Annals of the Academy of Romanian Scientists
Series on Agriculture, Silviculture and Veterinary Medicine
ISSN 2344-2085 Volume **15**, Number **1**/**2026**

FOOD SECURITY AND AGRO-INDUSTRIAL SYSTEM GOVERNANCE IN BIOHARMONY WITH THE STAGES OF THE CONTEMPORARY AND PROSPECTIVE GLOBAL INDUSTRIAL REVOLUTION

Romulus GRUIA[1] , Liviu GACEU[2]

Abstract. *This paper provides an integrated analysis of the relationship between food security and the governance of the agro-industrial system within the dynamic context of contemporary and prospective industrial revolutions (from Industry 3.0 to 6.0). Based on the premise that agro-food systems are complex adaptive systems, the research proposes an original conceptual model –* ***Development of Agri-Food in Convergence of Bioaharmonism (DACbio)****. This model correlates technological evolution (including Artificial Intelligence and the Internet of Things) with ecosystem dynamics, nutritional quality, and multi-level governance mechanisms. Beyond quantitative production, the study highlights the emergent outcomes of interactions between technological efficiency, ecosystem integrity, food information density, and governance quality. In this framework, the paper introduces and operationalizes innovative indicators, such as the* ***Agro-Rural Bioharmonism Index*** *and the* ***Food Information Density Index****, as tools for evaluating agro-food system performance. Based on this analysis, the study proposes public policies and implementation strategies focused on agro-food digitalization, the development of regenerative agriculture, and the strengthening of participatory governance. The major contribution of this work lies in formulating a bioharmonist paradigm that enables the transition from linear agro-industrial models to resilient and sustainable circular systems in an non-liniar world, capable of ensuring food security amidst global uncertainty*.

Keywords: Agri-food system, Agro-industrial governance, Bioharmonism, Food security, Industrial Revolution

DOI 10.56082/annalsarsciagr.2026.1.96

1. Introduction

The direct relationship between the civilizational perspective and industrialization, beyond economic development, represents a reconfiguration of the human-nature relationship and a restructuring of social and production systems.

[1] Prof.PhD. Eng. University of Transilvania from Brașov, Romania, Full Member of the Academy of 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 Romanian Scientists, Researcher CE-MONT & CSCBAS – National Institute of Economics Research, Romanan Academy, (e-mail: gaceul@unitbv.ro).

It is also an expansion of the collective capacity to transform energy and matter into goods and services, as well as an increase in the complexity of societal organization systems.

From this perspective, food security highlights structural vulnerabilities, being affected by contemporary crises that induce the fragmentation of global supply chains, dependence on intensive chemical inputs, systemic food waste, loss of agricultural biodiversity, but also digital corporate concentration.

Global industrialization is also continuously transforming agri-food systems, a fundamental aspect in the evolution of food because it represents one of the most important elements with civilizational effects. THE INDUSTRIAL REVOLUTION represents the changes that mark the transition from a traditional production system to an advanced one, namely a period of rapid, profound and radical technological transformations, which fundamentally modify the economy, social structure, way of life and culture of humanity.

In relation to food, an industrial development is carried out, which at a civilizational level represents the process by which society amplifies its production and organizational capacity, leading to one of the most profound consequences, namely the transformation of food from a local, biological product into a global, industrial and systemic product, specific to the activities of the rural space. In these areas, the primary activity is a predominantly agricultural economy or one based on natural resources, mixed activities, dominant natural/agricultural landscapes and a close-knit community. These are elements that entitle us to analyze the agro-rural space holistically, directly linked to food security and community sanogenesis, defined in the box below:

The agro-rural space is the specialized area dominated by the primary sector (agro-zoo-forestry) and complementary to mixed activities (agrotourism, small industry, energy).

The main purpose of this research is to analyze and develop an integrated framework for analysis and action regarding food security and the governance of the agro-industrial system in order to realize a "bioharmonious" development MODEL capable of ensuring the balance between agri-food production, nutritional quality, ecosystem sustainability and societal stability, following the path of simultaneous optimization of systemic resilience, technological efficiency and informational-nutritional quality of food

Working hypothesis - *the transition from the classical* ***"industrial-aggressive"*** *paradigm, which operates on the logic: quantitative maximization → cost externalization → ecosystem degradation, to the* ***"industry-food in co-evolution"*** relationship between the technological system and the biological system on the logic: *agriculture as a subsystem of industry → food as a product* *of global technological systems → civilization outsourcing food production to balanced industrial infrastructures.*

The specific objectives include four groups, namely: The framework objective is to analyze and model the relationship between *food security* and the *governance of the agro-industrial system* in the dynamic context of the contemporary and prospective stages of the industrial revolution, by integrating the principles of bioharmonism, as a paradigm of balance between natural, economic and societal systems.

(1) **Defining food security** in an expanded perspective based on the paradigm shift to adapt to the requirements of today's society (*conceptual objective*);
(2) **Methodological analyses**: characteristics, comparisons, risk assessment by finding solutions to optimize the development of the agri-food system in relation to global industrial evolution (*analytical objective*);
(3) **Developing an integrated conceptual framework** through an agri-food development model with specific indicators, respectively developing a strategy for applying the model in relation to global industrial evolution (*strategic objective*);
(4) **Examples of public policies** related to the theme as a tool with applicability in Romania (*applicative and governance objectives).*

- **Literature review**

The topic of the paper requires an interdisciplinary bibliography that combines concepts regarding food security, economic governance, industry 4.0/5.0 (industrial revolutions) [18, 24], but also the development of the bioeconomy through systemic bioharmony.

Regarding food security, the issue is highly debated, including at the level of international organizations [25]. Detailed analyses are made regarding the implications for global food governance [19], agrarian issues [20] and pathological aspects related to nutrition [23]. In parallel, approaches regarding the evolution of industrial revolutions in relation to the agro-industrial system are of interest. Works with a general vision [22], or those referring to technological adaptations [1] are relevant.

The specific analysis of the paper brings to the forefront bioeconomy, sustainability and bioharmony (the latter as a corollary of bioconvergence, synergy and ecology, emergence and resilience), all of this through benchmark references [4, 6, 21], including as sustainable development of businesses in the field of food production [2].

Last but not least, we mention the approaches of interest regarding the perspective of modern politics [3] and innovation in agribusiness and the future transformations expected for the agri-food system at the international level [5, 7, 12, 26].

In the Romanian context, a multidisciplinary perspective on agro-rural management is offered, introducing concepts such as eco-farming and bioeconomic zootechnics, adapted to the local specifics and to the current requirements of food and gastronomic sustainability, through a series of own works that de facto approach the idea of food security and how to adapt to the contemporary requirements of the food act. We refer to the aspects integrated through its specific steps: agriculture [8, 9,10,11] and its evolution in fragile areas [13], plus zootechnics [15], then the food industry [14] and the gastro-industry [16,17].

2. Materials and methods

This research is of an **exploratory-descriptive** type, with elements of qualitative and quantitative analysis. ***A mixed approach*** was chosen, in order to capture both objective data (quantitative) and subjective and contextual perspectives (qualitative). The analysis of the development and integration trend influenced by climate change and its different impact depending on altitude was carried out using principles of multi-criteria analysis, comparisons and statistical processing. Structurally, the research methodology used is based on a broad documentary and complementary analysis of the specialized literature, legislation and public policies in the field of food security and governance typologies, at national and European level.

3. Results and discussions

Considering that industrialization represents the increase in civilization's capacity to produce, organize, and distribute resources on a large scale and with increasing efficiency, through complementarity we can analyze the relationship between industrialization and food security, as the first existential element in the evolution of all human civilizations.

3.1. The historical evolution of industrial revolutions on the path of bioharmonism

Industrial development in relation to FOOD achieves a type of evolution that at a civilizational level represents the TRANSFORMATION of FOOD from a local, biological product into a global, industrial and systemic product specific to the activities of the rural space, through the **bioconvergent dynamics** of the processes of bioharmony. We specify that by "bioconvergence" we understand the process of convergent harmonization between biological, ecosystemic, technological, social and informational systems, oriented towards increasing the functional coherence of life and the staged civilizational stability.

In analyzing the theme, we start from the global civilizational evolution with the six stages of the industrial revolution described in various government strategies, as can be seen in Figure 1.

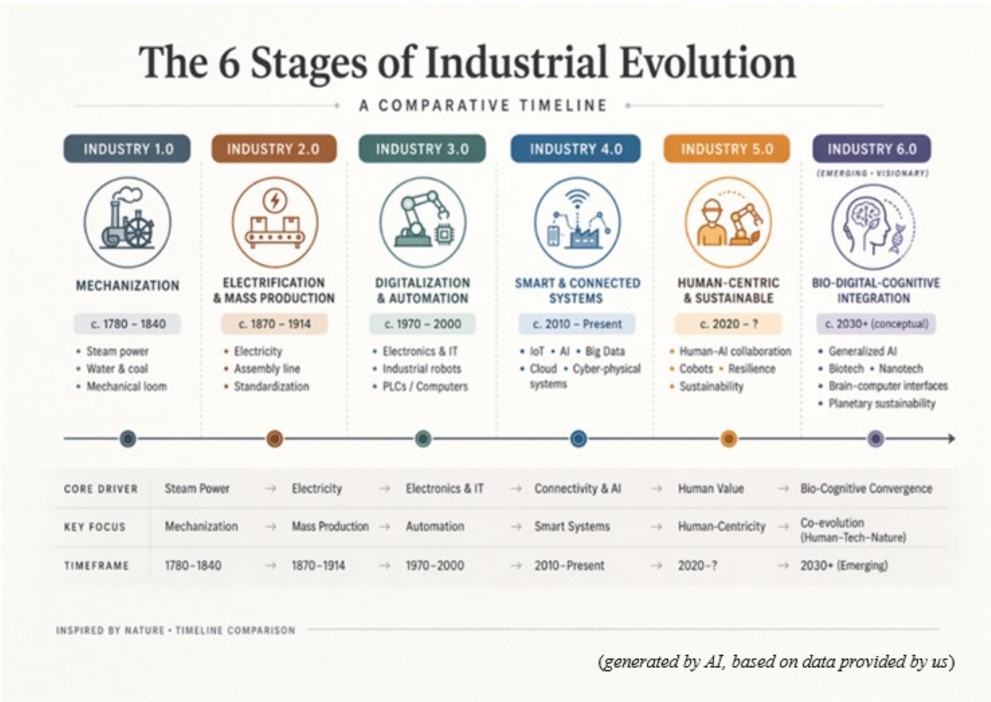

Figure 1. Evolution of global industrial revolutions over time

In our approach, we consider that civilizational evolution is directly linked to industrial revolutions, and the path of development is supported primarily on the principles of bioharmonism. We are talking about a new model of evolution described by the *Theory of Bioharmonism*, founded in 2019 by Romulus Gruia, professor at Transilvania University of Brașov, which is operationalized by integrating the *Theory of Basal Bioharmonism* and the *Theory of Generalized Bioharmonism*.

In short, systemic dynamics is of interest for understanding the evolution over time of food patterns and efferent governance. Bioharmonism is the concept and model that claims that the surrounding reality (life, society and consciousness) evolves between living systems (biosphere) and the natural and anthropic environment (technosphere), through the bioconvergence of specific P R O C E S S that induce harmonizing dynamic balances.

Explanatory, these processes are the following:

(a) **co-viability**: the capacity of biological, social or economic systems to survive and maintain essential functions in mutual interdependence, under conditions of stress or change;

(b) **co-evolution**: the process by which different systems (ecosystem, community, technology) evolve simultaneously and emergently, adapting harmoniously to internal and external changes;

(c) **co-regulation**: cybernetic mechanisms by which processes and flows in different sub-systems are mutually adjusted to maintain the balance and performance of the integrated system;

(d) **systemic coherence**: the degree of harmonization of objectives, values and actions within the system networks, so that all components contribute to the common goal of bioharmony (metamorphosis and optimal balance between human biology, anthroposystems and the environment);

(e) **co-decision**: the specific management decision to achieve the coherence of networks specific to systemic bioharmonism based on distributed processes between man-technology-natural system, resulting in the democratization of decision-making towards participatory governance in a "fluid politics".

Deepening the idea based on the evolutionary relationships on the agro-industrial-rural line, through the principles of bioharmony, we can see the mode of action of this demeres. Thus, the Bioharmonism Agro-Rural Model is a coherent framework for development with a holistic, participatory and sustainable valence, which integrates the ecological, economic, social, cultural and technological dimensions of rural communities in *a polyvalent and multi-level manner*, with the main goal of creating a resilient agro-rural ecosystem. All of these are based on the idea of adaptable anthroposystems, which are capable of generating sustainable added value.

We specify that the proposed model aims at bioconvergence through the path of bioharmonism through the point of synergy between the "polyvalent" LOCAL LEVEL (which generates resilience and cultural/ecological identity), with the "multi-level" SYSTEMIC LEVEL (which provides digital, logistical and legislative infrastructure) so that the expected resilience is profitable, with potential for societal emergence, in this case inducing the emergence of the new higher order in the rural space (Figure 2 and Figure 3).

The entire described dynamic can be found in a specific expression in the evolution of industrial revolutions, highlighting the development of the agri-food sector (Table 1).

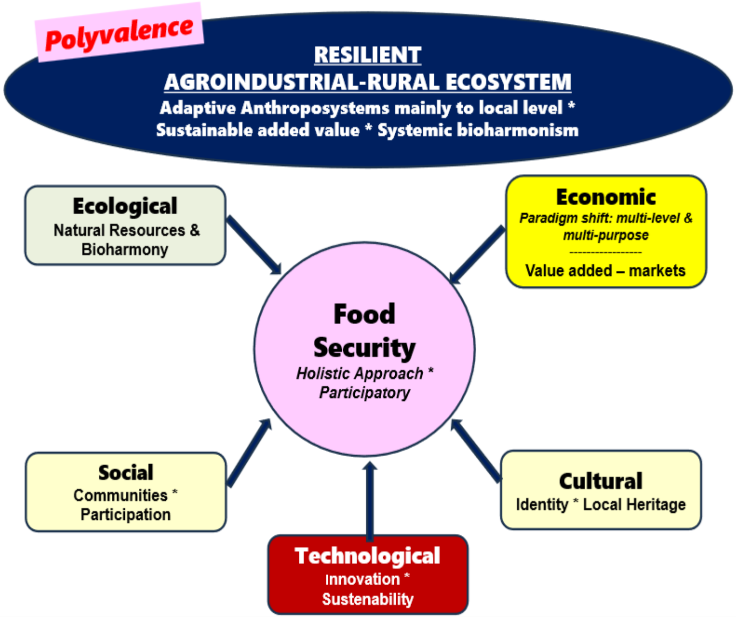

Figure 2. Local level of support a bioconvergent

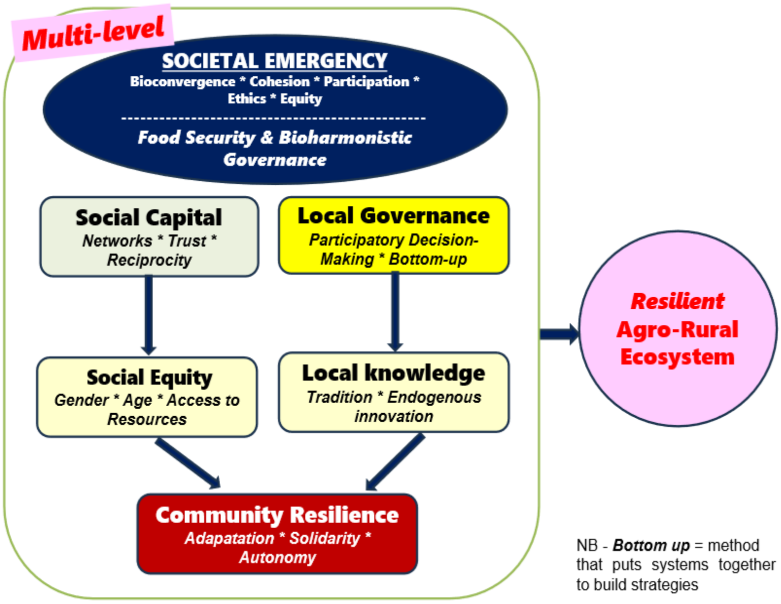

Figure 3. Systemic level of bioconvergent

Table 1. Stages of agri-food industrial evolution as a civilization vector

GLOBAL INDUSTRIAL EVOLUTION		**ADAPTATION OF INDUSTRIAL EVOLUTION TO THE DEVELOPMENT OF THE AGRI-FOOD SYSTEM**	
Stage	**Period**	**Specification**	**Conceptual evolution**
Industry 1.0	***Mechanization*** *(late 18th century – early 19th century)*	- replacement of human power with mechanical energy (extensive agriculture + beginning of mechanization)	➢ *Food = biological resource dependent on nature*
Industry 2.0	***Electrification and mass production*** *(late 19th century – early 20th century)*	- efficiency and large-scale standardization (electrification + beginning of intensive agriculture)	➢ *Food = economic commodity, mass product*
Industry 3.0	***Computerization and automation*** *(end of the 19th century – beginning of the 20th century)*	- integration of electronics and information systems in production (green revolution + chemistry + automation)	➢ *Food = industrial product with economic efficiency*
Industry 4.0	***Smart Industry*** *(approx. 2000–present)*	- physical and digital systems become integrated into smart grids (precision agriculture + digitalization)	➢ *Food = data system and health vector with systemic effectiveness*
Industry 5.0	***Sustainability and human-centeredness*** *(systemic effectiveness approx. after 2020)*	- technology serves man, does not replace him (ecological and social rebalancing)	➢ *Food = human value and personalization*
Industry 6.0	***Bioharmonistic bioconvergence*** *(emerging integronics / prospectively approx. after 2030/2040)*	- technological civilization integrated with the biosphere and human cognition (harmonious bioconvergence & bio-digital-cognitive co-evolution)	➢ *Food = bio-integrative information in individual-ecosystem bioharmony*

3.2. Development of the Agri-Food Development Model in Bioharmonistic Convergence (DACbio)

To generate the development model of the agri-food sector, we start from the general picture of agro-rural territorial development adapted for the coming decades, namely the Bioharmonious Agro-Rural Development Model (DARbio). We base ourselves on the "clarifying" question: *How do we organize rural space as a bioharmonious ecosystem ?*

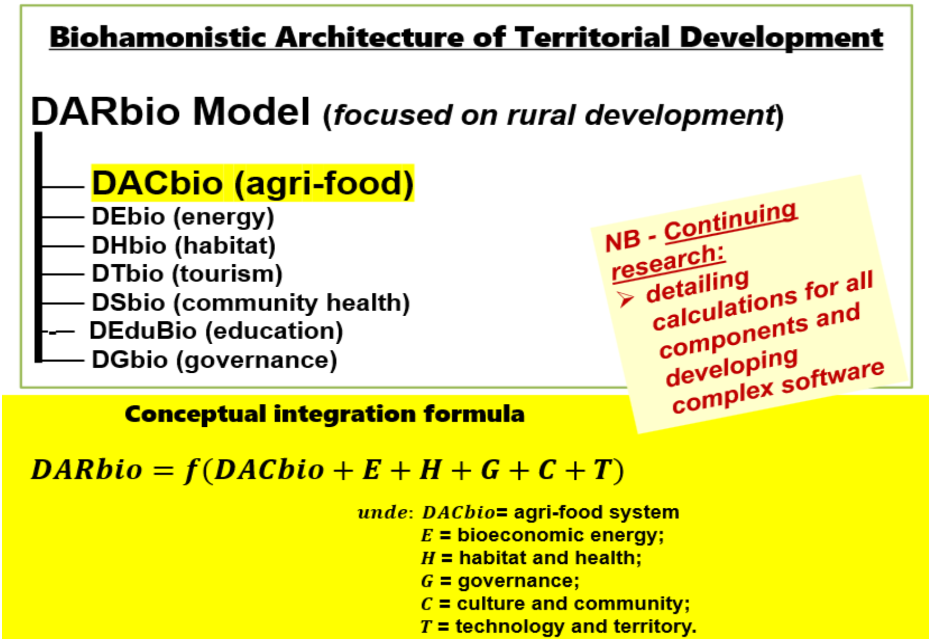

Figure 4. The Development of Agri-Food in Convergence Bioharmonism Model (*DACbio*) within the components of the general Rural Development Model *(DARbio*)

The DARbio model, in short, is the bioharmony of rural civilization, calculated as a weighted arithmetic average, representing the integrative bioharmonistic **territorial framework** of bioconvergence between agri-food systems, circular bioeconomy, resilient communities and ecosystems of living reality. The bioharmonistic architecture of territorial development, focused on rural development, consists of the components and metrication analyzed in the Figure 4.

In the context of what has been presented, we specify that Development of Agri-Food in Convergence of Bioaharmonism Model (DACbio) adapted to the specific conditions expected for the coming decades is the basic component regarding the bioharmony of regenerative agri-food production, which answers another question, that is, simply put: *How do we produce, process and distribute food in a bioharmonistic manner* ?

Essentially, the DACbio Model transforms industrial evolution from a linear process into a process of bioconvergence towards a bioharmonistic civilization, in which the agri-food system becomes the core of the balance between man, technology and nature. This dynamic is achieved along the lines of food security within the framework provided by the model structure (Table 2).

Table 2. DACbio Model Structure

Category	ASPECT ADDRESSED	STRUCTURAL ELEMENTS
Level 1	Ecosystemic	➢ soil, ➢ water, ➢ biodiversity, ➢ climate, ➢ food chains.
Level 2	Agro-productive	➢ regenerative farms, ➢ polyculture, ➢ livestock integraratio, ➢ smart agriculture.
Level 3	Nutritional	➢ functional food, ➢ nutrigenomics, ➢ information density, ➢ metabolic health.
Level 4	Societal	➢ resilient rural communities, ➢ social cohesion, ➢ local economy, ➢ regional food security.
Level 5	Civilizational	➢ the human-nature relationship, ➢ the development model, ➢ technological ethics, ➢ societal bioharmonism.

We find these levels in different combinations and expressions throughout the historical evolution of food safety, with defining specifics for each stage (Table 3).

Table 3. The evolutionary specifics of food security in the relationship between the mode of food production and the governance system of the era.

STAGE OF EVOLUTION	HISTORICAL SPECIFIC	DEFINING ELEMENTS AND GOVERNANCE LANDMARKS
Industry 1.0 → Agro-sistem tradițional mecanizat incipient	Extensive agriculture + beginning of mechanization	• Type of agriculture: subsistence + local market • Dominant energy: human, animal, beginning of mechanization (steam) • Structure: autonomous rural households • Food chain: short, local • Diversity: high (polyculture)
Industry 2.0 → Mass production agro-system	Electrification + beginning of intensive agriculture	• Type of agriculture: market-oriented • Technologies: advanced mechanization, electricity • Structure: commercial farms • Food chain: regional → national • Characteristic: standardization

Industry 3.0 → Industrialized Agro-sistem	Green revolution + chemistry + automation	• Technologies: fertilizers, pesticides, classical genetics • Structure: industrial intensive agriculture • Food chain: expanding global • Characteristic: quantity and yield maximization
Industry 4.0 → Digitalized Agro-sistem *(Smart Agriculture)*	Precision agriculture + digitalization (present)	• Technologies: IoT, sensors, drones, AI, Big Data, precision agriculture • Structure: smart farms, integrated into networks • Food chain: global, digitalized, traceable, food information density • Feature: real-time quality and optimization
Industry 5.0 → Human-centered agro-system and sustainability	Ecological and social rebalancing	• Values: sustainability, health, quality, multiple integration • Technologies: agroecology, bio, collaborative AI • Structure: hybrid systems (local + global) • Food chain: short + transparent
Industry 6.0 → Agro-biointegrative system *(concept emergent)*	Bio–digital–cognitive convergence	• Technologies: nutrigenomics, advanced biotechnologies, adaptive AI • Structure: smart and regenerative agri-food ecosystems • Food chain: personalized + ecosystemic • Characteristic: human–nature–technology co-evolution

The strategic interpretation and evolutionary synthesis reveal a series of explanatory interrelationships regarding the industrial evolution of food security (Table 4).

Table 4. *Evolutionary synthesis of food security and governance specifics*

STAGE	NATURE OF THE AGRI-FOOD SYSTEM	DOMINANT FUNCTION	STRATEGIC INTERPRETATION
1.0	Local Organic	Survival	Food as substance
2.0	Mass Economy	Productivity	
3.0	Industrial Intensive	Yield	Food as commodity
4.0	Digitally Intelligent	Optimization	Food as data
5.0	Human-centred Sustainable	Balance	Food as human value
6.0	Bio-Integrative	Co-evoluție towards systemic Coherence	Food as integrated biological information

It is found that the evolution is not only technological, but reflects a profound transition, from: *matter* → *energy* → *information* → *consciousness*.

This indicates the bioharmonistic essence in which the agri-food system evolves from a model of exploitation of nature to one of integration with nature, in which:

👉 **food becomes the interface between the biosphere, technology and human consciousness**

All these aspects lead us to the conceptual infographic modeling of the DACbio Systemic Model of Food Security & Governance in Bioharmonism (Figure 5).

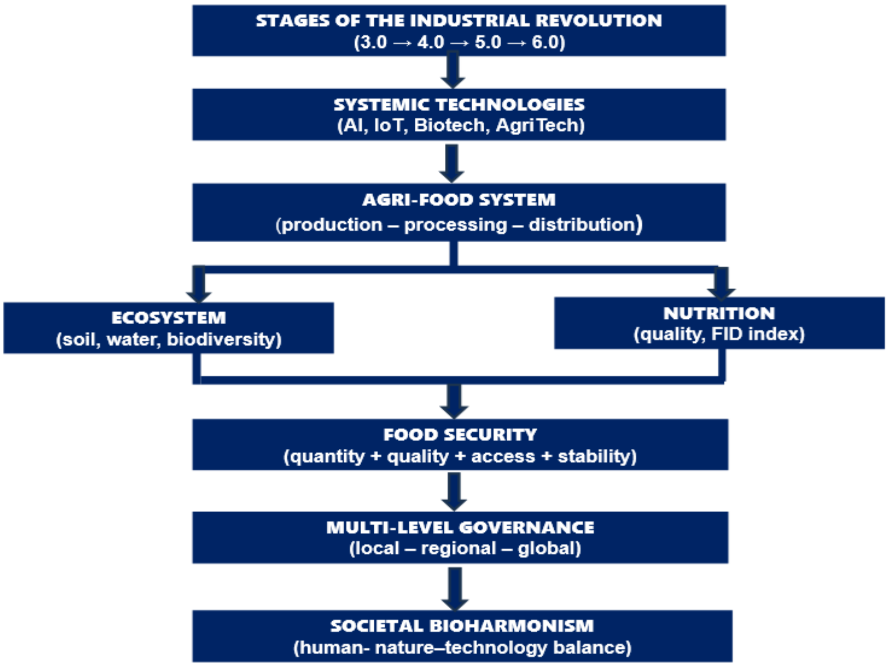

Figure 5. Block diagram of the DACbio model

This conceptual and functional flow becomes applicable through its objectification and application in case studies to solve specific food security problems.

3.3. Metricization of the DACbio method

According to the objective, the paper aims to develop a conceptual and applicative model that integrates food security and agro-industrial governance in the logic of global technological evolution, oriented towards optimizing the functioning of agro-food systems through the use of indicators, in accordance with the principles of bioharmonism.

The intention is to objectify the direct integration into the DACbio model through bioharmonism so that case studies of agro-food security become applicable in the future by identifying specific indicators, which represent the principle elements described in table 5.

Table 5. Definition and detailing of DACbio indicators in order to establish calculation formulas and related weights

No.	INDICATOR	DEFINITION	FORMULA
1	**Ecological Regeneration (Er)**	Measures the system's capacity to restore natural capital through regenerative practices.	$\mathbf{E_r = (B_d \cdot C_s \cdot R_s) : I_e}$ **B_d**: Soil and ecosystem biodiversity (numerical index). **C_s**: Carbon sequestration in soil and biomass. **R_s**: Rate of replenishment of water and nutrient resources. **I_e**: Negative ecological impact (chemical amendments, erosion).
2	**Food Health (As)**	Defines the biophysiological quality of food relative to the toxic footprint of production.	$\mathbf{A_s = (D_n \cdot B_a) : (T_x \cdot P_p)}$ **D_n**: Nutritional density (vitamins, minerals, antioxidants). **B_a**: Bioavailability of beneficial compounds. **T_x**: Toxin load (pesticides, heavy metals, microplastics). **P_p:** Degree of harmful processing (ultra-processing).
3	**Bioeconomic Circularity (Cb)**	Evaluates the efficiency of transforming waste into resources within local loops.	$\mathbf{C_b = (\sum M_r + \sum E_b) : (M_i + D_n)}$ **M_r**: Recycled / biochemically recovered secondary raw materials. **E_b**: Renewable energy generated from residual biomass. **M_i**: Virgin raw materials introduced into the system. **D_n**: Net non-recyclable waste disposed of in the environment.
4	**Climate Resilience (Rc)**	Represents the capacity of the agri-food system to absorb climate shocks and adapt quickly.	$\mathbf{Rc = (A_c \cdot D_s) : \Delta S_c}$ **A_c**: Technological and structural adaptive capacity. **D_s**: Structural diversity of crops and production systems. **ΔS_c**: Magnitude and frequency of climate shocks (drought, floods).
5	**Socio-Rural Equity (Se)**	Measures the fair distribution of value and the well-being of the communities that support the agri-food core	$\mathbf{S_e = (V_l \cdot A_r \cdot Q_l) : G_i}$ **V_l**: Economic value retained directly in the local community. **A_r**: Access to resources, education and technology for small producers. **Q_l**: Quality of life in rural areas (infrastructure, health). **G_i**: Gini coefficient of income inequality in the region.

6	**Bioethical Technological Intelligence (Tb)**	Synthesizes the extent to which digitalization (AI, IoT, SynBio) serves life, not just profit	$\mathbf{T_b = (E_t \cdot O_r) : (R_a + C_d)}$ $\mathbf{E_t}$: Technological efficiency (optimization of resources through AI/IoT). $\mathbf{O_r}$: Alignment with regeneration objectives (eco-centric algorithms). $\mathbf{R_a}$: Algorithmic or technological risks (loss of human/biological control). $\mathbf{C_d}$: Carbon footprint (energy consumption of data centers).
7	**Human Biharmony (Bh)**	Bioharmonistic well-being	$B_h=w_1L_v+w_2I_s+w_3E_d+w_4F_w+w_5S_p$ $\mathbf{L_v}$: Life expectancy index. $\mathbf{I_s}$: Access to services index. $\mathbf{E_d}$: Educational attainment index. $\mathbf{F_w}$: Well-being index. $\mathbf{S_p}$: Perceived health index. + Condition: $w_1+w_2+w_3+w_4+w_5=1$
x	**Integral Formula of the DACbio Model**	The system reaches the state of Bioharmonistic Bioconvergence (B_{cb}) and the product of the components tends towards the maximum sustainable value.	$B_{cb} = f\,(E_r,A_s,C_b,R_c,S_e,T_b, B_h)$ The architecture of the 7 DACbio dimensions through the SSD Evaluation grid (0 - 100), divided into 5 distinct levels of structural evolution, as follows: 🔴 0 – 20 points: Linear industrial system (critical development) 🟠 21 – 40 points: Optimized industrial system (fragile development) 🟡 41 – 65 points: Transition to Bioconvergence (moderate development) 🟢 66 – 85 points: Systemic sustainability (advanced development / co-existence) 🔵 86 – 100 points: Total Bioharmonist Bioconvergence (bioharmonistic performance development / co-evolution, coherence)

To transform industrial evolution from a linear process into a bioconvergence system through the DACbio Model, its architectural components must be expressed through ***principle formulas***. These mathematize the interdependencies between technology, nature and society, with the agri-food system as the core.

We note that to set the weights of the component indices in the calculation formulas of the DACbio Model, fixed, arbitrary weights cannot be used. Since the system tends towards a bioharmonistic civilization, *the weighting must be dynamic, adaptive and based on the entropy of the system*, ensuring that no component is sacrificed by another.

As an example: Development of Agri-Food in Convergence of Bioaharmonism Model (DACbio), is based on innovative indicators that go beyond classic agri-food metrics (productivity, yield, profit) and simultaneously measure the dimensions of the systemic complexity of the field (Figure 6).

DACbio 7 - dimension architecture

Size	*The Measured Element*	*Element category*	Recommended Weight (0 = very poor; 100 = optimal bioharmonistic performance)
E_r	Ecological regeneration	ecosystems	**20 %**
A_s	Agri-food health	nutritional	**15 %**
C_b	Bioeconomic circularity	metabolic	**15 %**
R_c	Climate resilience	adaptative	**15 %**
S_e	Socio-rural equity	social	**10 %**
T_b	Bioethical technological intelligence	technological	**10 %**
B_h	Human bioharmony	welfare	**15 %**

$$SSD = 100 \times \sum_{i=1}^{n} w_i \cdot I_i$$

where: SSD = Synthetic Score Development (*DACbio expression*);
I_i = Normalized indicator (0–1);
w_i= index weight;
$\sum w_i$ = 1.

➢ *Exemplification:*

$$SSD = 100 \times (0.20E_r + 0.15A_s + 0.15C_b + 0.15R_c + 0.10S_e + 0.10T_b + 0.15B_h)$$

Figure 6. Calculation formula and indicative example for the DACbio Synthetic Score (SSD)

3.4. Public policies and implementation strategies

It is useful to specify that politically and administratively the DACbio Model does not operate in an institutional vacuum, but is organically inserted into three major existing European frameworks, which it reinterprets from the perspective of systemic bioharmony:

- Common Agricultural Policy (CAP 2023–2027)
- Biodiversity Strategy 2030 & "From Farm to Fork"
- European Green Deal.

The analysis of agri-food policies and strategies along the lines of the principles of bioharmony makes it useful to recommend a ***public policy program*** as identified in the "honeycombs" in Figure 7.

Figure 7. Recommended public policy groups for agri-food development in convergence with the principles of bioharmonism

Continuing with the analysis, it is observed that the DACbio Model proposes highlighting a process of convergence towards a Bioharmonist Civilization, in which the agri-food system becomes ***the core of the balance*** between man, technology and nature. These are essentially finalized through a set of decisions, actions or inactions deliberately assumed by the state authorities to solve real-world problems, that is, a mode of application adapted to a certain area, such as through public policies specific to Romania (Table 6).

Table 6. Proposed public policies for the development of the agri-food sector in Romania

No.	TIPOLOGY OF PUBLIC POLICIES	DIRECTION OF IMPLEMENTATION AND ACTION
1	Bioharmonistic technological integration policies	➢ Complete digitalization of agri-food chains (farm-to-fork) ➢ Implementation of intelligent systems based on: - Precision agriculture - IoT sensors and predictive AI platforms ➢ Creation of open agri-food data infrastructures (open data)

2	Policies for expanded food security	➢ Redefining food security by including: - nutritional quality - information density - ecosystem sustainability ➢ Introduction of national indicators (Bcb, DDS, FDI etc.) ➢ Programs for equitable access to high-quality food
3	Agro-ecological and bioharmonistic policies	➢ Stimulating regenerative and circular agricultural systems ➢ Protecting agri-food biodiversity ➢ Integrating Agroecology principles into agricultural policies
4	Multi-level governance policies	➢ Decentralization of decision-making to local and regional levels ➢ Creation of participatory platforms (farmers – consumers – authorities)Integration of private and public actors in a co-governance model
5	Educational and awareness policies	➢ Introducing bioharmonistic food education into school curricula ➢ Nutritional and digital literacy programs ➢ Supporting interdisciplinary research (agro, IT, nutrition, ecology)

Conclusions

(1). **Future food security** is supported by the theoretical-applicative *DACbio model*, capable of underpinning public policies and sustainable development strategies through the bioconvergence of multiple integrations with emergent effect, correlating through bioharmony the harmonized industrial governance of agri-food systems, the informational quality of food and the ecosystem balance.

(2). The bioharmonistic convergence in agri-food development is conceptually and analytically based on the **bioconvergence process** expressed through the synergy point between the "polyvalence" of the local level and the systemic "multi-levels", so that through the expected dynamic balance, the homeoretic state with resilient potential is induced, but also emergently adapted to the context of global nutrition and industrial development.

(3). Development of Agri-Food in Convergence of Bioaharmonism Model is based on a polycentric structure of **participatory governance**, capable of reducing the risk of digital hyper-centralization, transforming food security from a quantitative objective into one of dynamic equilibrium, thus becoming a system with a *specific architecture*, i.e. self-regulation based on non-linearity and multi-level feed-back.

(4). The food system represents the most sensitive barometer of a civilization, so the evolution towards **Industry 6.0** expected for the future *Bioharmonist Civilization* can transform the global food crisis into an opportunity for evolutionary recalibration in generalized bioharmony, provided that catastrophes caused by human irresponsibility are overcome and disasters caused by human irresponsibility are avoided.

REFERENCES

[1] Abdulai, A. F. Digital agriculture in developing countries: A transformation with potential and challenges. Technology in Society, 71, Article 102100. cgiar.org (2022).

[2} Bocken, N. M., Short, S. W., Rana, P., & Evans, S. A literature and practice review to develop sustainable business model archetypes. Journal of Cleaner Production, 65, 42–56 (2014).

[3] Bronson, K., & Sengers, F. The politics of big data in the agrifood sector. Agriculture and Human Values, 39(2), 651–664 (2022).

[4] D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J.,. & Toppinen, A.Green, circular, bio economy: A comparative analysis of sustainability concepts. Journal of Cleaner Production, 168, 716–734. (2017).

[5] Gale, F., & Branch, B. Concentration and innovation in agribusiness sectors. American Journal Of Agricultural Economics, 64(2), 310–319. (1982).

[6] Georgescu-Roegen, N. The entropy law and the economic process. Harvard University Press. (Lucrare fundamentală pentru conceptul de bioeconomie și armonie ecologică). (1971).

[7] Government Office for Science. The future of food and farming: Challenges and choices for Global sustainability. Final Project Report. nih.gov (2011).

[8] Gruia, R. Managementul eco-fermelor, Ed Ceres București, p.41-50 (Eco-farms Managment) (1998).

[9] Gruia, R. Agroecosisteme și dezvoltare rurală în contextul schimbărilor climatice. *Revista de Științe Agricole și Economie Rurală, (Agroecosystems and rural development in the context of the climate change. Review of Agricultural Sciences and Rural Economy) 12*(2), 55–64. (2006).

[10] Gruia, R. Sisteme agro-montane şi durabilitate rurală. Editura Agris. (Agro-mountain systems and rural sustainability. Agris Publishing House) (2008).

[11] 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).

[12] Gruia, R. Bazele managementului și direcțiile viitoare de evoluție, Editura Lux Libris, (Management fundamentals and future evolution directions, Lux Libris Publishing House), p.137-198. (2013).

[13] 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).

[14] 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).

[15] Gruia, R. Zootehnia bioeconomică, Ed. Lux Libris, (Bioeconomic Animal Husbandry, Lux Libris Publishing House), 43-100, 143-172, 253-304. (2016).

[16] Gruia, R. Evoluția științifică a gastronomiei în cadrul actului alimentar, Editura Clarion Brașov (Scientific evolution of gastronomy within the food act, Clarion Publishing House, Brasov) p.17-68. (2018).

[17] Gruia, R. Inginerie gastronomică, Editura Clarion Brasov, (Gastronomic Engineering, Clarion Publishing House, Brasov) 710 pag., 35-238. (2024).

[18] Lajoie-O'Malley, A., Branson, K., van der Burg, S., & Klerkx, L. The technology rushed into agriculture: A critical discourse analysis of Agri-Food 4.0. Journal of Rural Studies, 78, 13–25. (2020).

[19] Margulis, M. E. The regime complex for food security: Implications for the global governance of food. Global Governance: A Review of Multilateralism and International Organizations, 19(1), 53–67. researchgate.net (2013).

[20] McMichael, P. Food regimes and agrarian questions. Fernwood Publishing (2013). [21] Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F., & Nita, V. The role of biomass and bioeconomy in a changing world. Resources, Conservation and Recycling, 101, 141–160 (2015).

[22] Schwab, K. The fourth industrial revolution. World Economic Forum. (2016).

[23] Swinburn, B. A., Kraak, V. I., Allender, S., Atkins, V. J., Baker, P. I., Pratt, C. A., ... & Dietz, W. H. The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. The Lancet, 393(10173), 791–846. (2019).

[24] Zambon, I., Cecchini, M., Egidi, G., Saporito, M. G., & Colantoni, A. Revolution 4.0: Industry vs. agriculture in a future vision for smart farming. Processes, 7(9), 617. (2019).

[25] XXX - FAO, IFAD, UNICEF, WFP, & WHO. (2023). The state of food security and nutrition in the world 2023: Urbanization, agrifood systems transformation and healthy diets across the urban-rural continuum. Food and Agriculture Organization. doi.org

[26] XXX - United Nations Industrial Development Organization (UNIDO). (2026). Agrifood systems transformation and the future of industrial development. UNIDO Policy Brief No. 27. unido.org