important feature of the method is that it tries to express the created but not obvious values (possibly damages) in monetary terms, thus making it easier to communicate the impact of those settlement developments and social investments that are otherwise very difficult to detect.

Investors use the cost-benefit (CBA) analysis method in the normal analysis of projects to determine whether the investment or other activities are economical or not. The SROI is also based on the logic of the cost-benefit analysis, but can be considered a different method [10]. SROI is suitable for providing additional information to investors and business executives who, in making their investment decisions, are aware of its social, environmental impacts. As an indicator, SROI is calculated as follows:

1. Determining the present value of a given social impact:

where SPV is the present value of the given social impact,

$$SPV = \frac{social\ impact\ value}{1+r} + \frac{(social\ impact\ value)^2}{(1+r)^2} + \dots + \frac{(social\ impact\ value)^t}{(1+r)^t} \quad (1)$$

r the discount rate,

t the duration.

the calculation of SROI indicator:

where

C_0 initial costs of the investment,

SROI social return on investments.

$$SROI = \frac{SPV}{C_0}, \quad (2)$$

Calculation of net NSROI indicator:

$$SNPV = SPV - C0, \quad (3)$$

where

SNPV the net present value of social impact,

$$NSROI = \frac{SNPV}{C_0}, \quad (4)$$

NSROI the net social return of the investment.

The SROI indicator is a ratio, which means how much social value a Hungarian Forint (HUF) investment creates in HUF. One of the problems that make it difficult to calculate the above formula is that it is not possible to assign monetary value directly to the social impact value. There is a need for methods that convert qualitative information to a quantitative value [8].

Another problem with the formula is that it is difficult to determine the appropriate „r" discount rate. According to the guidelines of the „Guide for calculating the social return on investment" [8], the recommended discount rate is 3.5%. Due to the lack of comparative market interest rates, [9] argue that a range of discount rates may be applied (not only 3.5%), considering that a higher discount rate reduces the return on investment. There is also need for a specific selection procedure according to [12] rather than the adoption of a standard discount rate based on the uncertainty over several years of social impacts.

There are different activities in each organization, so the representatives of organizations decide differently when analyzing the social return of their own activities. Consequently, it is not practical in itself to compare SROI indicators calculated for different activities of different organizations. Just as investors, in addition to information on financial returns, take information on financial returns into account when making an investment decision, social investors should also be aware of all the information produced as part of the SROI analysis, beyond the value of the SROI indicator. Organizations should emphasize to investors the importance of interpreting the SROI indicator in the context of a full analysis.

4. Criticism of SROI

There have been many criticisms of the SROI method in both scientific and applied literature. Monetary values assigned to social outcomes are problematic and often unreasonable, excessive, and overestimate the full impact of the activity under investigation [13],[14]. Changing social outcomes to value for money (applying the SROI method) could mean marketing the nonprofit sector, which undermines the ability to create and sustain a strong civil society [15].

However, the supporters of SROI argue that by assigning monetary value to non-financial results, these results can be understood and analyzed [16]. Another critical comment is that the SROI ratio is often published as the sole indicator of analysis, but it makes no sense to decide on a single indicator.

There is a need for some kind of forecast or similar calculations from other organizations to assess the impact. Another critical remark is that the SROI analysis is a resource-intensive process that can cause problems for charities, where human and financial resources may be limited, considering that significant input is required to determine the parameters of the social impacts under investigation [17, 18].

The SROI method was originally developed by the US-based Roberts Enterprise Development Fund (REDF) in the mid-1990s [19]. The criticism of the SROI model developed by REDF was the lack of standards, and that the results were unreliable and non-comparable. In the UK, the New Economics Foundation [20] further developed a widely used and standardized method since the late 1990s. NEF developed a six-stage framework to ensure that a wide range of organizations use the SROI method consistently. The SROI method contains a number of estimates, including discount rates, financial substitutes and applied impact assessment measures. They carry out a sensitivity analysis to determine which social impact is best for social return. In order to continuously monitor the social return on investments, it would be necessary to incorporate the SROI method into organizational operation.

5. Observations on SROI

The SROI is different from most other financial assessment methods because it collects and analyzes information about the social value of resources used by activities. Most evaluations simply do not contain such information, not to mention the impact of these resources on society. Most of the other methods of cost-benefit analysis only measure the results of the activity under investigation in a natural unit.

The SROI is based on such analyses that make it easier to evaluate and compare investment opportunities by measuring the time value of money, the amount of money invested, and many other factors such as risk. If this measurement succeeds, one of the listed multi-dimensional information will be a number that can be assessed by a simple decision rule, „the more, the greater the value the better”, so the best investment can be chosen. There are two suitable indicators for this: Net Present Value (NPV) and Return on Investment (ROI).

If the ROI is highlighted from the financial analysis and used for analyzing social environmental contexts (SROI) instead, then the previous results (NPV, ROI indicators) and the conclusions drawn from them may change in relation to the feasibility of an investment. The reason for this is that social expectations are the interests of the diverse environment, different cultures, the results of the SROI analysis can change the investors' return expectations for a given investment. These indicators can have a moderating effect on investors and their expectations of a single predefined (NPV, ROI) values of the indicators), the „more, the better” criteria for technology investments.

Conclusion

The application of SROI should not be rejected, by calculating this indicator it is possible to analyze several non-financial aspects, so more comprehensive conclusions can be drawn in the analysis of an investment, an activity. Some capital investment activities are not always reliable due to their impact on the environment and society. Investors completely ignore the consequences of these effects. However, the UN's „Sustainable Development Goals” document [21] illustrates that expectations for social and environmental change have increased significantly. This already influences the thinking of some governments, investors, and social organizations, which, when investing their capital, take the interests of the society and the environment into account in addition to private financial gain. The advantages and disadvantages of using the SROI method and the SROI indicator were analyzed above. We emphasized that besides traditional financial analyses, economical calculations, the results determined by the SROI method show the extent to which an investment or activity results in benefit or loss to society. The results calculated by the SROI method do not appear in the financial statements but are useful for the company. It makes it possible to understand the social and economic environmental impacts of an investment or activity by attempting to quantify the individual effects by the SROI method.

References

[1] Fogarassy, C., Lukács, Á.„ Nagy, H.: 2008. Potential benefits of linking the Green Investment Scheme of the Kyoto Protocol with institutional voluntary markets like the Chicago Climate Exchange. In ENVECON - UK Network of Environmental Economics.

[2] Horvath, B., Mallinguh, E., Fogarassy, C.: 2018. Designing Business Solutions for Plastic Waste Management to Enhance Circular Transitions in Kenya. SUSTAINABILITY, 10(5). http://doi.org/10.3390/su10051664

[3] Callahan, G.: 2001. What is an Externality? August 2001, 19, 8. The Free Market. The Mises Institute monthly. http://www.mises.org/freemarket_detail.aspx?control=367.

[4] Mozsár F.: 2000. Az externáliák szerepe a regionális gazdasági teljesítmény magyarázatában és növelésében. In: Farkas B. – Lengyel I. (szerk.): Versenyképesség – regionális versenyképesség. SZTE Gazdaság Tudományi Kar Közleményei JATE Press, Szeged, pp: 100–114.

[5] Varian, H.R.: 1991. Mikroökonómia középfokon. Egy modern megközelítés. Közgazdasági és Jogi Kiadó Bp.

[6] Fogarassy C., Horvath B., Kovacs A.: 2015. Cross-sector analysis of the Hungarian sectors covered by the Effort Sharing Decision – Climate policy perspectives for the Hungarian agriculture within the 2021-2030 EU programming period. Apstract - Applied Studies in Agribusiness and Commerce 9: 4 pp. 17-24. Paper: 1789-7874, 8 p.

[7] Fogarassy C., Bakosne B. M.: 2014. Externality analysis of sustainable cattle breeding systems. Hungarian Agricultural Engineering Volume 26, pp. 5-10. http://dx.doi.org/10.17676/HAE.2014.26.5

[8] Nicholls, J et al.: 2012. A Guide to Social Return on Investment. Office of the Third Sector UK.

[9] Yates B. T. – Marra M.: 2017. Introduction: Social Return on Investment (SROI). Evaluation and Program Planning 64. (2017) pp: 95-97.

[10] Yates B. T. – Marra M.: 2017. Social Return on Investment (SROI): Problems, Solutions … and is SROI a good investment? Evaluation and Program Planning 64. pp: 136-144.
[11] Emerson et al.: 2000. Social Return on Investment: Exploring Aspects of Value Creation in Non-profit Sector. San Francisco: The Roberts Enterprise Development Fund.
[12] Olsen, S. – Lingane, A.: 2003. Social Return on Investment: Standard Guidelines. Working Paper Series, Center for Responsible Business, UC Berkeley.
[13] McLoughlin, J, et al.: 2009. A strategic Approach to Social Impact Measurement of Social Enterprise: The SIMPLE methodology Social Enterprise Journal 5 (2), pp: 154-178.
[14] Wright, S. et al.: 2009. An Evaluation of the Transport to Employment (T2E) Scheme in Highland Scotland Using Social Return on Investment (SROI). Journal of Transport Geograpy, 17 (6), pp: 457-467.
[15] Eikenberry, A. M. – Kluver, J. D.: 2004. The Marketization of the Non-profit Sector: Civil Society at Risk? Public Administration Review, 64 (2), pp: 112-134.
[16] Henry, G.: 2000 'Why not use?' New Direction for Evaluation 88. pp: 85-97.
[17] Newcomer, K. – Brass, C. T.: 2015 Forging a Strategic and Comprehensive approach to evaluation within public and non-profit organizations integrating measurement and analytics within evaluation. American Journal of Evaluation 37/1. pp: 80-99.
[18] Ryan, K. E. – DeStefano, L.: 2000 Evaluation as a democratic process: Promoting inclusion, dialogue, and deliberation. New Directions for Evaluation 85.
[19] Wachowicz, J. – Chun, S.: 2000. Social Return on Investment: Exploring Aspects of Value Creation in the Non-profit Sector REDF Box-Set, Vol. 2. pp: 132-170.
[20] NEF: 2009. Nemzeti Fejlesztési Terv Regionális Programok Irányító Hatósága, www.palyazat.gov.hu
[21] UN: 2015. UN Department of Public Information: Sustainable Development of Goals – Guidelines.

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 18-21
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2019.35.18
Received: 2019.05.20. - Accepted: 2019.09.01.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
THE HUNGARIAN ACADEMY OF SCIENCES
and
SZENT ISTVÁN UNIVERSITY
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INTERPRETATION OF RISK ASSESSMENT PROCEDURES AND MANAGEMENT OF RISK FACTORS

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Abstract

The following study seeks to outline a line of thought through which industrial, environmental engineering processes and operations can be evaluated from a risk management perspective. Different risk management models usually consider the risk of introducing a new technique / technology from an environmental and human point of view.

Keywords

Risk assessment, risk factors, process analysis, environment and human risk management

1. Introduction

A distinction should be made between the environmental risk assessment of each substance and whether or not relevant environmental concentration values are available for the substance. In the former case, we can only determine the environmental risk by estimation, while in the latter case specific model calculations allow the risk assessment of the substance. In this case, concrete results can also be obtained with respect to environmental exposure (e.g. emission concentrations of industrial technologies, background concentration calculations, spread modelling) [1]. If specific measurement results are available for a particular substance, it is important to perform a critical (and statistical) analysis of the data and to examine the representativeness of the results. In doing so, we can get a realistic picture of real-world environmental emissions and refine our models of environmental emissions and exposure [2]. In the risk analysis of substance emissions, we need to distinguish between point sources and diffuse releases [2]. Local concentration values (PEClocal) are typically determined by point source discharges, which also affect regional concentrations (PECregional) to some extent. Determination of PEC according to Annex III to Directive 93/67 / EEC Annex III, which states that concentrations should always be determined at the local level when assessing environmental risks [3].

2. PEClocal and PECregional values and prediction of local and regional environmental concentrations predicted

An important factor in new techniques is the determination of PEClocal concentrations, i.e. the amount of material that is released into the environment from point sources. The PEClocal expresses the expected concentration that occurs at some distance from the source on the day the release occurs [4]. Thus, on the one hand, it gives specific concentration values, but it also provides information that can be considered to a certain extent hypothetical. The determination assumes that the point source is emitted on a regular basis, at defined intervals, so that any release date can be calculated. In some cases, time-dependent concentrations may also be required, which typically need to be considered during periodic releases [4]. PEClocal takes into account degradation and distribution processes. The determination of the PECregional concentration should be performed for larger areas of point or diffuse pollution and reported for the regional environment [4].

PEC values are derived from available measurement results (data), while PNECs are derived from laboratory test data or model ecosystem studies [1,5]. The PNEC definition defines a concentration below which a given substance does not pose a safety hazard. Thus, in practice, a relationship can be established between PNEC values and contamination limits “B”. To determine with certainty whether a given quantity of a substance constitutes a risk to the ecosystem, the environment, the PEC / PNEC ratio must be determined and conclusions drawn. If either of the PECs or the PNECs cannot be determined accurately, a quantitative risk assessment is not possible. According to this, a qualitative risk assessment should be carried out [6].

3. Estimation of environmental exposure

A given substance (pollutant) has some effect on the environment throughout its life cycle. Its quantity and concentration may vary, but this change also affects the ecosystem, constantly changing its qualitative characteristics [5,6]. Exposure estimation shall be made for all environmental compartments. The following stages of the life cycle of the substance shall be considered during the test: manufacture, processing, storage and transport, use (industrial, commercial, residential) and possible disposal or remediation. An important factor in the estimation of environmental exposure is the volume evolution of past releases [6,7].

These values should also be taken into account because they may cause background concentrations in the environment, i.e. they have a cumulative effect. Exposure levels shall be determined taking into account the measurement data and the results of any model calculations [7]. It should be determined whether the test substance is capable of producing stable or toxic degradation products by biological (biochemical) or abiotic route. If so, their environmental impact should also be considered [8].

In most cases, knowledge and data on biological degradation are only available for aerobic conditions, although anaerobic degradation factors should also be considered in sediment and soil studies. The possibilities of estimating environmental exposures are also strongly influenced by the salinity and pH of environmental elements [8].

4. Classification of measurement data at local and/or regional level

In any risk management process in an environment where specific measurement data is available (and not only calculated through model calculations), classification shall be made at local or regional level. Based on this, it is possible to compare with the calculated PEC values, so it is possible to decide which PEC value we can use to characterize the risk [9]. If the sampling areas in question are not geographically close to the point source for the pollutant, the background concentration of the area shall be reported (PECregional), to which the calculated local concentration values must be added (PEClocal). Purely PEClocal values are obtained when the pollutant concentration values measured in the sampling area are representative of the local character of a given emitting point source.

In the case of contaminated industrial sites, the point of discharge may, where appropriate, coincide with the contaminated site [5,9]. Sampling must take into account the different behaviour of the pollutants, i.e. changes in concentration to physico-chemical and biological effects [10]. In the case of substances produced in large quantities, which may have environmental risk characteristics, it should be borne in mind that use may vary over time, and thus environmental emissions may also be affected accordingly. In this case, all possible emission values must be added at the local level since emissions change over the life cycle of the substance. In the case of a regional risk assessment, the total emission values for all environmental compartments shall be added over the life cycle of the pollutant.

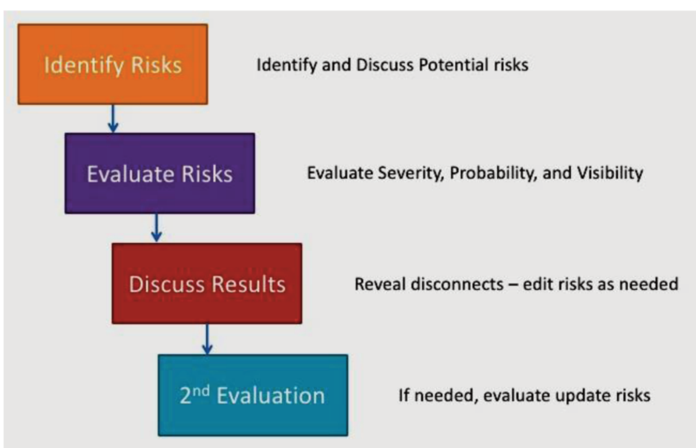

Figure 1. The risk assessment process [11]

Regional environmental concentrations should always be reported in relation to local background concentrations [6].

For long-lived substances that can be measured over several years (for example, chemically bound pollutants in complex compounds), it should be noted that exposure increases over the life-cycle of the substance [6,7,10]. The reason for this is that as the material decays, the bound pollutant is released in ever increasing concentrations. Where emission abatement technologies are used in a given sampling area, their effects shall also be considered in the environmental risk assessment of the pollutant and in the measurement of the quantity (concentration) of the pollutant emitted [7,10].

5. Risk characterization of environmental elements and aspects

Exposure to pollutants should be investigated on all environmental compartments since they can affect the entire natural environment in space and time. When calculating local and regional PECs, need to delineate a standardized environment for which we are conducting investigations, as this can interpret our results for a given environmental element [4,12]. Test phases and markings for standard environmental characteristics (based on Jenei, 2016) [12]:

–The density of the solid phase (RHOsolid)
–Density of water (RHOwater)
–Density of air (RHOair)
–Surface waters: suspended concentration (dry weight) (SUSPwater)
–Volume of the solid fraction in suspension (Fsolid/susp)
–Volume of water in suspension (Fsolid/water)
–Volume of solid in soil (Fsolid/soil)
–Volume of water in the soil (Fwater/soil)
–Volume of air in the soil (Fair/soil)

It can be seen from the above that the soil and the suspended material consist of three phases: air (soil only), solid and water. The density of the environmental element is determined by the density of the phases and their volume ratio, as follows (where "element" refers to the phases of each environmental element) [12]:

$$\text{RHOelement} = [\text{Solid element} \cdot \text{RHOsolid}] + [\text{Freshwater element} \cdot \text{RHOwater}] + [\text{Air element} \cdot \text{RHOair}]$$

From this equation, it can be concluded that the framework for the data for the whole environmental element is the data series of the three-constituent media, solid, water, and air. In the environment where any of the above three media is not present or is present below the detection limit, the equation must be modified accordingly.

6. Risk management aspects of wastewater treatment process

The limit values for surface water pollution and their application are set out in Decree 10/2010. (VIII. 18.) VM. The law specifies what heavy metal concentrations are allowed in surface waters and the concentration (from pollution limit "B") that is considered to be a heavy metal load. In line with the EU Water Framework Directive, efforts should be made to good ecological and environmental status of surface waters.

It is generally accepted if a new water treatment technology can reduce the concentrations of pollutants to below the statutory limits (pollution B limits) and achieving the remediation target value. At the same time, it is important to emphasize that there is a certain competition between water treatment technologies as to which technology can produce the highest possible efficiency.

As for the reviewed literature, important to note that environmental and human health risk assessment is closely related to the efficiency of a given water treatment technology, because the better efficiency of a technique, the better treatment results and the lower concentration of harmful substances decrease the risk of environment and human health problems. By analysing the environmental risk assessment (risk management) process of various pollutants, the accepted basic literature procedures [13,14,15] can also be used in the comprehensive risk management analysis of water treatment technologies presented in the literature [13].

All industrial wastewater treatment technologies have some indirect impact on a natural environment. Analysing this effect in practice means environmental risk analysis, which is usually done with indicator organisms (e.g. Daphnia, fish and fleas) [14,15]. From the point of view of the process of environmental risk management, a given technology lasts from the potential emission of pollutants (or the return of pollutants due to insufficient efficiency of the technology), to the accumulation of the environment until the potential contamination is realized [15].

Conclusions

Environmental and human risk analysis is an important task. We have seen the steps involved in identifying hazardous substances, analysing risky discharges, and calculating the level of risk. After that, it is possible to eliminate the risk. Risk analysis and calculation is a multi-step process that is standardized. In our view, one of the major issues is always the identification of potentially hazardous substances. If the potential risk substance is chemically identifiable, the risk management steps will follow. However, if the substance is presented in a chemically complex form, for example in industrial wastewaters, the digestion within the complex form is required as a first step. In this case, the determination of exact risk management steps could follow only the digestion of complex materials.

References

[1] CARTER, D.A., ROGERS, D.A., SIMKINS, B.J., TREANOR, S.D. 2017: A review of the literature on commodity risk management. J. Commod. Mark. 8: 1–17. p.

[2] SARKAR C., WEBSTER C. 2017: Urban environments and human health: current trends and future directions. Current Opinion in Environmental Sustainability 25: 33-44. p.

[3] ETINAY, N., EGBU, C., MURRAY, V. 2018: Building Urban Resilience for Disaster Risk Management and Disaster Risk Reduction. Procedia Eng. 212: 575–582. p.

[4] NGUYEN, V.N., GINIGE, K., GREENWOOD, D. 2018: Challenges in integrating disaster risk reduction into the built environment – The Vietnam context. Procedia Eng. 212: 316–323. p.

[5] CRAWFORD, M.H., CROWLEY, K., POTTER, S.H., SAUNDERS, W.S.A., JOHNSTON, D.M. 2018: Risk modelling as a tool to support natural hazard risk management in New Zealand local government. Int. J. Disaster Risk Reduct. 28: 610–619. p.

[6] WANG, F., GAO, Y., DONG, W., LI, Z., JIA, X., TAN, R.R. 2017: Segmented pinch analysis for environmental risk management. Resour. Conserv. Recycl. 122: 353–361. p.

[7] CRAIG, C. 2018: Risk management in a policy environment: The particular challenges associated with extreme risks. Futures.

[8] HANSEN, J., HELLIN, J., ROSENSTOCK, T., FISHER, E., CAIRNS, J., STIRLING, C., LAMANNA, C., VAN ETTEN, J., ROSE, A., CAMPBELL, B. 2018: Climate risk management and rural poverty reduction. Agric. Syst.

[9] MEHTA, N., DINO, G.A., AJMONE-MARSAN, F., LASAGNA, M., ROMÈ, C., DE LUCA, D.A. 2018: Extractive waste management: A risk analysis approach. Sci. Total Environ. 622–623: 900–912. p.

[10] BODAR, C., SPIJKER, J., LIJZEN, J., WAAIJERS-VAN DER LOOP, S., LUIT, R., HEUGENS, E., JANSSEN, M., WASSENAAR, P., TRAAS, T. 2018: Risk management of hazardous substances in a circular economy. J. Environ. Manage. 212: 108–114. p.

[11] The Risk Assessment Procedures. Basic steps of risk identification.
Web: https://image.slidesharecdn.com

[12] JENEI T. 2016: Leggyakrabban használt kockázatkezelési modellek összehasonlítása (Compare the most frequently used models of risk management). International Journal of Engineering and Management Sciences 1 (1): 1-11. p.

[13] SZÉKELY CS. 2014: A környezeti kockázatok és értékelésük (Environmental risks and their evaluations). Gazdaság és Társadalom (Journal of Economy and Society) 6(1): 15-28. p.

[14] AVEN T. 2016: Risk assessment and risk management: Review of recent advances on their foundation. European Journal of Operational Research 253: 1–13 p.

[15] ANSAH R.H., SOROOSHIAN S. 2017: Effect of lean tools to control external environment risks of construction projects. Sustainable Cities and Society 32: 348–356 p.

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 22-25
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2019.35.22
Received: 2019.06.05. - Accepted: 2019.09.01.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
THE HUNGARIAN ACADEMY OF SCIENCES
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SZENT ISTVÁN UNIVERSITY
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ECO-MANAGEMENT AND SUSTAINABILITY ASPECTS OF INNOVATIVE DEVELOPMENT STRATEGIES

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Abstract

During the post-industrial revolutions, until the 20th century. By the last third of the 20th century, two basic directions of industrial development could be defined. One preferred to invest in local resources, with the help of state-owned companies, while the other favored industrial innovation in the export of capital by national companies. The two directions of industrial development were in some ways similar. Ecological sustainability aspects have not been taken into account during the development and operation of the technology. From this, we can see that eco-management as the management of eco-conscious companies in terms of environmental management was not a preferred aspect at that time. In the last third of the 20th century, environmental problems and the social and economic effects of pollution had also become globalize and were becoming increasingly important aspects of corporate governance. This is also due to the fact that the environmental spread of contaminants did not stop within the boundaries of a particular company, but because of the environmental conditions, they showed increasing risks to human health and the environment. As a result, companies have increasingly focused on environmental and human aspects, avoiding negative externalities and risks.

Keywords

Sustainability, eco-management, economic transformation, theoretical background, enterprise strategy

1. Ecological aspects of each corporate behaviors

The issue of sustainability is now being raised not only at the ecological level but also at the economic and social level. This is what the Sustainable Development Goals (SDG) Framework suggests. Most target groups integrate not only ecological but socio-economic aspects. The global and local challenges of the 21st century, the escalating environmental crisis, problems arising from urbanization processes, overpopulation and changing economic conditions all reinforce the need for integrated thinking.

The strategy of municipalities and companies must necessarily focus on local responses to the challenges, as the economic and environmental interpretation of sustainability requires [1].

The concept of sustainable environmental management is widespread, which takes the form of four main corporate behaviors (depending on how they respond to emerging environmental problems) [1,2].

The following breakdown of behaviors is representative of the attitude of individual companies to the issue of ecological and economic sustainability [2].

One of the main types where companies neglect the environmental impact, in part or in full. Nowadays, this type of corporate behavior is typical only in developing countries, but fortunately less and less. The main problem with this behavior is that it takes into account not only environmental and human risk aspects but also the tangible manifestations of indirect policy regulation following possible contamination [3]. Where companies were fined by environmental measures for pollution or pollution, they could be covered by the profits from the sale of cheaper technology products. A significant problem has also been that in many cases, companies have undertaken to pay for pollution-related regulations rather than for technological innovation and to finance costly environmental investments [4].

Contrary to the behavior formulated in the first point, most companies have sought to mitigate environmental problems in some way, and to manage and eliminate risks. Companies were also encouraged by indirect policy regulations, and it should not be overlooked that the personal attitudes and environmental sensitivities of those responsible for corporate governance also contributed to solving the problems. Of course, for companies with this kind of behaviors, it meant technological innovation, financing environmental remediation, which led to a significant increase in expenditure [5]. Nowadays, companies that exhibit such behavior also have a supportive rebate system that allows countries to provide, for example, preferential interest-subsidized loan schemes and tax breaks [4,5].

The third type of company includes those companies that not only focus on the elimination of already existing environmental problems but also on the prevention of pollution. A complete set of tools is available for this purpose, such as waste water collection and treatment, as well as purification of waste water from technological operations. This is still available today, but can also be linked to the Life Cycle Analysis (LCA) of manufactured products and the economic development of production technology [6]. In the latter, circular economic aspects are also emerging. This involves technology development that results in reduced or zero waste production and focuses on recycling primary and secondary raw materials, including them in the input side of the production process.

The fourth form of corporate behavior is the demand of the 21st century [7]. The use of clean technologies is ultimately the final stage in the process of the third behavior described above. Thanks to innovation focused on pollution prevention, the goal is to develop clean technology, that is to say, environmental aspects must be taken into account at all stages of production and the necessary improvements must be made. Nowadays, the zero-carbon emission, the zero-waste competition is pointing in that direction [7,8]. Many large Hungarian companies, such as Richter Gedeon and Egis companies, the two giants of the pharmaceutical industries, produce an environmental report each year that assesses the operation of the technologies used in the company from an environmental and economic point of view [8].

2. Appearances of industrial ecosystems on enterprise level

The spread of the concept of green industry or industrial ecology shows progress not only in thinking but also in practical management behaviors. Industrial ecology reconciles social, economic and environmental aspects, focusing on environmental economic criteria. This may be interpreted as meaning that the analysis of technological industrial systems is not done in isolation but in a systemic perspective [9]. The sustainability of industrial technologies is usually analyzed on a matrix basis. On both the input and output sides, we focus on optimizing material and energy balances. Optimization emphasizes the coordinated operation of resources, capital, and energy, complemented by systemic analysis [8,9].

Companies that use industrial eco-systems integrate environmental costs into costs, accounting and prices. At the same time, it can be seen the positive environmental impact of all this [1,3,9]. When analyzing the operation of companies using industrial ecosystems, it is important to emphasize and the terms 'triple end' and 'double profit'. The triple end result is the expectation that social and environmental outcomes are reflected in the traditional profit-oriented system. The dual-profit approach can be interpreted as meaning that companies must not only focus on cost reduction and sustainable competitiveness but also aim to increase environmental efficiency and improve social performance [9].

Corporate behavior must also reflect that the company's operations favor eco-innovations in the production of the product, which requires a change in company strategy and an examination of environmental competitiveness [9,10]. The regulatory environment required for this is also assisted by the International Organization for Standardization, through the introduction and continuous improvement of its environmental management standards system. An increasing number of companies are adopting the ISO 14000 environmental standard family to effectively improve their environmental performance and sustainability [10]. The standard includes principles, applicable norms, and recommended decision-making mechanisms in the areas of environmental management, auditing, benchmarking, product lifecycle analysis and Circular Economic Value (CEV) calculations for all environmental elements, and to reduce and reset the pressures and pollutants to which they are exposed [10].

The pressures of society, the emergence, and expansion of social demands, and the shift in consumer preferences should also be mentioned as causes of changes in corporate attitudes and attitudes. If a company wants to remain competitive in the market, it must take into account that consumer demand for products made with environmentally friendly technology is increasing, as the environmental attitudes of society are constantly changing and improving [1,2,9]. In the development of personal attitudes, special attention is given to environmental education, its connection with sustainability and environmental awareness (a practical example of this is the Sustainability Student Days held every year by high school institutions, as well as the Carbon Free Day - Bike Program).

3. Innovative enterprise attitude in the future smart cities

Operational objective 11 of the UN Framework for Sustainable Development aims at mapping the relationship between settlements and society in general and formulates proposals for solutions such as sustainable urban planning and regional spatial planning, and addressing the negative impact of environmental disasters on settlements. Nowadays this target group has been supplemented with the strategic development program of smart cities, which has taken the planning, infrastructure development and coordination of social aspects to a new level. In the following, in addition to describing the urbanization roles of smart cities, we also discuss how this is related to social welfare aspects and changes in population preferences.

The issue of smart cities is one of the latest research areas in social and environmental science. The concept of the smart city means linking the future directions of urban development with priority areas such as ecological sustainability and optimization of urban water management, technological (IT) modernization and social aspects of urban development [10]. Urban development concepts are particularly important issues in terms of urbanization. 21st Century changes in modern metropolitan areas must necessarily be guided by the development ideas that follow. Today, technological advances, industrial modernizations, environmental awareness, the use of renewable and alternative energy sources cannot be ignored, nor do they have significant geographical, sociological implications [11]. The future lies in smart cities, that is, modern, liveable cities, where continuous technological developments (e.g. wastewater treatment, drinking water treatment technological developments), environmental (ecological) sustainability are brought into line with social needs, job creation, social welfare system development, with the modernization of transport, the relevant legal and normative system [10,11].

The study of Angelidou [12] also touches on the most important historical factors that have led to the emergence of smart cities today (and to some extent future ones). As a result of the technological explosion that has begun with the Industrial Revolution and has continued ever since urban development concepts always aim to build the city of the future by bringing high-tech technologies of the time into everyday life. After World War II, with the use of the state-of-the-art technology available at the time, the livelihood of major cities became a major issue. The prosperity of the individual, communities and urban populations and the provision of better living conditions have come to the fore. The 1960s saw the emergence of the "electronic urbanization" trend [11,12], the telecommunication model resulting from the development of information systems. It focused on urban work and telework, and on the modernization of services and education [12].

An important element of smart city development is monitoring the changes in society [12,13]. All segments of the technological and information revolution of the 21st century are closely linked and have an impact on society. Today, the knowledge and innovation economy is gaining ground. With the advancement of the knowledge economy and the emergence of the information society, the integration of IT systems into the economic life of smart cities should be promoted [13]. More and more industrial technology processes are controlled by software, taking over the human role, but human resources are essential for managing and developing software. In other words, in the smart cities of the future, technological and IT innovation must be encouraged, but education, vocational training, and tertiary education must also be developed (here is where the impact of technological innovation on society becomes visible) [13,14].

Another particularly important aspect of smart city development is the issue of environmental protection and environmental sustainability [14]. This approach combines the social and the "green" viewpoints, as smart and green developments and green technologies need to be approached in terms of social necessity and utility. Another important question is how technically this can be done [15]. The question of the relationship between sustainable development and technical development and the possibility of improving the quality of human life (such as "smart environment", "smart energy") arises [16]. In summary, the sub-systems of smart cities can be incorporated from an engineering point of view, through environmental sustainability, into social aspects [17].

Conclusion

Modern corporate governance needs to be in line with environmental and economic sustainability, so behaviors must reflect new eco-economic considerations. Corporate innovation strategies and production processes must be designed in such a way that efficiency must be kept in mind throughout the development process, which not only applies to product production but also incorporates the ecological "green" aspect. In conclusion, in my study, I wanted to present a research area that sheds new light on innovation developments. Municipal modernizations, smart cities, sustainable corporate governance are all integral parts of the future urban management system.

References

[1] SIMAI M. 2016: A harmadik évezred nyitánya: A zöld fejlődés esélyei és a globális kockázatok. (The opening of 21th century: Options of green development and global risks). Budapest: Corvina Kiadó Kft. 374 p.

[2] VILLÁNYI L., VASA L. (ed.) 2007: Agrárgazdaságtan. (Agricultural economy) Budapest: Szaktudás Kiadó Ház Publisher 215 p.

[3] SCHALTEGGER, S., F. LÜDEKE-FREUND, HANSEN, E. 2012: Business Cases for Sustainability: The Role of Business Model Innovation for Corporate Sustainability. International Journal of Innovation and Sustainable Development, 6(2), 95-119.

[4] SCHALTEGGER, S., E. HANSEN, & LÜDEKE-FREUND, F. 2016: Business Models for Sustainability: Origins, Present Research, and Future Avenues. Organization and Environment, 29(1), 3-10.

[5] SARKAR C., WEBSTER C. 2017: Urban environments and human health: current trends and future directions. Current Opinion in Environmental Sustainability 25: 33-44. p.

[6] CORRADO S., ARDENTE F., SALA S., SOUTER E. 2017: Modelling of food loss within life cycle assessment: From current practice towards a systematisation. Journal of Cleaner Production 140. pp. 847-859.

[7] FOGARASSY CS., KOVÁCS A. 2016: The cost-benefit relations of the future environmental related developments strategies in the Hungarian energy sector. YBL Journal of Built Environment 4 (1): 33-49 p.

[8] EUROPEAN ENVIRONMENT AGENCY 2014: National adaptation policy processes in European countries 2014. Luxembourg: Publications Office of the European Union. 130 p.

[9] WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT 2017: 8 Business Cases for The Circular Economy. World Business Council for Sustainable Development, Geneva, Switzerland.

[10] BLADES L., MORGAN K., DOUGLAS R., GLOVERA S., De ROSA M., CROMIEA T., SMYTH B. 2017: Circular Biogas-Based Economy in a Rural Agricultural Setting. 1st International Conference on Sustainable Energy and Resource Use in Food Chains, ICSEF 2017, 19-20 April 2017, Berkshire, UK. Energy Procedia 123: 89-96 p.

[11] BATTY M., AXHAUSEN K.W., GIANNOTTI F., POZDNOUKHOV A., BAZZANI A., WACHOWICZ M., OUZOUNIS G., PORTUGALI Y. 2012: Smart cities of the future. The European Physical Journal Special Topics 214: 481–518 p.

[12] ANGELIDOU M. 2015: Smart cities: A conjuncture of four forces. Cities 47: 95–106 p.

[13] HUSTON S., RAHIMZAD R., PARSA A. 2015: ‘Smart’ sustainable urban regeneration: Institutions, quality and financial innovation. Cities 48: 66–75 p.

[14] KÁPOSZTA J. 2016: Regionális összefüggések a vidékgazdaság fejlesztésében (Regional relations in rural development). Studia Mundi – Economica 3 (1): 52-61. p.

[15] NAVARRO C., ROCA-RIU M., FURIÓ S., ESTRADA M. 2015: Designing new models for energy efficiency in urban freight transport for smart cities and its application to the Spanish case. Transportation Research Procedia 12: 314–324 p.

[16] MATTONI B., GUGLIERMETTI F., BISEGNA F. 2015: A multilevel method to assess and design the renovation and integration of smart cities. Sustainable Cities and Society 15: 105–119 p.

[17] NEIROTTI P., DE MARCO A., CAGLIANO A.C., MANGANO G., SCORRANO F. 2014: Current trends in smart city initiatives: Some stylised facts. Cities 38: 25–36 p.

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 26-33
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2019.35.26
Received: 2019.08.01. - Accepted: 2019.09.10.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
THE HUNGARIAN ACADEMY OF SCIENCES
and
SZENT ISTVÁN UNIVERSITY
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IMPROVEMENT OF THE MICROCLIMATE MONITORING DEVICE IN THE GREENHOUSE

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Abstract

Plant production in a protected area is the most intensive form of production in agriculture. Plant growth is intense throughout the year to produce high yields and good product quality. By definition, microclimate represents the climatic conditions of small spaces measured up to 2m in height from the land surface. The factors of the microclimate are soil temperature, air temperature, air humidity, soil humidity, light, and the amount of carbon dioxide (CO_2). For intensive production indoors (greenhouses) it is very important that all factors of the microclimate be within the allowed limits for a particular cultivated crop. Therefore, our project aims at indicating these factors and signaling to the manufacturer if there is any reason for any of these factors to be corrected.

Keywords

microclimate, monitoring, greenhouse, computer, analysis

1. Introduction

Through this project, a device for monitoring indoor microclimate intended for intensive agricultural production was created. This device consists of 6 sensors, controlled by the ATmega328P microcontroller and an LCD display that shows the currently read values from the sensors, as well as a memory card slot and SIM module. Power is supplied by a battery, and the plan is to have it through a solar panel, which would help to preserve the ecology and reduce the cost of electricity. The data that is collected on the memory card contained in the microcontroller gives us the ability to read the measured data in real time. This way we can analyze the data for a certain period of time from one locality. The data can be sent to the user via SMS, thanks to the integrated SIM module. The ATmega328P microcontroller, through a program written for this purpose, gives the sensors precise instructions on how long and how to make measurements. The prototype of this system is housed in a wooden box on the top side of which has an LCD display, which protects all components from external factors. For the commercial version, a 3D model of the box was made, which will be made of hard plastic.

Protected areas provide intensive production, combined off-season vegetable production, greater control of disease and pests with the application of biological control, which also ensures healthier food. It is known that production under sheltered conditions ensures early harvesting but requires additional costs for heating. Although the prices of early vegetable produce are higher than the open-market products, the uniformity of the products, the quality and the speed of fruiting allow for a good market and better placement. [5, 6, 7] For the successful use of the buildings, it is important to choose the right place (flat surface or gentle fall, deeper groundwater level), then appropriate position and wind protection. Multiple objects are placed in parallel, so that objects with one roof on the long side are in the east-west direction, and those with two roofs in the north-south direction. This ensures that the plants are illuminated evenly throughout the day. All protected area objects should be placed in a place protected from strong and cold winds. For this purpose, fences and protective arches are erected. One meter high shelter protects ten meters behind the space. [4]

Controlling the microclimate in greenhouses is a responsible and complicated process since there are several factors that affect the climate and are mutually dependent. [8] To achieve the goal, which is the highest possible yield on given surfaces, with at the same time, we need to ensure the proper quality of the product for the cultivated plants adequate microclimate conditions while respecting the minimum energy consumption requirements. [3] Work on creating algorithms and software to help protect climate in a protected environment space is part of the process by which most of these factors are controlled with minimum energy costs. [9]

Figure 1. Grenhouses

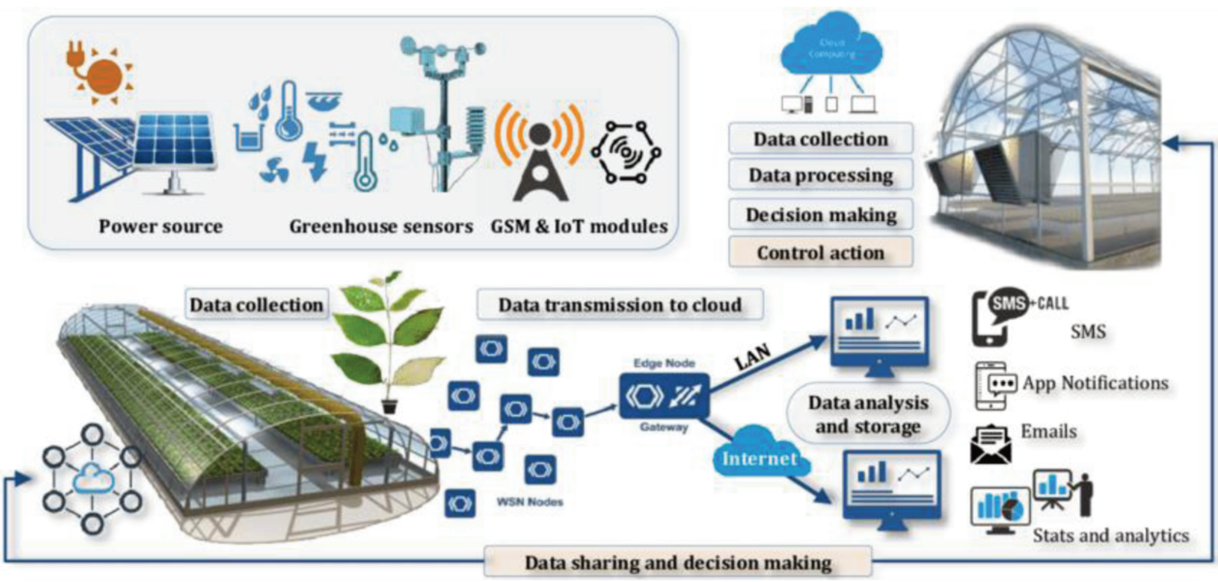

Figure 2. Smart microclimate monitoring systems

Modern microclimate control is today based on the basics of artificial technology intelligence. The programs that were developed included the expertise of experts and empirical knowledge of crop growers. [2] Device prototypes were tested in experimental greenhouses under controlled conditions and designed appropriately software. A model-specific algorithm (control program) was created for predictable climate environment, to be used to simulate energy efficiency and control scheme optimization. The algorithm is designed to be used for appropriate software that provides pre-processing of meteorological data as code model. [1] Using this approach, it is possible to simulate any enclosed structure, at an example of a greenhouse or greenhouse, where appropriate information must be provided. Controllers are devices that adjust various parameters to achieve the best possible microclimate while cultivating crops and at the same time fulfills the goal in terms of high yields and quality of fruits, with the primary goal - the least energy consumption. [10]

2. Material and Method

To create the project, an Arduino platform was used that contained a microcontroller to which the sensors were connected. After the sensors were connected, a program was written using which the microcontroller stores the data on the SD card, and in addition it was enabled to send data via SMS to the end user. In addition to the sd card and sms module, the project also contains an lcd that alternately displays data from the sensor.

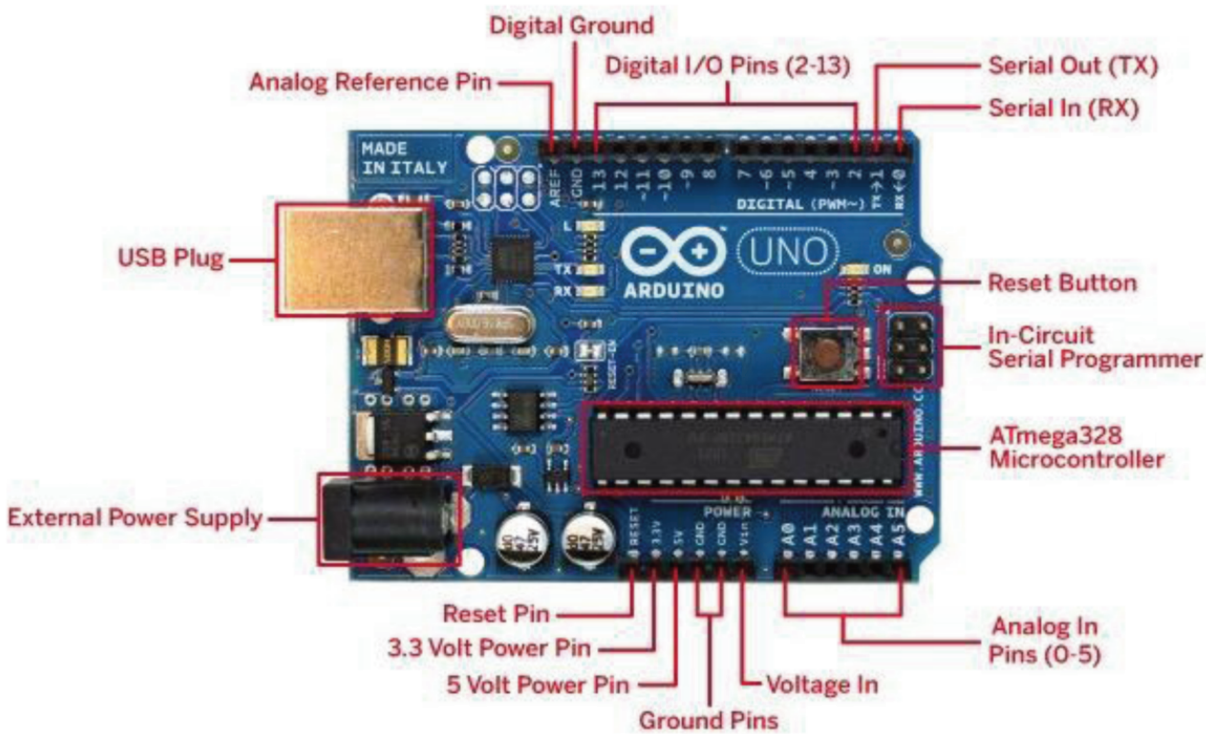

Figure 3. Arduino Uno

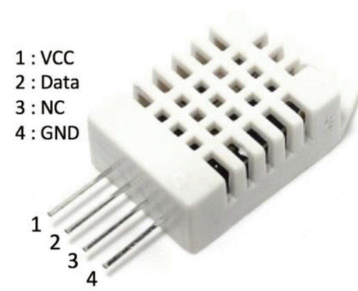

Figure 4. Soil temperature sensor and air temperature and humidity sensor

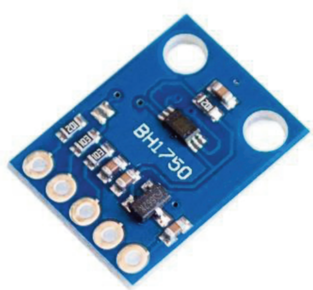

Figure 5. CO_2 content sensor and lighting sensor

Figure 6. Soil moisture sensor, sim module and sd module

Sensors were also used for the project, such as soil temperature sensor, air temperature and humidity sensor, CO_2 content sensor, lighting sensor, soil moisture sensor, sim module and sd module.

3. Results

By interconnecting all the components shown above, we obtained a prototype of a commercial device for monitoring microclimate in a greenhouse (Fig. 7). After connecting and putting the device into operation, an analysis of the device's performance was performed. Testing of the project was carried out in a facility of semi-tall greenhouse type during the month of January 2019. The unit was installed in one part of the greenhouse for 24 hours.

The data obtained are presented in an excel table by date, time, parameter they measure and size, as well as a diagrammatic representation.

The components of the system are interconnected by standard conductors, all of which are housed together in a wooden box because it is a prototype of the device. For the commercial version of the device, a 3D model of the box was made, which will be made of plasticized polymer (Fig. 8).

As mentioned earlier, this model of microclimate monitoring device is mounted in a high tunnel greenhouse. Measurements were made over a period of 24 hours and during this time the device recorded all the data from the sensors at specified intervals and stored them on the sd card. This set up (Fig. 9) allowed us to collect and use the data for further analysis of the device operation, and in addition to observe the microclimatic conditions that prevail inside the greenhouse.

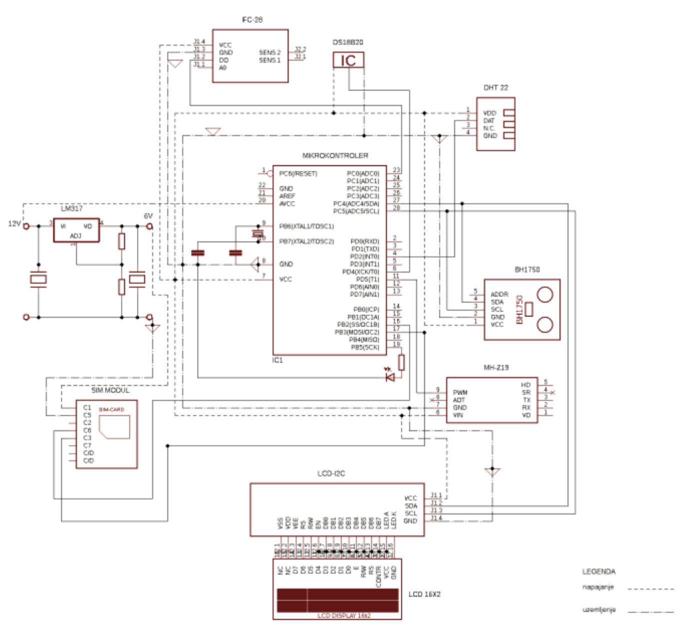

Figure 7. Electrical scheme of the device

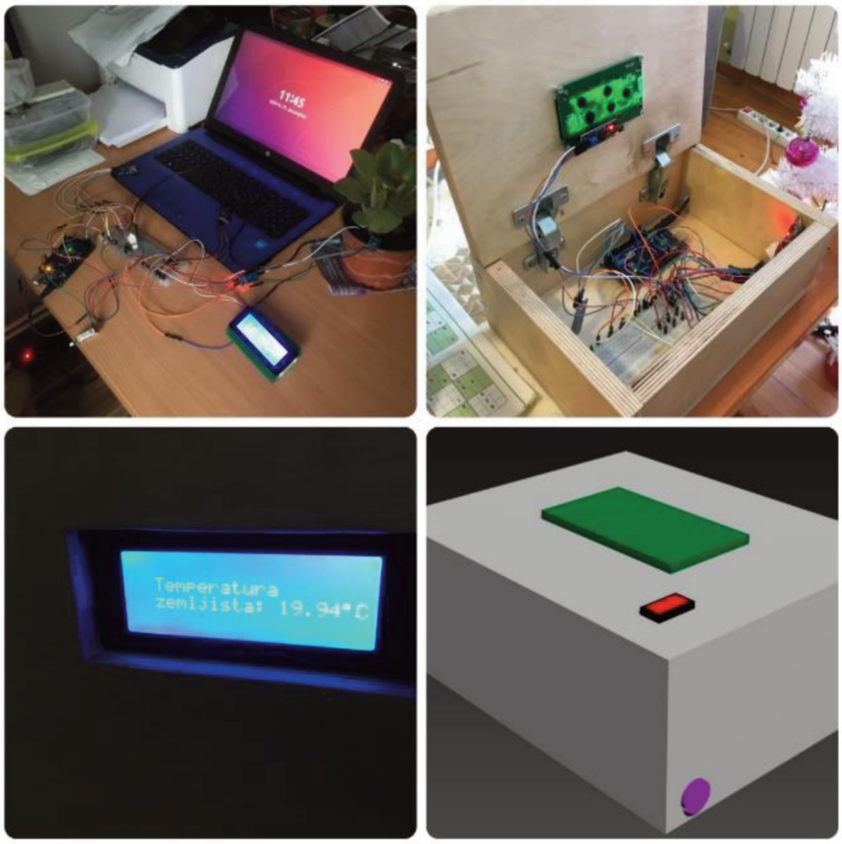

Figure 8. Layout of prototype microclimate monitoring device

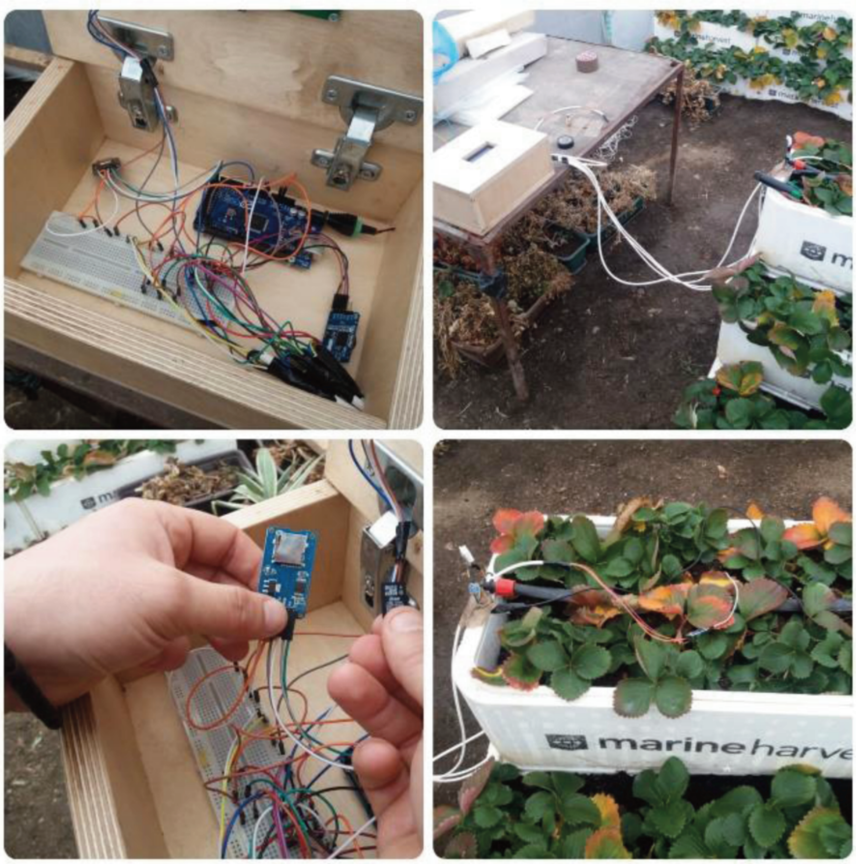

Figure 9. Setting up measurements

After 24 hours of measurement the sd card was removed and data was collected from it, what we received is shown in the following table (Table 1).

The table shows only part of the data because the total number of data exceeds the number of 2500 of consecutive measurements. In addition to the classic table, graphs of the measured magnitude were made (Fig. 10).

Table 1. Values from the sensors

Time	Air humidity	Air temperature	Soil moisture	Soil temperature	Lighting	Solar radiation	CO_2
2019/1/4 (Friday) 14:24:38	55.6	1.9	68	15.19	29	0.04	14
2019/1/4 (Friday) 14:25:10	55.2	1.9	66	15.13	1	0.00	162
2019/1/4 (Friday) 14:25:42	55.3	1.9	67	15.00	3	0.00	162
2019/1/4 (Friday) 14:26:14	55.8	1.9	67	14.94	31	0.05	298
2019/1/4 (Friday) 14:26:46	55.8	1.9	66	14.88	32	0.05	292
2019/1/4 (Friday) 14:27:18	55.9	1.9	66	14.81	32	0.05	288
2019/1/4 (Friday) 14:27:50	55.8	1.9	67	14.69	33	0.05	282
2019/1/4 (Friday) 14:28:22	55.8	1.9	67	14.63	33	0.05	272
2019/1/4 (Friday) 14:28:54	56.0	1.9	66	14.50	33	0.05	268
2019/1/4 (Friday) 14:29:26	56.1	1.9	67	14.44	33	0.05	262
2019/1/4 (Friday) 14:29:58	56.1	1.9	66	14.38	33	0.05	258
2019/1/4 (Friday) 14:30:30	56.2	1.9	66	14.25	33	0.05	252
2019/1/4 (Friday) 14:31:2	56.3	1.9	67	14.19	33	0.05	248
2019/1/4 (Friday) 14:31:34	56.3	1.9	66	14.13	33	0.05	242
2019/1/4 (Friday) 14:32:6	56.4	1.9	66	14.06	33	0.05	234
2019/1/4 (Friday) 14:32:38	56.4	1.9	66	13.94	32	0.05	236
2019/1/4 (Friday) 14:33:10	56.5	1.9	65	13.88	32	0.05	238
2019/1/4 (Friday) 14:33:42	56.6	1.9	66	13.75	32	0.05	236
2019/1/4 (Friday) 14:34:14	56.8	1.9	66	13.69	32	0.05	234
2019/1/4 (Friday) 14:34:46	56.9	1.9	66	13.63	31	0.05	230
2019/1/4 (Friday) 14:35:17	57.1	1.9	66	13.50	31	0.05	234
2019/1/4 (Friday) 14:35:49	57.2	1.9	66	13.44	31	0.05	232
2019/1/4 (Friday) 14:36:21	57.4	1.9	66	13.38	31	0.05	236
2019/1/4 (Friday) 14:36:53	57.5	1.9	65	13.31	31	0.05	236
2019/1/4 (Friday) 14:37:25	57.6	1.9	66	13.19	32	0.05	234
2019/1/4 (Friday) 14:37:57	57.6	1.9	65	13.13	32	0.05	232

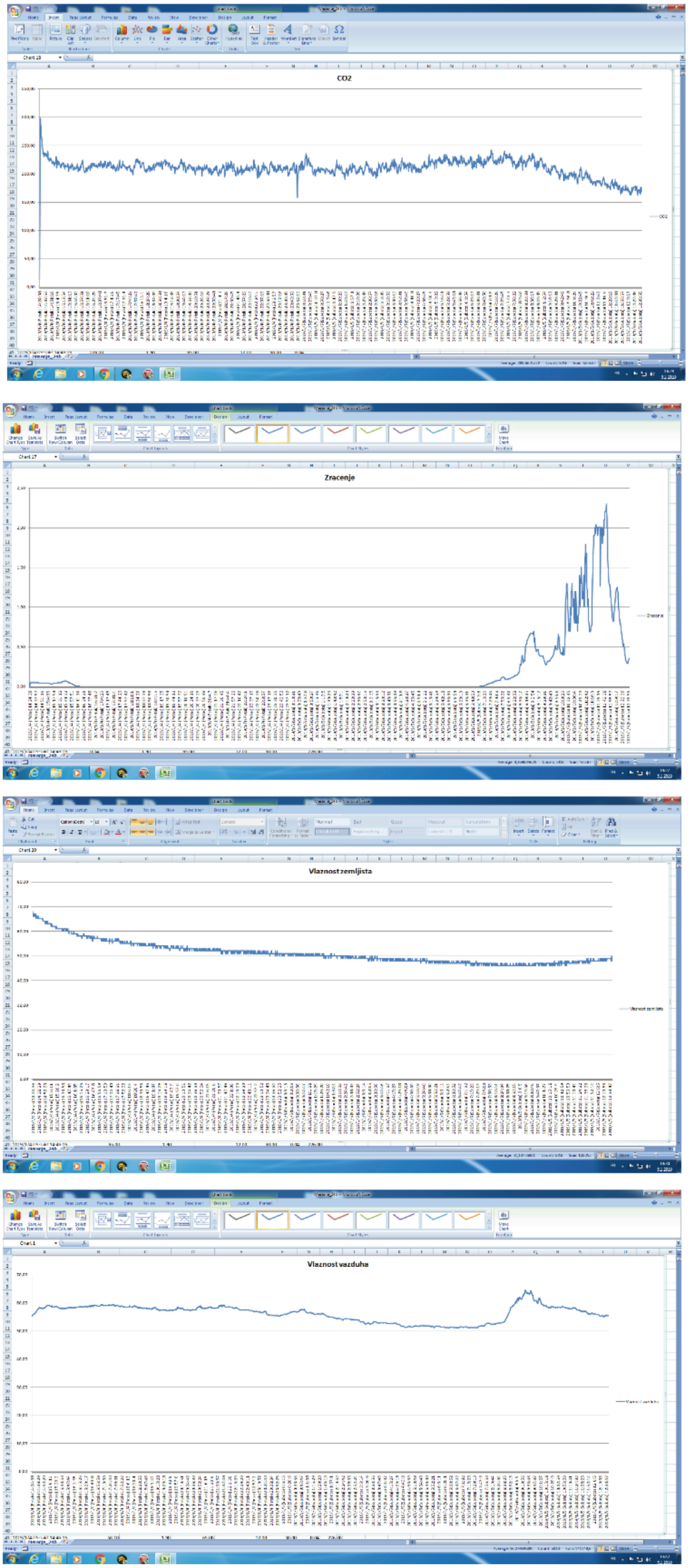

Figure 10. Graphical display of values from the sensor

Conclusion

The country of Serbia has great potential in agricultural production. However, our manufacturers do not have material resources in quantities as is the case in Western European countries. Therefore, the device we made may be available to Serbian manufacturers because his cost price is much lower compared to a similar product in e.g. Germany. This device is intended to help manufacturers to understand all the important microclimatic factors that affect the growth and development of their products and so respond in a timely manner to maintain all parameters within the limits allowed for the culture they grow. This device can also analyze data measured over a period of time and determine why a particular breeding problem occurs.

References

[1.] Bajkin A., Ponjican O., Orlovic S., Somer D.: (2005) Mechanization in horticulture, Faculty of Agriculture, Novi Sad. 216. p.

[2.] Bajkin A.: (1994) Mechanization in vegetable gardening, University textbook, Faculty of Agriculture, Novi Sad. 212 p.

[3.] Caneppele F.L, Gabriel Filho L.R.A., Rabi J.A., Damião B.: (2016) Estimate of GHG Emissions - The Greenhouse Gases - A University Campus in Connection with the Electric Energy Consumption. Agricultural Engineering Scientific Journal, Belgrade-Zemun, Serbia, December 2016. Vol. XLI. No 3., p. 1-6.

[4.] Djevic M., Dimitrijevic A.: (2009) Energy consumption for different greenhouse construction. Energy, 34, No. 9: 1325-1331.

[5.] Magó L., Jakovác F.: (2005) Economic Analysis of Mechanisation Technology of Field Vegetable Production. Hungarian Agricultural Engineering. Committee of Agricultural Engineering of the HAS, 18: 55-58.

[6.] Magó L., Hajdú J., Jakovác F.: (2005) Economic of Mechanisation of the Tomato Production Technology, Agricultural Engineering Scientific Journal, Belgrade-Zemun, Serbia and Montenegro, December 2005. Vol. XXX. No 4., p. 1-7.

[7.] Magó L., Jakovác F.: (2006) Economical Analysis of the Mechanised Field Cucumber Production and Grading Technology, Agricultural Engineering Scientific Journal, Belgrade-Zemun, Serbia, December 2006. Vol. XXXI. No 4., p. 43-50.

[8.] Mutwiwa U.N., Tantau H.J., Salokhe V.M.: (2006) Cooling of Greenhouses in The Humid Tropics - Problems and Solutions. Agricultural Engineering Scientific Journal, Belgrade-Zemun, Serbia, December 2006. Vol. XXXI. No 3., p. 73-84.

[9.] Popovic M.: (2004) Sensors and Measurements, University textbook, College of Electrical Engineering, Belgrade. 502. p.

[10.] Radojičić M.: (2001) Information Technology in Agribusiness, University textbook, Belgrade. 315 p.

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 34-38
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2019.35.34
Received: 2019.08.10. - Accepted: 2019.09.01.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
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TECHNICAL AND TECHNOLOGICAL PARAMETERS OF ISOBUS SYSTEM SUPPORTED MACHINERY MANAGEMENT

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Abstract

ISO organization in early 90s defined an industry standard for the communication protocol among electronic devices of different manufacturers of agricultural machines. After that, all of the market actors recognised that this technology would be very important for agricultural electronics. The appearance of ISOBUS products in the market was in the mid-2000s. ISOBUS description could be found in ISO-11783. It is a very complex and large electronics protocol standard based on CAN and SAE-J1939 standards, extended for the Agricultural Industry. The standard consists of 14 different parts and more than thousands of specification pages.

Through the standards and the related technical background, the production processes and the operations could be followed and monitored by the extensive Data Management. Farmers' and users legitimate needs and developing goal is to elaborate a decision support systems that follow-up the utilisation of the machines and ensure the quality of operations. For this purpose, it is essential to determine which technical, economical, technological parameters, detection, measurement, transmission, processing, and evaluation becomes necessary.

In our work, we reviewed which mechanical characteristics, settings are monitored within the ISOBUS system by the major machine manufacturers. We developed the system of parameters and derived features that provide effective farm-, and land-management in case of attached equipment for spreading of input materials and tillage implements.

Keywords

ISOBUS, Data Management, Standardisation, agricultural mechanisation, product development

1. Introduction

1.1. Fast development of the electronics applications

Similarly to other Industries, the agricultural industry saw a significant growth of electronics application starting from mid-late 80s. [9] Manufacturers with multiple development locations were also affected by the lack of a standardized protocol. In a fast growing environment the consolidation of product development organizations was not always a priority and therefore the presence of a robust industry standard was significantly supported by most of the industry players. Each team could easier concentrate on the development of the functionalities which could provide a competitive advantage. [8]

1.2. ISO11783 standard and the foundation of the AEF

After almost 20 years of application and development the ISOBUS (as defined in the standard ISO11783) has become a key element in the design of modern agricultural machinery. [5]

Even if the “plug and play” approach was the main concept inspiring the creation of the ISO11783 standard, there have been many factors which prevented a smooth and fast introduction of the ISOBUS products in the market:

–the complexity of the standard (more the 1,000 pages divided in 14 sections) [6]
–the rapid evolution of digital technology;
–the lifecycle of components of agricultural tractors and related return of investments;

The first two items mainly drove the creation of an industry consortium called AEF (Agricultural Electronics Foundation). This allowed manufacturers to create a common interpretation of the standard when applied to real products. [8]

Agricultural Industry Electronics Foundation, the AEF, was founded in October 2008 in Frankfurt at the VDMA. The founding members were 7 equipment manufacturers (John Deere, Grimme, Pöttinger, CNH, AGCO, Claas, Kverneland) and 2 associations (VDMA and AEM). AEF's aim was and is to provide resources and know-how for the increased use of electronics and electrical systems in mobile Farming Equipment. In the first years of its existence, it was clear that a succession of important tasks associated with ISO 11783 (ISOBUS) formed the main focus of AEF's work. [10]

Since its founding in 2008, the AEF has grown to a mature and independent Industry Foundation with over 200 members. [1]

1.3. ISOBUS Functionalities

For increased transparency towards the end-customers as well as to developers, the AEF has defined the so-called ISOBUS Functionalities that are now also the basis for the certification of ISOBUS products. The Functionalities encapsulate the different Control Functions on the ISOBUS network, such as the Terminal, the Tractor ECU, an Auxiliary device or a Task Controller. [10]

After a first period in which all the ISOBus sections release levels were defined in a certain ISO11783 implementation level it become evident that a more practical approach was needed to address the increasingly complexity. Eight main functionalities, each of them with its set of ISO11783 sections release, were then released by AEF, covering the main functional aspects addressed by the standard (Figure 1).

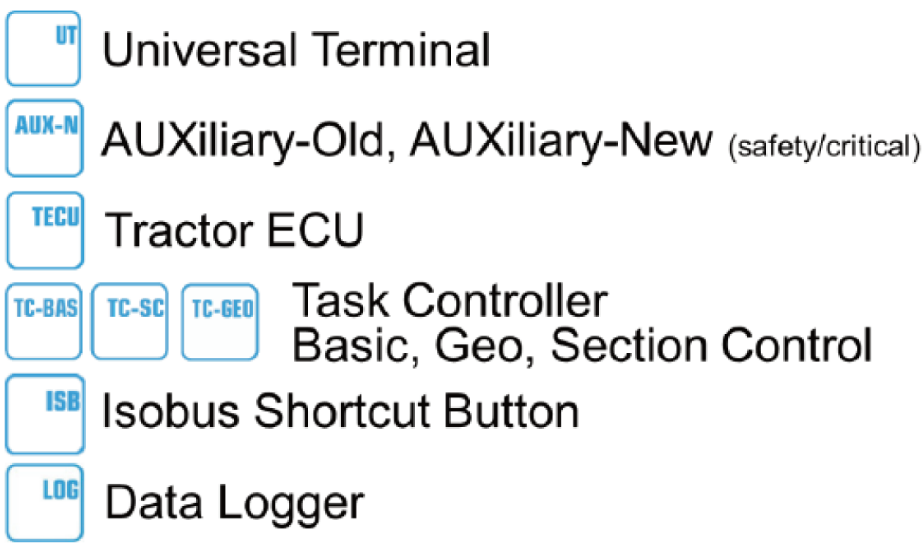

Figure 1. Today ISOBUS released functionalities [8]

The AEF has released the following Functionalities that can be certified today by the Conformance Test:
–UT – Universal Terminal. The capability of operating an implement with any terminal. The capability of using one terminal for operating different implements.
–AUX – Auxiliary Control. Additional control elements, such as a joystick, that facilitate the operation of complex equipment.
–TC-BAS – Task Controller - Basic. Describes the documentation of total values that are relevant for the work performed. The implement provides the values. For the exchange of data between farm management system and Task Controller the ISO-XML data format is used.
–TC-GEO – Task Controller – GEO-based. Additional capability of acquiring location based data – or planning of location-based jobs, as for example by means of variable rate application maps.
–TS-SC – Task Controller – Section Control. Automatic switching of sections, as with a sprayer

or seeder, based on GPS position and desired degree of overlap.
–TECU – Tractor ECU. The tractor ECU is the tractor‘s interface to the ISOBUS. This provides information, such as speed, power take-off RPM, etc on the ISOBUS for use by the implement.
–ISB – ISOBUS Shortcut Button. A button present on a Terminal, or in the Tractor cabin, to be used to send a global message to all connected Control Functions on the ISOBUS to go to an Idle/Shortcut state. This Functionality is not to be seen as an emergency button! The Functionality approach is flexible, and new functionalities that come up in the future can easily be added once the Guidelines are defined and released. Functionalities that are currently under development are for example: TIM / ISOBUS Automation and the TC-LOG. [2]

2. Material and Method

2.1. Tractor Implement Management

Tractor Implement Management is one of the next steps in the near future. Within AEF manufactures are creating a robust way of opening automation to ”trusted equipment” defining rules to clarify liability and guarantee a ”plug and play” approach to the customers. [7]

2.2. Data Management

Data Management facilitates the exchange of data with the mobile equipment in the field. Through this functionality the user gets his data into a management system for registration purposes and further future planning. [3] Newly planned data can be generated by a decision support advisory systems and taken back into the farming equipment for planned field tasks and operations through for example a wireless service or telematics portal of the manufacturer.

2.3. Connectivity

The end-customers, i.e. the farmers and contractors, expect a seamless connectivity of implements and tractors, now and in the future. Also of all systems and data, both in the field on his machines as well as to other software and services. Seamless connectivity can only be reached by industry cooperation and by acceptance and implementation of Industry Standards for communication and data exchange. An ‘open’ mind to connectivity with competitors and suppliers of Farm Management Software solutions and other Decision Management services is therefore a must for all companies and equipment manufacturers. [10]

2.4. Future Directions

Future challenges in ISOBUS development are focused at three points:
1. COPL (Cost Optimized Physical Layer):
Cost optimization allowing a higher diffusion of the ISOBUS technology (also more suitable for smaller machines). The goal is to reach lower volumes and smaller application.
2. WIC (Wireless Infield Communication):
3. HIS (High Speed ISOBUS):
–Distributed high-resolution position/correction signals.
–Digital Video Systems.
–Improved Service and Diagnosis (flash ECUs, Log-files, raw data streams for debugging).
–Mobile Internet on ISOBUS for dedicated server/client requests.
–High Voltage data Connection.

As technology evolves, manufacturers must take advantage of new opportunities with the end goal of providing farmers with a higher productive, higher quality and more efficient farming cycle. [4, 7]

3. Results

3.1. Overview of selected parameters for processing and monitoring of products of the market's leading agricultural machinery manufacturers

In first step of the research work the measured and processed parameters of most significant attached working equipment was defined. The sprayers, fertilizer spreaders and seed drills (including towed-, and attached version, and also the direct-, and mulch sowing machines) and the ploughs were selected.

For machines listed in the measurement and processing of the measured values of the following parameters were determined:

a. Worked area
b. Theoretical quantity
c. Weighed quantity
d. Applied quantity
e. Time in working position
f. Distance in working position
g. Pump speed
h. Spray pressure
i. Hopper volume
j. Current speed
k. Speed source
l. Operating hours - motor
m. Current track width
n. Motor torque in %
o. Motor speed in rpm
a. Average consumption AdBlue in l/ha

b. Average consumption Diesel in l/ha
c. Current blower fan speed
d. Blower fan speed setpoint
e. Minimum speed
f. Maximum speed
g. Target speed
h. Spread rate actual value
i. Spread rate setpoint
j. Working position
k. Setpoint in per cent
l. Theoretical residual quantity
m. Hopper content
n. Working width

3.2. The determination of monitored technical-technological parameters during the works of tractor and attached working machine combination

The next phase of work was the definition of the technical-, and technological parameters which could be measured, processed and displayed during the works of tractor and attached working machine combination. These characteristics were classified into four main groups.

The groups are:

Quality of work	Power-, and capacity-utilisation	Work safety	Cost

We denoted subgroups within the main groups, according to specificity, and the selected parameters were grouped in this way. The physical parameters which are the base of monitored technical and technological characteristics are presented in the Table 1 according to above illustrated classification.

To assure the quality of work it is important to ensure adequate working depth, tracking of the dispensed amount of input materials and analysis of energy consumption.

In terms of the power-, and capacity-utilisation the area, the time, and the quantity (by volume or weight) proves to be key factors.

The work safety can be provided by the in time detection of crash, injury or by detection of early signs of developing malfunctions e.g. the formation of irregular resonance, or limitation of overload, and the monitoring of drivers behaviour.

From the users part it is essential to take into account the cost. From this perspective the labour cost, the machine work cost, and the cost of inputs are most determinative and it is primary to follow-up them.

Conclusion and Recommendations

The technical solutions provided by the ISOBUS system – registering of the operating parameters of power machine and attached equipment – could review not only the technical and service characteristics of operation of each machine. There is an opportunity to overview the features on farm-management level that are the effective core devices for corporate governance, for efficient production and for successful planning too. These data in case of high-volume machine fleet, whether it is farm-fleet or contractors fleet, makes transparent the administration of machines and the performed tasks by their. These can be defined as the effective modules of the company's management systems.

From technical approach it is essential to ensure compatibility of ISOBUS communication between the products of different producers, between the power machine and attached implement, and on the level of telemetrical data transfer too. Mostly the European market of agricultural machines is the main market where the multi brand interconnectivity represents the biggest challenge. This innovative market is that where the ISOBUS has the widest application.

Acknowledgement

This publication has been completed within the framework of project "Agrárinformatikai Felsőoktatási és Ipari Együttműködési Központ létrehozása", No. FIEK_16-1-2016-0008.

References

[1.] AEF Website, http://www.aef-online.org
[2.] AEF ISOBUS Database, https://www.aef-isobus-database.org
[3.] Bártfai Z., Blahunka Z., Faust D., Ilosvai P.: (2009) Application of the Combined Wireless Sensor Network-, and Mobile Robot Technology for Monitoring. Mechanical Engineering Letters, SZIE GÉK, Vol 3., p. 148-156.
[4.] Bártfai Z., Faust D., Kátai L., Szabó I., Blahunka Z.: (2017) Terrain Surface Monitoring with IMU Equipped Mobile Robot. Book of Abstracts, 8th International Conference on Biosystems Engineering Tartu, Estonia, 11-13. May 2017. p. 15.
[5.] Benneweis R. K.: (2006) Facilitating agriculture automation using standards, 14 p.
[6.] International Standard Organization: ISO11783
[7.] Martinov M., Gronauer A., Kosutić S.: 2018 Highlights of 27th Club of Bologna Meeting 46.

Symposium "Actual Tasks on Agricultural Engineering", Opatija, Croatia, 2018. p. 19-28.
[8.] Mongiardo M.: (2017) ISOBus: the Industry Perspective, 27th Club of Bologna Members' Meeting Hanover, 12-13 November 2017., 14. p.
[9.] Stone M. L., Benneweis R. K., Bergeijk J. v. (2008) Evolution of electronics for mobile agricultural equipment, Transactions of the ASABE, Vol. 51(2): 385-390
[10.] Vlugt P. v. d.: (2017) ISOBUS: State of the Art and Future Directions, 27th Club of Bologna Members' Meeting Hanover, 12-13 November 2017., 12. p.

Table 1. Recommended follow-up ISOBUS values

Quality of work	Power-, and capacity-utilisation	Work safety	Cost
Working depth *Measured value:* • traction, drawbar deformation, • slip, • pitching angle of tractor	**Area** *Measured value:* • trip length, • Current speed, • Average speed, • attached machine width, • adjusted working width staging), • Direction of operation (coordinates)	**Crash, injury, resonance** *Measured value:* • engine oil viscosity, • temperature, • soot content, • hydraulic oil viscosity, • hydraulic oil temperature, • tire pressure, • vibration	**Labour** *Measured value:* • Number of vehicle card
Dispensed amount of input material *Measured value:* • PTO speed, • pump flow, • seed hopper weight, • seed plates speed, • fertiliser hopper weight, spreading disc speed	**Time** *Measured value:* • shift time, • engine operating hours	**Overload** *Measured value:* • gear, • motor temperature, • 3 point hitch height (working depth), • drawbar deformation, • PTO deformation	**Machine work** *Measured value:* • Work operation code, • Work operation date, • duration of work operations, • correction factor of work operations
Energy consumption *Measured value:* • fuel quantity, • actual fuel consumption, • exhaust gas temperature, • number of fuel card, • quantity and time of refuelling	**Volume or weight** *Measured value:* • seed hopper weight, • seed plates speed, • fertiliser hopper weight, • spreading disc speed	**Drivers behaviour** *Measured value:* • cabin temperature, • time of using automated steering, • field map setting	**Input material** *Measured value:* • amount of spreaded input materials, • area, distance × working width • unit price of inputs, • duration of the service, • cost of service

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 39-44
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2019.35.39
Received: 2019.09.01. - Accepted: 2019.09.10.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
THE HUNGARIAN ACADEMY OF SCIENCES
and
SZENT ISTVÁN UNIVERSITY
Faculty of Mechanical Engineering

EFFECT OF VARIOUS DRYING METHODS ON THE VOLATILE OIL COMPOSITION OF BASIL LEAVES

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Abstract

This article presents the results pertaining to the drying behavior of basil leaves (Ocimum basilicum L.) in natural air drying (~25-30°C, 2 days), hot-air drying (50°C, 6h, 1m/s), and vacuum drying (50°C, 8kPa, 7h) conditions.

This study focused on the chemical composition characteristics of essential oils extracted from fresh and different dried basil leaves. The results showed that drying methods had a significant effect on essential oil content and composition of basil leaves. The volatile oil found in herbs is very sensitive to some drying parameters (e.g. pressure, temperature, weather, non-uniform drying, etc.).

The quality of the vacuum dried product was assessed – from a twelve major constituents – as being higher than that of a hot-air dried and natural air dried products. Taking into account all these considerations we recommend the drying of basil leaves by vacuum drying.

Keywords

vacuum drying, hot-air drying, natural air drying, essential oil content, basil.

1. Introduction

Medicinal herbs and their preparations are widely used by human beings in the whole world. Basil (Ocimum basilicum L., Lamiaceae) is an annual or perennial plant from southeast Asia and central Africa and nowadays cultivated world-wide. This plant is widely used for its therapeutic properties, as well as, for aromatic and culinary purposes (Morales and Simon, 1997). The essential oil may be used directly in food or at the cosmetics industry for the production of shampoos, soaps, and perfumes. Basil essential oil contains mainly monoterpenes, sesquiterpenes, alcohols, aldehydes, ketones, esters and miscellaneous compounds (Lee et al, 2005).

One of the preservation methods ensuring microbial safety and extending shelf-life of foods is dehydration (Calín-Sánchez et al, 2012). However, drying must be performed carefully in order to preserve the aroma, appearance and nutritional characteristics of the raw herbs as much as possible (Crivelli et al., 2002). The drying may cause losses in volatilities or formation of new volatilities as a result of oxidation reactions, esterification reactions (Diaz-Maroto et al., 2002).

Due to economic reasons of natural drying is used in the developing countries, although it has the disadvantage of possible contamination by micro-organisms (Putievsky and Galambosi, 1999). The most common method of artificial dehydration is drying with hot-air. However, this method has several disadvantages and limitations. The color of the hot-air dried material changes, the product is shrinking, difficult to rehydrate and loss of essential oil content occurs (Calín et al, 2013). An alternative to a high temperature drying is the use of vacuum drying, using lower temperatures which can prevent some of the thermal damages in bioactive compounds and reduce the loss of essential compounds, because vacuum drying is a process in which moist materials are dried under a sub-atmospheric pressures (Uribe et al, 2016).

The aim of the research is examining the natural and artificial drying methods influence on the amount of the main components in the herb in comparison with the raw material.

2. Material and methods

Sample preparation

The basil samples were collected from an organic farm in Targu Mures (Romania), in 2017. The samples were obtained by cutting the plant manually. After that, the harvested samples was stored in plastic bags and kept in a refrigerator (Husqvarna, QT 4609 RW, Hungary) at temperature, frozen duration and relative humidity of 5°C, 4 h and 88-90%, respectively. Prior to drying process, basil leaves were separated from the stems. Later, the leaves were cut into 2-3 cm pieces.

Drying procedure

This article presents the results pertaining to the drying behaviour of basil leaves in natural air drying (~25-30°C, 2 days), hot-air drying (50°C, 6h, 1m/s), and vacuum drying (50°C, 8kPa, 7h) conditions.

The basil leaves are natural air dried on a mesh frame at ambient temperature in a well-ventilated room for 48 h (2 days) at average relative humidity of 63% - determined by a relative humidity meter (Testo). The air temperature is between 25-30°C, which was determined by a temperature gauge (Testo 4510 meter, Testo GmbH, Germany). The samples were spread in a single layer on a tray in the frame (50 g). The moisture losses of basil leaves were recorded at 1 hour intervals during the drying process by a digital balance (model JKH-500, Jadever Co., Taiwan) and an accuracy of 0.1 g.

Hot-air drying was carried out in a hot-air dryer (model LP306, LaborMIM, Hungary) at 50°C with an air flow rate of 1 m/s. Air humidity was regulated at ≈20%. The samples (50 g) were spread uniformly, in single layer on the trays of dryer. After 1h, the trays were taken out of the equipment, weighed, and then put back in the dryer. During the drying process, the weight of the basil leaves were recorded to construct a drying curve, and the temperature (material and air), air velocity, air humidity was measured using a Testo 4510 type meter (Testo GmbH, Germany). The mass was measured on an analytical balance (model JKH-500, Jadever Co., Taiwan) with a precision of ±0.1 g. The basil leaves were dehydrated until they reached the final moisture content (0,8%, w.b.).

Vacuum drying was performed in a laboratory-scale Kambic VS-50 vacuum dryer (Kambic Ltd., Slovenia). In the vacuum drying process, the basil leaves were spread uniformly in a single layer on a stainless steel tray. The leaves samples (50 g) were dried to a moisture content of 1,1% (w.b.) at an absolute pressure of 8kPa with a chamber temperature of 50°C. Thermocouples (two pieces) of vacuum drier were inserted into the basil leaves. The mass was measured on an analytical balance (model JKH-500, Jadever Co., Taiwan) with a precision of ±0.1 g. After 1h, the trays were taken out of the equipment, weighed, and then put back in the dryer.

The samples was dried until it reached the equilibrium moisture content. All the experiments were repeated thrice and the average of three results for each treatment was used in this paper.

Moisture content

The moisture content of basil leaves was determined gravimetrically in triplicate by drying 3 g samples at 105°C until constant mass was achieved. The moisture content was determined by drying samples in a convective oven (LP306, Labor MIM, Budapest, Hungary). The moisture content (M) of the samples in the drying process was calculated from (1):

$$M = \frac{W_t - W_k}{W_k} \tag{1}$$

The dimensionless moisture content (MR) of the samples was calculated using the following equation (2):

$$MR = \frac{M - M_e}{M_0 - M_e} \tag{2}$$

Chromatography

The SPME (Solid Phase Micro Extraction) sample preparation was made with manual tool. The GC-MS measurements were executed on a 5890 Series II – 5971 mass spectrometer system. The components were identified with Wiley and NIST databases and retention indices from different manuals (Novák et al, 2011).

In terms of product quality, twelve (eucalyptol, linalool, camphor, estragole, beta-elemene, beta-caryophyllene, alpha-guaiene, alpha-humulene, germacrene-d, delta-guaiene, alpha-cadinene and delta-cadinene) major constituents of basil leaves essential oil were quantified by gas chromatography–mass spectrometry (GC-MS).

3. Results and discussion

Effect of various drying methods on chemical components of basil leaves

A total of 36 essential oil components were identified. A typical GC-MS chromatogram profile of fresh and dried basil extract is showed in Fig. 1. The principal components of volatile oil of the basil leaves are eucalyptol,linalool, estragole, beta-elemene, germacrene-d, delta-guaiene and delta-cadinene (Yousif et al, 1999)

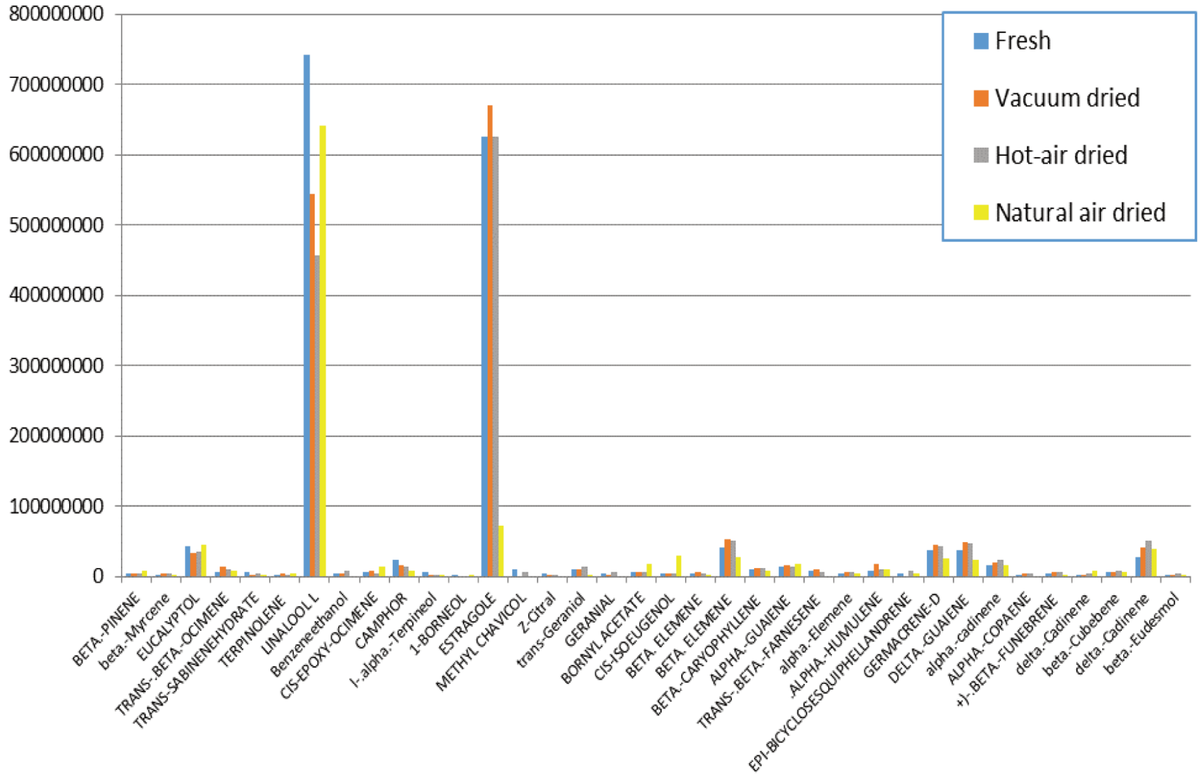

Figure 1. Comparison of basil based on the area value of total ion chromatograms (in bar graph)

Table 1. Concentration of the main essential oil components in basil

Components	Fresh (area)	Natural air drying (NAD)	Hot-air drying (HAD)	Vacuum drying (VD)
eucalyptol	43775484	+4,76% [1]	-19,46% [2]	-22,08% [3]
linalool	742065773	-13,46% [1]	-38,48% [3]	-26,58% [2]
camphor	24425461	-68,76% [3]	-43,01% [2]	-32,03% [1]
estragole	625315818	-88,56% [3]	+0,07 [2]	+7,08% [1]
beta-elemene	41861493	-33,39% [3]	+23,28% [2]	+26,55% [1]
beta-caryophyllene	9555398	-6,24% [3]	+15,47% [2]	+18,05% [1]
alpha-guaiene	12984727	+35,67% [1]	+10,99% [3]	+28,39% [2]
alpha-humulene	7166493	+29,85% [3]	+31,92% [2]	+136,66% [1]
germacrene-d	36272278	-32,05% [3]	+16,55% [2]	+25,94% [1]
delta-guaiene	37820670	-35,86% [3]	+25,11% [2]	+28,54% [1]
alpha-cadinene	15254299	+0,25% [3]	+51,06% [1]	+35,56% [2]
delta-cadinene	27993928	+36,72% [3]	+81% [1]	+48,3% [2]
Ranking	-	III.	II.	I.

Remark: The values in the chromatogram obtained with the GC-MS of basil refer to fresh plant matter.

Politeo et al. (2007) identified by GC-MS 33 essential oil components from basil leaves, most of which are consistent with those in this scientific work. Di Cesare et al. (2003) found that eucalyptol, linalool, eugenol, and methyleugenol predominated in basil from Liguria (Italy). The volatile profile of fresh basil was similar to those previously reported for Polish sweet basil, especially dominated by methyleugenol, eugenol, eucalyptol and linalool (Calín-Sánchez et al, 2012).

The concentration of the main constituents of basil leaves oil extracted from fresh and dehydrated samples are presented in Table 1.

Areas defined by the mass spectrum of essential oil components identified from the raw and dried basil leaves serve as a basis for ranking the drying methods. The area of the 12 main constituents found in the raw plant material was the control and the deviation – the effect of drying methods – was expressed as percentile form in Table 1. Differences due to drying were marked with a positive and negative sign in relation to the crude basil. In the brackets, we indicate the rank based on the values.

Table 1 shows the highest amount of essential oil in vacuum dried basil leaves (1) followed by hot-air (2) and natural air drying (3). The vacuum dried basil samples maintained their volatile composition much better when compared with the hot-air- and natural air dried ones.

Drying curve

The moisture loss was recorded at 1 hours intervals during the drying process in order to determine the drying curves. The experimental data sets from the different drying runs were expressed as moisture ratio (MR) versus drying time (t). The changes in the moisture ratio (MR) with time during natural air-, hot-air- and vacuum drying are given in Fig. 2. It can be observed that the moisture ratio decreases with drying time.

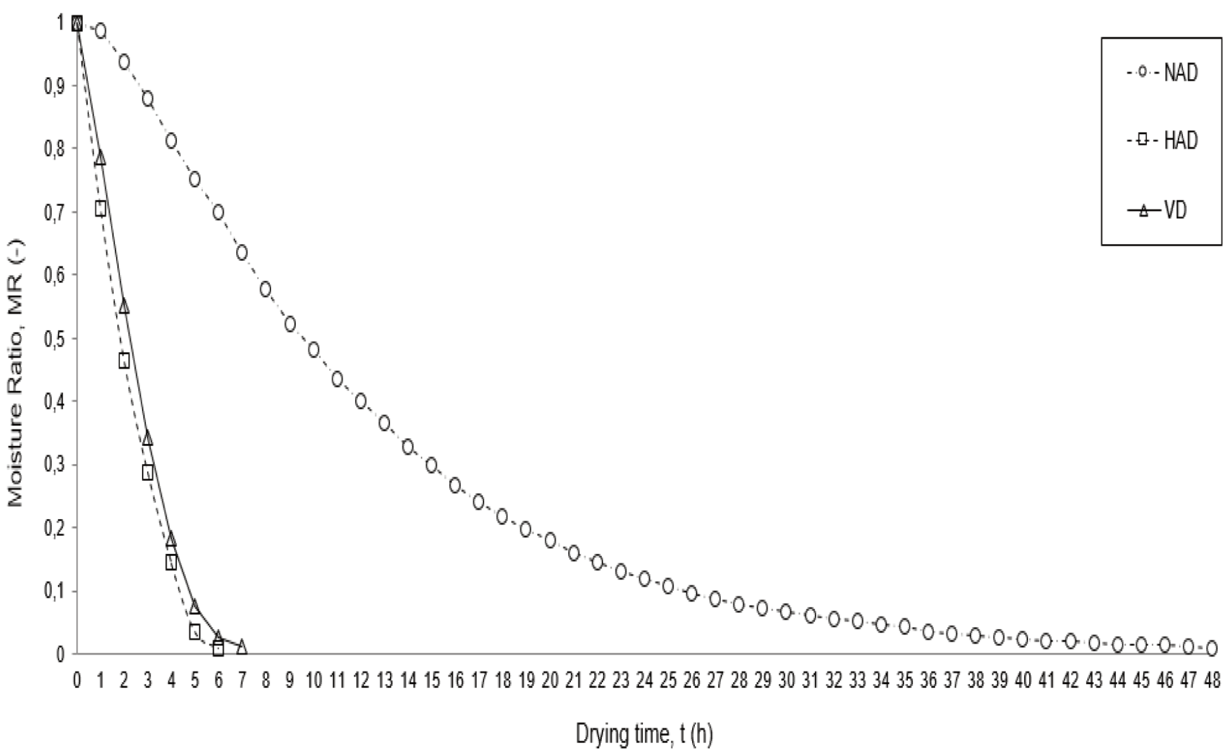

Figure 2. Drying curve of basil leaves dried by natural air-, hot-air- and vacuum drying
Remark: NAD – natural air drying, HAD – hot-air drying, VD – vacuum drying

The initial moisture content of the basil leaves was found to be 66,7% (wet basis: w.b.). The basil were dried by different drying methods until the final moisture content (0,8-1,4%, wet basis: w.b.).

The figure indicates that the drying period of the natural air drying process is longer than the hot-air dehydration, because of the minor drying rate. There is no significant difference in drying time between the two artificial drying. The artificial drying technique ended drying in 6-7 hours due to the faster drying rate while the natural technique ended drying in 48 hours. Another research group found similar results (Hii et al, 2008).

Conclusions

This study focused on the chemical composition characteristics of essential oils extracted from fresh and different dried basil leaves. The results showed that drying methods had a significant effect on essential oil content and composition of basil leaves. The volatile oil found in herbs is very sensitive to some drying parameters (e.g. pressure, temperature, weather, non-uniform drying, etc.), according to Parmar et al (2018), Tomaino et al (2005), Tsai et al (2013) and Díaz-Maroto et al (2007).

The quality of the vacuum dried (1) product was assessed – from a twelve major constituents (eucalyptol, linalool, camphor, estragole, beta-elemene, beta-caryophyllene, alpha-guaiene, alpha-humulene, germacrene-d, delta-guaiene, alpha-cadinene and delta-cadinene) – as being higher than that of a hot-air dried (2) and natural air dried (3) products (Calín-Sánchez et al, 2015). Losses in the content of essential oil in vacuum dried samples can also be observed. The amount oil losses is dependent on the pressure of vacuum drier. The applied vacuum (8000 Pa) at the vacuum drying probably split open the outer (exogenous) essential oil containers of the leaf.

A comparison between the vacuum drying and hot-air drying methods showed a difference in the quality of the dried basil leaves because hot-air drying uses relatively high temperatures and intensive ventilation, which causes undesirable alteration of the volatile compounds in the finished product (Abdollah et al, 2014) (Antal et al, 2011).

In the case of natural air drying, non-uniform drying and rewetting by the weather caused a loss of quality in plant material.

The three drying methods used greatly affected the drying characteristics basil leaves. Hot-air drying resulted in acceleration of the drying rate and water evaporation in the early stage of drying, however in the later stage the drying rate slowed down and approached the drying time of the vacuum drying. There is no significant difference between the drying times of the vacuum- and hot-air drying. Thanks to the low drying rate, the treatment time of natural drying is eight times that of artificial drying.

Taking into account all these considerations we recommend the drying of basil leaves by vacuum drying.

Nomenclature

db	dry basis	
m	mass	g
M	moisture content	kg/kg db
MR	moisture ratio	
Me	equilibrium moisture content	kg/kg db
M0	initial moisture content	kg/kg db
p	pressure	Pa
t	time	h
T	temperature	°C
wb	wet basis	%
Wt	sample weight at a specific time	kg
Wk	sample dry weight	kg

Acknowledgements

We would like to express our gratitude to Dr. István-Imre Nyárádi, Vice Dean of the Sapientia Hungarian University of Transylvania for raw materials. In addition, we would like to thank Eva Nagy assistant lecturer (University of Debrecen) for assistance in gas chromatographic analysis of raw and dried samples.

References

[1] Abdollah, G.P., Mahdad, E. and Craker, L. (2014). Effects of drying methods on qualitative and quantitative properties of essential oil of two basil landraces. Food Chemistry, Vol. 141(3), pp. 2440-2449.

[2] Antal, T., Figiel, A., Kerekes, B. and Sikolya, L. (2011). Effect of drying methods on the quality of the essential oil of spearmint leaves (Mentha spicata L.). Drying Technology. Vol. 29, pp. 1836-1844.

[3] Calín-Sánchez, Á., Figiel, A. Lech, K., Szumny A. and Carbonell-Barrachina, A.A. (2013). Effect of drying methods on the composition of thyme (Thymus vulgaris L.) essential oil. Drying Technology. Vol 31, pp. 224-235.

[4] Calín-Sánchez, Á., Figiel, A. Lech, K., Szumny A., Martínez-Tomé, J. and Carbonell-Barrachina, A.A. (2015). Drying methods affect the aroma of Origanum majorana L., analysed by GC-MS and descriptive sensory abalysis. Ind. Crops Prod. Vol 74, pp. 218-227.

[5] Calín-Sánchez, Á., Lech, K., Szumny, A., Figiel, A. and Carbonell-Barrachina, A.A. (2012). Volatile composition of sweet basil essential oil (Ocimum basilicum L.) as affected by drying method. Food Research International, Vol. 48, pp. 217-225.

[6] Crivelli, G., Nani, R.C. and L. F. Di Cesare (2002), Influence of processing on the quality of dried herbs. Atti VI Giornatescientifiche SOI. Spoleto 23-25 April, 2002, Vol. II, pp. 463-464.

[7] Diaz-Maroto, M.C., Pérez-Coello, M.S. and M. D. Cabezudo (2002), Effect of drying method on the volatilities in bay leaf (Laurusnobilis L.). Journal of Agricultural Food Chemistry, Vol. 50, pp. 4520-4524.

[8] Diaz-Maroto, M.C., Pérez-Coello, M.S., Sánchez-Palomo E. and González-Vinas, M.A. (2007). Impact of drying and storage time on sensory characteristics of rosemary (Rosmarinus officinalis L.). J. Sens. Stud. Vol 22, p. 34-48.

[9] Di Cesare, L. F., Forni, E., Viscardi, D. and R. C. Nani (2003), Changes in the chemical composition of

basil caused by different drying procedures. Journal of Agricultural and Food Chemistry, Vol. 51, pp. 3575–3581.

[10] Hii, C. L., Law, C. L. and M. Cloke (2008), Modelling of thin layer drying kinetics of cocoa beans during artificial and natural drying. Journal of Engineering Science and Technology, Vol. 3(1), pp. 1-10.

[11] Lee, S. J., Umano, K., Shibamoto, T. and K. G. Lee (2005), Identification of volatile components in basil (Ocimum basilicum L.) and thyme leaves (Thymus vulgaris L.) and their antioxidant properties. Food Chemistry, Vol. 91, pp. 131–137.

[12] Morales, M. R. and J. E. Simon (1997), "Sweet Dani": A new culinary and ornamental lemon basil. Hort. Science, Vol. 32, pp. 148-149.

[13] Novák, I., Sipos, L.,Kókai, Z., Szabó, K., Pluhár, Zs. and Sárosi, Sz. (2011). Effect of the drying method on the composition of Origanum Vulgare L. Subsp. Hirtum essential oil, analysed by GC-MS and sensory profile method. Acta Alimentaria, Vol. 40, pp. 130-138.

[14] Parmar. M.R., Bhalodiya, V.B. and Kapdi S.S. (2018). Temperature effect on drying and phytochemicals of basil leaves. International Journal of Engineering Science Invention (IJESI), Vol. 7, pp. 34-44.

[15] Politeo, O., Jukic, M. and M. Milos (2007). Chemical composition and antioxidant capacity of free volatile aglycones from basil (Ocimum basilicum L.) compared with its essential oil. Food Chemistry, Vol. 101, pp. 379-385.

[16] Putievsky, E. and B. Galambosi (1999). Production systems of sweet basil. In.: Hiltunen, R. and Holm, Y. (eds.), Basil: the Genus Ocimum. Harwood Academic Publishers, Amsterdam, pp. 54.

[17] Tomaino, A., Cimino, F., Zimbalatti, V., Venuti, V., Sulfaro, V., De Pasquale, A., et al (2005). Influence on heating on antioxidant activity and the chemical composition of some spice essential oils. Food Chemistry, Vol. 89, pp. 549-554.

[18] Tsai, M.L., Wu C.T., Lin, T.F., Lin, W.C., Huang, Y.C. and Yang C.H. (2013). Chemical composition and biological properties of essential oils of two mint species. Trop. J. Pharmac. Res. Vol. 12, pp. 577-582.

[19] Uribe, E., Marín, D., Vega-Gálvez, A., Quispe-Fuentes, I. and A. Rodríguez (2016), Assessment of vacuum-dried peppermint (Mentha piperita L.) as a source of natural antioxidants. Food Chemistry, Vol. 190, pp. 559-565.

[20] Yousif, A.N., Scaman, C.H., Durance, T.D. and Girard, B. (1999). Flavpor volatioles and physical properties of vacuum-microwave and air-dried sweet basil (Ocimum basilicum L.). Journal of Agricultural Food Chemistry, Vol. 47(11), pp. 4777- 4781.

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 45-58
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2019.35.45
Received: 2019.07.20. - Accepted: 2019.09.10.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
THE HUNGARIAN ACADEMY OF SCIENCES
and
SZENT ISTVÁN UNIVERSITY
Faculty of Mechanical Engineering

EVALUATION OF MUNICIPAL WASTE MANAGEMENT OPTIONS BY CIRCULAR PREVENTION TOOLS TO GIVE BETTER WAYS FOR SUSTAINABLE TRANSITIONS – A CASE STUDY OF HANOI

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Abstract

The transition management approach can help to improve municipal solid waste management in individual cities and city regions. The obsolete technological solutions of waste management cannot support efficient and sustainable urban waste management processes. We would like to present a possible solution to development of the municipal solid waste management system in a high population density megapolis, Hanoi (Vietnam). We examined the development opportunities at three strategic levels (governmental, enterprise and personal levels). We have analyzed the system at strategic, tactical, operational and reflexive levels also, using a transition matrix. Five development aspects and technological directions have been identified, and all of them could be applied at the three decision levels. We came to the conclusion that intervention is needed at all three levels. Based on our results, we have made proposals for the transformation of Hanoi solid waste management structure in the overall organizational structure.

Keywords

City waste management; circular evaluation, transition management; economy of waste prevention

1. Introduction

The purpose of this communication paper is to transform the municipal solid waste management system of Hanoi, Vietnam, with transition management. The novelty of the research is that it examines the transformation possibilities simultaneously at all three decision levels and reviews the development directions in a complex system. It puts forward proposals for transformation at both the technological and the residential (personal) level in order to develop a sustainable and efficient municipal waste management system.

This paper aims to examine the current status of solid waste management systems in Hanoi and to study the criteria system in evaluating and selecting solid waste treatment technologies which are being applied in the developed countries. On that basis, the author will apply these criteria in the specific conditions of Hanoi-the capital of Vietnam to give some recommendations in selecting suitable technologies to the local context. We would like to give a suggestion of circular transition of waste management system by selecting the circular blocks which could be help to transform the system more effectively. We determined the transformable blocks and each developing points of the system. Finally, we would like to give a technological and economical suggestion of municipal solid waste management system transformation and application to Hanoi, Vietnam.

Transition management objectives and strategic levels

The transition management and thinking are structure-based processes. Progress considering and the board generally help the depiction and improvement of practical and persuasive objectives and stories. Long term objectives are matched with momentary employable activities experiencing significant change considering, and executing nearby and worldwide procedures and their associations into the condition winds up conceivable with this methodology. Besides, it offers rules and guidance on collecting either auxiliary structures, or collaboration programs, which can demonstrate productive in achieving territorial or national objectives set as far as supportability (Wittmayer et al., 2016). These objectives are basically either plainly mechanical advancements, green developments, or atmosphere neighborly framework improvement ventures. Thusly, the motor of progress forms is comprised of development programs, however in these cases, change thinking additionally requires another, framework level translation (Kemp et al., 2007). Key advancement speculations have changed essentially in the course of the most recent couple of years, but sadly, the development approaches we as of now use are primarily reliant on the customarily acknowledged development hypothesis - the direct advancement show. In the straight model, the procedure of development creates the final product of another item or procedure, which is essentially an examination result, or a result of the new innovative arrangement. The fundamental direct successive systems (Brooks, 1995) of the advancement procedure are kept up by the improvement of new innovation. The transition management assumes that these exercises should offer explicit characteristics as far as what on-screen characters are sharing simultaneously, what forms they are interlinked with, and what sort of item or on the other hand administration they create, which can make the plan of explicit framework apparatuses and process methodologies conceivable. For instance, we could make reference to evolving partakers (assigning an objective gathering), characterizing the test in the particular progress process, the sort of procedures required for progress, or the utilization of procedure guideline apparatuses (Wittmayer et al., 2016).

Figure 1. presents the main objective levels of transitional thinking and development. On the upper level (Governmental decision level) placed the overall strategic possibilities, because the law background and direct / indirect forms of organizations could control the whole municipal waste management system. The second (and middle) level based on the small and medium enterprises. These companies could organize the technological parts of waste management. They could collect the municipal waste amount by new technical solutions and prepare waste materials to further application or other utilization. The individual level is the most important. Although the two other upper level could control the whole system, the personal thinking is the basis of the total management process. The transition management should focus on the change of personal thinking and attitude. The households could give more effort to the municipal waste management success, because they could collect each type of waste materials separately. Also an important question the acceptance of technological development by individual side.

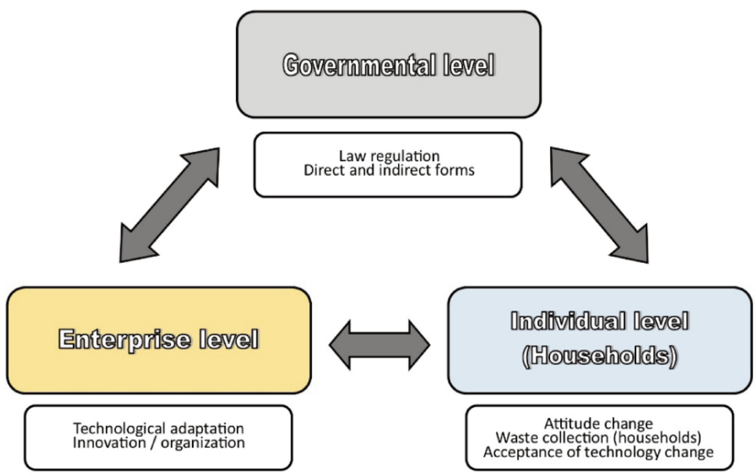

Figure 1. The main levels of transition thinking (Authors' own construction and edition)

The following table (Table 1) presents the levels of circularity and sustainability from value 1 to value 5. The KPI – Key Performance Indicators (which is presented by Table 1) define key system performance metrics based on a sustainable Business Model Canvas results, with five-grade scale. The five-level KPI values are based on expert judgement, it is construed as an objective indicator system. The expert compilation strives to find the most important indicators of the conditions for mitigating environmental externalities. Based on the KPI structure, the transition management should focus on the circular concept also. The higher circulating level of a municipal waste management system results more effective and sustainable overall operation. Therefore the information of Table 1 presents the values and properties of circularity, which should be combined with the sustainability and economic structures. By establishing circular levels, it is possible to transform the system towards the highest

Table 1. The method for transition structure improvement of municipal waste management system with Key Performance Indicators – KPI's (Authors' own edition)level of circularity.

Values	Circular level	Properties of economic structure
1	Lowest circularity	Disposal of waste
2	Low circularity	Recovery
3	Medium circularity	Reusing, recycling
4	High circularity	Upcycling, down cycling
5	Highest circularity	Prevention or zero waste (Refuse and reduce)

Structural properties of municipal waste management in developing countries

The solid waste management system is one of the main important system in urban development processes. Municipal solid waste treatment technologies could be transform by many kind of special urban properties. The current status of solid waste management system in Hanoi could not be utilize efficiently, because the system could not follow the changes of population and type of each municipal solid wastes. The habitat of people and the technological process of waste management causes problems, which should be solve by transition of management system.

Solid waste management is also one of the public management aspects that play an essential role in grasping opportunities and minimizing urban and rural difficulties against the negative aspects of increasing urbanization. This is a universal issue affecting every single person in the world. Poorly managed waste has been contaminating the world's oceans, clogging drains and causing the flood, transmitting diseases via breeding of vectors, increasing respiratory issues throughout airborne particles by burning of waste, harming creatures that consume waste unknowingly, and affecting economic development like through reduced tourism [1, 2]. The amount of waste generated is increasing day by day, accounting for a large part of the local budget as well as the government's work in treatment and significantly affects public health. Waste management will function as the sole highest funding thing for all administrations in low-income countries, in which it contains almost 20 percent of municipal budgets, on average. In those countries with middle-income, solid waste management typically accounts for at least 10 percent of municipal funds, while it accounts for roughly 4 percent in high-income nations [1]. The cost of waste management will increase 3-4 times in developing countries from about 20 billion US$ in 2010 to approximately 80 billion US$ in 2025. The rate of cost increase is higher in lower developed countries [3].

Developing countries often have inadequate waste management systems due to lack of financial resources, weak awareness, inefficient management systems, and sometimes improper technology solution applications [4]. Poor collection and disposal of urban solid waste lead deterioration of environmental aesthetics, local flooding, land, air, and water pollution [3, 5]. The consequence of these problems leads to human health hazards, which can only be minimized by implementing cost-effective technical and policy measures [6]. Many technologies have been introduced to overcome the severe consequences of poor waste management and human health risks. According to the hierarchy of waste management (WM), landfilling is the most used and worldwide spread method of municipal solid waste (MSW) disposal [7-11]. Landfills are a potential source of contamination as well as toxic substances, which can find their way into the natural environmental (soil and groundwater) by air (dispersed compounds) as well as by runoff [8, 12-15]. The MSW landfill area also releases the odors consisting of a complex mixture of organic compounds, hydrogen sulfide (H2S) and ammonia (NH3) which are the source of annoyance to nearby urban populations [16, 17]. It is demonstrated that the impact of the landfill goes outside of the sanitary security zone, so which may result in the corrosion of the caliber of drinking water, atmospheric air, sanitary and hygienic condition of agricultural lands on adjacent rural regions [18]. Mechanical-biological Treatment (MBT) for unsorted organic waste is one of the best technologies for the decomposition of organic components from the landfilling site can be done faster [19]. Composting is a method of waste recycling based on the biological degradation of organic matter under aerobic conditions, producing stabilized and sanitized compost products [20]. The composting technologies can constitute a viable alternative for the management of the organic fraction of MSW in developing countries, due to its simplicity, quick, and easy implementation [21]. Of all the recycling methods, composting is recommended due to its environmental and economic benefits [20]. It has many environmental benefits, such as reducing greenhouse gas emissions [22], decreasing leachate quantities once discarded in landfills [23], and improving soil quality when used as a soil amendment [20]. However, when improperly managed and performed, composting may cause various environmental issues including the formation of malodorous or toxic gases [24], bioaerosols [25], and dust [26], resulting in occupational health risks or disturbance to nearby residents [27]. Besides these traditional technologies, waste-to-energy technologies (WTE-T) are promising technologies, especially for developing countries, to turn waste into a useable form of energy [28]. It will play a vital role in sustainable waste management and mitigation of environmental issues [29, 30]. These technologies are generally classified as biological treatment technologies (or Biochemical process like anaerobic digestion technologies [31-36]) and thermal treatment technologies (or Thermochemical process such as pyrolysis [28, 34, 37], gasification [28, 38-42] and incineration [28, 34, 43-45] technologies). Solid waste management is a complex and multi-dimensional issue [46]. Management of MSW deals with many factors such as policy and legal framework, institutional arrangement, appropriate technology, operations management, financial management, public participation and awareness, the action plan for improvement [47, 48]. The key to successful development is the design of waste management systems adapted to local needs and traditions, rather than the selection and transfer of a single procedure or technology from one country or region to another [49].

Each country will decide to choose their strategy for sustainable municipal solid waste management system based on the specific conditions. Of all tools which are applied, life cycle assessment (LCA) by evaluating the environmental performance of municipal solid waste management system will help the decision-maker in selecting the best management strategy with minimum impacts on the environment [50]. From a life-cycle point of view, a comprehensive MSW management system includes all essential operational units from the collection, to shipping, to treatment, to recycling, and disposal. For instance, the landfill directive promoted biodegradable municipal waste (BMW) management systems is applied in Austria, Netherlands; economic instruments including Pay-As-You-Throw (PAYT) and an organic waste tax are applied in some of the EU member states; both BMW system and Landfill Allowance Trading System (LATS) in the United Kingdom (UK); Green Dot system in Germany [51, 52]. In Asian countries, the municipal waste management systems are being oriented to concentrate on sustainability issues; mainly through the incorporation of 3R (reduce, reuse and recycle) technologies [47]. The solutions for these countries are social and technical approaches with social approaches are changing the public behavior by improving the community through training, and encouraging partnerships with decentralized SWM, and the technical approaches are reducing biodegradable SW at the source, converting waste to energy, and using simple technology [53].

The selection and application of such technology depend upon different factors including the country's economic condition, priorities, and types of waste generated [54]. It also is one of the critical considerations for the success of a waste management system for a particular town/city. The technologies to be adopted for MSW management and processing predominantly depend upon MSW quantity, quality, and range of variations [55]. However, the efficiency of a particular technology depends on the criteria for which it is designed and planned. A wrong choice of waste processing technology can cause failure of the entire waste management system leading to lousy economics and environmental cost. There is much research conducted in the technologies applied to process municipal solid waste. However, there is a lack of attention in the study on how to define the criteria for choosing the suitable municipal solid waste technologies in developing countries with the constraints of financial, institutional, technical, and decision-making support system.

Hanoi is a special city and is a center of politics, economy, culture, education, training, science and technology of Vietnam. With the number of people around 8 million [56], the volume of generated municipal solid waste has increased rapidly these years. Until now, there has been limited progress of 3R goals with only two of nine goals have achieved some progress while the other related goals are still far from the desired targets [57].

At present, the municipal solid waste management system in Hanoi is not effective because of the lack of the appropriate financial, technical and human resources, the lack of technical infrastructure for recycling, collection, and transportation [58]. Solid waste transfer and disposal and source separation are not yet implemented throughout the city. Therefore, building a sustainable solid waste management system which is suitable for the local conditions is very important and urgent.

2. Materials and Methods

Transition management of current system

The transition management and circular transformation methods were applicate to solve the technological problem of Hanoi municipal waste management system. We determined the transformable points of current management system and give the possible solution of efficient transformation. Table 1 presents the transformation blocks and parts of management changes.

We accepted the aftereffects of Loorbach (2010), which describe four sorts of separated administration exercises in a societal setting according to the conduct of the performing artists involved. This can lay out whether a brought together mediation identifying with the disguise of externalities is required, or the backhanded main thrusts of market systems can prompt an increasingly reasonable working of waste management.

With these outcomes the supportability estimation of every one of the elements (key, strategic, operational and reflexive) and every one of the structure squares (offer, cost structure and income streams) were appropriately decided. The outcomes picked up demonstrated the overwhelming component and the legislative administration field where cognizant intercession is needed to quicken the disguise of externalities by waste management and process, so as to achieve the most cost-productive and best social transitions towards the supportable execution of bond firms, and from which the most influenced members of this progress can likewise be specified. To translate our outcomes, illustrative web charts were utilized in all the four instances of on-screen characters' conduct.

We would like to present a technological improvement with transitional management to get the maximum circularity and totally waste recyclable system as possible. Value 1 means the linear structure without any circular options. Value 5 means the totally circular system. Our aim could be the medium version, the mostly circular system because the current technological background with linear conditions could not give answers to municipal waste management questions in focus of sustainability and economic effectivity. With these outcomes the maintainability estimation of every variables (strategic, tactical operational and reflexive) and every one of the structure squares (value proposition, cost structure and revenue streams) were legitimately decided. The following figure (Figure 2) presents the transitional matrix with planned changes of current municipal waste management system. This transitional matrix shows the complex structure of circular transition management thinking of solid waste management improvement of Hanoi, Vietnam.

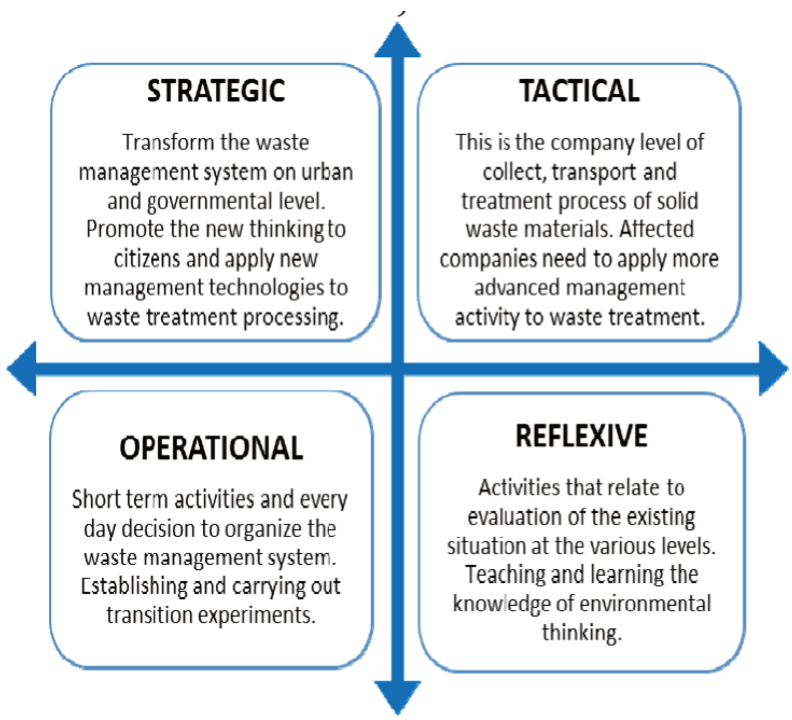

Figure 2. The transitional matrix of municipal solid waste management on each levels (Based on Osterwalder, 2004; with Authors' own modification)

Choosing improvement directions of technological background

To be able to select appropriate criteria and technologies, it is essential to have data on the current situation of the local solid waste management. Background data comprise sources of generation, quantity, and composition of solid waste, the current status of treatment technology, financial resources, stakeholder participation, institution framework, and policies/regulations. From these primary data, it is possible to identify the challenges and opportunities of solid waste management systems and from which all solutions can be identified. Solutions implemented for solid waste management include management plans and technological options. Management options include 3Rs (reduce, reuse, and recycling), public-private partnerships, awareness raising, education and training, and economic tools. With the change in the pattern of resource consumption and economic development, this becomes very important for the reduction and reuse of resources. Besides, waste can be converted to other types of resources such as compost, biogas, and energy. The conversion of waste into other energy sources will reduce the amount of solid waste to be disposed into the landfill, which should be the least preferred option in waste management.

Although many solutions have been applied in solid waste management, not all of them may be feasible for adoption. Thus, it is essential to evaluate the appropriateness of each solution based on the set of criteria and local conditions as presented in Table 2. Criteria used for SWM are versatile and dynamic according to situations and circumstances of solid waste in each city. This study applies twelve fundamental management criteria for five operation and utilization techniques. The twelve criteria are technology development, types of solid waste, operating scale, success factors, final products, capital investment, operating cost, land requirement, needed operating skills, possible adverse impacts, and contribution to energy and food security. The five extended SWM operation and utilization techniques include composting, anaerobic digestion, mechanical-biological treatment, landfill, incineration, refuse-derived fuel (RDF) or solid recovered fuel (SRF), pyrolysis, and gasification. After conducting the assessment of the appropriateness of technology, the decision-making process of appropriate solutions is implemented.

Analyzing the possible points of system improvement

The current technology options have been evaluated based on KPI values. Each technology solution has a value of between 1 and 5, making it clear which option seems to be the best solution for circularity. Adaptation of each technological solution is definitely necessary at the three decision levels examined (government, enterprise and individual / households levels also). The transition management assessment of the applied waste management methods was carried out with reference to the blocks described in the transition matrix

Table 2. The impact and influence of criteria on methods of SWM operation and utilization [19]; with Authors own modifications

Number of criteria	Part of each segments of transition analyses	Criteria	Composting	Anaerobe digestion	Sanitary landfill	Pyrolysis	Gasification
C1	VP	Solid waste characteristics	4	4	4	3	2
C2	VP	Waste quantity	5	4	3	3	3
C3	RS	Compliance with laws	4	3	4	3	2
C4	RS	Multisector involvement	4	3	3	2	3
C5	RS	Public acceptability	4	3	4	3	3
C6	VP	Possible adverse impacts (environment, society, economy)	5	4	4	4	2
C7	VP	Demand for final products	4	4	3	4	3
C8	CS	Initial investment	4	3	3	4	3
C9	CS	Operating cost	5	3	3	3	3
C10	RS	Time-consuming for the entire process	4	4	3	4	4
C11	CS	Complexity and required amount of raw materials	3	3	3	4	3
C12	CS	Wages in each parts of technologies	4	3	4	3	3

Notes: Prevention Values of each criteria's: from 1 – linear structure; to 5- fully circularity, based on Table 1. - Values of each circular levels. Abbreviations: VP – Value proposition; RS - Revenue streams; CS – Cost structure

3. Results and Discussions

Systematic approaches of waste management criteria's

Eleven criteria and five technical alternatives [19] to manage solid waste are presented in Table 2. This table describes an overview of solid waste treatment methods, which has been applied in cities worldwide and presents how each criterion relates to each solid waste disposal plan in general. However, to select suitable criteria for each locality, it is necessary to quantify by the score for the criteria. Table 2. is used as support tools for state management agencies in making appropriate decisions on the selection of solid waste treatment options to identify possible (potential) solid waste treatment options for each city or community. These techniques are paired with different criteria that can be used as a benchmark for a solid waste treatment technique. The level of impact is assessed by the score, scale of each criterion range from 1 to 5; on which level of circularity is fit for each methods. Each criterion is attributed to a value based on its score and presented in the table. From the total score of each plan, the local government or waste management units can quickly determine the technical method of treating solid waste by local conditions. Therefore, to ensure the effectiveness and feasibility of a solid waste management system, responsible state management agencies and stakeholders need to coordinate and consider all factors before deciding on the criteria and technical plans for solid waste treatment and score (scale). Table 2 presents the basic guidelines for the selection of suitable solid waste treatment options.

Results of transition management approach

To accomplish the most elevated usage of municipal waste management, center focuses were controlled by benchmarking of which primary outcomes are appeared at this. Table 3 shows the overview of each circular blocks of transitional management with values of circularity. With these results we could analyze the systematic improvement directions of total waste management process. The table shows that improvements are needed in all three respects (value proposition, cost structure and revenue streams) because the current system does not show partly or fully circularity.

Table 3. Results of system analyze to improvement (Authors' own edition)

	Strategic	**Tactical**	**Operational**	**Reflexive**
Value proposition	3.6 (C2)	3.8 (C6)	3.4 (C1)	3.6 (C7)
Cost structure	3.2 (C3)	3.8 (C10)	3.0 (C4)	3.4 (C5)
Revenue streams	3.4 (C8)	3.2 (C11)	3.4 (C9)	3.4 (C12)
Average of each transition level	3.4	3.6	3.2	3.4
Average of each of the evaluated blocks				
Value proposition	3.6			
Cost structure	3.3			
Revenue streams	3.3			

Notes: Value 1.0 means the total linear structure, value 5.0 means total circular version. Each columns contains the median value of each transition levels. The abbreviations of each blocks marked from C1 to C12 (according to Table 2 abbreviations)

Table 3 shows the average values of each evaluated blocks also. The highest value shown by the Value proposition. This means focusing on value creation during transition management, as it is possible to achieve quality change in this area. Technological innovation is not necessary for this, only efficiency has to be increased. Value proposition can be achieved by transforming corporate efficiency with centralized management.

Value proposition:

The transition thinking (about solid waste management) on four levels means the new value production with structural development. The current waste management system could not treat the whole amount of municipal waste and the rest could not manage with circular loop. The value proposition means a sustainable thinking also and this new idea causes more improvement necessary in waste management system. On strategic level the improvement means a new observe system from waste production until collection and final reuse and recycle. The current value proposition is linear structured system and could not works sustainable and circularly.

Cost structure:

The cost structure of the current waste management system could not support the total sustainable and circular development, because works with non-efficiency methods. The low percent of recycled rests of total waste amount and the percent of reusable first raw materials needs a new cost structure. The governmental decisions means a maximum medium circular and sustainable efficiency. The costs of eco-friendly working system and production of reusable and recyclable materials have to be considered, and the costs of education and training of human thinking and habit also. Communication between each segments of new business model, e.g. key partners and costumer segments are also important because their behavior and reactions are also increase the total costs of the system.

Revenue streams:

The decision segments of the system should to find a new solutions and opportunities even at the technological level to earn new revenue streams by circular transformation in operational field. This importance also presented by the observed literature and also focuses on their strategic facts. The sales revenue and cash flow also increase in long-term run with awareness of public and firm thinking. In the beginning it can causes monetary and indirect revenue streams.

Development strategies – Suggestion of each tecnological applications

The objective of assessing the appropriateness of solid waste treatment technology is to select the technologies that can be applied in the conditions of Hanoi. This assessment is based on the criteria system, which is used as the tools for the authorities to decide which technology should be adopted appropriately. The selection of criteria will depend on many factors such as natural environment, economy, technology, technology, and society. In Vietnam, the choice of technology also considers the national strategy for integrated solid waste management. In case of Hanoi city, five of the eight solid waste treatment technologies are selected such as (1) Compost; (2) Anaerobic digestion; (3) Sanitary landfill (with biogas collection system) or biological landfill; (4) Incineration (Incinerator); (5) fuel production from waste (RDF) or (SRF). The selection of these five technologies are based on their wide application in many countries around the world as well as in Hanoi. Three remaining technologies (MBT, pyrolysis, and gasification) are not compatible with Hanoi's economic, technical and human resource conditions. Although pyrolysis and gasification are advanced technologies, they are difficult and expensive to operate, while the MBT technology does not give the ultimate treatment solution for treated waste. Five technologies were compared based on 11 criteria as mentioned in Table 4, in which the multi-sector involvement criterion was rejected because it was considered the least important one in the Hanoi's condition. The calculation was performed using scoring system of 1 to 5 scores (5 = most favorable, 4 = favorable, 3 = Medium, 2= less favorable 1 = unfavorable). The point for each criterion is based on the consultation with experts, performance, on-site survey, and results of environmental monitoring. The total final score for each technology can be used as a "Sustainability Index" of technology. If technology has a high score, sustainability is high and vice versa. Based on the current status of solid waste management in Hanoi City, two scenarios assessing the suitability of solid waste treatment technology are given. Results of assessing the appropriateness of solid waste treatment technology presented in Table 4 (Scenario 1) with commingled waste and Table 5 (Scenario 2) with segregated waste.

As shown in Table 4, the total scores of five technologies assessed are not much different. For commingled waste, the technology's sustainability index shows the sanitary landfill with collection of biogas (37 points) as the most suitable technology, followed by incinerator with energy collection (36 points), composting (35 points), RDF or SRF (34 points), and anaerobic digestion (32 points), respectively.

The composition of commingled solid waste in Hanoi also contains a certain amount of household hazardous wastes (HHW) and many non-recycling components. Also, the composition of solid waste amount of Hanoi has a high biodegradable organic fraction (64.8-74.3% of wet weight) and high moisture (55-65%) so that sanitary landfill (with the collection of biogas) is a sustainable technology for solid waste management in Hanoi at present. Amount of non-recycling fraction (about 25% including plastic, diaper, textile, rubber & leather, styrofoam, wood) with high calorific value has increased significantly, and the biodegradable organic fraction has decreased from 2009 to 2015. Due to the lack of available land, incineration technology was ranked second with the possibility of energy recovery. However, the high moisture content of the solid waste and the highest investment and operation costs may limit the utilization of this technology.

The composting technology is ranked the third because the waste is commingled and therefore the separation step has to be carried out before the waste is composted and this step is labor intensive. At present, the quantity of solid waste at two composting plants takes at 35-64%, and the remaining non-compostable (taking 36-65%) are buried at a sanitary landfill or burned by the incinerator. Also, the quality of compost using commingled waste is low because the end product is mixed with scrap glass and plastics making it difficult to consume. The RDF technology ranked fourth. The anaerobic digestion technology has the lowest score due to uncertainties regarding investment and operation costs, low energy prices, damaged reputation due to unsuccessful plants as well as this technology need source-sorted organic. These results are consistent with the set targets for the management of solid waste in Hanoi as according to National strategies on integrated management of solid waste.

Table 4. Assessment of sustainability of treatment technologies for commingled waste (Scenario 1) (Authors' own research and edition)

Criteria		**Compost production**	**Anaerobic digestion**	**Sanitary landfill with the collection of biogas**	**Incinerator with energy collection**	**RDF or SRF**
Solid waste characteristics	*Separated solid waste at source*	-	-	-	-	-
	Commingled waste	2	2	5	3	3
Waste quantity		3	1	3	3	1
Compliance with standard/regulation of National Technology of Vietnam		5	5	5	5	5
Time-consuming for entire process		2	3	5	5	3
Complexity and required skills		5	3	4	2	3
Demand for final products		2	2	2	2	2
Initial investment		4	2	3	1	2
Operating cost		2	2	5	1	2
Land requirement: Large scale		2	3	1	4	3
Possible adverse impacts	*Odor*	2	2	1	2	2
	Municipal and industrial wastewater	2	2	1	4	3
	Dust and air pollution	2	3	1	2	3
Public acceptability		2	2	1	2	2
Total scores		**35**	**32**	**37**	**36**	**34**

Evaluation: Scoring system: 5 = most favorable, 4 = favorable, 3 = Medium, 2= less favorable 1 = unfavorable.

Table 5. Assessment of sustainability of treatment technologies for separated solid waste (Scenario 2) (Authors' own research and edition)

Criteria		**Compost production**	**Anaerobic digestion**	**Sanitary landfill with the collection of biogas**	**Incinerator with energy collection**	**RDF or SRF**
Solid waste characteristics	*Separated solid waste at source*	5	5	5	5	5
	Commingled waste	-	-	-	-	-
Waste quantity		5	5	5	4	4
Compliance with standard/regulation of National Technology of Vietnam		5	5	5	5	4
Time-consuming for entire process		2	3	1	5	4
Complexity and required skills		5	3	4	2	3
Demand for final products		4	4	1	4	3
Initial investment		5	3	4	2	3
Operating cost		5	3	4	2	3
Land requirement: Large scale		2	3	1	4	3
Possible adverse impacts	*Odor*	2	2	1	2	2
	Municipal and industrial wastewater	2	2	1	4	3
	Dust and air pollution	2	4	1	2	3
Public acceptability		2	3	1	3	3
Total scores		**46**	**45**	**34**	**44**	**43**

Scoring system: 5 = most favorable, 4 = favorable, 3 = Medium, 2= less favorable 1 = unfavorable.

Table 5 shows that total scores of all technologies in scenario 2 is higher than scenario 1 because solid waste is separated at the source to form clean, biodegradable organic, recyclable, and the remaining fraction. The assessment of treatment technologies for separated solid waste shows that the composting technology (46 points) is the most applicable, followed by anaerobic digestion (45 points), incinerator with energy collection (44 points), RDF or SRF (43 points), and bioreactor landfill or sanitary landfill (34 points), respectively.

The potential demand for organic fertilizers and soil conditioners in the surroundings of Hanoi is very high and exceeds the actual supply. With source separated clean, biodegradable organic fraction, the composting technology is the most suitable because of its simplicity, low cost, and high demand for composting products. The anaerobic digestion can produce green energy and soil conditioner from biodegradable organic fraction, and it is ranked the second after composting technology because of its higher complexity and cost compared to the composting technology. The bioreactor landfill or sanitary landfill with the collection of biogas require a large amount of land, generate leachate and emit an odor, and thus it has the lowest score. Components of remaining solid waste after separation (plastic, diaper, textile, rubber, leather, etc.) with high calorific value can be incinerated with energy collection and thus obtains higher score compared to RDF technology.

Development goals by transition of each organizing levels (based on the scenarios)

By assessing the sustainability of solid waste treatment technologies from two scenarios, Scenario 2 have specific advantages such as low operation, high quality of composting product, more efficient land use, lower environmental impacts and higher production of biogas, energy collection in comparison with the Scenario 1 so that scenario 2 will be selected for integrated solid waste management in Hanoi. These results are consistent with the situation of solid waste and the set targets for the management of solid waste in Hanoi. Also, it is clear that one technology would hardly achieve efficiency of solid waste management in Hanoi. The need for a combination of multiple technologies yields an integrated solid waste management system leading to zero waste for sustainable resource utilization in Hanoi. Ideally, the composting technology followed anaerobic digestion technologies is found to be the most sustainable for solid waste in the Hanoi. Incineration with energy collection is essential only for non-recycling solid waste (with high calorific value), and residual solid waste will always be needed for landfills. By separating solid waste at sources (application of Scenario 2), the City will be able to:

– Utilize 70 to 80% of the city's solid waste, among which about 60-70% can be used for producing compost and anaerobic digestion for generating energy. Remaining 10-20% can undergo recycling.
– The decrease in pollution caused by odor and leachate from landfills.
– Raise people's awareness of environmental protection.

To achieve zero waste management, the results of the two exampled scenarios show that waste separation at source is an essential factor that prevents waste from entering landfills. Implementing waste separation allows the collection of a great amount of recyclable waste that can be converted into useful materials. Besides, unmixed waste helps waste collectors save time during collection process substantially, and save cost for Hanoi’s waste management. The segregation of the waste is must for sustainable solid waste management, as the waste can be intercepted for recovery of materials and composting, anaerobic digestion, incineration and the minimal amount go to the sanitary landfill.

Conclusions

This study investigated the current situation of solid waste management in Hanoi from the collection, transportation, and processing. The rapid urbanization and industrialization in Vietnam caused the increase of waste generation and the variety of composition. Also, inappropriate waste management system in Vietnam has led to various environmental and health issues. To assess and select the appropriateness of solid waste treatment technology that can be applied in the conditions of Hanoi, this research applied benchmarking model with five of the eight solid waste treatment technologies which are widely used in many countries around the world such as (1) Compost; (2) Anaerobic digestion; (3) Sanitary landfill (with biogas collection system) or biological landfill; (4) Incineration (Incinerator); (5) fuel production from waste (RDF) or (SRF) and 11 criteria including (1) Solid waste characteristics; (2) Waste quantity; (3) Compliance with standard/regulation of National Technology of Vietnam; (4) Time-consuming for entire process; (5) Complexity and required skills; (6) Demand for final products; (7) Initial investment; (8) Operating cost; 9) Land requirement; (10)Possible adverse impacts, and (11) Public acceptability. Based on categorizing two scenarios of characteristics of waste such as mixed and separated, this paper resulted that the scenario 1 (commingled waste) has the technology's sustainability index with the sanitary landfill with collection of biogas (37 points) as the most suitable technology, followed by incinerator with energy collection (36 points), composting (35 points), RDF or SRF (34 points), and anaerobic digestion (32 points), respectively. The case for the scenario 2 (separated waste) shows that the composting technology (46 points) is the most applicable, followed by anaerobic digestion (45 points), incinerator with energy collection (44 points), RDF or SRF (43 points), and bioreactor landfill or sanitary landfill (34 points), respectively. It is clear that Hanoi needs to combine multiple technologies yields an integrated solid waste management system leading to zero waste for sustainable resource utilization. The composting technology followed anaerobic digestion technologies and incineration with energy collection are found to be the most sustainable for solid waste in the Hanoi in the condition of segregation of the waste at source, while the last option is the sanitary landfill.

Suggestions

We would like to make suggestions on which of the twelve development goals (presented by Table 2. in Results chapter) will strengthen prevention, e.g. minimizing the amount of waste and implementing the zero waste strategy. Primarily waste production should be reduced, because if less waste is generated in the system, the waste management can be more efficient. It is important to note that which part of the business models could be the prevention and how they relate to the circular economic concept. It is important to define the prevention levels of circular economy, therefore the development needs at the three transition management levels can be clarified. Based on our suggestion, if prevention is prioritized and development areas are identified (which could strengthen prevention), we can describe how transition management can be interpreted in circular business models. Based on our suggestion, it is necessary to focus on the following target areas in order to strengthen prevention as the key to system development.

–Solid waste characteristics

The heterogeneous composition of municipal waste results the prevention and making possible to operate efficiently the planned waste management system.

–Waste quantity

The increasing amount of waste strengthen the prevention.

–Public acceptability

The prevention increasing the acceptability of the developed municipal waste management system.

–Demand for final products

–Operating cost

–Complexity and required amount of raw materials

References

[1] Kaza, S., et al., What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. 2018: World Bank Publications.

[2] Hoornweg, D. and P. Bhada-Tata, What a waste: a global review of solid waste management. Vol. 15. 2012: World Bank, Washington, DC.

[3] Hoornweg, D. and P. Bhada-Tata, What a waste: a global review of solid waste management. 2012.

[4] Loan, N.T.P., Tài liệu hướng dẫn. Lựa chọn công nghệ trong quản lý chất thải rắn bền vững. Nghiên cứu điển hình tại Thành phố Hồ Chí Minh, Việt Nam. 2016.

[5] Themelis, N.J., et al., Energy recovery from New York City municipal solid wastes. 2002. 20(3): p. 223-233.

[6] Wajeeha Saleem, A.Z., Muneeba Tahir, Fatima Asif, Ghazala Yaqub, Latest technologies of municipal solid waste management in developed and developing countries: A review International Journal of Advanced Science and Research 2016. 1(10): p. 22-29

[7] Voběrková, S., et al., Effect of inoculation with white-rot fungi and fungal consortium on the composting efficiency of municipal solid waste. 2017. 61: p. 157-164.

[8] Koda, E., A. Miszkowska, and A.J.A.S. Sieczka, Levels of organic pollution indicators in groundwater at the old landfill and waste management site. 2017. 7(6): p. 638.

[9] Jovanov, D., B. Vujić, and G.J.J.o.e.m. Vujić, Optimization of the monitoring of landfill gas and leachate in closed methanogenic landfills. 2018. 216: p. 32-40.

[10] Gworek, B., et al., Impact of the municipal solid waste Łubna Landfill on environmental pollution by heavy metals. 2016. 8(10): p. 470.

[11] Vaverková, M.D., et al., Municipal solid waste landfill–Vegetation succession in an area transformed by human impact. 2019. 129: p. 109-114.

[12] Yang, L., et al., Photosynthesis of alfalfa (Medicago sativa) in response to landfill leachate contamination. 2017. 186: p. 743-748.

[13] Adamcová, D., et al., Environmental assessment of the effects of a municipal landfill on the content and distribution of heavy metals in Tanacetum vulgare L. 2017. 185: p. 1011-1018.

[14] Elia, G., et al., Numerical modelling of slope–vegetation–atmosphere interaction: an overview. 2017. 50(3): p. 249-270.

[15] Vaverková, M.D., et al., Environmental risk assessment and consequences of municipal solid waste disposal. 2018. 208: p. 569-578.

[16] Moreno, A., et al., Chemical characterization of emissions from a municipal solid waste treatment plant. 2014. 34(11): p. 2393-2399.

[17] Cheng, Z., et al., The identification and health risk assessment of odor emissions from waste landfilling and composting. 2019. 649: p. 1038-1044.

[18] Makarenko, N. and O.J.A.o.A.S. Budak, Waste management in Ukraine: Municipal solid waste landfills and their impact on rural areas. 2017. 15(1): p. 80-87.

[19] Sharp, A. and J.J.I.f.G.E.S.A.h.w.i.o.j. Sang-Arun, A guide for sustainable urban organic waste management in Thailand: Combining food, energy, and climate co-benefits. 2012.

[20] Wei, Y., et al., Environmental challenges impeding the composting of biodegradable municipal solid waste: A critical review. 2017. 122: p. 51-65.

[21] Jara-Samaniego, J., et al., Composting as sustainable strategy for municipal solid waste management in the Chimborazo Region, Ecuador: Suitability of the obtained composts for seedling production. 2017. 141: p. 1349-1358.

[22] (USEPA), U.S.E.P.A., Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013. 2015: p. Chapter-7-Waste.

[23] Adhikari, B.K., et al., Effectiveness of three bulking agents for food waste composting. 2009. 29(1): p. 197-203.
[24] Maulini-Duran, C., et al., VOC emissions from the composting of the organic fraction of municipal solid waste using standard and advanced aeration strategies. 2014. 89(4): p. 579-586.
[25] Wéry, N.J.F.i.C. and I. Microbiology, Bioaerosols from composting facilities—a review. 2014. 4: p. 42.
[26] Sykes, P., et al., Workers' exposure to dust, endotoxin and β-(1–3) glucan at four large-scale composting facilities. 2011. 31(3): p. 423-430.
[27] Pearson, C., et al., Exposures and health outcomes in relation to bioaerosol emissions from composting facilities: a systematic review of occupational and community studies. 2015. 18(1): p. 43-69.
[28] Moya, D., et al., Municipal solid waste as a valuable renewable energy resource: a worldwide opportunity of energy recovery by using Waste-To-Energy Technologies. 2017. 134: p. 286-295.
[29] Brunner, P.H. and H.J.W.M. Rechberger, Waste to energy–key element for sustainable waste management. 2015. 37: p. 3-12.
[30] Di Matteo, U., et al., Energy contribution of OFMSW (Organic Fraction of Municipal Solid Waste) to energy-environmental sustainability in urban areas at small scale. 2017. 10(2): p. 229.
[31] Baroutian, S. and C. Anyaoku, Decentralized anaerobic digestion systems for increased utilization of biogas from municipal solid waste. 2018.
[32] Van Fan, Y., et al., Anaerobic digestion of municipal solid waste: energy and carbon emission footprint. 2018. 223: p. 888-897.
[33] Tyagi, V.K., et al., Anaerobic co-digestion of organic fraction of municipal solid waste (OFMSW): Progress and challenges. 2018. 93: p. 380-399.
[34] Hinchliffe, D., J. Frommann, and E.J.E.G. Gunsilius, Waste to energy options in municipal solid waste management. 2017.
[35] Kusch, S. Understanding and managing the start-up phase in dry anaerobic digestion. in Proceedings in Research Conference in Technical Disciplines, Zilina, Slovak Republic. 2013.
[36] Kranert, M., et al., Anaerobic Digestion of Waste. 2012. 128-129.
[37] Bosmans, A., et al., The crucial role of Waste-to-Energy technologies in enhanced landfill mining: a technology review. 2013. 55: p. 10-23.
[38] Couto, N.D., V.B. Silva, and A.J.J.o.c.p. Rouboa, Thermodynamic evaluation of Portuguese municipal solid waste gasification. 2016. 139: p. 622-635.
[39] Thakare, S. and S.J.E.P. Nandi, Study on potential of gasification technology for municipal solid waste (MSW) in Pune city. 2016. 90: p. 509-517.
[40] Mazzoni, L. and I.J.I.J.o.H.E. Janajreh, Plasma gasification of municipal solid waste with variable content of plastic solid waste for enhanced energy recovery. 2017. 42(30): p. 19446-19457.
[41] Rajasekhar, M., et al., Energy Generation from Municipal Solid Waste by Innovative Technologies–Plasma Gasification. 2015. 10: p. 513-518.
[42] Arena, U.J.W.m., Process and technological aspects of municipal solid waste gasification. A review. 2012. 32(4): p. 625-639.
[43] Dong, J., et al., Comparison of waste-to-energy technologies of gasification and incineration using life cycle assessment: Case studies in Finland, France and China. 2018. 203: p. 287-300.
[44] Liu, A., et al., A review of municipal solid waste environmental standards with a focus on incinerator residues. 2015. 4(2): p. 165-188.
[45] Sebastian, R.M., et al., A technique to quantify incinerability of municipal solid waste. 2019. 140: p. 286-296.
[46] Di Nola, M.F., M. Escapa, and J.P.J.W.M. Ansah, Modelling solid waste management solutions: The case of Campania, Italy. 2018. 78: p. 717-729.
[47] Shekdar, A.V.J.W.m., Sustainable solid waste management: an integrated approach for Asian countries. 2009. 29(4): p. 1438-1448.
[48] Guerrero, L.A., G. Maas, and W.J.W.m. Hogland, Solid waste management challenges for cities in developing countries. 2013. 33(1): p. 220-232.
[49] Association, I.I.S.W., Waste and climate change, ISWA White Paper. 2009.
[50] Khandelwal, H., et al., Application of life cycle assessment in municipal solid waste management: A worldwide critical review. 2018.
[51] Pires, A., G. Martinho, and N.-B.J.J.o.e.m. Chang, Solid waste management in European countries: A review of systems analysis techniques. 2011. 92(4): p. 1033-1050.
[52] Neumayer, E.J.E.E., German packaging waste management: a successful voluntary agreement with less successful environmental effects. 2000. 10(3): p. 152-163.
[53] Dhokhikah, Y., Y.J.J.o.A.E. Trihadiningrum, and B. Sciences, Solid waste management in Asian developing countries: challenges and opportunities. 2012. 2(7): p. 329-335.
[54] Da Zhu, P.U.A., Chris Zurbrügg, Sebastian Anapolsky, Shyamala Mani, Improving Municipal

Solid Waste Management in India. WBI DEVELOPMENT STUDIES, 2008.
[55] Gupta, S., et al., Nation Challenges for Solid Waste Management. 2017. 9(2).
[56] GSOVN., Area, population and population density by province. Population and Employment. 2016: p. http://www.gso.gov.vn/default_en.aspx?tabid=774.
[57] Thang, N.T., Country Chapter, State of the 3Rs in Asia and the Pacific, The Socialist Republic of Vietnam. 2017: p. 37.
[58] Richardson, D.W., Community-based solid waste management systems in Hanoi, Vietnam. 2003, from the Faculty of Forestry, University of Toronto.

HUNGARIAN AGRICULTURAL ENGINEERING
N° 35/2019 59-
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print) / HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2019.35.59
Received: 2019.08.31. - Accepted: 2019.09.10.

PERIODICAL OF THE COMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF
THE HUNGARIAN ACADEMY OF SCIENCES
and
SZENT ISTVÁN UNIVERSITY
Faculty of Mechanical Engineering

POSSIBILITIES OF USING ROBOTS IN AGRICULTURE

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Abstract

The spread of robots is a global phenomenon. We can meet them today in different areas of life. Robotization has a relatively long history in industrial production and, in recent years, agricultural robots have emerged. A shrinking workforce mainly inspires the development of agricultural robots. It is a major challenge for developers to work with agriculture, as opposed to industry, with living materials and organisms. Because of these improvements, there are nowadays many successful examples of the use of robots in various agricultural operations.

Keywords

Robots, agricultural technologies, agricultural robots

1. Introduction

The spread of robots is a global phenomenon. We meet them in many different areas of life; production-service organizations are increasingly being used instead of human labor for robots to perform various tasks. According to early ideas, a robot could well replace humans in a difficult situation to perform dangerous and high-precision monotone tasks.

The industrial application of robots has a relatively long history. In many countries of the world and in many areas of economic life, we can find robots that work well. They are particularly widespread in the automotive industry.

Today, it is the second biggest market for professional robotics. Estimated to be strong demand for robots throughout the farming process, including planting, pruning, weeding, pick-and-place, sorting, seeding, spraying, harvesting, and materials handling (Fig. 1.).

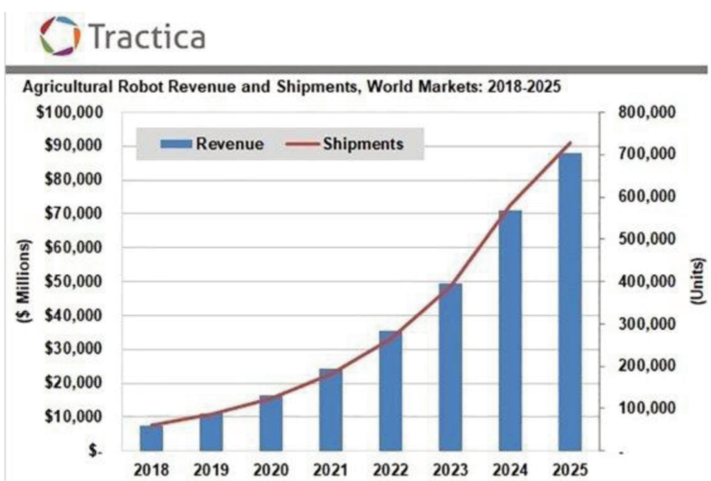

Figure 1. Agricultural Robot Revenue and Shipments (World Markets 2018-2025)
Source: (Tractica, 2016)

Figure 1 shows the projected dynamic growth expected in the sales of agricultural robots. It's well-known that food is a necessity that must be produced at all costs. We therefore need either more farmers or more ways to produce food with limited manpower. The robots are coming to the rescue." Within the next decade, farming as we know it is expected to be revolutionized by the use of self-driving tractors and robots that can perform time-consuming tasks now done by humans. However, more and more robots have recently been developed and tested for use in agriculture. Although some of these technologies are already available, most are at the research stage in labs and spin-off companies. Rising costs for farm labour and falling costs for self-driving technology also will provide further catalysts for the shift (Danielsca, 2016). The main purpose of this article is to demonstrate, through arbitrary examples, which areas of the robots developed as a result of improvements can be used in agriculture. A further aim is to summarize the opportunities and conditions necessary for the efficient use of robots also under the conditions of Hungarian agriculture. Nowadays robots can be found in almost every field of agriculture. Due to the limitations of the article, we are only discussing some field robots for illustration purposes.

2. Materials and Methods

Today, many robots can be used in agricultural technology. In accordance with the aims of the article, only a few of them are presented for purposes of illustration. Beyond personal experience, we rely on a large number of – mainly electronic – literary resources. In the author's opinion, the robots to be presented can be a good guide for domestic farmers in their technological developments.

3. Results and Discussions

There are some benefits of using robots. The most significant of these are following:

- –The robots will be autonomous. While people will be able to focus their mind on more interesting and important tasks. Whether it'll be purveyance, removing weeds and pest, caring for crops, you won't have to be behind them to get the job done. Thanks to online databases and forecasts, combined with the data provided by external and internal sensors, they will have a complete understanding of the situation, far beyond what any human could. This will allow them to make informed decisions and obtain the optimal outcome.
- –As all of these robots will be powered on batteries and electric motors, they will also have a positive impact on the energy consumption and carbon footprint of the farms.
- –Some of them might even be perfectly independent thanks to solar panels on them. They'll be an important part of a greener future for mass-scale farming. Besides, this will also allow for a quieter exploitation. Thus it will also reduce the noise pollution generated by agriculture.
- –The robots will help optimize the yield of the farms far beyond what could humanly be possible. Maximizing the production while minimizing the costs in energy, water, time, Tractors relentlessly roaming the fields with drones surveying cattle day and night and rovers on a permanent weed-control duty. Watering hectares and hectares of lands using only the optimal amount of water for each square meter.
- –Farm employment is far from a riskless job. It often exposes workers to pesticides, long working hours in the heat and sun, and poor sanitary conditions among other direct health risks. There are many serious health hazards affecting farmworkers. For instance, the Organic Dust Toxic Syndrome, caused by grain and silage dust, is a common illness among farmers. Less known, the exposure to excessive noise produced by machines can permanently damage workers' hearing. Furthermore, most of the work is physical and outside. Thus increasing the risk of accidents caused by fatigue, difficult environment and weather, and aging tools. However, only some of these risks are being covered by employment and health insurances. By bringing robots to do these tasks, we will be reducing the risks on the human workers. Which will not only have a positive impact on their lives, but also on the people around them, and the society at large.
- –And obviously, as mentioned above, the more efficient the farming, the better we all are. Maximizing yield while reducing the environmental and societal costs can help us tackle the challenges of a growing population and the lack of efficiency of modern intensive farming. We can all agree that a healthier planet would be a very strong improvement in everybody's lives!

As with any technological revolution, many questions need to be answered. Due to the fact that these robots will be in an open environment and will probably be massive pieces of machinery. While it's for obvious security reasons (you don't want a pilotless combine to go on a road trip), it can create serious entry barriers to start-up trying to break into this field (Jpvalery, 2018).

The development of agricultural robots must follow different principles than industrial robots. The reason for this is that agricultural production differs significantly from that of industry. In the development of agricultural robots, so-called "agricultural features" should be taken into account. The most important of them are the following:

- –We work with living materials in agriculture. It follows that technological interventions require special sensitivity, unlike most industrial operations
- –In the context of the foregoing: technological operations can be carried out under strict time-limits in an optimal quality. These time limits are defined by "biologically-agro-technically optimal" time intervals for technological operations in crop production.
- –Agricultural production is influenced by many factors. Because of this, the technological operations are very different. In addition to soil conditions and meteorological conditions, a number of other factors influence the need to perform the same technological operation differently on different fields.
- –The quality of agricultural operations cannot always be assessed immediately (in real time). Consider, for example, sowing, fertilizing, or plant protection. The quality of these can only be judged well after work.
- –Agricultural work is usually carried out not in one place but in a fragmented manner. In this case, moving and transporting devices and materials between boards is a special task.

The following are some examples of the well-known robotic solutions for growing field crops. The examples are arbitrarily changed without logical considerations. The examples illustrate what kind of robotic solutions can be used in agricultural practice.

Case IH autonomous tractor

Case IH and CNH Industrial's Innovation Group based the cables autonomous concept on an existing Case IH Magnum tractor with reimagined styling. The vehicle was built for a fully interactive interface to allow for remote monitoring of pre-programmed operations. The on-board system automatically accounts for implement widths and plots the most efficient paths depending on the terrain, obstructions and other machines in use in the same field. The remote operator can supervise and adjust pathways via a desktop computer or portable tablet interface.

Figure 2. Case IH autonomous tractor
Source: (Racine, 2016)

Through the use of radar, lidar (light imaging, detection, and ranging) and on board video cameras, the vehicle can sense stationary or moving obstacles in its path and will stop on its own until the operator, notified by audio and visual alerts, assigns a new path. The vehicle will also stop immediately if GPS signal or position data is lost, or if the manual stop button is pushed. Machine tasks can also be modified in real time with via remote interface or automatic weather warnings (Racine, 2016).

"In many parts of the world, finding skilled labor during peak use seasons is a constant challenge for our customers,” said Case IH Brand President Andreas Klauser.“Whileweoffer auto-steering and telematics on our equipment today for remote management of farm machinery and employees, this autonomous tractor concept demonstrates how our customers and their employees could remotely monitor and control machines directly. This technology will offer our customers greater operational efficiencies for tasks such as tillage, planting, spraying and harvesting.” (Racine, 2016).

Rowbot

Minneapolis-based start-up company is trying to bring more automation into agriculture. It has invented a self-driving “rowbot” that’s basically a lightweight tank on wheels with sensors and a GPS system that can drive between row crops, dispensing nitrogen fertilizer or completing other tasks. “Rowbots" can fertilize crops more efficiently and precisely, and hopefully in the future, plant some seeds.

Normally a corn farmer will spray much of the nitrogen fertilizer at the time of planting, and side-dress the corn crop with additional nitrogen in mid-June before stalks grow too high.

The problem is that spring rains often wash away much of the nitrogen, which isn’t really needed the most until the plant is growing fastest in June and July. Even adding nitrogen in June can be tricky, said Cavender-Bares, because heavy equipment can cause ruts, and by July the cornstalks may be too high to allow spraying.

The idea is for a fleet of “rowbots” to drive through a field two or three times a summer when the corn is growing most rapidly, spraying fertilizer to cover four rows at a time in the places and amounts where it is needed. The robots can also be linked to systems that tell it how much fertilizer to apply to different parts of the field, thereby saving farmers time and money (Meersman, 2018).

Figure 3. Rowbot in action Source: (Rosen, 2014)

Small enough to easily travel between planted rows of corn, Rowbot reduces the amount of fertilizer farmers use by dispensing it at the right time in the right amounts. The timing for corn is critical because once corn plants get too tall to run a tractor through the field farmers may miss applying fertilizer when it can be most beneficial. But with Rowbot the plants are undisturbed because of its small form factor. And because it provides the nitrogen directly in what is referred to as “side dressing” it eliminates potential overfeeding and nitrogen runoff which leads to polluting of local ponds, rivers and lakes. Thanks to its adjustable width (1.4m to 2.1m) and the positioning of the adjustable sensor (1m to 1.8m), the robot can be used on a wide variety of crops, for example cereals, beets, market garden crops (Rosen, 2014).

BoniRob

Given the scale of farming today, treating weeds chemically is really the only practical way for humans to keep them under control, because you can use tractors or airplanes to cover large areas in a short amount of time. But all of those necessarily deadly (to weeds) chemicals then get on the plants we don't want to kill (because we want to eat them), as well as getting washed into the soil. The most organic and eco-friendly way of dealing with weeds is the old-fashioned way: physically removing them. "Physical removal" can mean pulling weeds out completely, but that involves both grasping the weed and doing something with it. A better solution is to just smash it way down into the ground, which is faster, easier, and something a robot can do excellently.

Figure 4. The BoniRob Source: (Ackerman, 2015)

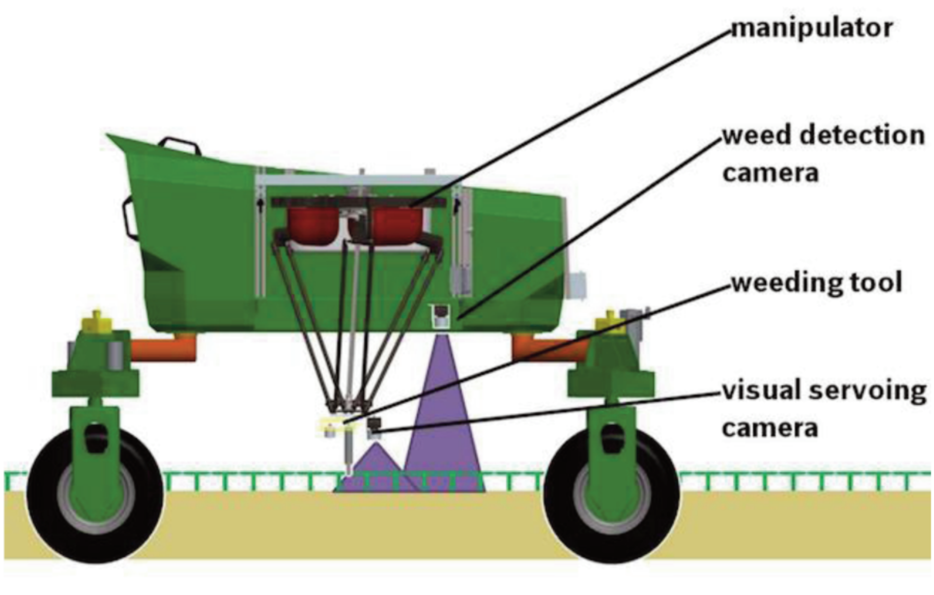

Figure 5. The main elments of BoniRob Source: (DIYI Team, 2015)

The stamping tool is 1 centimetre wide, and it drives weeds about 3 cm into the soil. It's designed to detect (through leaf shape) and destroy small weeds that have just sprouted, although for larger weeds, it can hammer them multiple times in a row with a cycle time of under 100 ms. Testing on a real carrot crop, which has carrots spaced about 2 cm apart and an average of 20 weeds per meter growing very close to the carrots themselves, the robot had no trouble at all. The maximum capability of the system is about 1.75 weeds per second at a speed of 3.7 cm/s and a weed density of 43 weeds per meter, but at lower weed densities, the speed can be cranked up to 9 cm/s.

BoniRob can navigate itself, adapting to many different field configurations. Its modular payload bay can handle up to 150 kilograms of stuff, and an onboard generator lets it run autonomously for 24 hours without needing to refuel (Ackerman, 2015)

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Ecorobotix

Targeted application of herbicide by the first ever completely autonomous robot for the ecological and economical weeding of row crops, meadows and intercropping cultures. The robot works without being controlled by a human operator. It covers the ground just by getting its bearings and positioning itself with the help of its camera and GPS. Its system of vision enables it to follow crop rows, and to detect the presence and position of weeds in and between the rows. Two robotic arms then apply a micro dose of herbicide, systematically targeting the weeds that have been detected. In bare fields or meadows the robot positions itself precisely thanks to its GPS RTK.

Figure 6. Ecorobotix with photovoltaic panels Source: (Ecorobotix, 2019)

Reliance on solar power makes the robot completely autonomous in terms of energy, even when the weather is overcast. As it adapts its speed to the concentration of weeds, it is most suitable for use in fields where the level of concentration is low to moderate, in order to cover the ground at a reasonable speed. We recommend using the machine after an initial standard application of herbicide, in order to replace subsequent applications and thus save an important amount of herbicide (more than 20x less than with a standard treatment). The machine can be completely controlled and configured by means of a Smartphone app (Ecorobotix, 2019).

SwarmFarm Robotics Philosophy

SwarmFarm never set out to automate agriculture or save labour – rather, their philosophy is to create new farming systems that are not possible on the back of a tractor.

The company was founded by farmers who have spent 20 years farming with modern technology that has seen such equipment as tractors, sprayers and planting machinery become increasingly larger and more complex. The farmers came up with the idea that multiples of small, lightweight robots working together in a 'swarm' would be the driver of new AgTech into farming.

A world-first robot designed to work with others to spray crops in swarms, and ultimately help to fill the rural labour shortage, SwarmFarm Robotics develops robots for farmers using advanced technologies to create new field practices and farming methods that simply aren't possible through traditional farming methods. For farmers, this means increased efficiency, higher yields and a lower impact on the environment. Swarm robots – small, simple and inexpensive – are poised to reverse the trend in agriculture towards ever bigger machines. These little workers behave autonomously, interacting with each other and the environment to achieve the desired outcome. The benefits include less damage to soil structure and greater precision for weeding and harvesting.

Figure 7. 4WD SwarmFarm robots carrying WeedSeeker technology cover the paddock spraying only living weeds Source: (Bloomer, 2017)

Figure 8. A robotic weeder leaves lettuce crops unharmed
Source: (FarmWise,2019)

FarmWise vegetable weeder

Silicon Valley start-up FarmWise[1] was founded in 2016 to create adaptable, robotic machinery that can help farmers improve productivity, crop health, and yields—thereby making agriculture more efficient and profitable. Also important to FarmWise is leveraging artificial intelligence technology to reduce the amount of herbicides and weed-killing chemicals farmers use. In the future, FarmWise would like to expand its artificial intelligence platform to automate other agricultural tasks, such as watering fields and harvesting crops.

The FarmWise machine drives over rows, detects weeds in the soil, cuts their roots and tosses them out of the row with an action mimicking that of a person using a hoe. Currently, one of the machines is operated in part by an on-field operator and a "teleoperation service" from a central centre. But the company hopes its machines will reach a higher level of autonomy by early 2019 so that one on-field operator could supervise more than one of the machines.

FarmWise's robots use a perception system powered by deep learning to capture and analyse plant images in real-time through the latest and finest available embedded computers.

Once the images are processed, the machines know where the weeds are and mechanically act on each plant: removing weeds around them if encountered without using a single drop of herbicide.

Conclusions

The main conclusion of this article is that farmers can already choose from several robotic options for improving agricultural technology and some of them already available. Rising costs for farm labor and expected falling costs for robotic technology also will provide further catalysts for the shift.

Although robots are about tomorrow, we must prepare for them today. Two interesting questions that remain are: Are the robots ready for farmers? Are farmers ready for the robots? These questions also need to be answered in Hungary. Not to mention that there are no universal solutions. There are no two identical farms, but there are two identical robots. Therefore, every farmer needs to think about whether he is taking advantage of robots or staying with conventional farming.

In this paper, we do not discuss the economic issues of using robots. A detailed examination of this topic is a task for the future.

[1] https://farmwise.io/

References

[1] Ackerman, E. (2015). Bosch ' s Giant Robot Can Punch Weeds to Death. IEEE Spectrum, 0–1. Retrieved from https://spectrum.ieee.org/automaton/robotics/industrial-robots/bosch-deepfield-robotics-weed-control

[2.] Alexander, D. (2018): 9 Robots That Are Invading the Agriculture Industry https://interestingengineering.com/9-robots-that-are-invading-the-agriculture-industry https://blog.robotiq.com/top-10-robotic-applications-in-the-agricultural-industry

[3.] Artificial Intelligence Revenue to Reach $36.8 Billion Worldwide by 2025. https://www.tractica.com/newsroom/press-releases/artificial-intelligence-revenue-to-reach-36-8-billion-worldwide-by-2025/

[4.] Bloomer, D. (2017). In Search of Farm Robots: Ch 1 | LandWISE. Retrieved October 17, 2019, from http://www.landwise.org.nz/precision-agriculture/in-search-of-farm-robots-ch-1/

[5.] Claver, H. (2019). Agricultural robot shipments to increase sharply - FutureFarming. Retrieved September 13, 2019, from https://www.futurefarming.com/Machinery/Articles/2019/7/Agricultural-robot-shipments-to-increase-sharply-455361E/?intcmp=related-content&intcmp=related-content

[6.] Danielsca, J. (2016). Future of farming: driverless tractors, ag robots. Retrieved October 17, 2019, from https://www.cnbc.com/2016/09/16/future-of-farming-driverless-tractors-ag-robots.html

[7.] DIYI Team. (2015). BoniRob – Vision-Based High-Speed Manipulation for Robotic Ultra-Precise Weed Control – Do It Yourself India Magazine. Retrieved October 17, 2019, from https://diyin.wordpress.com/2015/12/15/bonirob-vision-based-high-speed-manipulation-for-robotic-ultra-precise-weed-control/

[8.] Ecorobotix. (n.d.). Technology fir environment: an innovative, autonomous and economical machine. Retrieved from https://www.ecorobotix.com/wp-content/uploads/2017/02/ECOX_FlyerPres18-EN-1_RVB-1.pdf

[9.] Ford, M. (2015) Rise of the robots. Basic Books, New York. http://digamo.free.fr/marford15.pdf

[10.] Jpvalery. (2018). Is the Future of Agriculture in Robotics? Retrieved September 10, 2019, from https://www.robotshop.com/community/blog/show/is-the-future-of-agriculture-in-robotics

[11.] Lowenberg-DeBoer, J. et al. (2019): Economics of robots and automation in field crop production.

Vol.:(0123456789) Precision Agriculturehttps://doi.org/10.1007/s11119-019-09667-5
https://link.springer.com/content/pdf/10.1007%2Fs11119-019-09667-5.pdf

[12.] Meersman, T. (2018). Rowbots Systems help bring the future to farming - StarTribune.com. Retrieved September 7, 2019, from http://www.startribune.com/rowbots-systems-help-bring-the-future-to-farming/478998163/

[13.] Oliver, J. (2019): Future of agricultural mechanisation seems promising
https://www.futurefarming.com/Machinery/Articles/2019/10/Future-of-agricultural-mechanisation-seems-promising-485287E/

[14.] Racine, W. (2018). CNH Industrial Newsroom : Case IH Premieres Concept Vehicle at Farm Progress Show. Retrieved June 14, 2018, from https://media.cnhindustrial.com/EUROPE/CASE-IH/case-ih-premieres-concept-vehicle-at-farm-progress-show/s/3a2abb2b-d8a5-4b46-90bd-e788052f7be3

[15] Roldán, JJ. et al. (2016): Robots in Agriculture: State of Art and Practical Experiences DOI: 10.5772/intechopen.69874
https://www.intechopen.com/books/service-robots/robots-in-agriculture-state-of-art-and-practical-experiences

[16.] Rosen, L. (2014). Rowbot Robot Tends to Farmers' Fields. Retrieved August 21, 2019, from https://hplusmagazine.com/2014/09/22/rowbot-robot-tends-farmers-fields/

[17.] Sennaar K. (2019): Agricultural Robots – Present and Future Applications
https://emerj.com/ai-sector-overviews/agricultural-robots-present-future-applications/

[18.] Tholhuijsen, L. (2017): How farmers will benefit from smart machinery?
https://www.futurefarming.com/Machinery/Articles/2017/4/How-farmers-will-benefit-from-smart-machinery-459WP/

[19.] Tholhuijsen, L. (2019): Self-learning algorithm gets better at weed detection.
https://www.futurefarming.com/Machinery/Articles/2019/10/Self-learning-algorithm-gets-better-at-weed-detection-487567E/

[20.] Yaghoubi, S. (2013): Autonomous Robotsfor Agricultural Tasks and Farm Assignment and Future Trends in Agro Robots.International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS Vol:13 No:03
https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.418.3615&rep=rep1&type=pdf

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