

Methodology for additional ranking of agricultural areas with natural constraints - Bosnia and Herzegovina case study

Željko VAŠKO¹, Marko IVANKOVIĆ², Suzana MADŽARIĆ³, Nemanja JALIĆ¹ (✉)

¹ Faculty of Agriculture, The University of Banja Luka, Bulevar Vojvode Petra Bojovića 1A, 78000 Banja Luka, Bosnia and Herzegovina

² Faculty of Agriculture and Food Technology, The University of Mostar, Biskupa Čule bb 88000 Mostar, Bosnia and Herzegovina

³ CIHEAM Bari, Mediterranean Agronomic Institute, Via Ceglie, 9, 70010 Valenzano BA, Italy

✉ Corresponding author: nemanja.jalic@agro.unibl.org

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ABSTRACT

The research aimed to rank 109 municipalities previously classified into Areas with Natural Constraints (ANC) for agricultural production in Bosnia and Herzegovina (BiH). A tailored EDEO model was developed, operating with 12 criteria. Three criteria were selected from the four sub-groups: environmental, demographic, economic, and organizational. Initial data for each criterion score calculation were gathered from various secondary sources. The model aims to maximize the function by determining the distance of each municipality's values from each criterion's maximum or minimum value. The results revealed significant differences among municipalities, all previously classified into ANC, according to individual criteria and overall scoring. The additional classification of ANC municipalities based on extra criteria enables their prioritization for specific interventions in cases where providing financial and other support for the entire ANC is not feasible. The EDEO model also enables an objective adjustment of the level of support among municipalities that would otherwise be equally suitable for support because they all belong to areas with natural handicaps.

Keywords: ANC, modelling, rural development, policy support

INTRODUCTION

The suitability of pedological, climatic, and other conditions for agricultural production has been a topic as old as agriculture itself. Since the beginning of farming, certain regions have been recognized for their higher yields and better conditions for food production compared to others, where it has been more challenging, despite investing similar inputs and efforts. Climatic and geographic factors dictate the possibilities of cultivating specific plant and animal species, significantly influencing agricultural production and yields under comparable investment conditions (Njegovan, 2018).

The investment decisions of single farmers are linked to the profit they generate (Davidova et al., 2005; Chouinard et al., 2008; Rendel et al., 2013). Some authors advocate that farmers are making production decisions

based on total household wealth, not just on farm production profitability (Chouinard et al., 2008; Rendel et al., 2013; Blank et al., 2004). Nevertheless, profitability is the leading principle of most farmers when making managerial decisions about whether, what, and where to produce.

Due to the limited areas of agricultural land and the increasing need for food, the decision about where to produce food cannot be left solely based on the logic of profit. Therefore, issues of targeted treatment of certain areas for agricultural production have long been the subject of agrarian political decisions and special or additional financial and other support to farmers to equalize the economic conditions of farming between areas with more and less favorable conditions for agricultural production (Zdruli et al., 2017).

To correct market anomalies and consider economic, environmental, and social sustainability cohesion and coexistence (Tey and Brindal, 2015), it is necessary to determine which areas cannot compete in food production based on economic criteria alone. When the level of inequality is determined, different countries apply different compensation mechanisms, one of which is the granting of additional payments tailored to the European Union (EU) agricultural policy.

Citing various studies (Barnes et al., 2023), authors note that agricultural policies now strive to incorporate ecological and climatic objectives into payment systems while safeguarding food production and bolstering the resilience of farming communities. Natural disasters occur at intervals worldwide, affecting entire regions or countries (Qianwen and Junbiao, 2007; Israel and Briones, 2013; Coulibaly et al., 2020; Klomp and Hoogezand, 2018; Chapagain and Raizada, 2017; Li et al., 2022; FAO, 2012), temporarily reducing yields of crops and livestock. In contrast, areas with natural constraints face enduring disadvantages in achieving equivalent yields compared to less constrained regions or those with fewer drawbacks. The Less-Favored Areas (LFA) scheme, later transformed into ANC, was established in 1975, serves as a comprehensive mechanism to enhance the economic viability of agriculture in regions with natural handicaps. Standard criteria were developed by the European Commission's Directorate-General for Agriculture and Rural Development to meet the objectives of the Rural Development Policy 2007–2013 (Axis II), aimed at promoting more sustainable land management to enhance environmental and rural conditions (Eliasson et al., 2010; Papić and Bogdanov, 2021; Zielinski et al., 2022). Similarly, payments for production in areas with natural constraints were introduced to equalize economic conditions in agricultural production. Farm incomes were intended to increase through an annual compensatory allowance that compensates farmers for permanent natural handicaps, calibrated according to the severity of the handicap relative to various regional, national, and European benchmarks (Institute of European Environmental Policy, 2006).

In addition to supporting areas with natural constraints to compensate for lower yields and incomes, some authors argue that the model of support through direct payments is inefficient for both farmers' income and environmental goals (Pe'er et al., 2020). Research by Hagyo et al. (2015) highlights significant differences in production capacities between areas with and without natural constraints, including crop provision, animal husbandry potential, water supply, erosion control, habitat maintenance, pollination, recreation, water regulation, and global climate regulation. According to Dakpo et al. (2021) who studied three types of grazing farms in France, over 83% of beef cattle farms were located in Less-Favored Areas compared to 50% and 36% for dairy and mixed farms, respectively, supporting advocates of this approach and payments within the EU Common Agricultural Policy (CAP). The same research emphasizes that factors such as the economic viability of farm operations in sustaining family members and the broader economic prospects of rural regions influence decisions for family members to remain engaged in farming. Research on LFA payments considered the impacts of political, geographical, demographic, and economic factors, highlighting the importance of addressing poverty and environmental pressures in LFAs to ensure food security, income, and employment opportunities and to reduce migration out of these areas (Ruben and Pender, 2004).

Research conducted in Slovakia, (Valach, 2020) found that farms in areas without natural constraints exhibit better economic indicators (assets, liabilities, revenues, sales of own products and services, total costs, economic result, added value, and acquisition of tangible fixed assets) compared to farms facing natural constraints for agricultural activities, regardless of LFA (ANC) payments. The only indicator where no significant difference could be determined was employment maintenance, and according to the author's opinion, this payment could have contributed to maintaining employment in regions with natural constraints. Due to the presence of natural constraints and unequal economic conditions, farmers have migrated to more favorable agricultural areas, resulting in the depopulation of rural regions with natural

handicaps. Zielinski et al. (2022) found that farms in ANC in Poland have lower costs but also lower revenues, resulting in negative profits without subsidies for operating in ANC. LFAs globally contribute significantly to red meat production, although these farms have highly variable impacts on efficiency, financial sustainability, greenhouse gas emissions, and heterogeneity (Barnes et al., 2023). In terms of the total migration rate, municipalities with LFA subsidies are more stable than municipalities without the latter (Pelucha et al., 2013). The necessity of more sensitive treatment of disadvantaged rural areas lies in the results of the multifunctional agriculture support, which are limited in the context of territorial cohesion (Pelucha et al., 2013). Research conducted in China on rural economic resilience in impoverished areas suggests the need for policy enhancements to effectively improve the resilience and transformative capacity of rural economic systems. This entails focusing on industrial specialization, diversity, and cultivating the endogenous development capacity of villages and rural populations as a whole (Cui et al., 2023).

Similar to the applied EDEO model, the authors divided ANC in Poland into 7 groups based on the presence of significant natural constraints, specific constraints, or simply meeting one of the ANC criteria (Zielinski et al., 2022). During this classification, they primarily considered the natural characteristics of the areas (higher presence of natural handicaps correlating with greater ANC support). Closely related, the DLG (German Agricultural Society) aimed to define sustainable agriculture based on scientific methods. The assessment involves calculating the average of all indicator values within each of the single areas (ecological, economic, social), resulting in an index of sustainable achievement for the farm across these three sustainability dimensions (Ehrmann and Kleinhanß, 2008).

In the former Socialist Yugoslavia, there was no similar classification as in the EU context for areas with natural constraints, but similar attention was given to the development of mountainous and hilly-mountainous regions. In the last medium-term

agricultural development program of the then Socialist Republic of Bosnia and Herzegovina (1986-1990), it was noted that in the situation of limited resources for food production, there was a social interest in producing food in areas with lower natural potential (Republički komitet za poljoprivredu, šumarstvo i vodoprivredu BiH, 1986). This approach aimed to prevent these areas from being depopulated due to difficult living conditions and to maintain ecological balance. At that time, a total of 108 municipalities were categorized in mountainous regions, out of which 55 municipalities were designated. Four types of special support were planned for mountainous areas: (1) subsidizing inputs for agricultural production, (2) preferential interest rates on loans, (3) co-financing costs for professional development services, and (4) investments in fixed assets.

In the Republic of Srpska (one of two entities in BiH), for several years now, there has been a practice of applying higher percentages of incentives for capital investments in agriculture to farms located at altitudes above 600 meters above sea level. This policy acknowledges the challenging operating conditions faced by agricultural enterprises in higher altitude areas. In the entity Federation of Bosnia and Herzegovina, there is no similar incentive-sensitive approach to areas with natural handicaps.

The “Sustainable Economic Development and Environmental Protection in Areas with Natural Constraints in Bosnia and Herzegovina (ANC BiH)” project faced the challenge of being unable to provide equal support to all previously classified ANC municipalities. Therefore, the objective was set to conduct an additional objective ranking of all ANC municipalities in Bosnia and Herzegovina to select a smaller number that would receive additional financial support from the project.

MATERIALS AND METHODS

The research started from the need to select from the already demarcated ANC in Bosnia and Herzegovina those that have the greatest needs to be prioritized for additional support. For additional ranking of municipalities in Bosnia and Herzegovina classified as ANC based on

biophysical criteria, a modelling approach was used. The model, abbreviated as EDEO, from its four basic criteria groups - environmental, demographic, economic, and organizational was tailored to determine the ranking of each ANC municipality in the Republic of Srpska (RS) and the Federation of Bosnia and Herzegovina (FBiH) using a 4 x 3 matrix framework. Each of the four criteria groups includes three sub-criteria and is pondered for each, as illustrated in Table 1 and the formulas below. According to Ruben and Pender (2004), research, the interlocking of social, physical, economic, and demographic factors causes a path dependency characterized by the coexistence of various livelihood strategies and resource management regimes, confirming the influence of different factors on economic conditions in areas with natural constraints.

$$E_{(a)} = p_1 \left(\frac{a_{1i}}{a_{1max}} \right) + p_2 \left(\frac{a_{2i}}{a_{2max}} \right) + p_3 \left(\frac{a_{3i}}{a_{3max}} \right); \Sigma = 0.40 (RS); 0.25 (FBH)$$

$$D_{(b)} = p_4 \left(\frac{b_{1min}}{b_{1i}} \right) + p_5 \left(\frac{b_{2min}}{b_{2i}} \right) + p_6 \left(\frac{b_{3min}}{b_{3i}} \right); \Sigma = 0.25 (RS); 0.30 (FBH)$$

$$E_{(c)} = p_7 \left(\frac{c_{1min}}{c_{1i}} \right) + p_8 \left(\frac{c_{2i}}{c_{2max}} \right) + p_9 \left(\frac{c_{3min}}{c_{3i}} \right); \Sigma = 0.25 (RS); 0.25 (FBH)$$

$$O_{(d)} = p_{10} \left(\frac{d_{1i}}{d_{1max}} \right) + p_{11} \left(\frac{d_{2i}}{d_{2max}} \right) + p_{12} \left(\frac{d_{3i}}{d_{3max}} \right); \Sigma = 0.10 (RS); 0.20 (FBH)$$

$$Y_i = E_{(a)} + D_{(b)} + E_{(c)} + O_{(d)}$$

where: *i* – ordinal number of municipalities with natural constraints covering more than 60% of their agricultural land area. The meaning of other symbols (*p*, *a*, *b*, *c*, and *d*) is explained in Table 1.

The weighing ponderings in the model were determined based on consultations with focus groups in which key stakeholders were involved. These focus

Table 1. Criteria and sub-criteria for ranking municipalities with natural constraints

Criteria	Subcriteria	Ponder	RS	FBiH
a) Environmental	<i>a</i> ₁ The percentage of ANC agricultural land	<i>p</i> ₁	0.25	0.10
	<i>a</i> ₂ The number of livestock units per hectare of agricultural land	<i>p</i> ₂	0.10	0.10
	<i>a</i> ₃ The ratio of arable to total agricultural land	<i>p</i> ₃	0.05	0.05
b) Demographic	<i>b</i> ₁ Population density per km ²	<i>p</i> ₄	0.10	0.10
	<i>b</i> ₂ Migration rate relative to the population	<i>p</i> ₅	0.10	0.10
	<i>b</i> ₃ Average age of the population	<i>p</i> ₆	0.05	0.10
c) Economic	<i>c</i> ₁ Budget per capita	<i>p</i> ₇	0.10	0.10
	<i>c</i> ₂ The ratio of unemployed to employed	<i>p</i> ₈	0.10	0.10
	<i>c</i> ₃ Average wages	<i>p</i> ₉	0.05	0.05
d) Organizational	<i>d</i> ₁ Number of agricultural producer associations	<i>p</i> ₁₀	0.03	0.05
	<i>d</i> ₂ Number of agricultural cooperatives per 1,000 hectares of agricultural land	<i>p</i> ₁₁	0.03	0.05
	<i>d</i> ₃ Number of registered agricultural households	<i>p</i> ₁₂	0.04	0.10

groups consisted of representatives from academia, researchers, representatives from ministries, project representatives, and other experts in the specific field. The listed weights are specially tailored for the context of Bosnia and Herzegovina and should or could be adapted for other regions and countries, according to the opinion of key stakeholders.

Data were processed only for municipalities previously classified as ANC, as these municipalities were the subject of additional ranking. Data were separately processed for municipalities in the RS and municipalities in the FBiH (two major administrative areas in BiH).

RESULTS AND DISCUSSION

Within the ANC project in Bosnia and Herzegovina, data collection and processing were conducted to delineate areas with natural constraints. ANC delineation was done following the methodology of the EU Joint Research Centre (JRC), as outlined in the EU regulations

concerning ANC (Figure 1). The data elaboration used a reference period from 1960 to 1990, consistent with the EU JRC methodology, which helped avoid data gaps caused by the war period in Bosnia and Herzegovina (1991-1995) (Preliminary Maps of Agricultural Areas with Natural Constraints in Bosnia and Herzegovina, 2022). The criteria included similar research (Eliasson et al., 2010), temperature, heat stress, drainage, soil texture, stoniness, rooting depth, chemical properties of the soil, soil moisture balance, and slope.

Out of a total of 142 municipalities in Bosnia and Herzegovina, 109 municipalities met the criteria to be classified as Areas with Natural Constraints (ANC) for agricultural production. Based on twelve environmental, demographic, economic, and organizational subcriteria ($a_1, a_2, a_3, b_1, b_2, b_3, c_1, c_2, c_3, d_1, d_2, d_3$), shown and explained in Table 2, an additional classification of ANC municipalities in BiH was carried out.

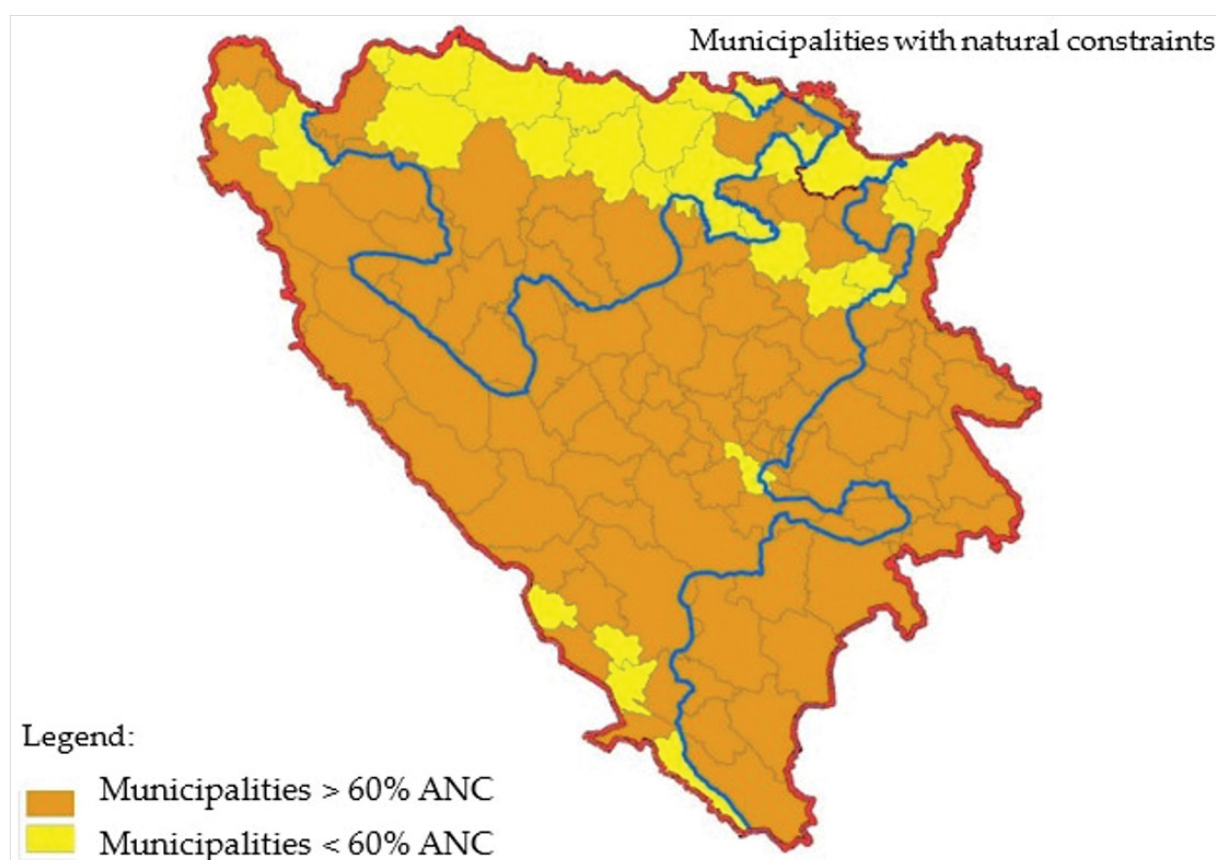


Figure 1. Map of ANC in Bosnia and Herzegovina represented at the level of municipalities using JRC methodology (ANC BiH Maps, 2022)

Table 2. Minimum and maximum values of all criteria for RS and FBiH

Criteria		Republic of Srpska		Federation of Bosnia and Herzegovina	
		Minimum	Maximum	Minimum	Maximum
The percentage of ANC agricultural land	a_1	61.4%	100%	60.1%	99.6%
The number of livestock units per hectare of agricultural land	a_2	0.01	2.41	0.04	2.6
The ratio of arable to total agricultural land	a_3	3.6%	85.8%	4.80%	84.40%
Population density per km ²	b_1	1.2	315.5	2.8	695
Migration rate relative to the population	b_2	+38.64%	-1.61%	-2.17%	+9.95%
Average age of the population	b_3	40.19	58.3	36.05	55.04
Budget per capita	c_1	415	9.550	201.5	8.303.7
The ratio of unemployed to employed	c_2	0	2.95	0.21	3.43
Average wages	c_3	978	1.832	949	2.081
Number of agricultural producer associations	d_1	0	4.05	0	1.88
Number of agri. cooperatives per 1,000 ha of agri. land	d_2	0	3.0	0	10.16
Number of registered agricultural households	d_3	0.49	11.76	0.54	40.58

As it is explained in the last column of Table 2, preference (more points) are given to municipalise: (1) with the larger agricultural land area; (2) with larger number of livestock units; (3) with larger share of arable land; (4) with lowest population density; (5) with a positive migration balance; (6) with youngest population; (7) with lowest budget; (8) with highest unemployment; (9) with lowest wages; (10) with better organized rural population; (11) with better organized farmers; and (12) with more active family farms.

Additional ranking, using the EDEO model, included 45 municipalities from the RS and 64 municipalities from the FBiH, in total 109, previously classified as ANC areas

in BiH. Based on the value assigned to each specific municipality for each sub-criterion, the appropriate number of points was determined considering the threshold, the minimum or maximum value, depending on the preference. The result of classification according to the applied model is a rank list of all classified municipalities, and the top ten municipalities in the Republic of Srpska and the Federation of BiH are listed in Table 3.

Thanks to the additional ranking, the ten best-ranked municipalities were selected as priorities for support as pilot municipalities by the ANC BiH project in Bosnia and Herzegovina.

Table 3. The ten best-ranked municipalities in the FBiH and RS using the EDEO models

	Federation of BH ANC municipalities	Points	Republic of Srpska ANC municipalities	Points
1	Teočak	54.54	Donji Žabar	51.99
2	Bužim	47.47	Kupres (RS)	51.68
3	Gračanica	46.85	Oštra Luka	50.87
4	Sapna	45.23	Ljubinje	50.73
5	Doboj istok	44.05	Čajniče	49.64
6	Žepče	43.54	Rudo	49.36
7	Visoko	43.34	Kneževo	49.16
8	Tešanj	42.28	Bratunac	48.16
9	Glamoč	40.94	Milići	47.90
10	Čelić	40.82	Vlasenica	46.75

Republic of Srpska

Generally, in terms of ANC criteria, municipalities in mountainous areas of the RS scored the highest. Regarding the criteria of the number of livestock units and the share of cultivated land, municipalities in the northern part of the RS excelled. Demographically, mountainous and Herzegovinian municipalities have the lowest population density and experience the highest migrations, while larger urban centers have the oldest population. Economically, municipalities with higher population densities have the smallest budget per capita, and municipalities in the eastern and southern parts of the Republic of Srpska face the highest unemployment rates. In terms of the organization of rural population criteria, sparsely populated municipalities have the highest number of associations per 1,000 inhabitants, while no dominant pattern is observed in cooperative distribution. Municipalities in the eastern part of the RS have the highest number of registered agricultural households relative to agricultural land area, likely due to smaller average land sizes and the dominance of labor-intensive agricultural production, such as raspberry farming.

The final selection of five from the ten best-ranked municipalities for support in the Republic of Srpska was made by the Ministry of Agriculture, Forestry, and Water Management of the Republic of Srpska.

Federation of Bosnia and Herzegovina

An analysis of the specified ANC criteria in the Federation of Bosnia and Herzegovina area showed that municipalities above 800 meters above sea level received the highest number of points, similar to the example of the Republic of Srpska. According to the ANC criterion for the percentage of agricultural land, the so-called mountainous municipalities also received the highest number of points. For the number of livestock units, there was no geographical distribution that defined the number of points; instead, the points varied from case to case. In demographic criteria, the lowest population density and highest migration were observed in mountainous and Herzegovinian municipalities, while the oldest population was found in larger urban centers. An analysis of economic criteria showed that the municipalities with

the highest population density had the smallest budget per capita, and the highest unemployment was found in small municipalities and those in the east of the FBiH. In the analysis of rural population organization criteria, the highest number of cooperatives was in the north, and the lowest in the south of the FBiH. The highest number of registered agricultural holdings relative to the area of agricultural land was found in the northern municipalities of the FBiH, while the lowest was in the south and east, which could be associated with small average land areas and the dominance of labor-intensive agricultural production.

From the list of ranked municipalities, for the ANC BiH project, a selection of ten pilot municipalities was made according to the specified EDEO model criteria. The Federal Ministry of Agriculture, Water Management and Forestry selected five from the ten best-ranked municipalities in FBiH.

The application of the described methodology confirmed that the EDEO model can be successfully used for the classification of local administrative units for various purposes, as was done in this case for ranking ANC municipalities. It is possible to modify and determine the weight of each of the four groups of criteria, and within the range of points for each group of criteria, adjust the significance, or weight, of each sub-criterion. In this way, starting from available data and predefined criteria and their interrelations, decision-making regarding the prioritization of financial and other support to local government units or other administrative units is made more objective.

DISCUSSION

The analytical framework and the obtained results help to improve the general understanding of the ANC approach and allow better channeling and fine-tuning of agricultural and other policy support measures (as was also suggested by (European Commission, 2012; Fellmann et al., 2021; Lu et al., 2022; Maris and Holmes, 2023; Lenormand, 2023). Although additional payments for farming based on ANC delimitation are still not in

force in BH, it is one of the declared strategic priorities for the future period (Strategic plan for rural development of Bosnia and Herzegovina (2018-2021) - framework document, 2018). The additional delineation of the ANC presented in this paper was used to grant support to prioritized municipalities within the project financed by the Government of Italy (ANC BiH) and demonstrated how to practically use the results of the basic and additional ANC classification.

The application of biophysical criteria for ranking the territory of Bosnia and Herzegovina into ANC and non-ANC confirmed that there are significant differences that justify such a classification, which has been in use in the EU for years (Barnes et al., 2023; Zielinski et al., 2022; Hlavsa et al., 2020; Papić Milojević and Bogdanov, 2024). 74.2% of the territory of Bosnia and Herzegovina met the criteria for classification in the ANC, but to belong to that group, it used to be crucial to cross the threshold in case of only one criterion, and sometimes the threshold was crossed for almost all criteria. Therefore, logical complaints are that all ANC cannot achieve the same level of support for compensation of natural handicaps (Kazakova Mateva, 2017), especially if it is taken into account that incentives for agriculture in BH are among the lowest in the region and significantly lower compared to the same incentives in the EU (Martinovska Stojchevska et al., 2021).

The benefits of the presented methodological tool are the provision of a better analytical and information base for policymakers so that they can more easily and objectively adjust agricultural and rural development policies, taking into account several factors for determining goals and tailoring measures that best fit the local state. Also, the benefit of the research is broader, because the applied model, although primarily developed for the needs of Bosnia and Herzegovina, can be used and additionally adapted in other countries for similar purposes. This primarily refers to the possibility of giving different weights to the current sub-criteria (as it was done in BH for its two entities), as well as the inclusion of additional or replacement of certain criteria in the model.

Limitations to research were different formats of certain data from secondary sources, and different methods of their collection, processing and publication, which required additional work and adjustment of some of the data. Also, one of the problems was the accuracy and reliability of the data, which correlates with the efficiency and competence of the institutions that were the source of the data used. Similar constraints may be encountered by those who will try to repeat similar modelling attempts. In the case of the use of the model by state institutions, the problem of providing input data will certainly be smaller, considering the networking of institutions and the mutual availability and exchange of data.

It would be useful if the other researchers would test the same model in another area and provide additional inputs to the development and calibration of the model for additional ranking of ANC (or some other) areas as presented in this paper.

CONCLUSIONS

A complex and significant task was undertaken by collecting and processing a large amount of data to classify the territory of Bosnia and Herzegovina into areas favorable and less favorable for agricultural production. Biophysical criteria and threshold values used in the EU-defined Regulation (EU) No 1305/2013 were employed for this purpose. For the previously determined expert contributions within the project funded by the Government of Italy to be used for decision-making in the agricultural policy domain and for disbursing additional incentives to agricultural farms operating in ANC, it is necessary for Bosnia and Herzegovina, including its entities and the Brcko District, to adopt in their original or modified form the EU regulations and to formalize them by adopting appropriate secondary legislation.

Considering that, according to the mentioned Regulation (EU 1305/2013), it is sufficient for any area (in the case of Bosnia and Herzegovina municipality) to meet just one of the eight qualification criteria to be classified as an ANC, a need for further ranking of municipalities

within the ANC is imposed. This is particularly relevant when the available financial resources are not sufficient to provide unified support to all areas with evident natural handicaps. For such cases, the EDEO model has been developed and used, which considers an additional twelve criteria from the groups of environmental, demographic, economic, and organizational factors. This model has been used for the first time to support the selection of ten pilot municipalities within the project Sustainable Economic Development and Environmental Protection of Areas with Natural Constraints in Bosnia and Herzegovina (ANC BiH). The possibilities and effectiveness of the application of the EDEO model, developed for the first time for the purpose of that project, have been confirmed, and the results of its practical application are described in this paper.

The conclusion of the research team is that the EDEO model can be used in its original or modified form for further classification of ANC, as well as rural areas in general, for other purposes. The model allows adjusting the balance of weights assigned to each criterion to fit certain situations, taking into account the particular ranking objectives and the presence of specific constraints in data availability in the area being applied.

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