INITIATIVES FOR AGRO-RURAL REVITALIZATION ACROSS ALTITUDINAL GRADIENTS IN THE CONTEXT OF CLIMATE CHANGE

Romulus GRUIA[1], Liviu GACEU[2]

Abstract. *This paper addresses the highly topical issue of climate change, emphasizing its differentiated impact across various altitudinal levels. Specifically, it analyzes the potential and corresponding solutions for agro-rural development, differentiated across low, medium, and high altitudinal groups—namely, three altitudinal zones: below 1,000 meters, between 1,000–1,500 meters, and above 1,500 meters. The study considers a range of climate change effects and adaptation measures aimed at achieving balanced and bio-harmonized development of rural and agro-silvo-pastoral areas, particularly in fragile (mountainous) zones. The analysis includes general principles and applies them to the specific context of Romania. Taking into account the polyvalence of variables, the study proposes a set of principles forming the basis of an action-oriented guide supported by a series of solutions for future decades. It examines various aspects of agro-rural revitalization along altitudinal gradients and develops a model for climate adaptation and agro-rural development tailored to altitudinal zones. The paper includes tables, maps, diagrams, and both theoretical and applied benchmarks of the proposed model, alongside a case study and resulting measures that demonstrate the coherence of public interventions in specific localities situated at 250 m, 650 m, and 950 m altitude. These findings show potential for nationwide replication.*

Keywords: agriculture, agrosilvopastoral systems, altitude, climate change, rural development

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1. Introduction

Dairy farming has long been an essential component of agriculture, providing a Climate change directly influences environmental conditions and natural resources, which can alter agricultural production patterns, water availability, ecosystem structure and rural development patterns [1, 41]. Depending on altitude, these effects vary significantly, and agro-rural development must be adapted to the realities of each area [8, 37].

[1] Prof.PhD. Eng. University of Transilvania from Brașov, Romania, Full Member of the Academy of the Romanian Scientists, Associate member of Academy of Agricultural and Forestry Sciences "Gheorghe Ionescu-Sisesti", Researcher CE-MONT & CSCBAS – National Institute of Economics Research, Romanian Academy, (e-mail: ecotec@unitbv.ro)
[2] Prof. PhD. Hab. Eng. University of Transilvania from Brașov, Romania, Coresponding Member of the Academy of the Romanian Scientists, Researcher CE-MONT & CSCBAS – National Institute of Economics Research, Romanan Academy, (e-mail: gaceul@unitbv.ro).

Agro-rural development on altitude gradients in relation to climate change is a crucial issue for the adaptation and resilience of rural communities and the agricultural sector to the challenges brought by climate change. Regions located at different altitudes are affected differently by these changes, and development strategies must take into account the particularities of each area [6,8,20,31,34].

These dimensions create the premises of a holistic approach, necessary to respond to the current challenges of climate change, rural migration, food security and social equity in rural areas. Therefore, as premises regarding agro-rural development, development on altitude gradients in relation to climate change is signaled, respectively an extremely worrying topic for the adaptation and resilience of rural communities and the agricultural sector in the face of the challenges brought by contemporary climate change.

The main purpose of this research is to analyze the dimensions and determinants of sustainable agro-rural development, with an emphasis on the integration of agro-ecological practices, the diversification of rural activities and the involvement of the local community in decision-making processes. The study aims in particular to identify good practices and barriers encountered in rural areas in Romania. More specifically, the purpose and utility of the study on "agro-rural revitalization initiatives" refers to the integration of resource management principles and practices to find solutions to the impact of climate change recorded on various areas specific to altitude gradients.

The framework objectives of the research refer to investigating the level of implementation of sustainable rural development principles in rural farms; to assessing the perception of local actors (farmers, authorities, NGOs) on the opportunities and challenges in the field of agro-rural development, and to identifying functional models of cooperation and innovation in rural areas.

As specific objectives, the paper aims to provide a better understanding of the systemic aspects related to agro-rural revitalization both theoretically and pragmatically. Thus, as a theoretical objective, the study proposes the description of some principles and action guidelines regarding the relationship between climate change and altitudinal level, with an impact on REVITALIZATION IN THE LINE OF INTEGRATED AGRO-RURAL DEVELOPMENT. As a pragmatic objective, it aims to highlight some solutions and recommendations regarding the revitalization of development taking into account current CLIMATE CHANGES, by adapting the models of agro-rural development differentiated on a biological-technical and managerial line. The objective of describing the aspects of differentiation regarding agro-rural development according to ALTITUDE is also addressed, in order to record an indicative ideological framework necessary for the elaboration of an integrated development model appropriate to the new requirements.

- **Literature review**

Agro-rural development is a complex field that involves interactions between agriculture, local economy, environment and public policies. The specialized literature emphasizes the transition from a sectoral approach to rural development, focused exclusively on agriculture, to integrated models that include economic diversification, ecological sustainability and community involvement.

The theoretical framework considers that agro-rural development represents an interdisciplinary field, located at the intersection of economic, social, environmental and agronomic sciences. From a theoretical perspective, the concept has evolved significantly in recent decades, moving from sectoral visions, focused exclusively on agriculture, to integrated and territorial approaches.

Another key element is the participation of communities in the decision-making process. The Participatory Rural Appraisal methodology was introduced [4], which revolutionized the way in which researchers and decision-makers interact with the rural population, encouraging bottom-up development processes.

A key starting point is the theory of endogenous rural development [36], which advocates the valorization of the internal resources of rural communities, as opposed to externally imposed development models. This theory emphasizes the capacity of communities to build their own development trajectories through local networks, family farming and economic diversification. In addition, the OECD (2006) proposes the new rural paradigm, which redefines the role of rural regions in a much more complex manner, suggesting the integration of environmental, economic and social objectives. This model promotes multi-sectoral, participatory and locally tailored policies, emphasizing the importance of inter-institutional cooperation and public-private partnerships. According to the Organization for Economic Cooperation and Development, the "new rural paradigm" involves decentralization, policy integration and a focus on local resources [39]. In a key paper [3], it highlights the role of dynamic strategies in European rural regions, using systemic models to analyze the complex relationships between agriculture, demography and quality of life.

Rural areas can no longer be perceived only as agricultural spaces [21], but as multifunctional areas, where agriculture coexists with tourism, environmental conservation and creative industries. This rural restructuring involves different regulations and policies, but also profound social transformations. He draws attention to rural areas as differently regulated territories, where agriculture is increasingly integrated into global markets, but also into the tourist and cultural circuit.

Similarly, a theory of endogenous rural development is proposed [36], focused on the valorization of local knowledge and the social networks of rural actors.

A geographical approach to rural restructuring [2,38], arguing that transformations in the economy and rural landscape are the result of the interaction between global forces and local initiatives. In addition, the importance of agricultural sustainability and natural resource management, central elements in sustainable rural development policies [25], is highlighted.

In the Romanian context [11,14] it offers a multidisciplinary perspective on agro-rural management, introducing concepts such as eco-farming and bioeconomic zootechnics, adapted to the local specificities and current sustainability requirements. Also, in recent works [15,16] the analysis is extended to the food and gastronomic dimension, considering sustainable nutrition as an integral part of rural development.

Another important theoretical direction is community participation in the planning and implementation of development strategies. The Participatory Rural Appraisal methodology is promoted, which emphasizes the importance of direct involvement of the rural population in making decisions that affect their lives [4,28,30].

A systemic approach is also applied to understand the complexity of interactions between policies, agriculture, biodiversity, demography and rural economy, providing a solid and nuanced theoretical basis from various points of view for analysis and modeling [3,9,18,22,27,26].

We find that international and Romanian literature converge on the need for an integrated model of agro-rural development, which takes into account local specificities, sustainability, community participation and economic diversification [10,19,40]. The integration of these dimensions is essential for the formulation of effective policies adapted to contemporary rural realities.

2. Methodology

This research is of an exploratory-descriptive type, with elements of qualitative and quantitative analysis. A mixed approach was chosen to capture both objective data (quantitative) and subjective and contextual perspectives (qualitative).

The present study uses a documentary analysis carried out by consulting reviews in the specialized literature, which refers to the analysis of documents containing information about the studied process, namely agro-rural revitalization on altitude gradients, in relation to climate change. The analysis of the development and integration trend influenced by climate change and their different impact depending on altitude was carried out using principles of multi-criteria analysis, comparisons and statistical processing. A managerial diagnosis is used with emphasis on the socio-economic aspects of the components of the integrated agro-rural system [7].

Structurally, the research methodology used can be described in summary as follows: (a) *Documentary analysis* – an analysis of the specialized literature, legislation and public policies in the field of rural development was carried out, at national and

European level; (b) *Sociological questionnaire* – applied to a sample of farmers and residents of rural areas, to collect quantitative data on agricultural practices, access to financing, community participation and perception of sustainability; (c) *Semi-structured interviews* – conducted with relevant actors (representatives of local authorities, agricultural consultants, leaders of rural NGOs), to delve deeper into qualitative themes regarding the dynamics of local development; (d) Case study – selection of a representative commune (e.g. Moieciu commune, Brașov county) for in-depth analysis of a local integrated agro-tourism development initiative.

3. Results and Discussions

To better understand the topic addressed, it is necessary to analyze the proposed theme punctually and then systemically. For a better understanding, the study was carried out in three parts, namely: (1) PRINCIPLES of altitudinal differentiated agro-rural development, in relation to climate change; (2) Agro-rural REVITALIZATION in areas of altitude and influence of climate change; (3) MODEL of Climate Adaptation and Agro-Rural Development at Altitude (acronym in Romanian: *ACDARA*).

3.1. PRINCIPLES of altitudinal differentiated agro-rural development, in relation to climate change

The basic benchmark from which we start in carrying out the study is the principle of AGRI-FOOD BIOHARMONY ON THE PATH TO SUSTAINABLE DEVELOPMENT IN THE TERRITORIAL PROFILE OF ROMANIA. In this sense, we mention as a starting premise, at least five stringent aspects, which we have noted from previous analyses, and which we show in summary in the box below:

PENTAVALENCE OF INTERVENTIONS
FOR REVITALIZING THE ROMANIAN AGRICULTURAL SECTOR:

1. Irrigation projects
2. Agro-forestry curtains
3. Projects to consolidate and diversify food processing systems
4. Projects to capitalize on the Romanian natural heritage through agro-eco-tourism
5. Increasing competitiveness by accessing European funds with maximum efficiency, with the renegotiation of the subsidy per hectare at least as a benchmark for the European average (250 €/ha) from 160 €/ha currently.

As previously shown, the components of the agricultural sector are **strongly influenced by climate altitude**, so studies are required on the adaptation of plant production, but especially animal production and livestock numbers across different species [5,6,17,23,24,32,34].

Table 1. Agro-rural activities and policies differentiated by altitudeActivități și politici agro-rurale diferențiate altitudinal

No.	***CRITERION***	***Mountainous area (high)***	***Hilly area (medium)***	***Plain area (low)***
1.	Type of agriculture	Extensive, pastoral	Mixed: crop + livestock	Intensive, cereal
2.	Dominant crops	Hay, potatoes, rustic vegetables	Fruit trees, vines	Cereals, oilseeds
3.	Dominant livestock industry	Sheep, cattle	Cattle, pigs	Pigs, poultry
4.	Settlement type	Dispersed, isolated	Valley cluster	Dense road network
5.	Level of mechanization	Low	Environment	High
6.	Road infrastructure	Precarious	Partially developed	Developed
7.	Tourism potential	High (nature, traditions)	Good (landscape, culture)	Low (outside the Delta/meadows)
8.	Challenges	Depopulation, poverty, isolation	Erosion, road maintenance	Monoculture, drought
9.	Opportunities	Eco-tourism, mountain products	Agritourism, diversification	Technology, export

The tabular data were processed in Figures 1 and 2, in which maps related to climate change and temperature changes estimated at the national level were generated, but with territorial zoning.

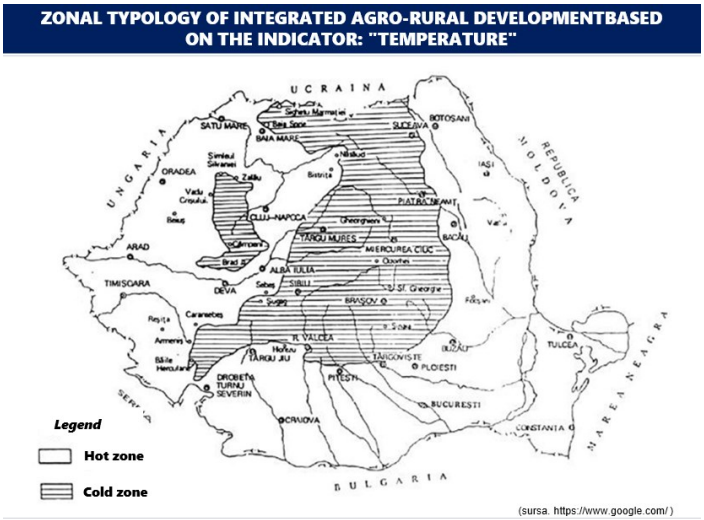

Figure 1. Principle temperature zoning in Romania

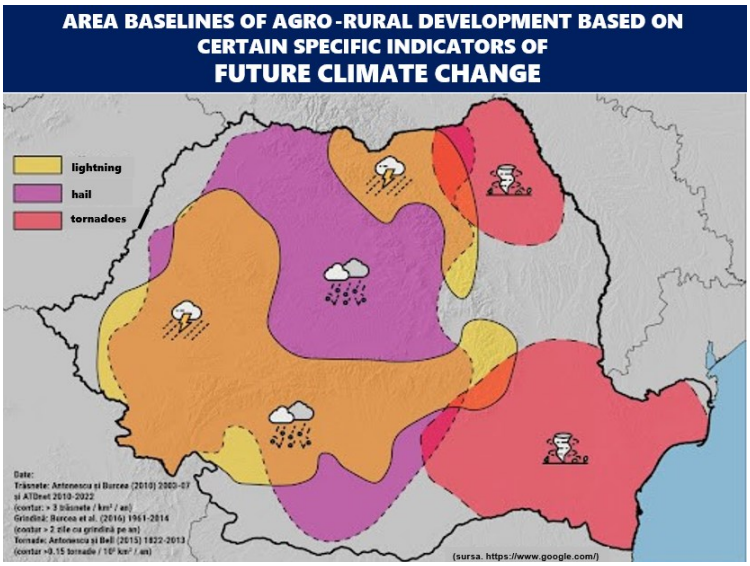

Figure 2. Future climate change zoning predicted for the Romanian area

The complexity of climate change and its impact on agriculture and rural areas requires the analysis of empirical observations, but repetitive, and which are often paradoxical and unpredictable. Statistically, a series of paradoxes of climate change are also observed in terms of extreme weather conditions. We can therefore see the unpredictability of climate systems and how their rapid changes can lead to phenomena that do not align with our expectations, based on traditional climate models, which confuses us technologically and as public policies.

All this clearly shows that these phenomena, processes, reactions and human actions are becoming undeniable and require intervention and countermeasures. A list of paradoxes regarding the increasingly frequent extreme weather conditions currently clearly indicates, including for agro-rural development, the important concerns of understanding and solving climate upheavals: - severe drought and torrential rains / - global warming and cold winters / - high variability of temperatures over short periods / - intensification of extreme phenomena / - the unsuspected impact of climate change / - behavioral confusion of the human population, but also of the biodiversity of species as a whole.

Therefore, within the framework of this study, in a first analysis we will break down the different situations by altitudinal groups, with the idea of being able to differentiate the technologies applied and the necessary development policies (Table 2).

Table 2. Climate change characteristics as a benchmark for altitudinal differentiated agro-rural policies

No.	***CRITERION***	***Mountainous area (high)***	***Hilly area (medium)***	***Plain area (low)***
1.	Altitude	> 800 m	300 – 800 m	< 300 m
2.	Mean annual temperature	0–8 °C	8–10 °C	10–11.5 °C
3.	Recent temperature trends	Slower growth (+0.5–1 °C)	Moderate growth (+1–1.5 °C)	Sharp growth (+1.5–2 °C in recent decades)
4.	Mean annual precipitation	800–1,200 mm	600–800 mm	450–600 mm
5.	Recent precipitation trends	Slight decrease, but with increasing heavy snowfall	Increased variability (torrential/localized rain)	Moderate decrease (more frequent droughts)
6.	Frequency of extreme events	Increased: snowstorms, avalanches, strong winds	Average: hail, heavy rain, landslides	High: heat waves, drought
7.	Snow cover duration	90–180 days/an	30–70 days/an	10–30 days/an
8.	Impact on agriculture	Shortening of the growing season, reduction of cultivable areas	Soil erosion, localized crop losses	Increased risk of drought, unstable yields
9.	Impact on biodiversity	Retreat of alpine species to higher altitudes	Changes in flora/fauna composition	Expanding thermophilic species
10.	Socio-economic impact	Impact on tourism and mountain infrastructure	The need to adapt agricultural work	Impact on agri-food production

Following this distribution (from Table 2) we move on to the analysis of the possibilities of zonal agro-rural revitalization in Romania.

3.2. Agro-rural REVITALIZATION at altitude in relation to climate change and agricultural impact

Of interest are the "cause-effect" aspects that can direct agro-rural revitalization initiatives through the necessary measures, adapted to altitude groups (Figure 3).

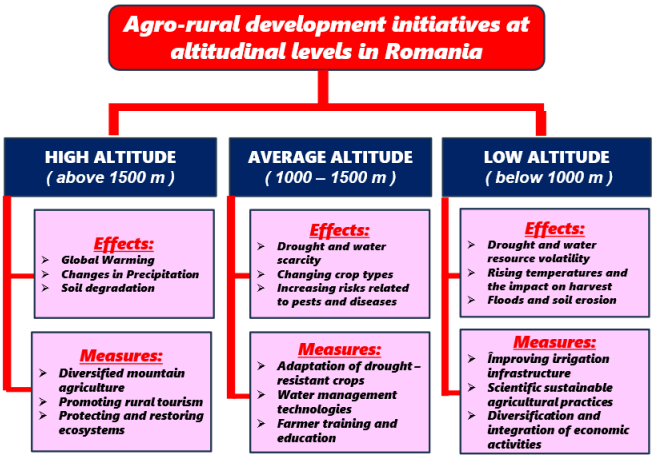

Figure 3. Summary of measures regarding agro-rural development on altitudinal gradients

The characteristics of agro-rural revitalization in Romania in the zonal reflection related to altitude show that the altitudinal variation and the impact of climate change on the typology of the development model must be adapted to achieve the expected bioharmonistic yield [10,13]. In short, our observations and those in the specialized literature indicate the following prospective adaptations of the agro-rural development mode in relation to altitudinal zones and climate impact:

• In mountainous and high altitude regions, the impact shows that climate change can modify the types of viable crops and reduce water resources. Therefore, mountainous regions maintain traditional practices - such as sheep farming, forestry and crafts - through agri-environment schemes, infrastructure improvement and cultural heritage conservation [12,28,33,35].

• In hilly and plateau regions, the impact highlights: the risk of production and biodiversity losses, so that depressional and high-hilly mountain areas, or hilly and plateau areas, can have mixed agricultural and non-agricultural, multifunctional approaches (traditional agro-zootechnics, agro-tourism, manufacturing food processing and gastrotourism).

• In low-lying and hilly regions, the impact indicates that the risks of general drought and implicitly pedological drought, extreme temperatures and floods, which are more frequent, are high. Low-lying areas can focus on the modernization of agriculture and tourism through intensive agriculture that is complemented by a shift towards agrotourism, a high-performance food industry and the modernization of infrastructure and non-agricultural activities.

3.3. Agro-rural revitalization based on a theoretical MODEL necessary for future applications, the Altitude Climate Adaptation and Agro-rural Development model (*ACDARA*)

The opportunity of the model is linked to the fact that it allows the formulation of differentiated, sustainable and resilient strategies, intended to support integrated and sustainable agro-rural development in our country. In short, through zonal examples and multi-criteria analysis tools, a conceptual basis is provided for a series of adaptive interventions and territorial policies, which integrate the climate risks specific to each altitudinal zone (plain, hill, mountain) taking into account the local adaptive capacity.

The desired final result is related to agro-rural resilience differentiated according to the altitudinal zone, directly proportional to the direction of sustainable rural development, with the integration of climate change in local strategies.

The principle structure of the model is described in the diagram in Figure 4.

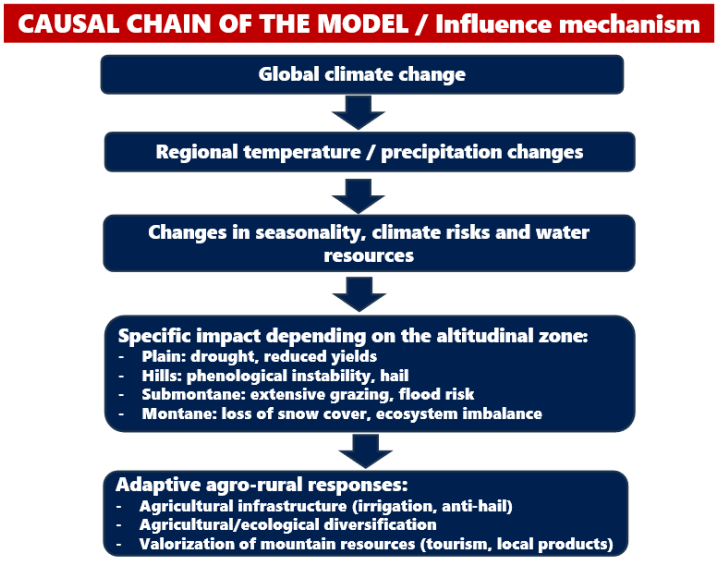

Figure 4. Block diagram of the ACDARA Model

The determining factors for the development of the model refer to global climate change (temperatures, precipitation, extreme phenomena); to altitude as a differentiating ecological factor; to the local economic structure (types of crops, grazing, related activities); and to a series of transversal dimensions, the most important being those relating to: - public policies differentiated by altitude / - local adaptive capacity / - agro-ecological innovation and revitalization initiatives.

All of these are found as landmarks of the proposed ACDARA model, namely in the basic formula through the relationship:

D = f (A, R, C)

where:
D = Sustainable agro-rural Development,
A = Altitude,
R = Area-specific climatic Risks,
C = Local adaptive Capacity (resources, technology, Human capital).

To understand the applications, we present the general structure of the formula:

D=wA·A′+wR·R′+wC·C′D = w_A \cdot A' + w_R \cdot R' + w_C \cdot C'D=wA ·A′+wR·R′+wC· C′

where:
A′,R′,C′A', R', C'A′,R′,C′ = indicators with standardized values (normalized between 0 and 1),
wA,wR,wCw_A, w_R, w_CwA,wR,wC = the weights assigned to each factor, with the sum:
wA+wR+wC = 1w_A + w_R + w_C = 1wA+wR+wC = 1

Applying the formula makes it possible to quantify the functional components of the model in the dynamics of its development (Table 3).

Table 3. The main functional components of the ACDARA Model

No.	*Components*	*Specification*
1	Zonal Climate Diagnosis (ZCD)	➢ Identification of dominant risks (drought, hail, instability)
2	Local Resources Analysis (LRA)	➢ Agricultural infrastructure, natural and human capital
3	Differentiated Adaptive Strategy (DAS)	➢ Measures adapted to each area
4	Monitoring & Evaluation (M&E)	➢ Monitoring results and recalibrating interventions

All of these are analyzed according to the altitude group. Thus, within the conceptual framework of adaptation: "altitude zone" as an agro-climatic determinant that decisively influences both the climate of each area and the agro-rural aspect through the use of agricultural land and food processing, we differentiate the following aspects, according to the proposed model: (a) ***Plain and wetlands*** (0–300 m): fertile soils, warm-humid climate turned arid, adapted Mediterranean cereal crops and plants / modern intensive animal husbandry based on the principle of quantity; (b) ***Hills*** (300–800 m): milder climate, mixed use (fruit growing, viticulture, vegetable growing, floriculture) / bioeconomic animal husbandry based on eco-development through the "man-ecosystem-nature" eco-technique. (c) ***Mountains*** (>800 m + depressions): cold climate, alpine pastures, extensive animal husbandry based on quality principles, subsistence agriculture.

In graphic expression, the image elaborated in the map in Figure 5 is eloquent, on the four existing geographical areas in Romania: mountain, hill, plain, wetlands,

with the predominant profile of agro-rural development in relation to the specific climatic impact.

Figure 5. Zonal typology of integrated agro-rural development altitude & climate

It should be noted that the situation described in Figure 6 is not static, but in continuous dynamics, which requires a specific analysis of the changes estimated for the coming decades (Table 4).

Table 4. The impact of climate change on agro-rural development depending on the altitudinal zone in Romania

ALTITUDINAL ZONE	ALTITUDE (m)	CURRENT CLIMATE CHARACTERITICS	ESTIMATED CLIMATE CHANGES	IMPACT ON AGRICULTURE	RECOMMENDED AGRO-RURAL REVITALIZATION
Plain	**0–300**	Temperate-continental climate, frequent drought in summer	Increase in average temperatures; decrease in summer precipitation	Reduced grain and corn yields; high water stress	Smart irrigation; transition to drought-resistant crops (e.g. sorghum, chickpeas)
Low hills	**300–600**	Moderate climate variability; active viticulture	Sudden temperature changes; increased risk of hail	Problems in grapevine phenology; instability in orchards	Agroforestry systems; hail net; adapted varieties
High hills	**600–800**	Wetter climate; permanent pastures; traditional orchards	Decrease in the number of frost days; earlier springs	Possible extension of the growing season; risk of tree diseases	Agricultural diversification; introduction of organic farming
Submontane zone	**800–1,200**	Low average temperature; pastoral activity	Slow warming; changes in precipitation	Possible extension of grazing season; flood	Sheepfold modernization; selective reforestation;

			patterns	risks	agro-rural tourism
Mountain zone	**>1,200**	Cold climate; limited agriculture; extensive grazing	Reduction of snow cover; climate instability	Loss of ecosystem balance; stress for fauna and flora	Ecological conservation systems; rural development through ecotourism and certified mountain products

The above highlights a series of principles and directions for future agro-rural policies, differentiated by "agro-eco" altitudinal zones that we can consider for their potential application in Romania.

3.4. Case study: Brașov County

As an example of applying the proposed model, we analyze a case study using Brașov County as a benchmark. Therefore, in Figure 6 we present a series of aspects in synthesis, through a poster presenting this study.

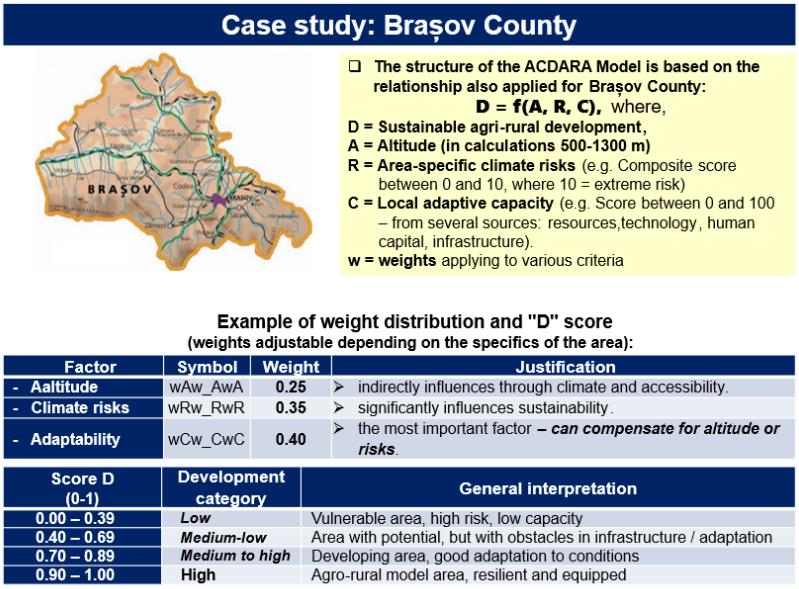

Figure 6. Application of the *ACDARA Model* to the altitudinal areas of Brașov County

The results of the application of the climate adaptation and agro-rural development model at altitude (*ACDARA*) indicate a series of working ideas and measures for their implementation. More specifically, the agro-rural development model specific to Brașov County indicates that this area has adaptive potential, in the context of climate change, the application of sustainable development

principles and the mountain and submountain specificity of Brașov County, resulting in the following interventions and concrete actions (see box):

➢ Adapted to local conditions, the model reveals that the diversity of altitudinal areas, existing infrastructure and social capital can constitute solid foundations for modernized agriculture and a multifunctional rural space.
➢ The mountain area of Brașov County urgently needs investments in adaptive infrastructure, agricultural education and sustainable tourism integration, with altitudinal zoning.
➢ The hilly and peri-urban area has the potential to become an agro-industrial core through innovation and cooperation.

Following these considerations, a series of examples result as initiatives for agro-rural revitalization of low, medium and high altitude areas through adaptive interventions and territorial policies specific to Brașov County. The quantification of sustainable agro-rural development was applied based on measurable values for A, R and C, with weights (w) assigned to each factor, for localities in different altitudinal areas of the county (e.g.: Hărman, Râșnov, Moeciu), the final results being those in Table 5.

Table 5. Measures to revitalize agro-rural development in Brașov County

Locality	*Altitude (A)*	*Climate risk (R = 0...10)*	*Local adaptation score (C=0...100)*	*Agro-rural activity (D = 0...1)*	***"ACDARA" measure***
Hărman	250 m	5 = drought	70	0,7...1,0 = grain farms and technical plants	Digital irrigation
Râșnov	650 m	7 = hail	65	0,4...0,7 = potatoes, orchards	Hail protection systems
Moeciu	950 m	8 = snowfall	50	0,0...0,4 = hayfields, rural tourism	Integrated agri-tourism

Conclusions

(1). PRINCIPLES AND DIRECTIONS GUIDELINES FOR ACTION on a series of revitalization initiatives in altitudinal areas in relation to climate change emphasize that strategic approaches must align with local conditions, so that mountain areas prioritize the consolidation of tradition and environmental schemes, lowland areas focus on transforming agricultural dependence through tourism and modernization, and hilly regions adopt diversified and multifunctional strategies.

(2). Agro-rural revitalization is differentiated ALTITUDINALLY, so in mountainous and high altitude areas, the emphasis should be on sustainable

agriculture and the protection of natural resources, and in lowland and hilly areas, adaptation solutions should focus on efficient water management and soil protection.

(3). Revitalization initiatives require adaptation to CLIMATE CHANGE by adopting sustainable agricultural practices, adapting drought-resistant crops, using modern water management technologies, and diversifying crops to reduce risks and ensure long-term sustainable agricultural production.

(4). The flexibility and diversification of agriculture, together with innovative technologies and sustainable economic development strategies, are essential for INTEGRATION of sustainable agro-rural development on altitude gradients in the context of climate change, which can modify viable crop types and reduce water resources, while in lowland and hilly regions, the risks of drought, extreme temperatures and floods are more frequent, which represents a complex challenge for the coming decades, but also an opportunity to build more feasible and resilient communities.

(5). The ACDARA model provides a useful analytical and application framework for decision-makers, farmers and researchers, showing through altitude differentiation and climate risk integration that integrated and efficient agro-rural development can be supported in Romania, and extending the model from the case study to regional strategies could considerably improve the coherence of public interventions in the face of climate change regarding agro-rural revitalization that reflects regional characteristics related to altitude, traditional practices - such as sheep farming, forestry and crafts, all maintained through agri-environment schemes, infrastructure improvement and cultural heritage conservation.

R E F E R E N C E S

[1] Altieri, M. A., Nicholls, C. I., Henao, A., Lana, M. A., Agroecology and the design of climate change-resilient farming systems. *Agronomy for Sustainable Development, 35*(3), 869–890. https://doi.org/10.1007/s13593-015-0285-2, (2015).

[2] Beciu, S., Popa, O., Nistor, S., Olteanu, V., The socio-economic dimension of rural development for the North-East Region of Romania, African Journal of Agricultural Research Vol. 6(28), pp. 6042-6051 (2011)

[3] Bryden, J., Efstratoglou, S., Ferenczi, T., Knickel, K., Johnson, T., Refsgaard, K., & Thomson, K. Towards sustainable rural regions in Europe: Exploring inter-relationships between rural policies, farming, environment, demographics, regional economies and quality of life using system dynamics. Routledge. (2011).

[4] Chambers, R. The origins and practice of participatory rural appraisal. World Development, 22(7), 953–969. https://doi.org/10.1016/0305-750X(94)90141-4, (1994).

[5] Drăgoi,M., Iamandi,I, Munteanu,S., Ciobanu,R., Țarțavulea,R. and Ladaru, R.G.,. Incentives for Developing Resilient Agritourism Entrepreneurship in Rural Communities in Romania in a European Context, Sustainability, 9(12), 2205 (2017)
[6] Dumitru, M. Adaptarea agriculturii la schimbările climatice. Revista de Agroecologie, 15(2), 45–58. (2017).
[7] Gruia,R. Managementul eco-fermelor, Ed Ceres București, p.41-50. (1998).
[8] Gruia, R. Agroecosisteme și dezvoltare rurală în contextul schimbărilor climatice. *Revista de Științe Agricole și Economie Rurală, 12*(2), 55–64. (2006).
[9] Gruia, R. Sisteme agro-montane şi durabilitate rurală. Editura Agris. (2008).
[10] Gruia,R. Modular agriculture – paradigm of globalization dynamics within the context of climatic and scientific changes, Environmental Engineering and Management Journal „Gh. Asachi" Technical University Iași, Vol.9, nr.12, 1601-1606, (2010).
[11] Gruia, R., Bazele managementului și direcțiile viitoare de evoluție, Editura Lux Libris, p.137-198. p.137-198.
[12] Gruia, R. Montanologic memento: Water in the Carpathians, water from the Carpathians, Journal of Montanology, CE-MONT-INCE / Academia Română, FMR, București, Vol. I (1) 2014, p.87-102. (2014).
[13] Gruia, R. et al. Integronic alimentation through whole natural food biodiversity, in relation with altitude Gradation, 2nd International Conference ESPERA 2014, Book Series: Procedia Economics and Finance, Vol.22/2015, p.114-123 (2015).
[14] Gruia, R. (2016). Zootehnia bioeconomică, Ed. Lux Libris, 43-100, 143-172, 253-304, (2016).
[15] Gruia, R. Evoluția științifică a gastronomiei în cadrul actului alimentar, Editura Clarion Brașov, p.17-68. (2018).
[16] Gruia, R. Inginerie gastronomică, Editura Clarion Brasov, 710 pag., 35-238. (2024).
[17] Herrero, M., Thornton, P.K., Notenbaert, A.M., Wood, S., et al. Smart Investments in Sustainable Food Production: Revisiting Mixed Crop-Livestock Systems. Science, 327(5967), 822-825. (2010).
[18] Jitea, M., Arion, F., The role of agri-environment schemes in farm economic sustainability from high natural value transylvanian areas, Environmental Engineering and Management Journal 14(4), doi 10.30638/eemj.2015.105 (2015).
[19] Kruszlicika, M., Chiritescu, V., Gavrilescu, C., Gavrilă, V., Andrei, D., The structure of the rural economy in Romania. Case study on macro-region 2. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca: Agriculture (2014)
[20] Marin, C., Popescu, G., Impactul schimbărilor climatice asupra agriculturii din România. Editura Academiei Române. (2020).
[21] Marsden, T. New rural territories: Regulating the differentiated rural spaces. Journal of Rural Studies, 14(1), 107–117. https://doi.org/10.1016/S0743-0167(97)00043-4, (1998).
[22] Mikulcak, F., Newig, J., Horcea-Milcu, A.I., Hartel, T., Fischer, J. Integrating rural development and biodiversity conservation in Central Romania. Environmental Conservation,pp.1-9. (2013).
[23] Nicholson, C.F., Blake, R.W., Reid, R.S., Schelhas, J.W. Environmental Impacts of Livestock in the Developing World. Environment, Development and Sustainability, 3, 145-163. (2001).
[24] Perry, B.D., Randolph, T.F. The Impact of Livestock and Livestock Systems on the Environment and Human Well-Being. Philosophical Transactions of the Royal Society B: Biological Sciences, 359(1445), 1145-1165. (2004).
[25] Pretty, J.. Agricultural sustainability: Concepts, principles and evidence. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1491), 447–465. https://doi.org/10.1098/rstb.2007.2163 (2008)

[26] Popescu , A., Dinu, T.A., Stoian, E., Şerban, V., Ciocan,H., Romania's mountain areas - Present and future in their way to a sustainable development, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol.22(4), 549-564 (2022)

[27] Reif, A., Rușdea, E., Păcurar, F., Rotar, I., Brinkmann, K., and 3 more . A Traditional Cultural Landscape in Transformation, Mountain Research and Development, 28(1), 18-22 (2008)

[28] Rey, R., Gruia, R. SYNTHESE du Programme de development montagnard et Formation des ressources humaines dans la zone des Montagnes Carpates de Roumanie, Conference internationnale ”5e Biennale Europeenne de la Montagne”, La Bresse / Lorena, France, oct. 2013,17-18. (2013).

[29] Sandu, D.D., Corad, B., Iamandi-Cioinaru, C., Man, T.C., Marin, M., Moldova, C., Neculau, C., Tesliuc, E.D., Grigoras, V.A., Stanculescu, M.S., Atlas marginalized rural areas and local human development in Romania Atlasul zonelor rurale marginalizate ş I al dezvoltării umane locale din România (In Romanian)(2016).

[30] Schrieder, G., Munz, J. , Jehle, R., Rural Regional Development in Transition Economies: The Case of Romania Europe-Asia Studies , Nov., Vol. 52, No. 7 (Nov., 2000), pp. 1213-1235 (2000).

[31] Sin, G., Jelev, I*Agricultura României în contextul schimbărilor climatice globale*. Editura Academiei Române (2018).

[32] Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., de Haan, C. Livestock's Long Shadow: Environmental Issues and Options. Food and Agriculture Organization of the United Nations (FAO). (2006).

[33] Stoicescu, I., Pătru-Stupariu, I., Hossu, C., Peringer, A., Land Use Guidelines to Maintain Habitat Diversity of Wood- Pastures in the Southern Carpathians Under Projected Climate Change. Landscape Online (2019).

[34] Thornton, P.K., Herrero, M. Adapting to Climate Change in the Mixed Crop and Livestock Farming Systems in Sub-Saharan Africa. Nature Climate Change, 5(9), 830-836. (2015)

[35] Tudoran, G., Zotta, M. Adapting the planning and management of Norway spruce forests in mountain areas of Romania to environmental conditions including climate change. Science of the Total Environment 1:698:133761.doi: 10.1016/j.scitotenv.2019.133761. Epub 2019 Aug 23. (2019).

[36] Van der Ploeg, J. D., Renting, H., Brunori, G., Knickel, K., Mannion, J., Marsden, T., ... & Ventura, F. Rural development: From practices and policies towards theory. Sociologia Ruralis, 40(4), 391–408. https://doi.org/10.1111/1467-9523.00156 (2000).

[37] Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. I. Climate change and food systems. *Annual Review of Environment and Resources, 37*, 195–222. https://doi.org/10.1146/annurev-environ-020411-130608 (2012).

[38] Woods, M. Rural geography: Processes, responses and experiences in rural restructuring. SAGE Publications. (2005).

[39] *** - OECD. *Adapting agriculture to climate change: Policies to support a sustainable and resilient sector*. OECD Publishing. https://doi.org/10.1787/9789264239135-en (2015).

[40] *** - European Commission. *A farm to fork strategy for a fair, healthy and environmentally-friendly food system*. https://ec.europa.eu/food/farm2fork_en (2020)

[41] *** - World Bank. *Transforming food systems for a resilient rural future*. World Bank. https://www.worldbank.org/en/topic/agriculture/publication/transforming-food-systems (2021).