doi: 10.52370/TISC24303MC

THE STRUCTURE OF LIMITING FACTORS IN ADAPTING AGRICULTURAL FARMS TO CLIMATE CHANGES

Milivoje Ćosić[1]; Miroljub Ivanović[2]

Abstract

The aim of this transversal research was to examine the latent structure of the framework factors in their modification by climate changes in agricultural farms. The pertinent sample included (N = 178) farmers from Kolubara district. The average age of participants was 58.63 ± 6.02. The Questionnaire of limiting factors in adapting to climate change and business operations of agricultural farms was used in this research. Exploratory factor analysis was applied on the 12 manifest variables regarding the framework in adaptation to climate change. Using Promax rotation, with 57.68% of the total variance explained, four hypothetical basic latent dimensions were extracted and interpreted as: General external contributions, Irrigation, Finance and Material and human resources. The obtained total value of Cronbach's α indicates the reliability of internal consistency type. That confirms the satisfactory internal consistency of the isolated factors and the valid applicability of the measuring instrument used on Serbian sample, while suggestions for more efficient operationalization and revision of the applied construct were given.

Key Words: *farmer, latent dimensions, questionnaire validation, limiting factors, climate risks*
JEL Classification:

Introduction

Climate change contributes to product quality, production costs and, in turn, to the operations of agricultural farms, i.e. there are limits in

[1] Milivoje Ćosić, PhD, University of Bijeljina, Faculty of Agriculture, 76300 Bjeljina, Republic of Serbia, 0655076094, micko.cosic@gmail.com
[2] Miroljub Ivanović, An academician, PhD, Serbian Academy of Innovation Sciences, 11000 Belgrade, Serbia, 0648752832, miroljub.ivanovic@gmail.com

applying the strategy of adaptation and mitigating the impact of climate change (Bouraima et al., 2024). In the first decade of the XXI century, the domain of agriculture was characterized by the expansion of foreign authors in the research of the complex set of agricultural farms and the latent structure of the construct of limiting factors in the adaptation of farmers to climate change. However, no empirical study examining the perception of the agricultural population regarding the aforementioned phenomenon has been presented in Serbia. Agricultural production is subjected to various risks, especially those generated by climate change and very bad weather. The dangers of climate change include the phenomenon of excessive air temperature, insufficient amount of water that falls from clouds to the surface of the ground or is formed on the ground by condensation or sublimation of water vapor near the ground, as well as the occurrence of storms, hail, drought and frost (Hossain et al., 2024).

Numerous authors have been researching the perception of farmers on the consequences of the dangers of climate change, which are manifested in the reduction of the yield of plant production, changes in the quality of raw materials, the appearance of diseases and animal organisms, changes in the soil (erosion), the reduction of livestock production as well as entropy in business (Varyvoda & Taren, 2024). With the aim of intensifying the resilience of agricultural farms, they proved that agriculture is sensitive to climate change, i.e. that adaptation and depreciation are significant consequences of climate change. Adaptation to climate changes shows a process of immediate coping with uncertain future events, risk taking and appropriate application of adaptive skills in managing agricultural operations (Jyothi & Vijayabhinandana, 2023). However, amortization to the greatest extent implies a reduction in the amount of greenhouse gas emissions. In research (Guo et al., 2024,) it was indicated that adaptation as a strategy is significantly applied in local self-government (level of agricultural holdings), while the mitigation strategy is widely applicable.

In order to adapt to climate change, farmers face a deficit of technical knowledge, a lack of financial resources and an inadequate area of agricultural land (Kalenov et al., 2024). In addition, the authors consider factors such as lack of information and lack of capital and knowledge as the main limitations of adaptation among farmers. They suggest that the lack of agricultural land among farmers, and their failure to observe climate changes negatively contributes to agricultural production. Also,

the studies (Oben et al., 2024) point out that the high amounts of insurance premiums, and the lack of risks covered by insurance, the insufficient supply of agricultural insurance, as well as distrust in insurance contribute to the insufficient use of insurance for farmers. Authors (Zhou & Vilar-Zanón, 2024) claim that the agricultural advice service is the most significant factor in the lack of knowledge about climate change. On the other hand, the study (Peltonen-Sainio et al., 2023) draws attention to the availability of information that can increase the application of certain adaptation strategies. Due to the lack of tendency to introduce new systems in agriculture, older farmers face the limitations in the application of new production practices and technology. Finally, according to research results (Suhaeb, et al., 2024;), the call to agricultural producers to adapt to climate change manifests itself in an adequate choice of the right adaptation strategy.

Given that in Serbian agricultural population, no empirical works have been published that dealt with this problem, the main aim of this cross-sectional study is to examine the latent structure of the construct of limiting factors in the adapting to climate changes in agricultural farms. In accordance with the findings of previous studies and the aim of the research, an alternative hypothesis was tested: H – It is expected that the applied multivariate method will, from the set of manifest variables, extract the most representative hierarchical structural model among agricultural farmers.

Research methodology

Participants sample and procedure

A pertinent sample of participants of both sexes (N = 220) included the population of agricultural farmers from five municipalities of the Kolubara district: Valjevo, Ub, Lajkovac, Osečina, and Ljig. The age of participants ranged from 20 to 65 years. The average age of participants was (M = 58.63, SD = 6.02). The farm sample was chosen by random selection, with the only criterion being that the participants were engaged in agriculture as a primary or supplementary activity, i.e. that they are registered in the Register of Agricultural Holdings in the Republic of Serbia. The research was approved by the ethics committee of the Serbian Academy of Innovation Sciences from Belgrade. The survey was conducted in February 2024. The average duration of completing the questionnaire was 20 minutes.

Measuring instruments

The Questionnaire of limiting factors in adapting to climate change and business operations of agricultural farms

The used questionnaire on the impact and consequences of climate change on the business of agricultural farms (Oplanić et al., 2021) included variables related to individual characteristics: age, level of education and place of residence, size of arable land, external influences, methods of irrigation, finances and resources. The participant's task was to mark the degree of agreement with the stated statements on a five-point Likert-type scale for measuring attitudes (1 = It's not limiting at all to 5 = It's not limiting a lot). The total score for the subscales is obtained by adding up the scores on the associated variables, where a higher score means a greater impact and consequences of climate change on the business operations of agricultural farms. The reliability coefficient (Cronbach's α) of the internal consistency of the used measuring instrument is 0.83.

Statistical analysis

Descriptive statistical method and exploratory factor analysis - method of principal components, with Promax rotation and Kaiser normalization were used for data processing. The reliability analysis was conducted to determine the internal consistency of the applied questionnaire, which was expressed by the Cronbach's alpha coefficients. The software IMB SPSS, *Statistics for Windows*, version 26.0 was used for statistical data processing.

Results and discussion

The basic descriptive statistical parameters of the analyzed manifest variables applied in the research on the entire sample of participants are shown in Table 1.

Table 1: *Descriptive parameters of the observed variables*

Variables	M	SD	Min	Max	Sk	Ku	K-S
Availability of agricultural land	3.17	1.09	1	5	0.35	0.05	$p \leq 0.01$
Labor force availability	3.01	1.18	1	5	0.14	0.90	$p \leq 0.03$

Possibility of own irrigation	3.24	1.34	1	5	0.26	0.16	$p \leq 0.03$
Financial resources needed to implement adjustment measures	3.75	1.16	1	5	0.47	0.87	$p \leq 0.03$
The possibility of introducing new technologies adapted to climate change	3.36	1.03	1	5	0.03	0.75	$p \leq 0.03$
Reliability and timeliness of weather forecasting services	2.96	1.25	1	5	0.62	0.49	$p \leq 0.01$
Availability of affordable property and crop insurance programs	3.32	1.26	1	5	-0.85	0.34	$p \leq 0.01$
Financial assistance from the local or state administration at the time of damage	3.68	1.14	1	5	-0.26	0.60	$p \leq 0.01$
Legal regulations on production, farming and management of the farm	3.30	1.08	1	5	-0.38	0.45	$p \leq 0.01$
Availability of public information on ways to adapt to climate changes	2.97	1.12	1	5	-055	0.22	$p \leq 0.05$
Own knowledge about climate change and the need to adapt your farm	2.80	1.05	1	5	-0.43	0.58	$p \leq 0.05$

Legend. M = Arithmetic mean; *SD* = Standard deviation; Min = Minimum value; Max = Maximum value; *Sk* = Skewness; *Ku* = *Kurtosis*; K-S = Kolmogorov–Smirnov test. The value of standard error (*SE*) of *Sk* is 0.15, and of *Ku* is 0.23.

The obtained statistically significant values of the Kolmogorov-Smirnov test of normality of data distribution for a given significance threshold α, as well as skewness and kurtosis, range within the limits of the allowed values, between -1 and +1. This indicates the homogeneity of the results, that is, there are no statistically significant variations in the distribution of scores from the Gaussian curve, which is a prerequisite for conducting further parametric analyses.

In order to examine the latent structure of the measurement space of limiting factors in adapting to climate change, an exploratory factor analysis - method of principal components – was carried out in Table 2.

Table 2: *Characteristic factor roots and percentage of explained variance after applying Promax rotation*

Main components	**λ**	**% of the explained variance**	**Cumulative % of the explained variance**
1.	23.10	48.15	48.15
2.	1.88	3.90	52.05
3.	1.43	2.98	55.03
4.	1.26	2.64	57.68

Annotation. λ = Characteristic root or eigenvalue of Lambda

By matrix factorization, four characteristic roots were extracted, which according to the Gutman-Kaiser criterion - KG have a value ($\lambda \geq 1$), and with oblique Promax rotation explain 57.68% of the total variance. Examining the matrix, it is noted that the first main component has the highest possible variance, i.e. includes as much variability as possible, while the second, third, and fourth components contain the largest remaining possible residual variation.

Table 3 shows the factorial loadings of the original variables and the first principal component, where a higher absolute value of the factorial saturation implies a higher relevance in the interpretation of the factor structure.

Table 3: *Scope and structure of the first rotated Promax component H_1*

Variables	Scope	Structure	h^2
Reliability and timeliness of action	0.75	0.72	0.62
Availability of affordable property and crop insurance programs	0.68	0.64	0.46
Availability of public information on ways to adapt to climate changes	0.67	0.69	0.43
The possibility of introducing new technologies adapted to climate change	0.66	0.61	0.40
Legal regulations on production, farming and management of the farm	0.62	0.57	0.39

Annotation. The table shows the factorial loadings of variables greater than or equal to ($\geq$ 0.32) on the isolated statistically significant main component, as well as the communality of manifest variables above the acceptable level of 0.50. All factor saturations are statistically significant ($p \leq 0.01$).

The obtained mathematical solution – communality, which represents the proportion of shared variance within the manifest variables in the factor matrix, is above the acceptable stochastic level of 0.50 (Tabachnick & Fidell, 2013). Based on the communality value, that is, the part of the total variance that the variables share with the extracted factor, it is concluded that the coefficients on that factor solution are high, which indicates a homogeneous analyzed space. Therefore, the first most interpretable obliquely (Promax) rotated main component (H_1) includes the largest number of manifest variables, which with a certain probability, represent limiting factors in adaptation to climate change.

Statistically significantly uniform factorial loadings of the variables in this hierarchically superior but independent latent dimension, hypothetically, with the conspicuously greatest contribution of the

manifest variable reliability and timeliness of weather forecasting services, can hypothetically be interpreted as the most intensive common factor of the second order F_1 – *General external contributions*.

Table 4: *Purpose and structure of the second rotated Promax component H_2*

Variables	Scope	Structure	h^2
Availability of public irrigation system	0.60	0.570.38	0.39
Possibility of own irrigation	0.57	0.54	0.33

Annotation. The table shows the factorial loadings of the variables (≥ 0.32) on the isolated statistically significant main component, as well as the communality of the manifest variables above the acceptable level of 0.50. All factor saturations are statistically significant ($p \leq 0.01$).

The second statistically significant main component, which contains 3.90% of the mutual variance, refers to the latent dimension that includes two manifest variables. From a theoretical point of view, this hierarchically isolated mutual factor can theoretically be defined as a mutual factor of the second order F_2 – *Irrigation*.

The second-to-last third main component of the four-factor solution in Table 5, which includes three interconnected original variables of limitations in climate change adaptation, is generated by financial causes. Therefore, in accordance with the factorial saturations, their orthogonal latent scope and structure can be named as a mutual factor of the second order F_3 – *Finance*.

Table 5: *Purpose and structure of the third rotated Promax component H_3*

Variables	Scope	Structure	h^2
Financial resources needed to implement adjustment measures	0.55	0.51	0.33
Financial assistance from the local or state administration at the time of damage	0.53	0.500.30	

Annotation. The table shows the factorial loadings of the variables (≥ 0.32) on the isolated statistically significant main component, as well as the communality of the manifest variables above the acceptable level of 0.50. All factor saturations are statistically significant ($p \leq 0.01$).

Table 6: *Purpose and structure of the fourth rotated Promax component H_4*

Variables	Scope	Structure	h^2
Labor force availability	0.59	0.46	0.34
Availability of agricultural land	0.87	0.45	0.32

Own knowledge about climate change and the need to adapt your farm	0.40	0.36	0.30

Annotation. The table shows the factorial loadings of the variables (≥ 0.32) on the isolated statistically significant main component, as well as the communality of the manifest variables above the acceptable level of 0.50. All factor saturations are statistically significant ($p \leq 0.01$).

At the end of the mathematical solution, the fourth hierarchically isolated Promax component in the domain of limitations in adapting to climate change, due to the influence of three manifest variables, explains the minimum percentage of the mutual variance (community) of the data. The variable availability of agricultural land has the highest projection (0.87). In accordance with the obtained factor saturations, this latent dimension in the context of the extracted four-dimensional model can, given the manifest variables that define it, be theoretically interpreted as a mutual factor of the second order F_4 – *Material and human resources*. Definitely, there are enough empirical arguments to hypothetically name the four mutually independent isolated statistically significant principal components of the latent structure in the factor matrix, in accordance with the item saturations on diagonally rotated second-order factors, as Promax factors: *general external contributions, irrigation, finance, and material and human resources.*

Discussion

Mathematical solutions found – factorial findings in this research, identical to previous empirical studies, emphasize that the lack of resources and financial assets, limiting access to institutions, as well as the lack of timely information related to weather forecasts, represent limiting factors of agricultural farms adapting to climate change. Similar limiting latent dimensions in their research were obtained by (Khan et al., 2024), where agricultural producers highlight limited access to land and capital, sudden temperature changes, lack of financial reserves and uninsured production as common limits in adaptation to climate change. Findings obtained in foreign research (Thinda et al., 2021) on the latent structure of limiting factors in the adaptation of agricultural farms to climate change match the results in this empirical study, so it is possible to make a comparison with their results based on the same methodology. Therefore, for more effective adaptation to climate change in agricultural production, planners and creators of the current agricultural policy should moderate their decisions towards solving the main limiting factors in

accordance with the isolated Promax latent dimensions of the tested farmers in this empirical study.

This transversal study has certain *methodological limitations*, which to a certain extent condition the obtained results and which should be analyzed when interpreting the obtained findings. First, the pertinent sample of participants is not representative of the entire population because it included only participants from the same administrative district, at one point in time, which could affect the generalization of the results to all regions of Serbia. Second, in this research, only the self-assessment method of all variables was used, which is why there is a problem that the participants show the investigated domains below the actual level or exaggerated in order to minimize their problem or emphasize it more, which can cause an error in the collected data, i.e. the existence of methodological variance can be assumed. Also, since the correlational design research was conducted, inverse relationships between the examined variables are also assumed, which does not allow conclusions to be drawn about the causal-consequential codependence between the limiting latent dimensions in the adaptation to climate change in agricultural farms. However, despite the aforementioned methodological limitations, this cross-sectional study provided relevant results and an important basis for further research, as well as important implications for agricultural practice. It shows that the extracted Promax factors explain a significant segment of the variance, which may suggest directions for further research in this area. It would be important for future studies to include a larger number of participants from the territory of the whole of Serbia. In addition to using the self-assessment measure for the applied questionnaire, which represents the four-factor model in this study, some other sources of data should also be taken into account, e.g. agronomists and agricultural engineers or students of agriculture who would assess the limiting latent dimensions in adapting to climate change in the agricultural sector. Finally, subsequent research should be of a longitudinal design, which would enable a more complete understanding of the complex structures of relationships examined in this paper. From the theoretical viewpoint, the contribution of the results of this empirical study is manifested in the definition of the economic and social aspects of the limiting factors in the adaptation of climate change among farmers. In addition, the results obtained in our sample can now be compared to the findings obtained in other regions and other countries, since he same methodology was used. This research contributes to the factual „screening“ of the extracted latent structure as limiting factors in the

adaptation to climate change in agriculture, especially since from this aspect, this problem has not been investigated in the Serbian population. Also, the results of the research enable diagnostics, that is, identification of the model of the factorial structure of limiting factors among farmers according to climate change. In addition, the used measuring instrument has satisfactory validity and reliability, which increases the heuristic contribution of the work, as well as the practical implication of our empirical research. Therefore, the possible effect of the obtained relevant findings can serve researchers in the Serbian-speaking area as a starting reference for subsequent empirical studies in order to obtain new information in the construct of latent dimensions as limiting factors in the adaptation of agricultural farms to climate change.

Conclusion

The analysis of the results in this factorial study gives an insight into the fact that the phenomenon of the structure of limiting factors in the adaptation of agricultural farms to climate change is present among the agricultural population in Serbia. The research findings of the analysis of the main components on the sample of agricultural producers show the existence of a four-factor model, which with 57.68 explained total variances hypothetically defined mutual factors of the second order: General external contributions (F_1), Irrigation (F_2), Finances (F_3) and Material and human resources (F_4). The communalities of each latent variable are relatively high, which signals that the variance of the manifest variables is satisfactorily covered by the factors. In addition to its theoretical and practical significance, this factorial study also has certain methodological limitations: (I) the pertinent sample is structured only from male agricultural producers, exclusively from the territory of the Kolubara district, which makes it impossible to represent and generalize the results to various agricultural subpopulations and (II) the measuring instrument is based on self-assessments, which is characterized by shortcomings such as honesty of participant's answers and cognitive distortions, i.e. increased correlation between variables. Regardless of the methodological limitations of this research, the theoretical implications of the results are reflected in the attempt to explain the variance of the extracted factors, while the practical implications of this empirical study are manifested in the provision of guidelines primarily oriented towards the education of agricultural experts, i.e. to implement the variables of the four-factor structure in their practice for the sake of limiting factors and their adaptation to climate changes and the operations of agricultural

farms. The questionnaire used in this research provides very useful and reliable information, and it can be applied in the future studies in the Republic of Serbia. The obtained factorial results can be relevant for deriving implications when creating a program of constructs of limiting factors for agricultural farms in adapting to climate change. In addition, a better insight into the model of the causal-effect structure of relations of the set of limiting dimensions in adaptation to climate change and the operation of agricultural farms would be enabled by the analysis of future longitudinally collected data with similar constructs, on a larger and more representative sample of participants, of both sexes, from the wider area of the Republic of Serbia.

References

1. Bouraima, M. B., Ibrahim, B., Qiu, Y., Kridish, M., & Dantonka, M.. (2024). Integrated Spherical Decision-Making Model for Managing Climate Change Risks in Africa. *Journal of Soft Computing and Decision Analytics*, *2*(1), 71–85. https://doi.org/10.31181/jscda21202435

2. Guo, X., Chmutova, I., Kryvobok, K., Lozova, T., & Kramskyi, S. (2024). The race for global leadership and its risks for world instability: Technologies of controlling and mitigation. *Research Journal in Advanced Humanities, 5*(1), 178–191. https:// doi.org/10.58256/5wzf9y48

3. Heranval, A., Olivier L., & Maud T.. (2022). Application of machine learning methods to predict drought cost in France. *European Actuarial Journal* 13, 1–23.

4. Hossain, M., Kuddus, M. A., Foysal, A. M., Sahriar Khan, R., Moniruzzaman, Mia, M. T., … & Shiam, S. A. A. (2024). Climate Change and Current Adaptation Strategies in the Haor Areas. *Journal of Knowledge Learning and Science Technology*,*2*(3), 230–241. https://doi.org/10.60087/jklst.vol2.n3.p241

5. Jyothi, V., & Vijayabhinandana, B. (2023). Farmers Information Landscape: Trends and Transformation.*The Indian Research Journal of Extension Education (IRJEE) 24*(1),12–19. https://doi.org/10.54986/ irjee/2024/jan_mar/12–18.

6. Kalenov, K. T., Rustamov, N. I., & Utemuratova, R. B. (2024). Modern Trends and Factors of Financial Development of the Agricultural Sector

in the Republic of Karakalpakstan, Taking Into Account Agricultural Insurance. *Information Horizons: American Journal of Library and Information Science Innovation 2*(1), 97–101.

7. Khan, Z., Shah, S. A., Haseeb, A., Hanif, M., Rauf, A., & Khan, I. (2024). Farmers perception of climate and impact on the production of main crops in the balocchistan province of Pakistan. *International Journal of Contemporarz Issues in Social Sciences, 3*(1), 492–504.

8. Oben, E. E., Ndi, H. N., & Tchuikoua, L. B. (2024) What Premiums are Livestock Farmers Willing to Pay for Indemnity Insurance in the West Region, Cameroon? *Asian Journal of Agricultural Extension, Economics & Sociology, 42*(1), 114–127. https://doi.org/archive.jibiology.com/id/eprint/2244

9. Peltonen-Sainio, P., Jauhiainen, L., & Känkänen, H. (2023). Finnish farmers feel they have succeeded in adopting cover crops but need down-to-earth support from research. *Agronomy, 13*(9), 2326–2334. https://doi.org/10.3390/agronomy13092326

10. Suhaeb, F. W., Tamrin, S., Jumadi, & Irwan. (2024). Community Adaptation Strategies To Climate Change: Towards Sustainable Social Development. *Migration Letters, 21*(S2), 943–953.

11. Thinda, K. T., Ogundeji, A. A., Belle, J. A. & Ojo, T. O. (2021). Determinants of relevant constraints inhibiting farmers' adoption of climate change adaptation strategies in South Africa. *Journal of Asian and African Studies, 56*(3), 610–627.

12. Varyvoda, Y,. & Taren, D. (2024). COP 27 insights to increase food-systems climate adaptation and resilience. *Nutrition Reviews, 82*(1), 1–4. https://doi.org/10.1093/nutrit/nuad035

13. Zhou, N., &Vilar-Zanón, J. L. (2024). Impact Assessment of Climate Change on Hailstorm Risk in Spanish Wine Grape Crop Insurance: Insights from Linear and Quantile Regressions. *Risks, 12*(2), 20–29. https://doi.org/10.3390/risks12020020