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ENHANCEMENT OF THE MARKET ATTRACTIVENESS AND SUCCESS OF STARTUPS ON THE CIRCULAR ECONOMY AND SUSTAINABILITY PRINCIPLES

Purpose. *The purpose of this study is to develop the methodology and the framework for assessing the level of environmental friendliness of startups in the agricultural sector and their compliance with the circular economy and sustainable development principles using T. L. Saaty's analytic hierarchy process (AHP) to enhance their market attractiveness and success.*

Methodology / approach. *The author's methodology was created based on the AHP approach which is a comprehensive decision-making framework used to divide complex problems into a clear hierarchical structure. This approach enables the evaluation and comparison of multiple criteria facilitating informed decision-making. Calculations have been made in the RStudio.*

Results. *The authors' methodology and the framework for assessing the startups' environmental friendliness and compliance with the circular economy and sustainability principles were created. The unique program was developed and executed in the RStudio using R programming language. The created methodology is based on the hierarchical criteria system consisting of three main criteria – "Compliance with the EU environmental standards and sustainability principles promotion", "Compliance of the startups' business model to the circular economy and sustainability principles", and "Resource usage rationality" with the corresponding sub-criteria. It was determined that the first criterion has the highest impact on the startup eco-friendliness with a weight of 49.2 %, the second one has a weight of 28.7 %, and the third one – 22.1 %. The system of requirements for the AHP experts was also developed.*

Originality / scientific novelty. *It was substantiated that the application of the original authors' methodology and program enhance the startups' market attractiveness and success by strengthening their brand image. The proposed solution facilitates the implementation of the circular economy and sustainability principles for innovative businesses, leading to improvements in environmental protection and waste management.*

Practical value / implications. *The methodology has been tested on the example of the authors' bioenergy startup for producing eco-friendly biofuels using agricultural and food industry wastes and minimising the usage of toxic substances. Based on the experts' opinion and using the authors' unique program it was calculated that the startup complies with the circular economy and sustainability principles and has an eco-friendly brand image with a 78.6 % probability.*

Key words: *agricultural sector, startup management and marketing, marketing research, environmental protection, R programming, web design, waste management.*

1. INTRODUCTION

The transformations taking place all over the world require new approaches to solving the accumulated socio-economic and environmental problems. The concept of circular economy (also known as closed-loop economy) is coming to the forefront

actively replacing the so-called traditional, linear model of development and economy [1]. In particular, the European Union (EU) adopted the Circular Economy Action Plan [2], and Ukraine, having signed the Association Agreement with the EU, is harmonising its national laws with the EU legislation, and in 2017, it adopted a National Waste Management Strategy aimed at implementing circular economy principles in the national economy.

In the linear model of economic systems development, products are first produced, then used for a certain period, and at the end of their life-cycle they are utilised (take-make-dispose principle). In contrast to the linear model, the theoretical and methodological approaches that form the basis of the circular economy concept are based on the "3R" principle [3]:

- Reduce – aims at the reduction of the use of natural resources, including energy. Emphasis is on the rational use of resources and preference is given to the use of renewable energy sources and other reusable materials. This is not only about minimising the impact on the environment but also the promotion of sustainable practices.

- Reuse – involves the efficient use of produced products, extending their life-cycle, and reducing overall waste. This approach encourages responsible consumption and contributes to more sustainable and eco-friendlier lifestyle.

- Recycle – provides maximum usage of by-products and waste products. By implementing effective recycling programs, the amount of waste sent to landfills can be minimised and people can contribute to a more sustainable economy. In practice, according to the Circularity Gap annual report that was presented at the World Economic Forum in Davos, only about 9–10 % of materials in the world are reused [4]. These data therefore highlight the need for greater awareness and adoption of circular economy principles for a more sustainable future.

At the same time, in modern economic studies, the "3R" concept has been extended by adding other components, as shown in Figure 1 [5].

In Ukraine, despite difficult economic conditions, the principles of circular economy and rational use of natural resources are being actively implemented. For example, Myronivsky Hliboproduct (officially private joint-stock company MHP) builds biogas plants (complexes) to process waste from poultry farms [6], and Corporation Obolon (officially private joint-stock company Obolon) sells beer by-products to agribusinesses as fodder for cattle [7]. And the number of examples of the implementation of circular economy principles into the national economics of Ukraine is constantly growing.

So, according to the concept of sustainable development based on the principles of the circular economy, society urgently needs fundamental reforms in almost all sectors of the economy, especially in agriculture, where waste recycling and the use of by-products remain on a quite low and unsatisfactory level. Such an approach will help minimise environmental risks associated with both agricultural waste and environmental pollution, bringing sustainable development goals closer to the agricultural sector and society as a whole.

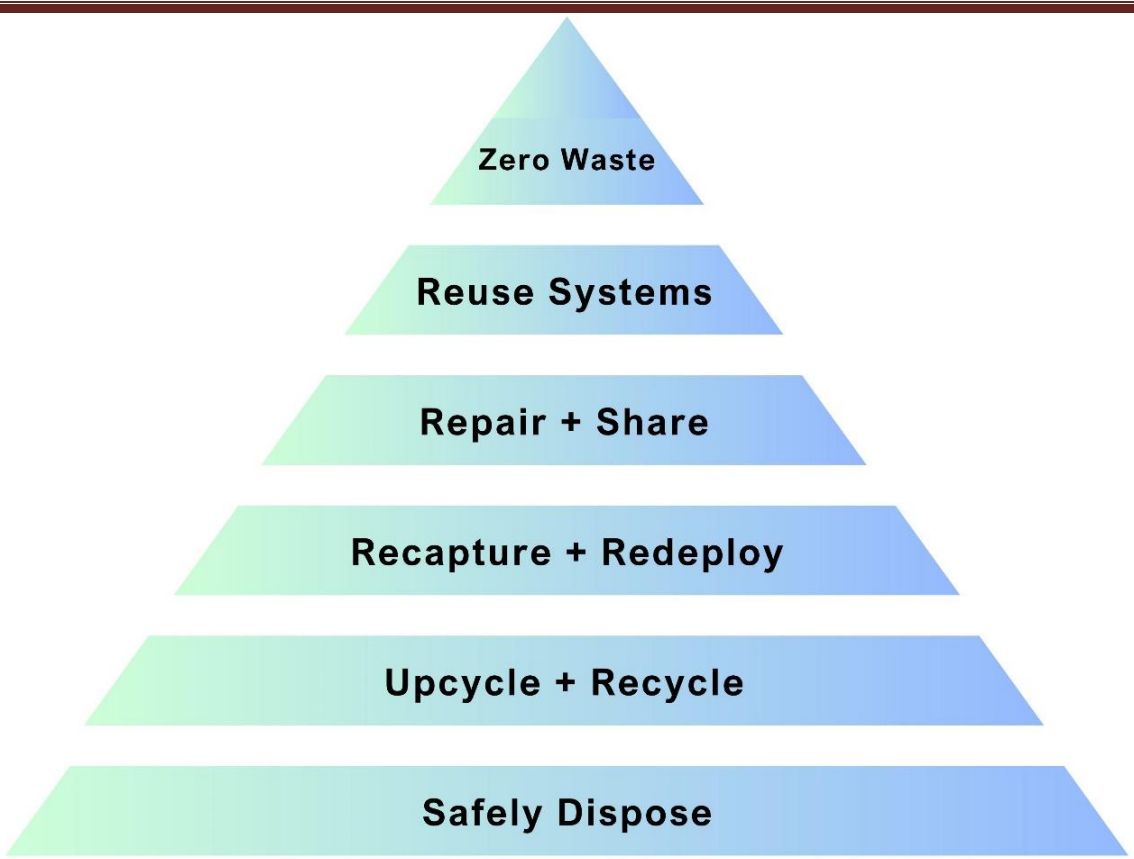

Figure 1. The extended "3R" circular economy concept

Source: visualized by authors based on data [5].

The study aims to develop the methodology and the framework for assessing the level of environmental friendliness of startups in the agricultural sector and their compliance with the circular economy and sustainable development principles using T. L. Saaty's analytic hierarchy process to enhance their market attractiveness and success. The developed framework was tested on the example of the authors' startup in the sphere of agricultural waste management.

2. LITERATURE REVIEW

The Food and Agriculture Organisation of the United Nations estimates [8] that agricultural inefficiency leads to about one-third of the food produced being wasted. In particular, high-income countries tend to lose food at the consumption stage, while developing countries mostly lose food at the production and storage stages [9].

The analysis of the literature sources shows that even though more and more attention is being paid to the implementation of circular economy principles in agriculture, the issues related to the sphere of organic waste processing, as well as the organisation and successful functioning of innovative enterprises (agricultural startups), still require attention. Existing studies are mainly focused on the management of agricultural enterprises and increasing their efficiency [10–12], ecologisation of agricultural production and agro-technologies improvement [13–16], as well as social problems of the rural population [17; 18].

At the same time, many types of startups operating in the modern agricultural

sector focus on developing software and analytics for smart farm management (for example, Granular – an American startup and eAgronom digital platform – an Estonian startup). Precision farming projects focus on energy saving, increasing efficiency, optimising and minimising the usage of herbicides and pesticides, etc. using big data and predictive analytics (Paul-Tech – Estonian startup).

Startup companies offering specialised trading platforms for connecting farmers with suppliers or consumers without intermediaries are also quite popular (La Ruche Qui Dit Oui – French startup, Agrospace – a digital agricultural services platform of Kyrgyzstan and Tajikistan). Startups that are engaged in obtaining and analysing plant data (e.g. studying the microbial composition of specific plants, genetic expression, etc.), focus their activities on improving the quality of seeds and advise farmers in the sphere of breeding (Benson Hill Biosystems – American startup).

Smart irrigation – startups helping to control and automate water usage on farms utilising special databases and monitoring in real-time the state of strawberries, grapes, etc., ensuring sustainable growth and optimising water and energy supply (Hortau and HydroPoint – Canadian and American startups).

In the cattle industry, startup companies (RanchPal – an Estonian startup, Corbiota – a German startup) are known for developing software and hardware aimed at optimisation of cattle production – from breeding models to genomics.

Next-generation farms are innovative companies that use advanced technologies to provide alternative farming methods in conditions that cannot support traditional agriculture. In particular, the American company AeroFarms offers aeroponic growing technology, as well as the use of LED lighting for growing agricultural products without soil or sunshine, year-round and anywhere.

In turn, Ecogreenplates, a Ukrainian startup, is focused on producing disposable tableware from renewable raw materials, particularly corn. By using corn as a raw material, Ecogreenplates contributes to reducing the environmental impact of single-use tableware, offering a biodegradable and compostable solution for various events and occasions [19].

The rise of circular economy and sustainability-focused startups in the agricultural sector reflects the increasing demand for innovative technologies and eco-friendly practices. This trend underscores society's growing awareness of the importance of sustainable production and lifestyle choices. It's an encouraging indication of human collective commitment to building a more environmentally conscious future.

There are also various international initiatives related to these issues. For example, in the European Union, EitFood is Europe's leading food innovation initiative working to improve the food system and make it more sustainable, healthy, and secure. The initiative implements its activities in such areas as creating and promoting food industry innovation, education, entrepreneurship, and public engagement.

The T. L. Saaty's analytic hierarchy process (AHP) approach is widely applied across diverse fields, including engineering, healthcare, creative industries, traditional business, and innovative entrepreneurship – startup development. The relevance of the implementation of the AHP approach and other quantitative methods for the startup

assessment, such as the Bayesian networks [20], was proved in our previous studies and the investigations conducted by other scientists. In particular, the effectiveness of the AHP approach usage was proved in one of the recent studies dedicated to Brazilian startups [21]. The study results suggest that they lack maturity in practices related to strategic management, brand management, external image management, and internal communication management. The study highlights the significance of financial resource allocation, stakeholder relationships, and brand management in communication strategies.

At the same time, the authors of the paper [22] proved that the multi-criteria analysis based on Saaty's AHP can be effectively used for evaluating startup investment alternatives to diversify risks and allocate resources between several projects according to global priorities. B. Lee with his colleagues [23] identified key factors that can improve the competitiveness of artificial intelligence (AI) technology-based startups. The study found that the subject area, especially the strategic mind of the subject, is the most crucial factor for the success of AI startups.

The paper [24] presents a hybrid approach of AHP and several other methods for solving the multicriteria problem of optimal selection of a business site in the presence of a set of candidate sites. The proposed approach is efficient, quite accurate, and reduces the computational complexity, making it ideal for business managers to make decisions based on the qualitative data in selecting an ideal business site.

In the paper [25] the relevance of using the AHP approach to assess the importance of successful entrepreneurial skills, as perceived by entrepreneurs and aspiring entrepreneurs, was demonstrated. The key findings reveal that business management and/or critical and creative thinking skills are the top two criteria for success. The authors also determined that aspiring entrepreneurs underestimate the importance of persistence and overestimate the importance of creative thinking and innovation, as well as human resources management. These are quite interesting findings in terms of innovative business development.

Thus, based on the literature review, we have set the following research objectives, that have not been previously considered in published works:

- to analyse the current state of the implementation of circular economy and sustainability principles in the agricultural sector, especially for innovative startup development;
- to develop the methodology and the framework for assessing the level of environmental friendliness of startups in the agricultural sector and their compliance with the circular economy and sustainable development principles using T. L. Saaty's analytic hierarchy process approach;
- to test the proposed methodology on the example of the authors' startup for processing agricultural waste into eco-friendly biofuels;
- to develop recommendations for strengthening the eco-friendly image of startups as an essential component of their brand to achieve a positive perception of startup products by consumers and thus enhance startup market attractiveness and success.

3. METHODOLOGY

In the study, the methods of systematic, situational, comparative, and economic analyses, as well as complex, structural-logical, and dynamic approaches have been used.

The measures for increasing the market attractiveness and success of a startup in the agricultural sector are based on the authors' methodology created based on AHP approach. This methodology aims to assess the startup's compliance with circular economy and sustainable development principles and, as a result, to propose measures to improve this compliance and strengthen the eco-friendly brand image of the innovative business project.

The T. L. Saaty's analytic hierarchy process [26; 27] is a comprehensive decision-making framework that can be utilised to divide complex problems into a clear hierarchical structure. This approach enables the evaluation and comparison of multiple criteria, thereby facilitating informed decision-making.

One of the unique features of the AHP approach is that after the division of complex problems into smaller, manageable parts, experts or groups of experts assign weights (also known as priorities) to each criterion based on its relative importance, according to their professional opinion. In terms of the methodology developed in this study, it is recommended to involve three to five experts, as it provides an optimal balance between the input of multiple perspectives and the avoidance of excessive complexity and inconsistency.

The unique authors' program was developed in the YAML format to perform AHP calculations and visualisations for our study. The program is based on the "ahp" R package [28] implemented through the RStudio software [29] using the R 4.0.3 version [30]. Our previous studies, in particular [20; 31], support the effectiveness of using mathematical and quantitative approaches for assessing parameters related to environmental safety, circular economy, and sustainable development. So, the example of the R code execution in RStudio using the "ahp" R package is shown in Figure 2.

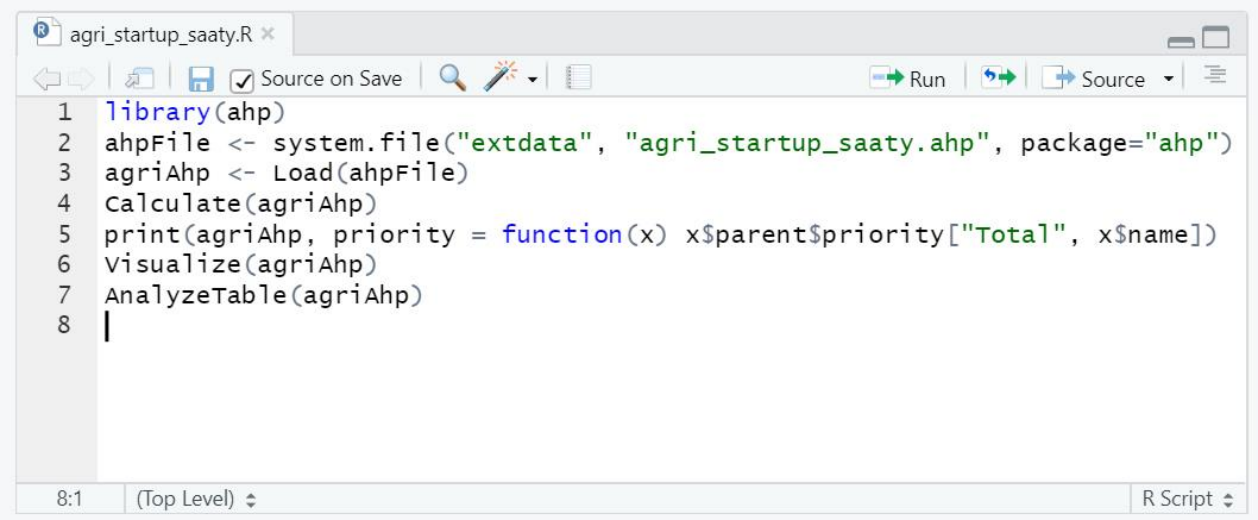

Figure 2. The R code execution in RStudio

Source: developed and visualised by authors.

The software was chosen because of its several key advantages. First, R is a powerful programming language and environment that is widely used for statistical computing and graphics. Its open-source nature, extensive package ecosystem, and strong community support make it ideal for developing custom analytical tools such as our methodology and the AHP framework for assessing the level of environmental friendliness of startups. RStudio, an integrated development environment for R, enhances the user experience by providing a user-friendly interface, debugging tools, and integrated support for version control. RStudio has remained the most popular and convenient tool for working with the R language for many years.

Using R ensures that our methodology is reproducible and transparent. All steps, from data input to final visualisations, are shareable, promoting openness in scientific research. R excels in data manipulation and visualization, which are crucial for presenting the results of AHP analysis. The "ahp" package integrates well with other R packages, allowing for seamless data handling and the creation of informative visualisations. Another important advantage is that the active R community and extensive documentation provide valuable resources and support, facilitating continuous improvement of our framework.

The most important metric of the correct application of any methodology based on T. L. Saaty's AHP approach is the inconsistency indicator (or consistency ratio), which is described in detail in [26]. The inconsistency indicator is also calculated in RStudio using the "ahp" R package and must be less than 10 % to consider obtained results as reliable.

4. RESULTS

The key approach used in this study to assess the startup's compliance with circular economy and sustainable development principles is the analytic hierarchy process, developed by T. L. Saaty. AHP is a hierarchically structured decision-making approach that implements both qualitative and quantitative analysis based on expert opinions [26; 32]. So, it is important to describe the main peculiarities of the AHP approach that make it suitable and convenient for this study.

First of all, the AHP framework is designed for complex decision-making involving the analysis of multiple criteria or factors that are compared in a structured way based on their relative importance. The essence of the AHP approach is its hierarchical structure – the decision criteria are organised into a hierarchy, which consists of a goal at the top, followed by criteria, sub-criteria, and alternatives at the lower levels (from now on referred to as elements). This helps to clarify the considered problem and breaks it down into smaller parts that experts can assess.

AHP uses pairwise comparisons to assess the relative importance of different criteria and alternatives. Experts responsible for decision-making compare pairs of elements and determine which one is more important, providing a numerical value to quantify the comparison. The comparison is made using Saaty's nine-point fundamental scale. This scale assigns a numerical value to the intensity of preference, where 1 means equal importance, and 9 indicates an extreme preference for one

element over another:

1 point – equal importance of components;
2 points – weak importance;
3 points – moderate importance;
4 points – moderate plus importance;
5 points – strong importance;
6 points – strong plus importance;
7 points – very strong or demonstrated importance;
8 points – very, very strong importance;
9 points – extreme importance [26].

The consistency of the pairwise comparisons is evaluated through a consistency ratio (CR). This ratio indicates how consistent the comparisons are and CR below 0.1 (less than 10.0 %) is considered acceptable [26]. From the pairwise comparisons, AHP derives weights for each criterion or sub-criterion. These weights represent their relative importance in the context of the overall decision. After calculating the weights, AHP combines them to derive a weighted score for each alternative, guiding experts to a final decision.

The analytic hierarchy process is great not only for decision-making but it is also an excellent visualisation framework. The hierarchical structure helps to break down complex problems into manageable parts that can then be visually represented using diagrams, schemes, or tables. This allows decision-making experts to see the relationships between different elements. Additionally, the pairwise comparisons used in AHP provide a numerical value to quantify the importance of different components, which can be analysed to identify patterns and trends. The "ahp" R package created by C. Glur [28] makes these visualizations even more convenient and customizable.

So, the AHP approach is a reliable and effective method for evaluating various factors involved in innovative projects and startup development. This means that with the help of this approach, we can create the methodology and the framework for assessing the level of environmental friendliness of the startup and its compliance with the circular economy and sustainable development principles for the enhancement of the startup's market attractiveness and success. This will provide valuable insights for founders, investors, and environmentally conscious consumers about the startup's ecological impact. By incorporating the AHP approach into the evaluation process, it becomes possible to combine the assessment of both quantitative and qualitative data to ensure that startups are not only financially viable but also socially conscious and eco-friendly.

So, our methodology is based on the authors' AHP hierarchical criteria system representing the framework for evaluating the startup's compliance with circular economy and sustainable development principles, and the eco-friendliness of its brand image. The developed framework is presented in Figure 3. The authors' hierarchical criteria system is designed considering the results of our previous studies on environmental protection, decarbonisation processes, and sustainability principles [31; 33]. The hierarchical criteria system is programmed and executed in the RStudio

software using the "ahp" R package. An example of methodology implementation in the RStudio programming environment is shown in Figure 4.

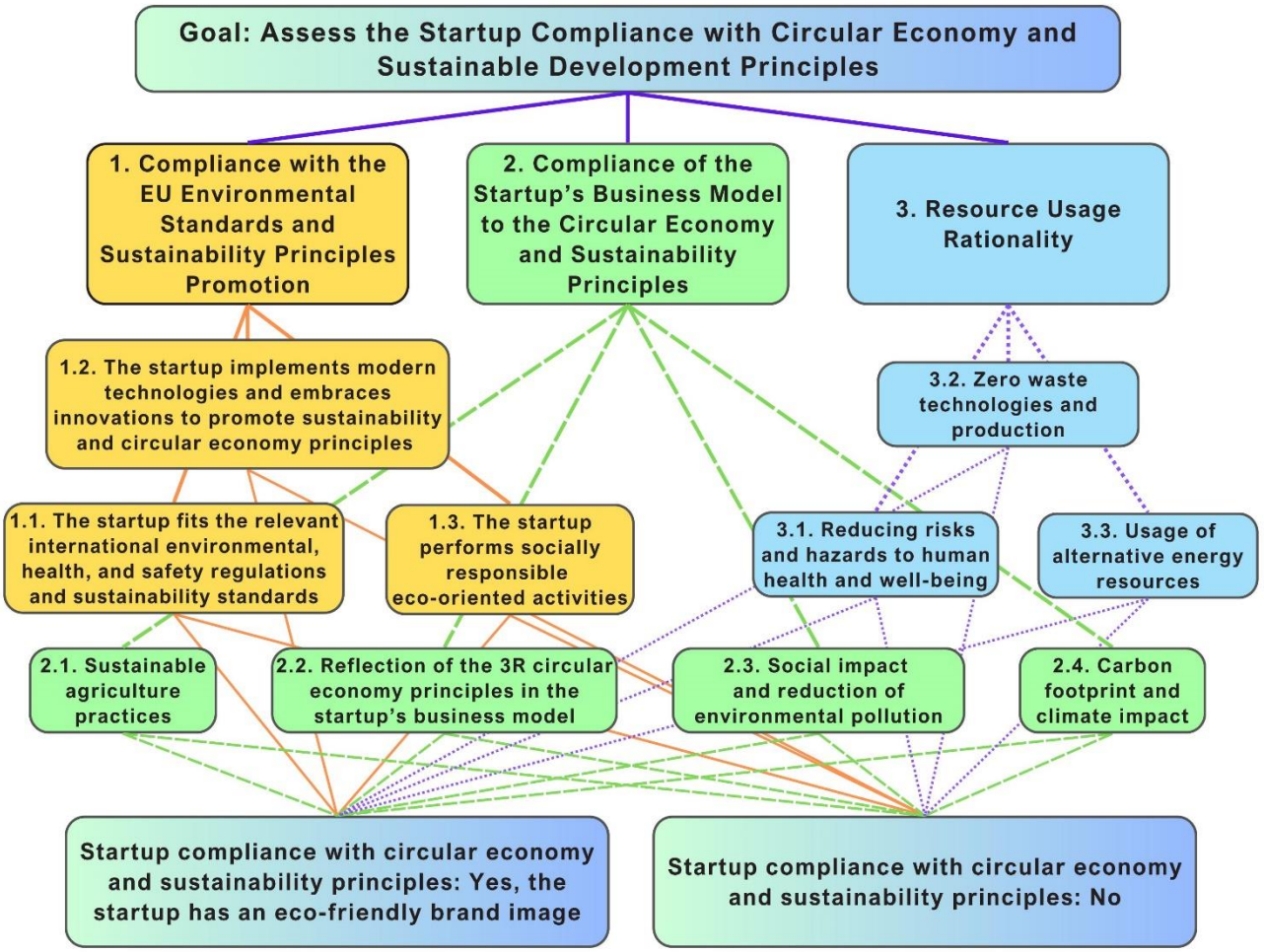

Figure 3. The authors' framework for evaluating the startup's compliance with circular economy and sustainable development principles and the eco-friendliness of the startup's brand image

Source: developed and visualised by authors.

At the highest level of the hierarchical system, there is a goal to assess the startup's compliance with circular economy and sustainable development principles. The first criterion is "Compliance with the EU environmental standards and sustainability principles promotion" which includes the following sub-criteria:

1.1. The startup fits the relevant international environmental, health, and safety regulations and sustainability standards – it has ISO certification or recognitions from international organisations dedicated to sustainability and circular economy, and participates in green marketing and environmental management initiatives, including eco-labeling, etc.

1.2. The startup implements modern technologies and embraces innovations to promote sustainability and circular economy principles – it uses data analytics, artificial intelligence, automatisation, etc. to improve profitability and streamline production processes.

1.3. The startup performs socially responsible eco-oriented activities – it

organises advertising and social media campaigns, workshops, seminars, webinars, etc. to raise awareness of the public about the environmental sphere issues; provides employees with training on sustainability and socially responsible practices; promotes biodiversity and preserves natural habitats.

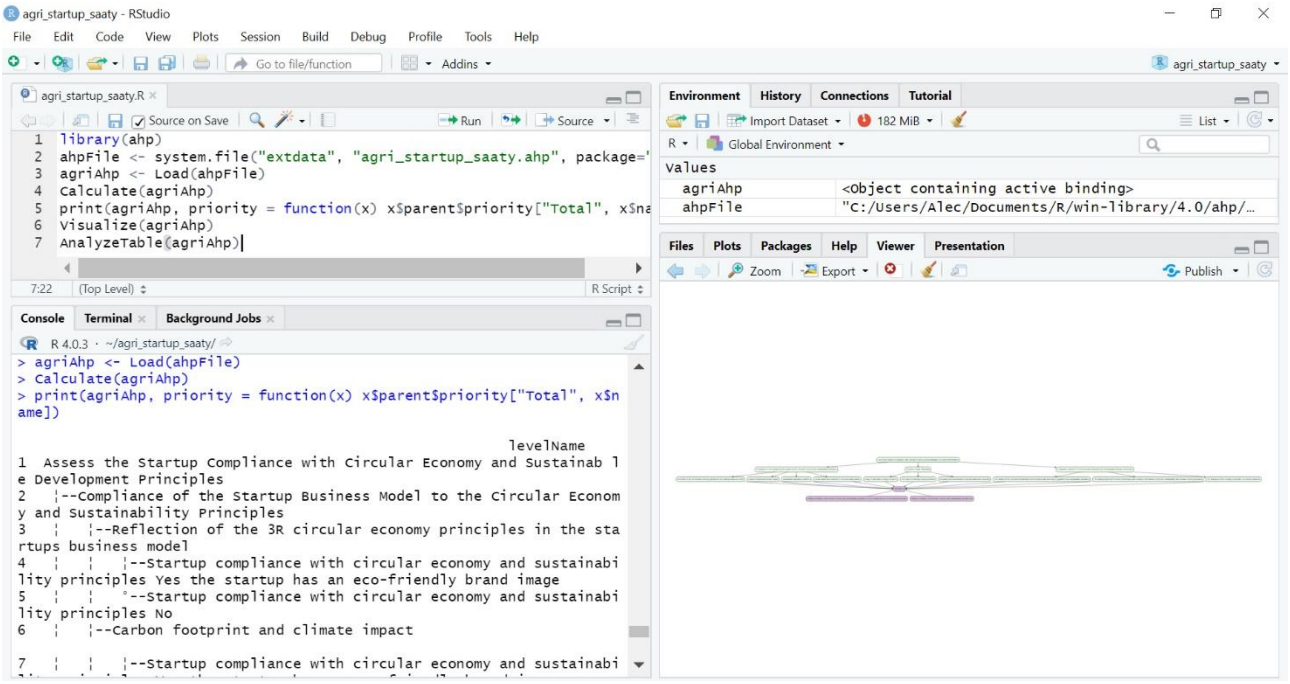

Figure 4. The authors' program performance using the "ahp" R package in the RStudio programming environment for startup evaluation

Source: developed and visualised by authors.

The second criterion is the "Compliance of the startup's business model to the circular economy and sustainability principles" and it includes the following sub-criteria:

2.1. Sustainable agriculture practices – the startup engages in sustainable farming practices such as organic farming, regenerative agriculture, permaculture, reuse of organic waste, biofuel usage, etc.

2.2. Reflection of the "3R" circular economy principles (Reduce, Reuse, Recycle) in the startup's business model.

2.3. Social impact and reduction of environmental pollution. The startup promotes social sustainability by engaging with local communities and considering the social impacts of its operations to reduce social risks. The startup practices do not harm the environment or biodiversity, and prevent and mitigate the pollution of air, soil, surface & groundwater.

2.4. Carbon footprint and climate impact – the startup activities are directed at the reduction of the carbon footprint, greenhouse gas emissions, and climate change mitigation.

The third criterion is "Resource usage rationality" and it includes the following sub-criteria:

3.1. Reducing risks and hazards to human health and well-being by adopting

practices that minimise harmful substance usage, prioritising safety in the workplace, and the health of ecosystems and human communities.

3.2. Zero waste technologies and production – the startup implements strategies to reduce waste and has robust systems for recycling or reusing waste products.

3.3. Usage of alternative energy resources – the startup's production is based on renewable materials and/or resources or the startup produces them.

On the lower level of the hierarchical system, there are two alternatives (Figure 3). One of them states that there is the startup's compliance with circular economy and sustainable development principles and thus the startup has an eco-friendly brand image. The other one states that there is no startup's compliance with circular economy and sustainability principles. So, the final decision will be choosing one of these alternatives based on the calculation results.

According to the developed methodology, three to five AHP experts are involved in evaluating the eco-friendliness of the startup. These experts must be provided with proper instructions and training on the usage of the AHP methodology to assess how well the startup complies with the circular economy and sustainable development principles. Experts should not be familiar with the software used for AHP calculations, as the information provided by them will be added to the program by an IT specialist. In this study, the authors added information from the experts to the program.

To ensure accurate and reliable assessments of startups, three proposed requirements, provided in Figure 5, should be met by these experts. First of all, the AHP experts have to be unbiased and objective in their evaluation of the startup's compliance with the provided circular economy and sustainability criteria and sub-criteria. So, experts should base their opinion on the actual startup characteristics, activities, and achievements, they should rely on objective data-driven analysis.

The experts should use reliable sources of information such as national and international reports on sustainability issues relevant to the startup, the startup's reports (if available), ISO certifications, official national and international statistics repositories, reports and insights from internationally recognized analytical agencies and experts like Gartner, CB Insights, and Crunchbase, and other relevant documents.

The second requirement is the experts' high expertise level, as the expertise is very important in terms of the developed methodology. They must have relevant experience in such fields as sustainable development, green and circular economy, green marketing, and environmental management. They should have a good understanding of international (including the EU) environmental, health, and safety regulations and standards, as well as the best practices for eco-friendly business operations based on their professional and/or academic experience. Taking into account the fact that this methodology is primarily designed for the assessment of innovative businesses in the agricultural sector, it is required that experts are also familiar with modern sustainability technologies and trends in the analysed sphere.

As can be seen from Figure 5, the expertise is considered in terms of five key components:

1. Qualification – the AHP experts should have at least a Bachelor's degree in a

relevant field such as environmental science, sustainability, and circular economy, or significant practical experience working with these issues. A Master's degree or PhD in one of the described fields is preferred.

Figure 5. Requirements for experts assessing the startup's compliance with circular economy and sustainable development principles and the eco-friendliness of their brand image

Source: developed and visualised by authors.

2. Knowledge – experts should deeply understand the modern circular economy and sustainable development principles, relevant environmental regulations, and standards. The expert should be familiar with the latest technologies, inventions, and innovations used in the agricultural and related spheres.

3. Competency – experts should understand how to use the AHP methodology to assess the startup's compliance with the circular economy and sustainability principles. Experts need to have strong analytical and critical thinking skills.

4. Adherence to the principles of ethics and academic integrity, including transparency, confidentiality maintenance, acknowledgment of conflicts of interest, and adherence to academic standards.

5. The following personal qualities of experts should be taken into account:

- commitment to professional growth and continuous professional development both in their field of interest and in related fields;

- ability to assess the situation and make well-thought-out decisions quickly;
- ability to manage their time effectively and implement decisions on time;
- ability to create favorable psychological working conditions in a team;
- discipline, organisation, and good time management skills (Table 1).

Table 1

Compliance of the experts with the requirements

Requirements		Experts		
		No. 1	No. 2	No. 3
Quali-fication	Scientific degree	Doctor of Technical Sciences	Doctor of Pedagogical Sciences	Doctor of Physical and Mathematical Sciences
	Academic status	Professor in the sphere of environmental protection	Professor in the sphere of ecology and environmental management	Professor in the sphere of economics
	Position	Professor at the Ukrainian university	Professor at the Ukrainian university	Head of the department at the Ukrainian university
	Work experience	More than 30 years	More than 25 years	More than 35 years
Knowledge		Is an expert in such fields as environmental risk assessment, mathematical modeling and quantitative methods for environmental protection, circular and green economy, information technologies in environmental management, geoinformation systems, industrial ecology, and environmental design. Participates in international scientific projects and has more than 200 scientific publications dedicated to the expertise area	Has significant scientific, pedagogic, and professional experience in the spheres of ecology and environmental protection, circular and green economy, and sustainable development. Is a leader of ecologically oriented international Jean Monnet, Visegrad Fund, and Erasmus+ projects. Has more than 150 scientific publications and conference presentations dedicated to the required expertise area	Has extensive experience in the fields of marketing and management, economic cybernetics, business and data analytics, using quantitative and qualitative methods for market research, econometrics, green marketing and circular economy. Has more than 250 scientific publications and conference presentations on the above-described topics
Competency		Have a good mathematical understanding of the AHP approach usage and how it is implemented in the RStudio environment; have strong analytical and critical thinking skills		
Adherence to the principles of ethics and academic integrity		The expert adhered to the mentioned principles according to Article 58 of the Law of Ukraine on Higher Education [34] and the requirements of internal university documents		
Personal qualities		Meet all the stated requirements described in paragraph 5 of the expertise components section		

Source: created by the authors.

The third requirement is that the AHP experts have to ensure consistency in their evaluations by applying the same standards and criteria to all startups under assessment.

Their evaluations should be consistent with the overall goal of the startup assessment and also experts have to ensure consistency for the pairwise comparisons while assessing the relative importance of different criteria, sub-criteria, and alternatives.

The selection of experts is extremely important and can be conducted by applying such methods:

- appointment method;
- phone method;
- the method of mutual recommendations;
- the method of consistent recommendations;
- the method of nomination by research teams.

In this study, the experts have been chosen using the appointment method, taking into account the personal and professional qualities of the scientists selected for the research.

The developed methodology and AHP framework have been tested on the example of the authors' bioenergy startup for producing eco-friendly biodiesel without using highly toxic substances for the production processes and implementing the secondary use of fat-containing agricultural or food industry wastes (organic waste recycling). It is proposed to use a complex homogeneous catalyst containing, in addition to the traditional alkaline catalyst, surface-active additives that are lipophilic surfactants [35]. The obtained results based on expert judgment of the bioenergy startup are presented in Table 2.

Table 2

Results of the AHP expert assessment for the authors' bioenergy startup

Goal, criteria, and sub-criteria	Weight	Startup's compliance with circular economy and sustainability principles: YES, the startup has an eco-friendly brand image	Startup's compliance with circular economy and sustainability principles: NO
1	2	3	4
Goal: assess the startup's compliance with circular economy and sustainable development principles	100.0 %	78.6 %	21.4 %
1. Compliance with the EU environmental standards and sustainability principles promotion	49.2 %	38.9 %	10.2 %
1.1. The startup fits the relevant international environmental health and safety regulations and sustainability standards	30.9 %	24.5 %	6.4 %
1.2. The startup implements modern technologies and embraces innovations to promote sustainability and circular economy principles	14.5 %	11.4 %	3.1 %
1.3. The startup performs socially responsible eco-oriented activities	3.8 %	3.0 %	0.8 %

Continuation of Table 2

1	2	3	4
2. Compliance of the startup business model to the circular economy and sustainability principles	28.7 %	24.7 %	4.0 %
2.1. Sustainable agriculture practices	17.6 %	15.6 %	2.0 %
2.2. Reflection of the "3R" circular economy principles in the startups business model	5.6 %	4.7 %	0.9 %
2.3. Social impact and reduction of environmental pollution	3.4 %	2.8 %	0.6 %
2.4. Carbon footprint and climate impact	2.1 %	1.6 %	0.5 %
3. Resource usage rationality	22.1 %	15.0 %	7.2 %
3.1. Reducing risks and hazards to human health and well-being	14.9 %	12.2 %	2.7 %
3.2. Zero waste technologies and production	5.2 %	1.1 %	4.1 %
3.3. Usage of alternative energy resources	2.0 %	1.7 %	0.3 %

Note. Color coding indicates the significance of numbers – the greater the parameter's value, the more intense the color.

Source: calculation results obtained according to the authors' methodology and program execution in the RStudio programming environment.

According to the methodology, to conclude that a startup complies with the circular economy and sustainability principles and has an eco-friendly brand image, it is required that the "YES" alternative is 75.0 % or more. So, as can be seen from Table 2, our bioenergy startup satisfies the circular economy and sustainability principles, because the corresponding "YES" indicator is 78.6 %. Among these 78.6 %, the contribution of Criterion 1 is 38.9 %, Criterion 2 is 24.7 %, and Criterion 3 is 15.0 % (Figure 3). It is also important to state that the inconsistency indicator for all criteria is less than 10 %, proving the obtained results' precision.

Analysing the data in Table 2, it is also important to emphasise that the criterion with the highest impact on the startup eco-friendliness and with the highest weight is "Compliance with the EU Environmental Standards and Sustainability Principles Promotion" (Criterion 1) – 49.2 % with the sub-criteria "The startup fits the relevant international environmental health and safety regulations and sustainability standards" playing the most important role with a weight of 30.9 %.

At the same time, criterion 2 "Compliance of the Startup Business Model to the Circular Economy and Sustainability Principles" is in the second position with a weight of 28.7 %, while criterion 3 "Resource Usage Rationality" is in the third position with a weight of 22.1 %.

5. DISCUSSION

It is well-known that startups and entrepreneurs are at the forefront of technological progress and innovation, developing new products and services to meet

the changing needs and demands of the growing number of consumers. At the same time, startups have a low success rate that often leads to financial losses for investors and startup teams. Proof of the high failure rate of startups can be found in numerous academic and professional papers, as well as in interviews with startup founders.

In 2021, the CB Insights agency identified the 12 most common reasons why startup projects fail [36]. With the help of qualitative analysis methods, they have considered more than 100 startup failure stories provided by their teams, founders, and investors since 2018 [37]. CB Insights experts have found that one of the main reasons for startup failures was the lack of demand for their products, which was observed in 35 % of the considered projects. Startups may have a great product, but if they fail to use marketing tools effectively and develop a strong brand, their products will not be accepted by the market, leading to low sales and ultimately business failure.

Moreover, startups often operate in highly competitive markets dominated by established players with more resources and recognisable brands. In such circumstances, startups need to form authentic and appealing brands to differentiate themselves from competitors using effective marketing tools. Marketing activities always involve the search and analysis of a large amount of information about the market, similar and/or related products, as well as consumers, suppliers, intermediaries, competitors, etc. So, marketing is an effective and very important tool for strengthening the competitiveness of a business, shaping its positive image in the socio-economic environment, and also an essential component for successful startup development.

In our opinion, the application of the authors' methodology and framework for assessing the level of environmental friendliness of startups and their compliance with the circular economy and sustainable development principles provides significant benefits. In addition, it enhances the startup's market attractiveness and success by strengthening its brand image. These ideas are also proved by the works of F. Gatto and I. Re [38], S. Sehnem with colleagues [39], T. H. H. da Silva and S. Sehnem [40], as well as R. Greer at al. [41].

Besides the widely recognized Minimum Viable Product (MVP) concept, there is another important concept – Minimum Viable Brand (MVB) that is a crucial starting point for a startup and shapes the future established brand of a company raised from the startup project. According to [42], MVB consists of such aspects as brand essence, team values, values and characteristics of the target audience, key differentiators of the project, the experience of startup founders and team members, and brand identity elements such as logo and fonts. In addition, an eco-friendly brand image can positively influence all these elements and thus determine a startup's MVP and MVB.

So, many startups fail due to a lack of demand for their products, and with increasing consumer preference for green and sustainable products, startup founders have to implement the circular economy and sustainable development principles into their production processes, management, and brands from the initial startup development stage. Eco-friendliness, circular economy, and sustainability principles are considered the added-value elements that significantly benefit innovative projects becoming success boosters in the market, especially in the agricultural sphere. In this

way, the startup founders will satisfy the needs of the growing number of eco-conscious consumers and enhance the startup market attractiveness and success.

The complexity of assessing the level of compliance of innovative enterprises and promising startups with the principles of circular and green economy, sustainable development, etc. has been noted by various researchers. In particular, to evaluate the success of breakthrough innovations and business projects, their eco-friendliness, etc., the authors of [38] used such characteristics as "technology-push" and "market-pull" strategic orientations of business models as optimisation criteria. In their opinion, it is the transition to a bio-based economy that ensures that future generations will have adequate natural resources and living conditions. In other words, the bio-economy will ensure sustainable growth. The authors conclude that in today's market environment, the greenest and most circular economy-oriented business models are those focused on eco-sustainable and bio-based materials, nutraceuticals, and microalgae production.

In turn, the authors of [40] used a qualitative approach to evaluate eco-oriented startups in the field of food technology in Brazil and collected data through interviews with managers of food techs, as well as from reports, presentations, product catalogs, consultations in companies sites, Instagram, Facebook, LinkedIn profiles, and videos on the companies YouTube channels. Then, thematic analysis has been used to analyse the data.

The qualitative analysis has also been used by the authors [41] to analyse the prospects, eco-friendliness, and environmental sustainability in the catering industry in the Netherlands. The authors selected such quantitative indicators of success as CO_2 emissions range, reduction of food waste, and percentage of animal protein, etc., which will help them to meet their circular economy and sustainability goals within catering. Their research provides new practical insights into promoting and expanding sustainable production methods for a circular economy by leveraging circular startups. They have highlighted 15 key principles for linking niche innovations with established practices to reach circularity and sustainability.

Specially selected experts in the fields of environmental protection, environmental management, and eco-marketing implemented the multi-criteria optimisation task of establishing the level of eco-friendliness and environmental sustainability in our study using the hierarchy analysis methodology with the help of pairwise comparisons. This made it possible to harmonise the opinions of experts and obtain reliable results in assessing the success and eco-friendliness of startup projects, as confirmed by the obtained inconsistency indicator value.

6. CONCLUSIONS

Thus, the analysis of the current state of the implementation of circular economy and sustainability principles in the agricultural sector startups has been done. It has been shown that there is an urgent need for framework development as an effective tool for the assessment of the environmental friendliness level of innovative agricultural startups, as well as for the enhancement of their market attractiveness and success.

As a result, the methodology for assessing the startup environmental friendliness and compliance with the circular economy and sustainable development principles has been created using T. L. Saaty's analytic hierarchy process approach. For the proposed methodology, the unique program in the YAML format has been developed and executed using the RStudio integrated development environment.

The system of requirements for the AHP experts has also been developed in the study. Experts have to be unbiased and objective, they must have a high expertise level, considered in terms of five components – qualification, knowledge, competency, adherence to the principles of ethics and academic integrity, and personal qualities. They also have to ensure consistency in their evaluations.

For the aim of testing the methodology we have used the authors' bioenergy startup for processing fat-containing agricultural and food industry wastes into eco-friendly biofuels while minimising the usage of toxic substances. Based on the experts' opinion and using the authors' unique program, it has been calculated that this bioenergy startup satisfies the circular economy and sustainability principles and has an eco-friendly brand image with a 78.6 % probability, which is more than the threshold value of 75.0 %.

It has been substantiated that the application of the developed methodology and framework for assessing the level of environmental friendliness of innovative startups and their compliance with the circular economy and sustainable development principles enhances their market attractiveness and success by strengthening their brand image.

The proposed methodology and framework will allow interested stakeholders to choose the most eco-friendly startup project among the others and eventually reach a higher level of success for this innovative project due to compliance with the circular economy and sustainable development principles.

7. LIMITATIONS AND FUTURE RESEARCH

One of the main problems in choosing the most promising startup projects from the environmental perspective is assessing their eco-friendliness level. That is why the study proposes the methodology for assessing the priority of alternatives using T. L. Saaty's analytic hierarchy process approach. The analysis quantifies the relative degree of interaction of individual elements in the developed hierarchy, and, based on this, it is possible to conclude that a particular project complies with the principles of circular economy and sustainability.

However, there are several limitations to the implementation of the proposed methodology and framework related to the features of the AHP approach. In particular, the AHP approach is mathematically complex and requires a deep understanding of the method for accurate implementation or good skills of working in specialised software, like RStudio. This could limit its applicability in practical settings. The AHP approach can become even more complex with the addition of more criteria and sub-criteria, making it less scalable for larger assessments. Moreover, the pairwise comparison process in AHP is largely based on the subjective judgments of experts. This could lead

to inconsistencies and inaccuracies in the evaluation process if the experts are not instructed properly.

The developed methodology and framework for assessing the level of environmental friendliness of startups and their compliance with the circular economy and sustainable development principles is a meaningful step forward in promoting sustainable development and decarbonisation practices within the agricultural sector. By implementing T. L. Saaty's analytic hierarchy process approach, we have formed the basis for creating similar frameworks tailored to other sectors and industries. This approach can fundamentally change eco-friendliness assessment of the startups and will allow developing a more comprehensive methodology.

In addition, according to the priorities identified in the study, the most important criterion for experts to assess a startup's eco-friendliness is its compliance with the EU environmental standards and sustainability principles promotion, while startup business model greening and ensuring that the carbon footprint is minimised are also quite important. Since the hierarchy analysis method requires pairwise comparisons to solve multi-criteria optimisation problems, the selection of relevant knowledgeable and experienced experts is one of the most important steps that will further ensure the consistency of their opinions and the accuracy of the startup's sustainability and eco-friendliness assessment.

Taking into account our commitment to sustainable innovations in the low-carbon industry, we plan to advance the authors' startup, which focuses on converting agricultural and food industry waste into eco-friendly biofuels. We want to get a successful position in the market, form an eco-friendly brand image, and promote sustainable solutions within the agricultural sector and beyond.

Future research should aim to explore the eco-friendliness of innovative enterprises and startups in larger samples, involving experts from different countries and also implementing other quantitative methods, such as the Bayesian networks analysis.

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