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Farmers' Knowledge, Training Needs and Skills in the Bioeconomy: Evidence from the Region of Western Macedonia †

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Abstract: The aim of this paper is to explore farmers' training needs, their lack of knowledge and skills, and their willingness to participate in related training programs in the Western Macedonia Region. Summary statistics and multivariate analyses were performed for the data analysis. The results indicate a low level of knowledge about the bioeconomy and its practices. Furthermore, the findings revealed the high willingness of farmers for future adoption of the bioeconomy, and the need to create bioeconomy training programs.

Keywords: bioeconomy; multivariate statistical analysis; sustainability; training needs assessment; Western Macedonia

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1. Introduction

The reduced availability of fossil fuels, climate change, resource conversion, food security, and population growth are some challenges that rural areas and agriculture are facing [1]. The transition to the bioeconomy contributes to the economic development of rural areas, as it refers to the shift of society towards sustainability [2]. There are several definitions available in the literature, and the most representative is the one that defines bioeconomy as "the production of renewable biological resources and their conversion into food, feed, bio-based products, and bioenergy via innovative, efficient technologies. In this regard, bioeconomy is the biological motor of a future circular economy, which is based on the optimal use of resources and the production of primary raw materials from renewably sourced feedstock [3]". To achieve sustainability in the agricultural sector, farmers and workers in agriculture must have the knowledge and skills to implement new practices and technologies [4].

The aim of this paper is to provide input on farmers' training needs, their lack of knowledge and skills, as well as their willingness to participate in related training programs. These outcomes would be useful for understanding the several training dimensions of the bioeconomy in the agricultural sector of the Western Macedonia Region (WMR) and future research on this subject.

2. Materials and Methods

Quantitative research was conducted between 1 January and 10 March 2023 using a structured questionnaire. Most questions were formulated on the typical five-point Likert scale of agreement. The questionnaire was completed by 331 farmers, from the four Regional Units of the WMR (Grevena, Kastoria, Kozani, and Florina).

Validity and reliability tests were performed prior to multivariate statistical analysis, using the statistical program SPSS (version 28). Validity tests for the structure of the

questionnaire were conducted by five experts in questionnaire research before it was distributed to farmers. Then, the *a-Cronbach* test was used to ensure the reliability of this research and determine the consistency, accuracy, and objectivity of the research instruments. In total, 116 variables were included in the analysis. The *a-Cronbach* coefficient value was found equal to 0.920, showing a reliable scale. Two-Step Cluster Analysis (TSCA) was performed in order to classify the farmers based on common characteristics. Furthermore, a Categorical Regression model (CATREG) was used to determine the factors that influence the farmers' choices to implement bioeconomy practices.

3. Results

3.1. Summary Statistics

Results indicated a low level of knowledge of bioeconomy and its practices (M = 2.67). The level of bioeconomy practices implementation is low (M = 2.46). The main barriers to bioeconomy practices adoption are: (a) a lack of related financial resources (M = 4.81), (b) a lack of incentive to invest (M = 4.43), (c) the high cost of the bioeconomy (M = 4.42), (d) the high technological level of the bioeconomy (M = 4.35), and (e) the lack of training, and unqualified research and labor staff (M = 4.29). It is worth mentioning that responders' willingness to adopt bioeconomy practices in the future is high (M = 3.33).

To promote bioeconomy in the WMR, efforts should be mainly focused on developing bioeconomy training programs (M = 3.91). Actually, the majority of the responders mentioned their interest in participating in a training program in the future. More specifically, their interest is higher in issues related to water conservation and irrigation management (M = 3.62), national and EU funding and programs for bioeconomy (M = 3.37), waste management (M = 3.09), rational use of natural resources (M = 3.00), transition to the post-lignite era incorporating the bioeconomy (M = 2.97), utilization of biomass and liquid manure for energy production (M = 2.95) and, finally, application of sustainable agriculture-livestock technologies such as Precision Agriculture (M = 2.94).

3.2. TSCA

TSCA was implemented to segment the population into groups of farmers with common characteristics in terms of "Willingness to apply bioeconomy practices". Five clusters were created using 11 variables. According to the Silhouette measure of cohesion and separation, the clustering process is satisfactory. The first cluster consists of 81 farmers (24.5%), and the second cluster consists of 41 farmers (12.4%). The third cluster, which is the smallest, has 35 farmers (10.6%). In the fourth cluster, 59 farmers (17.8%) are classified.

Finally, the fifth cluster is the most numerous, as there are 115 farmers (34.7%). Table 1 lists the mean values of the variables of each cluster.

Table 1. Characteristics of each cluster.

Variable	Clusters				
	1	**2**	**3**	**4**	**5**
Knowledge in bioeconomy [1]	2.77	2.83	2.06	2.61	2.75
Advantages of bioeconomy on the farm [1]	3.22	3.15	2.65	3.54	3.09
High cost of bioeconomy [2]	3.98	3.71	4.51	4.95	4.86
Unqualified research and labor staff [2]	4.40	2.63	4.66	4.27	4.74
Lack of incentive to invest [2]	4.12	3.15	4.54	4.81	4.90
Lack of financial resources and financing [2]	4.62	4.59	4.71	4.98	4.99
High technological level and lack of know-how [2]	4.12	2.98	4.51	4.66	4.80
Application of bioeconomy practices [1]	2.42	3.12	3.34	3.19	1.61
Interest in applying bioeconomy practices [1]	3.77	2.80	2.20	4.03	3.16
Promoting bioeconomy through training programs [2]	3.38	4.20	4.83	4.24	3.49
Interest in adopting innovations [1]	3.70	3.80	3.43	3.98	3.15

[1] (1 = very low, 5 = very high), [2] (1 = strongly disagree, 5 = strongly agree).

3.3. CATREG

Then, to further analyze the variable that was created from TSCA "Willingness to apply bioeconomy practices" (dependent variable), CATREG was performed for the total sample (331 questionnaires) to identify the factors that influence farmers' choice to implement bioeconomy practices. The 13 independent variables were gender, age, marital status, occupation, educational level, income, municipality, distance from the nearest city, current adoption of bioeconomy (1 = very low, 5 = very high), barriers of bioeconomy adoption (1 = strongly disagree, 5 = strongly agree), advantages of bioeconomy adoption (1 = strongly disagree, 5 = strongly agree), participation in training programs regarding the application of bioeconomy practices (1 = strongly disagree, 5 = strongly agree), and interest in innovation adoption (1 = very low, 5 = very high). Additionally, it yielded an R2 value equal to 0.800, indicating a significant relationship between the "Willingness to apply bioeconomy practices" and the group of selected predictors (80.0% of the variance in the "Willingness to apply bioeconomy practices" rankings is explained by the regression of the optimally transformed variables used). The F statistic value 4.075, with $\alpha = 0.00$, indicated a consistently well-performing model.

The relative-importance measures of the independent variables show that the most important predictors are: (a) current adoption of bioeconomy (31.1%); (b) barriers to bioeconomy adoption (16.9%); and (c) age (10.3%). The additional significance of the independent variables is estimated at 58.30%.

A better prediction of "Willingness to apply bioeconomy practices" can be derived from the transformed plots (Figure 1) of the main independent variables that present the higher relative importance measures (more than 0.100). The most influential factors predicting the "Willingness to apply bioeconomy practices" are "current adoption of bioeconomy" (1 = very low, 2 = low, 3 = neutral, 4 = high, 5 = very high), "barriers of bioeconomy adoption" (1 = strongly disagree, 2 = disagree, 3 = nor disagree/nor agree, 4 = agree, 5 = strongly agree), and "age" ($1 \leq 20$, 2 = 21–30, 3 = 31–40, 4 = 41–50, 5 = 51–60, $6 \geq 61$). This means that farmers have very low levels of bioeconomy adoption, agree that bioeconomy's application has many barriers, are 41–50 years old, and are more willing to adopt bioeconomy practices in their farms.

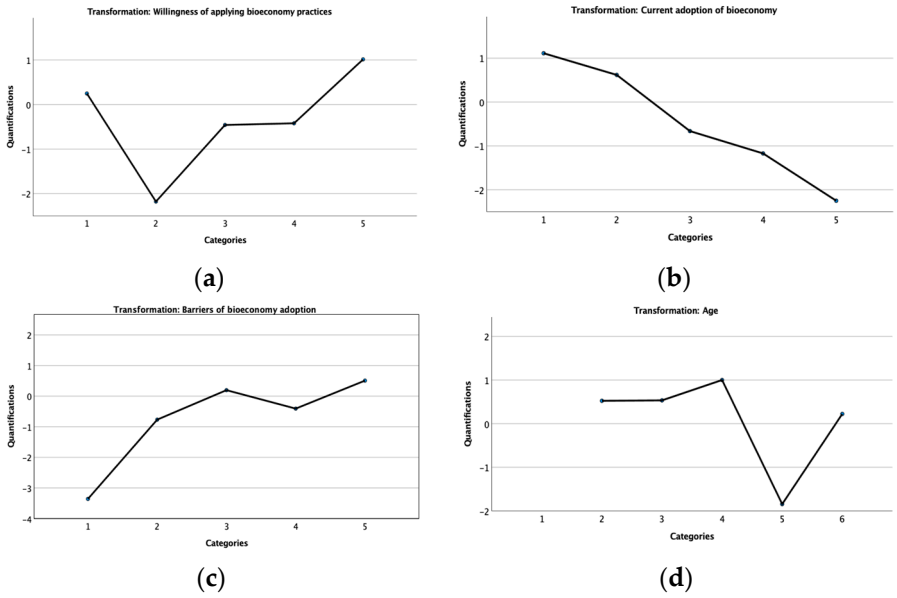

Figure 1. Transformed plots: (**a**) willingness to apply bioeconomy practices; (**b**) current adoption of bioeconomy; (**c**) barriers of bioeconomy adoption; (**d**) age.

4. Discussion

The results showed that farmers' low level of knowledge of the bioeconomy is one of the main barriers to the bioeconomy transition, which is also supported by the bibliography [5]. However, their high willingness for future adoption has to be the key to promoting the bioeconomy. Training is necessary for turning toward new sustainable practices [6]. Based on these results, separate training programs for each cluster should be created, focusing on the specific needs of each group. In addition, CATREG revealed the three variables that influence farmers' willingness to adopt bioeconomy practices in their farms.

5. Conclusions

The findings of this paper highlight the importance of constant and relevant training. The segmentation of the farmers into several discrete clusters with common characteristics is a great opportunity to improve the already-existing training programs. Moreover, the outcomes showed a remarkable interest in bioeconomy training, so they would be useful for understanding the current development of the bioeconomy in Greece and future research on this subject.

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