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Short food supply chains versus meal planning using artificial intelligence

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Abstract

A healthy diet, organic food products, promoting local food products are important issues for modern man. The consumer is looking for healthy and valuable food products directly from the farmer (producer). Therefore, the issue of shaping short food supply chains from local farmers is gaining importance. The consumer uses applications to search for recipes and plan meals (breakfast, lunch, dinner) and multifunctional devices to prepare them. Such repetitive activities can be personalized, automated through the use of artificial intelligence, which will significantly facilitate the consumer's activity in this area. The aim of the article is to define an artificial intelligence module for planning meals using local food products supplied directly by farmers. The important elements of the module are: short food supply chains from local farmers, planning and preparing daily meals and identifying relationships in the area of artificial intelligence.

Keywords: *short food supply chains, farmer (producer), AI – artificial intelligence*

1. Introduction

The organization of short food supply chains aims to minimize the distance that food travels from the farmer (producer) to the consumer. This action leads to the strengthening of local food systems, which coincides with the

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"from farm to fork" strategy developed by the European Commission. In terms of these actions, short food supply chains are those where there are no intermediaries between the farmer and the consumer, and in special cases, a maximum of one intermediary is allowed. In this way, consumers' access to fresh food products is improved and the profit for the farmer as the producer of this food is maximized. Eliminating the intermediate link in distribution also reduces greenhouse gas emissions in the entire food supply chain to consumers.

Thus, the organization and functioning of short food supply chains is beneficial for the farmer, consumers and the natural environment. It should be emphasized that consumers themselves are increasingly looking for and are interested in buying food of reliable origin from local farmers, suppliers or processors. Farmers themselves are also taking action to shorten the supply chain of products produced on farms by avoiding intermediaries in supply chains. The form of sale of agricultural products proposed as part of these activities generates a lower price of products for the final consumer. The expectations of the modern consumer are a generator for the creation of local food networks, including farmers' markets and direct sales.

Direct sales are the simplest and most direct type of relationships, in which the consumer buys food products directly from the producer. This sale can be carried out directly on the farm, at the market, via the Internet or through delivery directly to the consumer. In the case of direct sales, personal interactions are an important element, which build credibility and trust between the farmer and the consumer. Based on such trust, consumers choose the option of delivering food products directly to their home, and the task of the local farmer is to organize the delivery of their products directly to the recipients. An important element in this activity is the delivery of fresh and on-time products, which is a challenge for the local producer. A helpful tool in this section is artificial intelligence, which will support the process of organizing and delivering food directly to the home. The purpose of this article is to present a model of an artificial intelligence module for planning meals using local food products delivered directly by farmers.

2. Literature Review

The literature analysis addressed two important aspects, i.e. (1) the use of artificial intelligence in short food supply chains, (2) the analysis of short food supply chains. Artificial intelligence in food supply chains is implemented in several areas. In this set, we distinguish, among others, the use of AI in information management in a sustainable food supply chain. Such an approach was proposed in the article [1], which identified key factors influencing the effectiveness of AI application in sustainable supply chain management. In the set of these factors, data quality, system interoperability and the need for adaptive algorithms were indicated. New principles for AI implementation were also proposed to improve the sustainability of practices in food supply chains. The authors pointed out the lack of comprehensive analyses regarding the potential of AI tools in information management in sustainable food supply chains. In turn, the publication [2] presented research on the impact of AI and Big Data on forecasting disruptions in food supply chains in the aspect of counteracting food shortages. Machine learning and blockchain were indicated as possibilities that can support the process of managing disruptions in food supply chains. The authors of the publication [3] emphasize that keeping up with the rapidly developing economy requires continuous transformation. In the field of the food supply chain, such a transformation can only be carried out by discovering new horizons and innovative solutions that can be implemented at the stage of organizing and implementing food supplies. Based on the conducted research, it was emphasized that there is a significant increase in the number of publications and studies related to the implementation of artificial intelligence in the food supply chain. The leaders in this area are Great Britain, India, China and the USA, which emphasizes that the implementation of AI in the field of shaping food supply chains is an important element of the transformation of knowledge to food logistics. The authors of the publications [4] and [5] also conducted research on the application of artificial intelligence in food supply chains. Based on literature research of 303 publications, the most popular AI techniques were identified and their application in various areas of planning, organizing, shaping and implementing food supply chains was presented. Additionally, the publication [5] presents AI tools used in food supply chains in terms of the Industry 5.0 concept.

Emphasizing the need to implement artificial intelligence in the field of planning, organizing, shaping short food supply chains is an important element of the functioning and development of these chains. However, the implementation of AI tools requires a process of analyzing the functioning or implemented short food supply chains in selected areas. In the article [6], the analysis of short food supply chains was related to the impact of last mile logistics on consumer intentions when purchasing organic food via the Internet. Issues related to trust, prices, supply chain were addressed, and the aim of the study was to see how sustainable supply options can improve consumers' perception of the long-term profitability of organic food. The study showed that in the interests of the environment, last mile logistics and website response time are key factors determining consumers' willingness to pay for organic food. In turn, the article [7] analyzed short food supply chains from an economic perspective and their impact on the environment. It was indicated that short food supply chains face problems that inhibit the development of these chains in the economy. The link between short food supply chains and the concept of Industry 5.0 was also emphasized. Article [8] is an analysis of the consistency and divergence between the choices of farmers and consumers depending on different types of agricultural product markets. The research results showed that a direct relationship with farmers is a key factor for consumers. In turn, farmers (producers) value proximity only when it does not generate additional logistical burdens. Therefore, delivery time and product availability are crucial, and a longer delivery time has a more negative impact on the consumer than on the farmer. In article [9], the authors presented the results of research carried out as part of the agroBRIDGES project, which was carried out in Lithuania, Latvia and Poland. The aim of the study was to determine what steps should be taken in the design, planning, implementation and evaluation of the organization of events promoting short food supply chains. An example event was organized in March 2023 and artificial intelligence tools were used to manage the event. Article [10] presents the results of research on the analysis of the functioning of short food supply chains implemented in urban areas, with a particular focus on urban food producers. The research, which included an analysis of the urban area, in-depth interviews with technical experts, and an analysis of the functioning of the urban food supply chain, was conducted in Breda (The Netherlands). The article [11] presents the research results relating to the analysis of the level of awareness, use and willingness to pay for products distributed within short food supply chains and the analysis of the problems faced by producers using short supply chains.

3. Artificial intelligence module in meal planning

For the purposes of the study, the following assumptions were made:

(1) A meal is a set of foods eaten according to a specific time of day. Meals such as breakfast, lunch and dinner were included in the study.
(2) Local food products are used at the meal preparation stage.
(3) Food products are delivered by local farmers or producers directly to the consumer.
(4) The transport process is carried out using vehicles.
(5) Implementing artificial intelligence tools at the meal planning stage.

The artificial intelligence module in meal planning using local food products supplied directly by farmers can be presented as an ordered trio of elements, i.e.:

$$\boldsymbol{AIMP} = \langle \boldsymbol{SSFSC}, \boldsymbol{MS}, \boldsymbol{AI} \rangle, \tag{1}$$

where:

$\boldsymbol{AIMP}$ – AI meal planning module,
$\boldsymbol{SSFSC}$ – short food supply chain system,
$\boldsymbol{MS}$ – meal structure,
$\boldsymbol{AI}$ – AI relations.

The systemic approach to the topic of short food supply chains in the field of meal planning with the use of artificial intelligence refers to the issue of planning food supplies in urban areas in the environmental perspective [12], the implementation of the transport service itself, taking into account various means of transport [13] and the issue of ecological distribution of loads in cities [14], including the promotion of pro-ecological behaviors in the field of logistics [15]. At this stage, the use of digital twins [16], intelligent logistics [17], the assumptions of the Industry 4.0 concept [18] and genetic algorithms [19] are also important at the stage of planning, organizing, implementing and evaluating short food supply chains. The short food supply chain system has been defined taking into account the presented factors:

$$\boldsymbol{SSFSC} = \langle \boldsymbol{LFP}, \boldsymbol{LF}, \boldsymbol{SV}, \boldsymbol{SL}, \boldsymbol{SC} \rangle, \tag{2}$$

where:

$\boldsymbol{LFP}$ – set of local food products,

$$\boldsymbol{LFP} = \{lfp_1, lfp_2, lfp_3, \dots, lfp_i\}, \tag{3}$$

$\boldsymbol{LF}$ – set of local farmers,

$$\boldsymbol{LF} = \{lf_1, lf_2, lf_3, \dots, lf_j\}, \tag{4}$$

$\boldsymbol{SV}$ – set of vehicles,

$$\boldsymbol{SV} = \{sv_1, sv_2, sv_3, \dots, sv_k\}, \tag{5}$$

$\boldsymbol{SL}$ – set of localities,

$$\boldsymbol{SL} = \{sl_1, sl_2, sl_3, \dots, sl_l\}, \tag{6}$$

$\boldsymbol{SC}$ – set of consumer,

$$\boldsymbol{SC} = \{sc_1, sc_2, sc_3, \dots, sc_n\}. \tag{7}$$

The process of preparing meals is based on the concept of a meal, which takes into account the consumer's experience and recipes. Consumer preferences are also an important element of the process. Based on the adopted assumptions, the structure of the meal was defined:

$$\boldsymbol{MS} = \langle \boldsymbol{MP}, \boldsymbol{FPC}, \boldsymbol{FP}, \boldsymbol{CP}, \boldsymbol{MBP} \rangle, \tag{8}$$

where:

$\boldsymbol{SR}$ – set of recipes,

$$\boldsymbol{SR} = \{sr_1, sr_2, sr_3, \dots, sr_m\}, \tag{9}$$

$\boldsymbol{MP}$ – set of meal proposals,

$$\boldsymbol{MP} = \{mp_1, mp_2, mp_3, \dots, mp_p\}, \tag{10}$$

$\boldsymbol{FPC}$ – set of food products at the consumer,

$$\boldsymbol{FPC} = \{fpc_1, fpc_2, fpc_3, \dots, fpc_r\}, \tag{11}$$

$\boldsymbol{FP}$ – set of food products,

$$\boldsymbol{FP} = \boldsymbol{LFP} \cup \boldsymbol{FPC}, \tag{12}$$

$\boldsymbol{CP}$ – set of consumer preferences,

$$\boldsymbol{CP} = \{cp_1, cp_2, cp_3, \dots, cp_q\}, \tag{13}$$

$\boldsymbol{MBP}$ – set of meals to be prepared,

$$\boldsymbol{MBP} = \{mbp_1, mbp_2, mbp_3, \dots, mbp_o\}. \tag{14}$$

Artificial intelligence tools in the process of preparing meals from local food products can be used in several important areas:

- AI generates recipes and optimizes the meal plan in terms of the number of calories, diet used, seasonality of food products, etc.,
- AI optimizes meals taking into account hardware limitations and communicates directly with devices, e.g. communication between artificial intelligence tools and Thermomix,
- AI prepares a list of products to be purchased based on consumer preferences, cooking style, availability of local products,

- AI analyzes the purchasing history of consumers,
- AI as a communicator in the consumer-farmer and farmer-consumer relationship,
- AI optimizes delivery routes from farmer to consumer,
- AI dynamically consolidates orders from many farmers to a single collection point for local food products,
- AI as an advisor at the stage of selecting food products from a given farmer.

In the defined $\boldsymbol{AIMP}$ module, an important activity is to determine the relations $\boldsymbol{AI}$ in the process of applying artificial intelligence at the stage of planning meals from local products directly supplied by farmers. It is based on these relations that the artificial intelligence tools used by the consumer will be able to plan a personalized meal that takes into account local food products. The relations are identified based on the algorithm for planning meals from local food products supplied directly by the farmer to the consumer (Fig. 1).

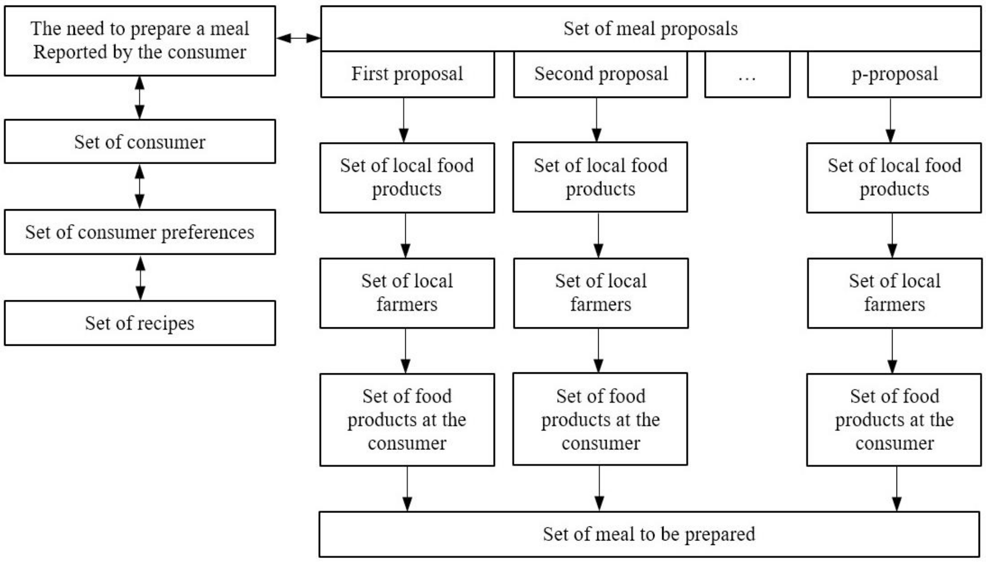

Fig. 1. Algorithm for planning meals from local food products supplied directly by the farmer to the consumer

4. AI meal planning module – example

The research process involved describing the elements of an artificial intelligence module in meal planning using local food products supplied directly by farmers $\boldsymbol{AIMP}$.

Description of element one - short food supply chain system $\boldsymbol{SSFSC}$. Aim: to identify the constituent elements of the collections $\boldsymbol{LFP}, \boldsymbol{LF}, \boldsymbol{SV}, \boldsymbol{SL}, \boldsymbol{SC}$:

$\boldsymbol{LFP}$ – set of local food products, $\boldsymbol{LFP} = \{lfp_1, lfp_2, lfp_3, lfp_4, lfp_5\} \equiv \{\text{potatoes, carrots, onions, lettuce, eggs}\}$,
$\boldsymbol{LF}$ – set of local farmers, $\boldsymbol{LF} = \{lf_1, lf_2, lf_3, lf_4, lf_5\} \equiv \{\text{Barwice, Resko, Gryfice, Karlino, Rymań}\}$,

$\boldsymbol{SV}$ – set of vehicles,

$\boldsymbol{SV} = \{sv_1, sv_2, sv_3, sv_4, sv_5\} \equiv \{\text{Fiat Ducato, Mercedes Sprinter, Renault Master, Fiat Combo, Ford Transit}\}$,

$\boldsymbol{SL}$ – set of localities, $\boldsymbol{SL} = \{sl_1, sl_2, sl_3, sl_4, sl_5\} \equiv \{\text{Szczecinek, Nowogard, Kołobrzeg, Koszalin, Białogard}\}$,

$\boldsymbol{SC}$ – set of consumer, $\boldsymbol{SC} = \{sc_1, sc_2, sc_3, sc_4, sc_5\} \equiv \{\text{family of 3, family of 2, family of 3, family of 3, family of 4}\}$.

Description of element two - meal structure $\boldsymbol{MS}$. Aim: to identify the components of the harvest:

$\boldsymbol{MP}$ – set of meal proposals,

$\boldsymbol{MP} = \{mp_1, mp_2, mp_3, mp_4, mp_5\} \equiv \{\text{potatoes with carrots, hard − boiled eggs with lettuce, potato salad, carrots cooked with potatoes, vegetable salad − potatoes, onion, carrot, egg}\}$

$\boldsymbol{FPC}$ – set of food products at the consumer,

$\boldsymbol{FPC} = \{fpc_1, fpc_2, fpc_3, fpc_4, fpc_5\} \equiv \{no\ products, two\ eggs, no\ products, one\ carrot, onion\}$.

$\boldsymbol{CP}$ – set of consumer preferences,

$\boldsymbol{CP} = \{cp_1, cp_2, cp_3, cp_4, cp_5\} \equiv \{\text{egg allergy, vegetarian diet, no allergies, vegetarian, no preference}\}$.

Description of element third - AI relations $\boldsymbol{AI}$. Aim: to identify of relations:

- relation of the attribution of food products to the farmer (Table 1): $\alpha: \boldsymbol{LFP} \times \boldsymbol{LF} \longrightarrow \{0,1\}$,
  while the size $\alpha(lfp_i, lf_j) = 1$, when the product lfp_i has a farmer lf_j, otherwise $\alpha(lfp_i, lf_j) = 0$,

Table 1. Relation of the attribution of food products to the farmer.

set of local food products	set of local farmers				
	$lf_1 = Barwice$	$lf_2 = Resko$	$lf_3 = Gryfice$	$lf_4 = Karlino$	$lf_5 = Rymań$
lfp_1 = potatoes	0	1	1	1	0
lfp_2 = carrots	1	0	1	0	1
lfp_3 = onions	1	0	1	1	0
lfp_4 = lettuce	1	1	0	1	0
lfp_5 = eggs	1	1	1	1	1

- relation of vehicles to the farmer (Table 2): $\beta: \boldsymbol{SV} \times \boldsymbol{LF} \longrightarrow \{0,1\}$,
  while the size $\beta(sv_k, lf_j) = 1$, when the vehicle sv_k has a farmer lf_j, otherwise $\beta(sv_k, lf_j) = 0$,

Table 2. Relation of vehicles to the farmer.

set of local food products	set of local farmers				
	$lf_1 = Barwice$	$lf_2 = Resko$	$lf_3 = Gryfice$	$lf_4 = Karlino$	$lf_5 = Rymań$
sv_1 = Fiat Ducato	1	0	0	0	0
sv_2 = Mercedes Sprinter	0	0	1	0	0
sv_3 = Renault Master	0	1	0	0	0
sv_4 = Fiat Combo	0	0	0	0	1
sv_5 = Ford Transit	0	0	0	1	0

- relation between consumer and preference (Table 3): $\delta: \boldsymbol{SC} \times \boldsymbol{CP} \longrightarrow \{0,1\}$,
  while the size $\delta(sc_n, cp_q) = 1$, when the consumer sc_n has preferences cp_q, otherwise $\delta(sc_n, cp_q) = 0$,

Table 3. Relation between consumer and preference.

set of consumer preferences	set of consumer				
	sc_1 = family of 3	sc_2 = family of 2	sc_3 = family of 3	sc_4 = family of 3	sc_5 = family of 4
cp_1 = egg allergy	1	0	0	1	0
cp_2 = vegetarian diet	1	0	1	1	1
cp_3 = no allergies	0	1	1	0	0
cp_4 = vegetarian	1	0	1	1	1
cp_5 = no preference	0	1	0	0	0

- relation between consumer and food products (Table 4): $\varepsilon: \boldsymbol{FPC} \times \boldsymbol{SC} \longrightarrow \{0,1\}$,
  while the size $\varepsilon(fpc_r, sc_n) = 1$, when the product fpc_r has a consumer sc_n, otherwise $\varepsilon(fpc_r, sc_n) = 0$.

Table 4. Relation between consumer and preference.

set of consumer preferences	set of consumer sc_1 = family of 3	sc_2 = family of 2	sc_3 = family of 3	sc_4 = family of 3	sc_5 = family of 4
$fpc_1 = no\ products$	0	0	0	1	0
$fpc_2 = two\ eggs$	1	0	0	1	0
$fpc_3 = no\ products$	1	1	0	1	0
$fpc_4 = one\ carrot$	1	1	1	1	1
$fpc_5 = onion$	0	1	0	0	1

- relation of the farmer to the locality (Table 5): $\gamma: \boldsymbol{LF} \times \boldsymbol{SL} \longrightarrow \{0,1\}$,

  while the size $\gamma(lf_j, sl_l) = 1$, when the farmer lf_j is from the location sl_l, otherwise $\gamma(lf_j, sl_l) = 0$.

Table 5. Relation of the farmer to the locality.

set of consumer preferences	sl_1 = Szczecinek	sl_2 = Nowogard	set of consumer sl_3 = Kołobrzeg	sl_4 = Koszalin	sl_5 = Białogard
$lf_1 = Barwice$	1	0	0	1	1
$lf_2 = Resko$	0	1	0	0	1
$lf_3 = Gryfice$	0	1	1	0	1
lf_4 = Karlino	1	0	1	1	1
lf_5 = Rymań	0	1	1	0	1

5. Conclusion

Short supply chains and meal planning using artificial intelligence are research aimed at developing tools supporting the meal planning process. The modern consumer makes conscious choices in the selection of food products as components of the meals consumed. They consciously choose food products produced by local farmers or producers. They emphasize their nutritional, health-promoting and pro-ecological values, and the elimination of the intermediary link contributes to lowering the price of food products and reducing the number of transports. Reducing the number of transports means less pollution, which has a beneficial effect on the living environment of the consumer planning meals. We identify such actions as pro-health and pro-ecological, but to achieve them, it is necessary to skilfully plan the process of preparing meals in correlation with the planning of short food supply chains.

Taking into account the analysed approach to food selection and meal planning, research was conducted to identify an artificial intelligence module in meal planning using local food products supplied directly by farmers. The proposed module specified, among others, short food supply chains, meal structure and the artificial intelligence component in meal planning. Individual elements of the module were defined and the relationships between the module elements were defined in the area of artificial intelligence. In order to verify the proposed module, experimental studies were conducted. It should be noted that these are initial studies that will be continued.

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References

[1] Alok Yadav, Rajiv Kumar Garg and Anish Sachdeva (2024) “Artificial intelligence applications for information management in sustainable supply chain management: A systematic review and future research agenda.” *International Journal of Information Management Data Insights* **4** (**2**): 100292, https://doi.org/10.1016/j.jjimei.2024.100292.

[2] Phemelo Tamasiga, El houssin Ouassou, Helen Onyeaka, Malebogo Bakwena, Ari Happonen and Malesela Molala (2023) "Forecasting disruptions in global food value chains to tackle food insecurity: The role of AI and big data analytics – A bibliometric and scientometric analysis". *Journal of Agriculture and Food Research* **14**: 100819, https://doi.org/10.1016/j.jafr.2023.100819.

[3] Ibtissam Zejjari and Issam Benhayoun (2024) "The use of artificial intelligence to advance sustainable supply chain: retrospective and future avenues explored through bibliometric analysis." *Discover Sustainability* **5** (**174**), https://doi.org/10.1007/s43621-024-00364-6.

[4] Sourabh Bhattacharya, Kannan Govindan, Surajit Ghosh Dastidar and Preeti Sharma (2024) "Applications of artificial intelligence in closed-loop supply chains: Systematic literature review and future research agenda." *Transportation Research Part E: Logistics and Transportation Review,* **184**: 103455, https://doi.org/10.1016/j.tre.2024.103455.

[5] Justyna Patalas-Maliszewska, Małgorzata Szmołda and Hanna Łosyk (2024) "Integrating Artificial Intelligence into the Supply Chain in Order to Enhance Sustainable Production – A Systematic Literature Review." *Sustainability* **16** (**16**): 7110, https://doi.org/10.3390/su16167110.

[6] Kumar Vikas, Sindhwani Rahul, Zhang Justin Zuopeng and Gaur Jighyasu (2025) "Optimizing short food supply chains through understanding consumer preferences for organic foods via e-commerce platforms and last-mile logistics." *British Foo Journal* **127** (**5**): 1788-1809, DOI: 10.1108/BFJ-05-2024-0507.

[7] Kumar Vimal, Verma Pratima, Shah Bhavin and Kumar Vikas (2025) "Redesigning short food supply chains for sustainable livelihoods and economies worldwide: a review of contributions from the British Food Journal" *British Food Journal* **127** (**5**): 1848-1874, DOI: 10.1108/BFJ-05-2024-0556.

[8] Horvath Camille, Koning Martin, Raton Gwenaelle and Combes Francois (2024) "Short food supply chains: The influence of outlet and accessibility on farmer and consumer preferences. Two discrete choice experiments." *Food Policy* **129**: 102763, DOI: 10.1016/j.foodpol.2024.102763.

[9] Oleksiuk Adam and Rull Quesada Katarzyna (2025) „ Virtual Collaboration Through Online Events as a Manifestation of Dynamic Marketing Capabilities in Developing Short Food Supply Chains: Experiences from Lithuania, Latvia and Poland." *Contributions to Management Science* **F252**: 321-345, DOI: 10.1007/978-3-031-81233-0_16.

[10] Zhu Yuheng and Tsoulfas Giannis T. (2024) "Fostering urban short food supply chains: evidence from the Netherlands." *E3S Web of Conferences* **585**: 11003, DOI: 10.1051/e3sconf/202458511003.

[11] Aguado-Gragera Clementina, Sama-Berrocal Celia, Mesías Francisco J., Crespo-Cebada Eva and Diaz-Caro Carlos (2024) "Challenges and opportunities of short food supply chains in Spain: A stakeholder participatory study." *Journal of Agriculture and Food Research* **18**: 101276, DOI: 10.1016/j.jafr.2024.101276.

[12] Lasota Michał, Zabielska Aleksandra, Jacyna Marianna, Gołębiewski Piotr, Żochowska Renata and Wasiak Mariusz (2024) "Method for Delivery Planning in Urban Areas with Environmental Aspects". *Sustainability* **16** (**4**): 1571, DOI: 10.3390/su16041571.

[13] Jacyna Marianna, Gołębiewski Piotr and Szczepański Emilian (2015) "City transport service model taking into account different means of transport". *Transport Means – Proceedings of the International Conference* **2015**: 160-168, 117726.

[14] Jacyna Marianna and Szczepański Emilian (2013) "Holistic approach to the ecological cargo distribution in urban areas with use of multi-modal transport. " *WIT Transactions on the Built Environment* **130**: 53-65, 97104, DOI: 10.2495/UT130051.

[15] Reshetnikova Olga, Dyczkowska Joanna, Olkiewicz Marcin and Paszkowska Dagmara (2021) "Promoting Pro-ecological Behavior with Logistics Operators in Poland and Ukraine." *Rocznik Ochrona Srodowiska* **23**: 642-654, DOI: 10.54740/ros.2021.045.

[16] Ubowska Agnieszka and Królikowski Tomasz (2024) "New technologies in the educational process on the example of FlexSim software – the digital twin solution. " *Procedia Computer Science* **246**: 4751-4758, 150888, DOI: 10.1016/j.procs.2024.09.340.

[17] Grunt Maciej, Błażejewski Andrzej, Pecolt Sebastian and Krolikowski Tomasz (2022) "BelBuk System – Smart Logistics for Sustainable City Development in Terms of the Deficit of a Chemical Fertilizers. " *Energies* **15** (**13**), 4591, DOI: 10.3390/en15134591.

[18] Kostrzewski Mariusz, Sompolski Kacper and Krolikowski Tomasz (2022) "How profitable i sit to apply Industry 4.0 solutions in blister factories. " *Procedia Computer Science* **207**: 3275-3283, 184401, DOI: 10.1016/j.procs.2022.09.386.

[19] Wozniak Waldemar, Stryjski Roman, Mielniczuk Janusz and Wojnarowski Tomasz (2015) "Concept for the application of genetic algorithms in the management of transport offers in relations to homogenous cargo transport." *Proceedings of the 26th International Business Information Management Association Conference - Innovation Management and Sustainable Economic Competitive Advantage: From Regional Development to Global Growth, IBIMA 2015*, 2329 – 2339, 121845.