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CONTENTS

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Eco-Driving: The Path to Sustainable Transport Within the Framework of the Green Transition on the Example of the Republic of Belarus

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Abstract

In the article, the authors' definition of the concept “eco-driving” as a practical, quickly implemented and low-cost tool for sustainable transport within the framework of the green transition, combining environmental efficiency (reduced harmful substances emissions), economic efficiency (fuel savings, reduced vehicle maintenance and repair costs, extension of the vehicle components and assemblies service life) and social efficiency (improved road safety, reduced road accidents, formation of an environmental culture) has been clarified and scientifically substantiated. The study covers current issues related to the eco-driving principles, reflects the relationship of eco-driving with sustainable transport, green transition and sustainable development goals. It is proposed to implement the eco-driving business process in the activities of transport organizations of the Republic of Belarus: the proposed business process with the image of a context diagram has been developed; the choice of key criteria for eco-driving assessment has been substantiated; a system for assessing eco-driving and driver motivation has been created; savings from the introduction of eco-driving have been reflected. In order to scale up the project on the introduction of eco-driving in the activities of transport organizations of Belarus, a roadmap with visualization in the form of a Gantt chart has been developed. The results obtained allow us to expand the understanding of eco-driving as a key element of sustainable transport within the framework of the green transition. The introduction of eco-driving in the activities of transport organizations of the Republic of Belarus will contribute to environmental sustainability, increasing economic efficiency, and increasing social responsibility.

Keywords: eco-driving, green transition, sustainable transport, sustainable development goals, business process

1.Introduction

Relevance and problems of the study. Sustainable transport based on the practice of eco-driving is becoming an important scientific and practical research area in the context of modern green transition trends. Its relevance and problems are due to global challenges related to climate change, environmental pollution, resource depletion and the increased need for sustainable development within the framework of the green transition.

Transport is one of the main sources of air pollution. Every year, the amount of CO_2 dioxide (CO_2) emissions resulting from transport activities amounts to more than 8 Gt CO_2. In 2023, CO_2 emissions from fuel combustion in the transport sector accounted for 25% of total emissions, with road transport accounting for more than 75%. In 2023, road vehicles were the largest polluters, accounting for three-quarters of all transport-related emissions. Emissions from cars have increased by around 20% over the past ten years to 3.2 Gt CO_2, making them the largest source of road transport emissions globally. Heavy-duty trucks are also major polluters, emitting around 2 Gt CO_2 annually worldwide (Statista, 2023).

Transport was also the second largest source of global greenhouse gas emissions, with cars polluting the most (15%) (Statista, 2023).

In the Republic of Belarus, about 70% of air pollution comes from road transport, which has a negative impact on the sustainable transport development. At the end of 2023, more than 11.2 thousand organizations of various forms of ownership and more than 36 thousand individual entrepreneurs operated in the belarusian transport complex. At the same time, the number of vehicles belonging to organizations and in the citizens personal ownership at the end of 2023 amounted to more than 4,2 million units (of which 73,5% were passenger cars, 8,9% were trucks) (National Statistical Committee of the Republic of Belarus, 2025).

Pollutants emissions into the atmospheric air of Belarus at the end of 2023 amounted to 897.9 thousand tons (98 kg per capita), including 408.4 thousand tons (44 kg per capita) from mobile sources. At the same time, in 2023, there was a dynamic in pollutants emissions into the atmospheric air from mobile and stationary sources (the growth rate by 2022 was 102.9%) (National Statistical Committee of the Republic of Belarus, 2024).

Given the understanding of the problems' importance, priority attention should be given to the greening of transport at present, as it is directly related to the key challenges of our time. The study proposes to use eco-driving as a key element of sustainable transport, which has significant potential for reducing the carbon footprint, increasing the transport energy efficiency (reducing fuel consumption, increasing the vehicles service life), and increasing economic and social efficiency.

However, in the Republic of Belarus there is no practice of using eco-driving due to low awareness and insufficient motivation, technical and technological limitations, economic barriers, organizational and managerial problems, regulatory aspects, weak government support.

In this regard, the aim of the study is to provide theoretical justification and develop practical recommendations for the implementation of the business process "eco-driving" in the activities of transport organizations of the Republic of Belarus, as a key element of sustainable transport within the framework of the green transition.

The aim of the study determined the formulation and solution of the following tasks:

- to explore the economic essence of the concept "eco-driving", to propose an original definition of the concept from the point of view of sustainable transport within the framework of the green transition;
- study and supplement the principles of eco-driving as a sustainable transport element;
- implement the business process "eco-driving" in the activities of a transport organization based on the example of Rising Ltd.: justify the choice of key criteria for assessing eco-driving; create a system for assessing eco-driving and motivating drivers; reflect the economic effect of implementing this business process - savings in fuel costs and replacement of vehicle components and assemblies; substantiate the importance of training employees in eco-driving;
- develop a roadmap for the introduction of eco-driving into the activities of transport organizations of the Republic of Belarus.

The scientific novelty of the obtained results is emphasized by the importance of eco-driving as an element of sustainable transport within the framework of the green transition, and the proposed recommendations will contribute to the formation of an environmental culture, a reduction in environmental impact, an increase in economic and energy efficiency, and an improvement in the life quality of the population. This is an important step towards green transition and achieving sustainable development goals.

The object of the study is eco-driving as an element of sustainable transport within the framework of the green transition. The subject of the study is recommendations for the introduction of eco-driving in the activities of transport organizations of the Republic of Belarus.

2.Materials and Methods

The identified problems were identified based on the results of a comparative analysis of domestic and foreign literature reflecting the relevance of environmental issues, the eco-driving effectiveness; an oral survey in transport organizations engaged in freight road transport.

In studying approaches to defining the essence of the concept “eco-driving”, an analysis of the definitions by foreign and domestic authors was used, based on which, using the methods of deduction and induction, the author’s definition of the concept of “eco-driving” was proposed from the point of view of sustainable transport within the framework of the green transition.

To assess the effectiveness of eco-driving, authors used statistical and comparative methods to analyze data on harmful emissions, fuel consumption. Summarizing the obtained research results, based on the application of mathematical and statistical methods, the choice of key criteria for assessing eco-driving was substantiated; a system for assessing eco-driving and driver motivation was created; the effect eco-driving implementation was calculated. In order to scale up the project, a roadmap for introducing eco-driving into the activities of belarusian transport organizations was developed with visualization in the form of a Gantt chart.

Thus, the study used complementary general scientific (classification, comparison, explanation, induction and deduction, scientific proof, logical, comparative methods of analysis) and specific methods of cognition (generalization, graphic), as well as systemic and comprehensive approaches.

The theoretical basis of the research is the study and systematization of scientific publications of domestic and foreign scientists on eco-driving, statistical data on environmental damage; industry reports, international and national regulatory legal acts; internet sources, which made it possible to make a theoretical selection and determine the main research topic.

3.Results

The term “eco-driving” was first used in 1998 by the Swedish National Driving School (Caban, Vrábel, Šarkan, & Ignaciuk, 2019). Since then, researchers have begun to study the characteristics of eco-driving. As a result of the analysis of the authors' opinions regarding the concept under study, we identified three approaches found in the literature:

1. Ecological and energetic - a comprehensive approach that essentially combines the concepts of “eco-driving”, energetic (fuel efficiency) and environmental aspects (reduction of emissions, minimization of environmental impact). This approach is the most common in specialized and scientific literature. Barkenbus (2010), Martin, Chan & Shaheen (2012), Barth & Boriboonsomsin, (2009), Ahlstrom & Kircher (2017), Sivak & Schoettle 2012), Ayyildiz, Cavallaro, Nocera & Willenbrock (2017) focus on reducing fuel consumption and harmful emissions through optimizing driving style. Eco-driving as a tool for reducing vehicle fuel and energy consumption is considered by Fafoutellis, Mantouka & Vlahogianni (2021), Hsu, Lim & Yang (2017), Mensing, Bideaux, Trigui, Ribet & Jeanneret (2014). Eco-driving as a tool for reducing hazardous emissions into the atmosphere is considered by Kutzner, Kacperski, Schramm & Waenke (2021).

Barkenbus, J. N. (2010) defines eco-driving as a driving strategy that minimizes fuel costs and emissions without significantly increasing travel time.

Sivak & Schoettle (2012) emphasize that eco-driving allows to reduce fuel consumption by 5–20% depending on the type of road.

Gudkov (2018) considers eco-driving as an element of “green logistics” and notes that driver training can reduce fuel consumption by 10–15%.

This approach corresponds to the principles of systems analysis, reflects the dual nature of eco-driving, is used in modern research, and is supported by the international regulatory framework.

2. The behavioral approach to the essence of the eco-driving concept focuses on the human factor as a key element of efficient and environmentally friendly driving. The idea of the approach is to form long-term driver habits through training and motivation (Zarkadoula, Zoidis, & Tritopoulou, 2007), (Ayyildiz et al., 2017), (Fafoutellis et al., 2021), (Dehkordi, Larue, Cholette, Rakotonirainy, & Rakha, 2019), (Sanguinetti, Kurani, & Davies, 2017). This approach is simple and accessible, but requires personal discipline from the driver, interest in maintaining economical and at the same time more environmentally friendly driving. The impact of eco-driving on road safety is considered by Alam & McNabola (2014), Ahlstrom & Kircher (2017), Nævestad (2022). The authors Af Wåhlberg, (2007), Caban et al. (2019) in their definitions note the simultaneous achievement of environmental and transport-safety efficiency, which is a certain advantage of the approach.

3. The technological approach to the essence of the concept of eco-driving emphasizes that the use of modern technologies transforms eco-driving from a subjective driving style into a controlled, measurable and automated process. This approach combines engineering solutions, telematics and artificial intelligence to achieve maximum fuel efficiency and environmental friendliness. Ayyildiz et al. (2017), Barić, Zovak, & Periša, (2013) believe that automating the process will allow to obtain accurate data and achieve greater results from the use of eco-driving.

Despite the existence of various studies in the field of reducing vehicles fuel consumption, the concept of "eco-driving" in the Republic of Belarus appeared relatively recently, hence there is an almost complete lack of publications on this issue. Among Belarusian authors, one can note the works of Meshcheryakova & Kryukova (2023), who consider eco-driving as a tool for increasing the economic efficiency of transport organizations due to savings in fuel consumption and vehicle repairs.

In the studies of Prozorov & Zakharov (2020), Kolacheva & Chertakova (2017), Lenich (2024), Smirnov (2023) the issues of reducing fuel consumption when introducing eco-driving are considered, and eco-driving is mentioned as an effective tool for reducing the environmental burden.

Based on the analysis of literary sources, we have clarified the existing concepts and proposed a comprehensive author's definition: "eco-driving is a practical, quickly implemented and low-cost tool for sustainable transport within the framework of the green transition, combining environmental efficiency (reduced CO_2, greenhouse gases and solid particles emissions, reduced noise), economic efficiency (fuel savings, reduced vehicle maintenance and repair costs, extended vehicle components and assemblies service life) and social efficiency (improved road safety, reduced road accidents, formation of an environmental culture)".We believe it is necessary to consider eco-driving as a fast and low-cost way to reduce the transport carbon footprint without radical changes to the infrastructure. This makes it a key element of sustainable transport within the framework of the green transition and achieving the Sustainable Development Goals (SDGs):

1. Connection with sustainable transport:

- reducing emissions: eco-driving aims to optimize driving style to reduce fuel consumption and, as a result, CO_2, greenhouse gases and solid particles emissions. This is a key element in the transition to sustainable transport with a lower environmental impact;
- increasing efficiency: eco-driving involves using optimal speed, smooth acceleration and braking, and the correct choice of gears, which will improve fuel efficiency and reduce overall operating costs;
- extending vehicle life: smoother, gentler driving reduces engine, brakes, tires and other components wear, resulting in longer vehicle life and lower maintenance and replacement costs.

2. Connection with green transition:

- reducing dependence on fossil fuels: eco-driving helps reduce fuel consumption, which not only helps reduce emissions but also reduces dependence on fossil fuels and encourages the transition to alternative energy sources;

- closed-loop economy: increasing the resources for auto components;
- developing environmental awareness: the introduction of eco-driving promotes the environmentally responsible behavior development among drivers and increases their environmental issues awareness;
- supporting the electric vehicles and other clean technologies adoption: eco-driving can be integrated into driver training programs for electric vehicles and other low-emission vehicles to maximize their efficiency and minimize their environmental impact.

3. The development of sustainable transport is linked to the following SDGs:

- SDG3: ensure healthy lives and promote well-being for all at all ages (reduce the carbon footprint, the less emissions, the cleaner the air; the number of diseases and deaths from exposure to air pollution will be reduced);
- SDG7: ensure universal access to affordable, reliable, sustainable and modern energy for all (increase the energy efficiency of freight transport; reduce emissions and improve air quality);
- SDG9: build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (the introduction of eco-driving can stimulate the development and implementation of innovative technologies in the field of transport, the development of smart driver assistance systems);
- SDG11: make cities and human settlements inclusive, safe, resilient and sustainable (improving air quality and reducing congestion and noise in cities, making cities more livable; cities sustainability: eco-driving is a component of sustainable transport and sustainable urbanization);
- SDG12: ensure sustainable consumption and production patterns (eco-driving promotes more efficient use of resources (fuels), reduces waste and promotes the transition to more sustainable consumption patterns; vehicles service life increase, transport resource intensity reduction: development of a circular economy in the auto industry; optimization of logistics operations in transport activities, use of multimodal transportation;
- SDG13: take urgent action to combat climate change and its impacts (eco-driving helps reduce CO_2, greenhouse gases and solid particles emissions, which is a direct contribution to the fight against climate change and its impacts; research analysis has shown that if 10% of drivers switch to eco-driving, global CO_2 emissions from transport will decrease by 1.5%) (United Nations, n.d.).

Thus, eco-driving is not only an element of sustainable transport, but also part of the strategy for the transition to a low-carbon economy; it contributes to achieving the SDGs – which is the core of the green transition strategy.

Contribution to the green transition and achievement of the above-mentioned SDGs can be made by adhering to the basic eco-driving principles (IRU, n.d.):

1. Optimal engine control:
- smooth acceleration: maintaining engine revolutions in the “green” sector on the tachometer of the vehicle’s dashboard;
- use of higher gears: preferential movement in higher gear, quick switching to higher gears when speed increases;
- minimizing idling: reducing engine idling to a minimum, turning off the engine when stopped for more than 30 seconds.

2. Movement dynamics:
- maintaining a constant vehicle speed (optimal speed provides 8–10% fuel savings), using cruise control, avoiding speeding;
- predictive driving, preparing in advance for changes in traffic conditions (upcoming stops, slowdowns or turns);
- smooth driving style leads to 12–15% fuel savings; minimal use of emergency braking;
- selection of the optimal route to reduce mileage and stops in traffic jams and at traffic lights, combining several short routes.

3. Vehicles technical preparation:
- regular monitoring of tire pressure will allow for safe driving, reduce road resistance, reduce tire wear and fuel consumption (optimal tire pressure provides 3–5% fuel savings);

- reduction of "useless" vehicle load – heavy tools, unused pallets and other unnecessary items (every 100 kg increases fuel consumption by 5–7%).

4. Climate adaptations:

- winter operation – warm up the engine for no more than 5 minutes, use of viscous oils;
- summer operation – reducing the time of air conditioning use, optimal air conditioning at 22–24°C (every degree lower will lead to increased fuel consumption), using natural ventilation at low speed.

5. Psychological aspects:

- peripheral vision training;
- motivational mechanisms: financial incentives (for fuel consumption savings).

6. Technological aspects:

- application of a real-time recommendation system on fuel economy and driving habits;
- eco-mode scale on the instrument panel.

It has been proven that regular application of eco-driving principles increases vehicle life by 20–30%.

Thus, it can be noted that the principles of eco-driving as an element of sustainable transport are closely interconnected and form a single complex system that allows for an environmental effect (reduction of emissions into the environment), an economic effect (reduction of operating costs, resource conservation, increased energy efficiency) and a social benefit (reduction of accidents, reduction in the number of diseases and deaths from exposure to polluted air).

However, despite the potential benefits, there is no eco-driving practice in Belarus for a number of reasons:

- low awareness. Lack of information remains the main obstacle to the eco-driving implementation in transport organizations. Driving schools do not pay attention to eco-driving, transport organizations do not conduct training for drivers. Many heads of transport organizations do not see a direct financial benefit (delivery times prevail in transportation, not fuel savings; strict delivery schedules force drivers to use an aggressive driving style);
- insufficient motivation, organizational and management problems. Many drivers prefer to use familiar driving methods. Insufficient drivers' motivation is due to the fact that their salaries do not depend on fuel savings; there are no bonuses for drivers who follow eco-driving principles. Transport organizations lack a systematic approach, there are no corporate standards or KPIs for eco-driving; - technical and technological limitations. High-mileage vehicles are difficult to adapt to eco-modes; lack of smart driver assistance systems. Lack of software for analysis: few local IT solutions for monitoring driving style; foreign systems are expensive and not always adapted;
- economic barriers. The implementation of GPS devices, telematics, training of employees and drivers requires financial investments, small businesses are not ready to spend money on the project, since they do not see a direct financial benefit;
- regulatory aspects. Lack of mandatory standards: there is no legislative definition of eco-driving, the traffic regulations do not contain clear criteria for the "eco-style" of driving, and there are no requirements for training drivers. For example, National Strategy for Sustainable Development of the Republic of Belarus until 2035 (2020) provides measures to develop communication routes, ground infrastructure, the transition to alternative fuels. At the same time, it does not mention eco-driving;
- weak government support: lack of tax breaks (transport tax reduction) and subsidies for "green" carriers, etc.

Based on the conducted research, we consider it necessary to implement eco-driving in transport organizations of Belarus. Let us consider implementation of "eco-driving" business process on the example of Rising Ltd. It will include constant use of eco-driving principles; daily operations for collecting and analyzing data on each vehicle through the GPS; the eco-driving assessment system proposed by the authors; informing drivers about KPIs weekly; compiling monthly reports, calculating monthly drivers'

bonuses (fines) for (non)compliance with eco-driving principles. The “eco-driving” business process context diagram, compiled using the software product AllFusion Process Modeler r7, is shown in figure 1.

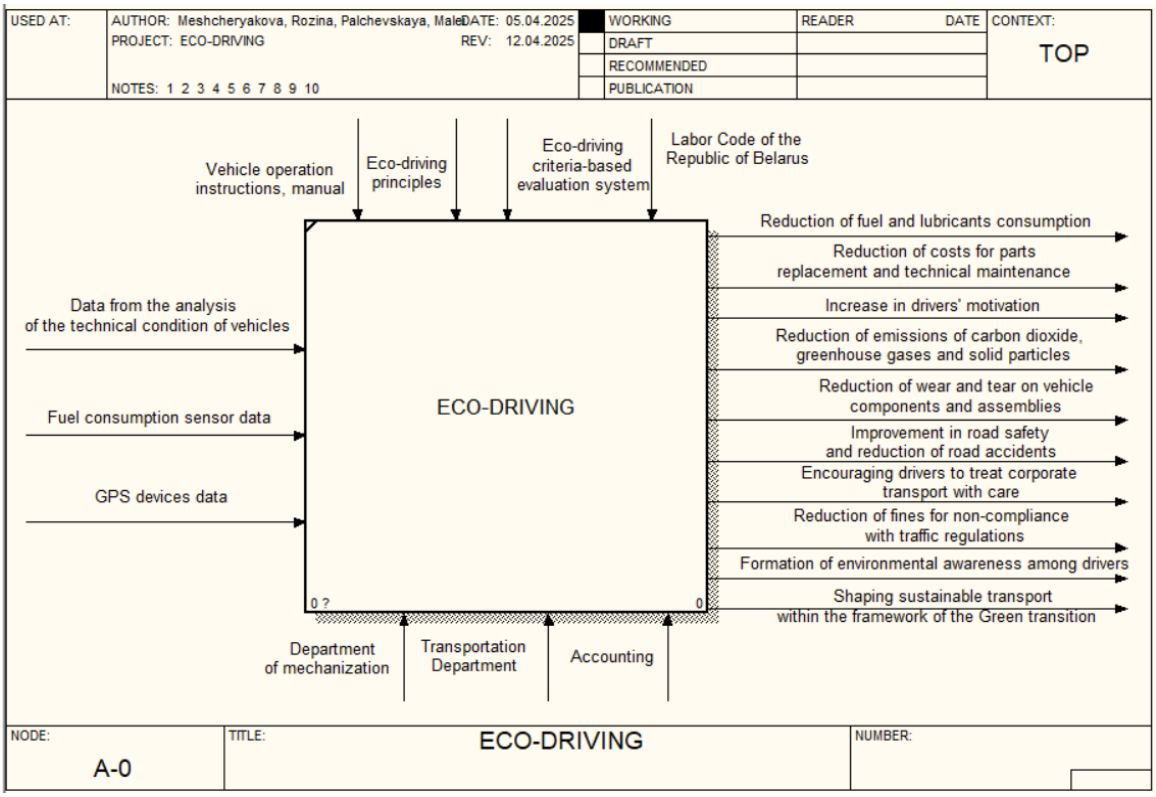

Figure 1. *The “eco-driving” business process context diagram*

Let's calculate the effect of implementing the “eco-driving” business process at Rising Ltd.

The vehicle fleet of Rising Ltd. consists of 163 vehicles. However, only 100 vehicles are equipped with GPS devices, which will be require expenses to implement GPS for 63 vehicles. The cost of installing one GPS device is 406,25 US dollars. The organization has 163 drivers in total, the average salary of one driver is 900 US dollars.

Eco-driving involves monitoring the control parameters of vehicle operation and assigning eco-scores to the driver according to established criteria. The following are selected as the key criteria for assessing the effectiveness of eco-driving:

- adaptive cruise control. Allows you to automatically maintain the required vehicle speed. As a result, fuel consumption decreases;
- idling. It is recommended to warm up the engine before starting to move for no more than 5 minutes and start moving, smoothly reach cruising speed and the engine will warm up effectively;
- coasting. When coasting, fuel is used minimally to maintain the engine idling;
- engine revolutions. Each truck has its own economic engine revolutions mode - the “green” zone, which is reflected on the tachometer on the vehicle's instrument panel. When driving, the engine revolutions should be in the “green” zone. Exceeding it, the torque decreases along with the power, and fuel consumption increases;
- engine braking. Use of a retarder, a device designed to reduce the speed of a vehicle without using the main braking system. When braking with the engine, fuel is not used and the braking system (brake discs and pads) operates in a gentle mode;
- fuel consumption – a key indicator of eco-driving. Fuel consumption increases with sharp acceleration and braking of the vehicle, at high speed, when driving in low gears, with irrational air

conditioner use (climate control), when the vehicle is overloaded, long engine warm-up in winter, with an aggressive driving style.

Thus, the eco-driving assessment system proposed by the authors includes such key criteria as adaptive cruise control, idling, engine load, engine revolutions, fuel consumption. Each criterion is assigned a certain number of eco-points, in accordance with the technical characteristics of the vehicles (tables 1, 2).

Table 1. *Scale for converting fuel consumption into eco-points*

Fuel consumption, liters/100 km	Number of eco-points, points
Scania R440	
32 and more	0–75
30–31	76–90
29 and less	91–100
Volvo FH16	
35 and more	0–75
32–34	76–90
31 and less	91–100
Mercedes 1844LLS	
34 and more	0–75
31–33	76–90
30 and less	91–100

Table 2*. Evaluation system for key eco-driving criteria, eco-points*

Criterion	Eco-points by vehicle brands		
	Scania R440	Volvo FH16	Mercedes 1844LLS
Adaptive cruise control	65–100	60–100	60–100
Idling	70–100	65–100	60–100
Engine load	60–100	60–100	65–100
Engine revolutions mode	60–100	75–100	75–100
Fuel consumption	75–100	75–100	75–100

Drivers who have mastered and applied eco-driving principles will gain higher eco-points, receiving a monthly bonus. If drivers do not comply with eco-driving rules, they will have low eco-points, thus receiving a fine (Table 3).

Table 3. *Driver incentive system for eco-driving*

Vehicle brand	Total eco-points	Salary bonus (fine) as a percentage of monthly salary
Scania R440	0–200	(10%)
	201–330	(5%)
	331–414	5%
	415–480	10%
	481–500	15%
Volvo FH16	0–205	(10%)
	206–335	(5%)
	336–415	5%
	416–485	10%
	486–500	15%
Mercedes 1844LLS	0–205	(10%)
	206–335	(5%)

	336–415	5%
	416–485	10%
	486–500	15%

It's assumed that the mechanics will receive information on each vehicle daily via the GPS and enter data according to the key criteria for assessing eco-driving into rating tables for each vehicle. The mechanics will summarize the drivers' indicators weekly, assign overall eco-scores according to the adopted eco-driving assessment system, inform the drivers about the (non-)achievement of eco-driving indicators at the end of each work week. Then, the mechanics summarize the data (overall eco-score for each driver) monthly to provide information to the accounting department. The accountant will review the summary table with overall eco-scores for each driver every month to calculate bonuses or fines for (non-)compliance with eco-driving rules.

The benefits of eco-driving for transport organizations have been proven and the effect of eco-driving has been quantified in scientific studies. Thus, the practice of introducing eco-driving shows fuel savings of up to 20%, and in some cases up to 30% (depending on the mileage of the vehicles and operating conditions).

Next, we calculate the savings on fuel costs after the introduction of eco-driving in Rising Ltd., based on average fuel consumption savings of 10% (table 4).

Table 4. *Calculation of fuel cost savings at Rising Ltd.*

Vehicle brand	Quantity, units	Annual fuel consumption, l		Fuel savings, l	Annual fuel cost savings (excluding VAT), US dollars
		actual value for 2024	after the introduction of eco-driving		
Scania R440	50	11725000	10552500	1172500	721820.32
Mercedes 1844LLS	63	15876000	14288400	1587600	977366.25
VOLVO FH16	50	12950000	11655000	1295000	797234.37
Total:	163	40551000	36495900	4055100	2496420.94

Based on the calculations, it can be seen that fuel savings at Rising Ltd. could amount to 4055100 liters per year, which directly reduces emissions of CO_2 and other pollutants, and in the long term, eco-driving could become a key tool for achieving the goals of the green transition.

Next, we will analyze the effect of replacing vehicle components and assemblies.

The vehicle driving style directly affects driving safety, wear of parts. Some parts last much longer with a smooth driving style (following the principles of eco-driving increases the mileage of the vehicle before the next repair or maintenance), while an aggressive driving style leads to accelerated wear and more frequent replacement of parts, which increases the cost of maintenance (Nogin & Butkov, 2004).

As an example, we will examine the replacement of the main vehicle components and assemblies, the wear of which directly depends on eco-driving:

- brake system (brake pads, brake discs). When eco-driving, engine braking is recommended, which reduces the load on the brake system;
- engine and its components. High revolutions and sudden loads increase wear of the VT mechanism; eco-mode reduces thermal overloads, reducing the risk of ring sticking and wear of piston group liners and engine cylinders;
- transmission. Smooth gear shifting reduces wear on the clutch disc on a MT; abrupt starts and "throwing" the clutch lead to its rapid overheating. Smooth gear shifting reduces the load on the gears and

synchronizers on gearboxes; aggressive acceleration can lead to premature wear of the friction clutches in an AT.

The calculations do not take into account a complete engine replacement, we conditionally assume that vehicles with this breakdown will be sold. However, repair of some engine components will be carried out by mechanics at the organization.

Let us assume that the maximum mileage of vehicles at the organization will be 900000 km, after which the vehicles will be sold. The conditional vehicles mileage requiring components and assemblies' replacement before and after the introduction of eco-driving is presented in table 5.

Table 5. *Conditional vehicles mileage requiring components and assemblies' replacement before and after the introduction of eco-driving, km*

Name	Conditional vehicles mileage requiring components and assemblies' replacement		Changes
	before implementing eco-driving	after implementing eco-driving	
Brake system	every 60000	every 80000	20000
Engine components	up to 500000	up to 900000	400000
Transmission (clutch kit)	every 450000	every 650000	200000
Total:	-	-	620000

As a result, it is clear that after the introduction of eco-driving, the mileage of vehicles increased for each component and assembly considered for replacement.

In table 6 the calculation of savings due to the increase in the mileage of the vehicle before the next replacement of components and assemblies is presented.

Table 6. *Savings due to increasing the vehicle mileage before the next components and assemblies' replacement, US dollars*

Vehicle brand	Name of the component, assembly	Approximate cost of components, assemblies	Cost of replacement of components, assemblies		Savings on replacement of components, assemblies
			before implementing eco-driving	after implementing eco-driving	
Mercedes 1844LLS	Brake system	468.75	7031.25	5156.25	1875
Volvo FH16		390.63	5859.38	4296.88	1562.5
Scania R440		562.5	8437.5	6187.5	2250
Total:	-	-	21328.13	15640.63	5687.5
Mercedes 1844LLS	Engine components	1312.5	2625	1312.5	1312.5
Volvo FH16		1156.25	2312.5	1156.25	1156.25
Scania R440		1718.75	3437.5	1718.75	1718.75
Total:	-	-	8375	4187.5	4187.5
Mercedes 1844LLS	Transmission (clutch kit)	1875	3750	1875	1875
Volvo FH16		1500	3000	1500	1500

Scania R440		968.75	1937.5	968.75	968.75
Total:	-	-	8687.5	4343.75	4343.75
TOTAL:	-	-	38390.63	24171.88	14218.75

Therefore, it is clear that after the introduction of eco-driving, the savings due to the increase in the vehicle mileage before the next components and assemblies' replacement will amount to 14218.75 US dollars.

Personnel training is an important stage, since the result of the implementation of eco-driving will depend on the awareness of mechanics, the knowledge gained by drivers about the eco-driving principles and their practical application.

It is assumed that training of mechanics will take place at Rising Ltd. through invited specialists working at specialized service centers maintaining vehicles owned by the transport organization. Mechanics will be trained in technical characteristics of vehicles; use of eco-driving monitoring systems; practical recommendations on eco-driving; eco-driving assessment system. The cost of training three mechanics will be 1406.25 US dollars, including obtaining lectures, practical and video material for subsequent training of drivers.

It is proposed that driver training be carried out through mechanics at Rising Ltd., through lectures, video materials, and practical advice on eco-driving (for drivers with low eco-scores, weekly information and repetition of theoretical material, viewing of video material are proposed).

Thus, with the constant income from the provision of transport services by Rising Ltd., it is clear that the resulting savings on fuel and replacement of vehicle components and assemblies will cover all costs associated with the implementation of eco-driving: one-time (for training mechanics, installing GPS devices) and current (costs for driver bonuses).

The introduction of eco-driving also contributes to the increase of environmental awareness of society: environmentally responsible behavior is formed in drivers, their awareness of environmental problems increases, which is especially relevant in the context of the green transition. The correct application of eco-driving principles not only reduces fuel consumption and costs for repair and maintenance of vehicles, but also improves road safety, reduces the likelihood of accidents, and minimizes the impact of harmful substances on the environment, which speaks not only of the economic and social, but also the environmental effectiveness of eco-driving.

Let us display the strategic plan for the eco-driving implementation in the activities of belarusian transport organizations in the form of a road map, in table 7.

Table 7. *Roadmap for the implementation of eco-driving in the Republic of Belarus*

Stage	Aim	Tasks	Deadlines	Responsible
1. Preparatory stage				
1.1 Setting goals	Development and approval of the National Program for the Sustainable Transport Development in the Republic of Belarus (containing a chapter on eco-driving)	- introduction of the legislative term "eco-driving", including in traffic regulations; - formation of environmental culture; - transport decarbonization; - environmental situation improvement: reduction of emissions into the environment, congestion and noise reduction;	10 months	Council of Ministers of the Republic of Belarus, Ministry of Transport and Communications of the Republic of Belarus, Ministry

		- road safety improvement; - government support: development of tax incentives or subsidies for "green" carriers;		of Economy of the Republic of Belarus, Association "BAMAP"
1.2Creating mandatory eco-driving standards	Developing corporate standards or KPIs for eco-driving	- informing managers of transport organizations about economic, social and environmental efficiency; - selection of key performance indicators for assessing eco-driving; - development of corporate standards or KPIs for eco-driving; - application of the Instructions for the operation of vehicles using the principles of eco-driving, taking into account the vehicles technical features; - creation of a memo on eco-driving;	2 months	Association "BAMAP"
2. Implementation of eco-driving				
2.1 Employee training	Theoretical and practical training of employees: mechanics, drivers	- training of those responsible for eco-driving in the technical features of vehicles, collection and analysis of data on key performance indicators for assessing eco-driving; - obtaining theoretical knowledge and practical recommendations for drivers;	10 days	Association "BAMAP", management of organizations, mechanics
2.2 Analysis of the technical condition of the vehicle fleet of a transport organization	Conducting an analysis of the technical condition of the vehicle fleet	- checking the vehicles technical condition; - collecting fuel consumption data; - driving style analysis; - accident assessment;	1 month	Management of transport organizations, technical services, mechanization department
2.3 Technical implementation and support of eco-driving	Optimization of vehicle operation	- installation of monitoring systems (GPS); - control over compliance with eco-driving principles; - regular vehicles maintenance; - reporting automation; - driver incentive system development;	3 months	Technical services, mechanization department, accounting
3. Control and optimization				
3.1 Performance monitoring	Analysis of results	- monthly data collection and analysis; - eco-driving assessment;	Monthly	Technical services,

		- training correction (working on mistakes); - work on continuous improvement: updating regulations and key performance indicators for eco-driving;		mechanization department, analytical department
3.2 Scaling up the eco-driving project	Expanding the eco-driving program	- implementation in the country's transport organizations; - implementation in driving schools; - participation in eco-projects	Constantly	Ministry of Transport and Communications of the Republic of Belarus, Association "BAMAP"

In order to visualize the presented roadmap, a Gantt chart was created (Figure 2).

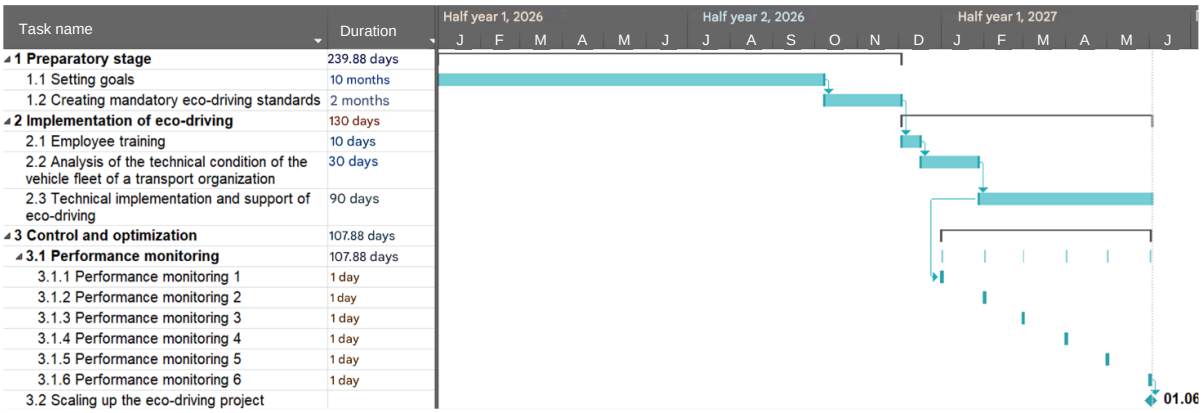

***Figure 2**. Gantt chart of the roadmap for the implementation of eco-driving in transport organizations of the Republic of Belarus*

The key advantage of the roadmap is its comprehensive approach, which covers all aspects: from regulatory to technical implementation. It is **a** step-by-step, realistic and well-founded strategic plan for the implementation of eco-driving in transport organizations of the Republic of Belarus.

4.Conclusion

Based on the conducted research, the following final provisions can be highlighted:

- approaches to defining the essence of the concept "eco-driving" are proposed; the author's definition of "eco-driving" is clarified and scientifically substantiated from the point of view of sustainable transport within the framework of the green transition;

- based on a comparative analysis of literary sources, the basic principles of eco-driving as an element of sustainable transport are systematized;

- the business process "eco-driving" is proposed for implementation in the activities of transport organizations of the Republic of Belarus, using the example of Rising Ltd.: the proposed business process is described using a context diagram built in the IDEF0 notation; the choice of key criteria for assessing eco-driving is substantiated; a system for assessing eco-driving and driver motivation is created; savings from the introduction of eco-driving are calculated, which highlights its economic efficiency;

- for the practical implementation of the proposed solutions, a roadmap for the introduction of eco-driving has been developed, with visualization in the form of a Gantt chart, including specific stages, tasks and deadlines, which will allow scaling eco-driving at the level of the entire transport industry of the Republic of Belarus.

Authors consider the presented research to be a completed work containing new scientific and practical results in the field of eco-driving, which makes a significant contribution to the development of sustainable transport within the framework of the green transition.

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Global Environmental Governance: Institutional Integration and Sustainable Development in the Era of Ecological Transformation

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Abstract

The article will address both theoretical and practical aspects of global environmental security and sustainable development in the modern world, including the historical trends of the development of international environmental cooperation, the category of ecological humanism, the functions of various institutions which act to guarantee the safety of the environment. The study analyses the involving of national ecological policies into international environmental governance and critically debating principles of sustainable development and international collaboration as important preconditions for effective solving the problems. Special emphasis is placed on mechanisms of environmental protection, resource management, and the role of international organizations in coordinating global environmental efforts.

Keywords: Environmental security, Sustainable development, Ecological humanism, Global environmental governance; International environmental cooperation; Environmental policy integration; Natural resource management.

1.Introduction

The concept of global sustainable development, by its essence, encompasses the development of socio-economic progress programs aimed at improving human living conditions and protecting the environmental ecosystem in the context of globalization, directing natural resources, investments, and technologies toward humanitarian goals. Therefore, questions about what philosophical laws, principles, and regulations should govern the process of global sustainable development, and whether these laws can be understood, studied, and effectively applied to the activities of ecological parties, are attracting attention from everyone, especially philosophers and social scientists. However, finding answers to these questions is not simple; the complex, contradictory, and synergetic characteristics of opportunities to ensure the priority of socio-ecological activities in global sustainable development are particularly relevant due to the complex processes that necessitate philosophical study of the status, role, and increasing importance of ecological political parties in the “nature-society-human” system relationships.

Particularly, the strategic objectives and opportunities for developing international relations of national environmental parties, as well as developing mechanisms for organizing, managing, and controlling their activities based on new paradigmatic approaches, are becoming increasingly important, especially in light of the need to address global environmental challenges following the coronavirus pandemic that has seriously threatened the world. This includes the necessity to develop new mechanisms for organizing, managing, and monitoring their activities through novel paradigmatic approaches, particularly in addressing global environmental challenges in the post-pandemic world.

2.Materials and Methods

Current literature tends to focus particularly on the activities of certain institutions responsible for ensuring ecological security, prioritizing the absolutization of factors that determine specific directions. However, when approaching threats to human life and the future of civilization from a complex-systematic perspective, the concept of ecological humanism, in general, pertains to human life, and its content becomes concrete within the framework of specific social relations. That is, "the content of the concept of humanism becomes concrete in human relations with nature and acquires a universal character" (Mamashokirov, S. 2012). "Therefore, governments could ensure ecological security worldwide by applying economic sanctions against states that evade ensuring ecological security and by refusing to purchase their goods. In this context, the 'economic whip' method would be genuinely effective. Although international cooperation on preventing ecological disasters threatening humanity has been formed to some extent and important measures have been implemented, it is still necessary to further intensify efforts in this direction. This is because a truly comprehensive, effective, impartial, unified international system that governs environmental protection and creates adequate, comfortable living conditions for humanity has not yet emerged. The improvement of international ecological cooperation will remain one of the vital necessities in the subsequent stages of human development." (Juraev, Y. A. 2013).

In our view, to define the meaning and content of the concept of "ecological humanism" (as a social phenomenon and moral-ethical category), it is necessary to determine: firstly, answers to questions about whether humanism is a theoretical doctrine, idea, or practical activity concerning the improvement of human natural living conditions; secondly, the role of ecological activity subjects (institutions) in the system of mechanisms that determine the social content, essence, practical results, and prospects of the concept. This methodological approach is necessary to specify its authenticity or artificiality.

According to Professor Y.O. Juraev, a prominent legal scholar in Uzbekistan, there are two main approaches to limiting state sovereignty within the framework of global ecological sustainability issues: "The first is voluntary, arising from the internal needs of a particular state and corresponding to the interests of the people and society. In limiting the ecological sovereignty of the state, the 'ecological factor' should be placed above state authority. Just as state power is subject to law, the entire system of state power should be subordinated to the ecological factor. The second approach involves limiting sovereignty through coercion by other states or according to international law requirements" (Mohammad, 2011).

Effectively resolving various conflicting situations that arise in interstate ecological political relations within a particular region remains one of the most complex challenges facing the international community. It is known that throughout environmental history, proposals regarding the active use of the international community's extensive capabilities, and when necessary, even the implementation of radical political measures to resolve such situations, have been repeatedly expressed. This issue began to be discussed internationally as early as the beginning of the last century.

Specifically, one of the most significant historical examples in this regard is the prestigious international Congress organized by the UN in Bern, Switzerland, on November 17-19, 1913. At this important forum, L. Forrer, the official representative of Switzerland, put forward a proposal of crucial and fundamental importance. In his speech, he emphasized the following points: "If natural objects requiring protection, such as oceans, deserts, and wastelands, do not belong to any particular state or belong to several countries (transboundary), their protection requires special attention. In complex situations where a state cannot achieve necessary results through its own efforts and actions, or where state intervention causes significant damage to the legitimate interests of citizens of other states without bringing any benefit to nature protection, the entire community of civilized states or a certain group of them should have the right, based on international agreements, to compel such states to comply with generally accepted requirements and adopt an approved way of life." (Alexandrov & Moiseev, 1992).

This proposal aiming at strengthening the role of the international community in addressing global environmental problems was considered highly progressive and decisive for its time,. Such an approach retains its urgency today and sill plays a crucial role in modern international environmental policy.

In this context, it is important to emphasize that the arms race between certain states or groups of states, the development of nuclear and other weapons of mass destruction (even their preventive testing in local areas), poses a serious threat to global ecological security and sustainable development. For instance, according to a report by the UN Special Committee on Environmental Protection, the detonation of a single nuclear charge equivalent to 10,000 tons of TNT in such tests leads to complete or large-scale destruction of vegetation in an area ranging from 400 to 1,300 hectares. The detonation of a neutron bomb equivalent to one thousand tons of TNT at an altitude of 200 meters would destroy microorganisms in 40 hectares, insects in 100 hectares, vegetation in 330 hectares, amphibians and reptiles in 250 hectares, and numerous mammals and birds across 490 hectares of land (Pokrovsky, 1975).

In the current period of deepening global problems and strengthening correlational interconnections, amid the intensification of the planet's ecological situation and its prospects, even in pessimistic, skeptical, and fatalistic attitudes, one can observe some degree of confidence and hope in the results of ecological parties' activities in developing individual ecological consciousness and culture. For example, Academician A. Pokrovsky wrote nearly half a century ago: “Modern humans have always been in a state of war with nature. Its devastating consequences are being felt more strongly year by year. If we do not cultivate a culture of human relationship with nature, it may lead to tragic consequences” (Fursov, 2015).

The issue of preserving biological diversity came to the attention of the international environmental community after the 1972 Stockholm Conference on Environmental Protection. The Convention on Biological Diversity was signed by 180 states in Rio de Janeiro in 1992. The Convention aims to conserve biological diversity and ensure its sustainable use. It urges participating states to develop specific national strategies, approve necessary legislative documents, and realize actions aimed at establishing and maintaining systems of protected areas.

“On June 5, 1972, at the UN Conference on the Environment in Stockholm, a decision was made to celebrate World Environment Day. The purpose of this decision was to direct the international community's attention to environmental protection problems and develop specific measures to prevent global ecological crisis. For 47 years, various events and competitions have been held worldwide to commemorate this date. Various ecological actions are organized, including creating gardens and environmental cleaning initiatives. This is not without reason, as nature needs attention today. Various ecological problems pose serious threats to human life” (Wilsford, (Ed.). 1995).

Particularly, “Many people don't realize that our usable water is running out; by 2030, there will be a 40% gap between water demand and available water supply. We have only 15 years to solve the water problem”, says Mina Guli, a Young Global Leader of the World Economic Forum. Notably, in a survey conducted by a team of 750 experts, the depletion of clean drinking water was assessed as a genuine global threat to the world's population. In fact, the drinking water problem has already become one of the foremost challenges facing the world's population. It's not easy for those who don't have sufficient water for use and spend their days searching for clean drinking water! How can those who waste water understand these feelings!”

In 1985, American political scientist R. Robertson first introduced the concept of “globalization” into scientific discourse, and the idea of “sustainable development” that constituted its content created a corporate project (ideal-utopian) for organizing international relations - globalization that undermines national state sovereignty and independence (in both domestic and foreign policy). According to this project, while the formation of a universal world order and the future subordination of all states was given relative priority, alternative views were also put forward regarding this approach.

For example, according to prominent Russian scholar A.I. Fursov, globalization undermines planetary unity by eliminating all "unprofitable" surplus population from over two hundred interconnected "growth points" spread across the world . Therefore, understanding this concept as an opportunity to balance the natural environment and anthropogenic, anthropotechnogenic pressure effects is a utopian view. These perspectives, in reality, do not lead to sustainable development but rather, deviating from their intended targets, lead to societal destabilization, resulting in the loss of stability and ultimately halting development.

In autumn 1983, UN General Assembly Resolution No. 38/161 was based on the conclusions presented in the reports "North-South: A Program for Survival" and "Common Crisis: North-South Cooperation for World Recovery" prepared by the Independent Commission on International Development Issues (the Brandt Commission) in 1980 and 1983. The Brandt and Brundtland Commissions, along with O. Palme's Independent Commission on Security and Disarmament Issues, established the triad of UN international security institutions. These three leaders headed social democratic parties within the Socialist International of Europe, with W. Brandt serving as its president.

Globally, the concept of "Sustainable Development" was first introduced in 1987 in the report titled "Our Common Future," prepared by the UN World Commission on Environment and Development under the leadership of Norwegian politician and public figure G.H. Brundtland. This concept was elevated to a conceptual framework in the World Change Program, and the following were declared as its main directions, which leads to the conclusion that "the idea of Sustainable Development was not formed in a vacuum." Based on the considerations of the "Brundtland Commission":

- Formation of future "contours" of population, natural environment, and sustainable development trends;
- Creation of an international decision-making system for global management of the biosphere's ecological balance;
- Announcement of perspectives on solving problems of energy, industry, human settlements, and international economic relations in the context of natural environment and sustainable development .

Subsequently, at the Socialist International Congress in Santiago in November 2006, a special Commission on "Global Society Sustainable Development" was established within its structure.

3.Results

Leading research centers, scientific institutes, and universities worldwide, along with prominent scholars, are meticulously studying global sustainable development, its universal criteria, and classification principles of its directions. These institutions are particularly focused on analyzing the politicization trends of global environmental movements and their legal and moral foundations, investigating opportunities for developing institutional systems of international environmental political relations, and examining tasks for harmonizing the socio-political activities of environmental parties in the context of globalization.

A comprehensive review of current philosophical literature reveals various approaches and methods for classifying the integration stages of environmental movement subjects (particularly institutions) based on different criteria. While we do not aim to absolutize any single approach, through comparative analysis, we can establish our position and demonstrate it chronologically from a historical perspective. The historical development stages of this phenomenon can be relatively and conditionally classified as follows:

1. The 1950s-1970s marked the beginning of the organizational institutionalization stage of the international environmental cooperation movement system. Establishment of fundamental frameworks aimed at organizing, managing, and monitoring environmental protection on a planetary scale characterizes this period. The first major international environmental organizations and initial global environmental protection protocols were established this time, leading the foundation for future international environmental cooperation.

2. During the 1980s-1990s, global environmentally Sustainable Development Goals (SDGs) and Sustainable Development Strategy (SDS) fundamentals were developed following by their implementation policies, which made this stage was particularly significant as it witnessed the emergence of comprehensive environmental protection frameworks and the establishment of concrete sustainable development objectives. Increased awareness and acceptance of environmental issues at both governmental and public level characterized this period, leading to more structured approaches to environmental protection and sustainable development.

3. We have been observing the stage of transnational cooperation and integration of national states' environmental and political relations to implement the complex tasks outlined in global SDGs and SDS till today. This present-day phase is classified by intensified international collaboration, the development of cross-border environmental initiatives, and the strengthening of multinational approaches to environmental challenges. The mentioned period has experienced the appearance of more sophisticated environmental protection mechanisms and enhanced coordination between nations in addressing global environmental issues.

These stages illustrate the progressive evolution of global environmental cooperation and sustainable development efforts, also reflects increasing difficulties and interconnectedness of environmental challenges facing our world today.

The local nature of environmental agreements between states, individual approaches to solving global environmental problems based on national interests, and priority given to protecting specific components of nature are defined in the first stage of international environmental movement institutions' integration. However, the 1950s and 1960 hosted several international meetings and conferences on environmental protection, resulting in the adoption of documents of local or regional significance. An early globally important document in this context was the resolution passed during the 17th session of the UN General Assembly in 1962, which emphasized the necessity of harmonizing economic development with environmental protection and stipulated that it should be under the management and control of international public organizations.

In 1968, UNESCO, the World Health Organization (WHO), and the International Union for Conservation of Nature (IUCN), co-organized an intergovernmental conference on biosphere protection problems. This conference was the first to examine scientific principles for nature and natural resource conservation. From 1970, under UNESCO's guidance, a long-term program titled “Man and Biosphere” began implementation, aimed at nature protection and conservation.

The foundations of modern states' international environmental political relations were developed at an international symposium held in Founex (Switzerland) in 1971. The Stockholm Declaration, adopted at the UN Conference on the Human Environment in 1972, can be considered the turning point of this first stage. This document declared that improving and maintaining the quality of the natural environment where humans live is a crucial factor affecting peoples' well-being. Furthermore, the document emphasized that “man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations.”

This issue began to be incorporated into state Constitutions adopted after 1972 and national environmental protection laws worldwide. Specifically, the Stockholm Declaration outlined 26 fundamental principles directly related to environmental protection. These principles addressed human environmental rights, duties, obligations, responsibilities, states' rights to use natural resources within their territory, sovereignty, conservation of natural resources for future generations, liability for environmental damage, the necessity of collaborative solutions to global environmental problems, and other related matters.

The 1972 Convention Concerning the Protection of World Cultural and Natural Heritage was aimed at protecting unique objects where particularly valuable types of ecological systems exist. The Convention

on International Trade in Endangered Species of Wild Flora and Fauna, adopted in Washington in 1973, came into force in 1975. Currently, the number of member countries to this Washington Convention (known by its English acronym CITES) has exceeded 154. (Its headquarters is located in Geneva, Switzerland).

The main impetus for adopting this convention was the reduction and even extinction of many plant and animal species due to attempts to profit from international trade in endangered wildlife species, worth thousands to millions of US dollars annually. The convention was based on a list of rare and endangered plant and animal species, mutually agreed upon by participating states. It emphasized that trading these species could harm their populations and that such activities required international control. The export, import, and re-export of species included in this list can only be carried out with permits approved by the member states of this convention.

4.Discussions

Currently, the global community is concerned with the problem of civilization's movement toward global sustainable development. The following conditions related to social, economic, and ecological aspects contributed to the emergence of this problem: 1) The dominance of "consumer philosophy" – for many centuries, humanity has followed a "resource-based" path of development, where principles such as "man is the king of nature" and "consumerism for prosperity" prevailed. Throughout its developmental history, humanity has used the surrounding natural environment as a source of resources to satisfy its growing needs; 2) The dominance of resource-depleting technologies. This dominance was determined by the supremacy of economic interests and the illusion of inexhaustible resource potential; 3) An inadequate mechanism for natural resource pricing. During this period, a situation emerged where the assigned value of resources did not reflect their true cost. This method of economic management resulted in the depletion of natural resources and environmental degradation.

The concept of global sustainable development is oriented toward the comprehensive development of human society, providing ecological, economic, and social services to all members of society based on the principles of purposeful existence, rational use of nature, economic efficiency, and social justice. In this context, it maintains natural-ecological, socio-economic, and life-supporting systems in a stable state and serves to meet the standard spiritual and material needs of both present and future generations.

The prioritization of the subjective factor – the human factor – in the realization of objective social, economic, and political conditions and opportunities for global sustainable development is acquiring the status of a regularity. According to this pattern, the globalization of ecological parties' activities is decisively influenced not only by ecological material-technical and innovative technological foundations that ensure society's sustainable ecological development but also by moral and ethical factors.

Therefore, the causes negatively affecting the globalization of inter-ecological party relations should primarily be sought in society's spiritual and cultural development level. Indeed, the spiritual and cultural mechanisms that have emerged as a result of the integration and globalization of ecological parties' relations should be viewed as an opportunity to organize national states' international social, economic, and political relations based on the requirements of ecological parties' globalization.

5.Conclusions

National states' deep understanding of the necessity for integration into global environmental policy and their implementation of practical actions in this direction clearly demonstrate their responsible and conscious attitude toward socio-ecological reality. Since this approach stems from the needs of protecting sustainable development, it fully corresponds not only to national interests but also to the interests of all humanity and plays a crucial role in solving global environmental problems. Based on these important principles, the following conclusions can be drawn:

First, the integration directions of national ecological parties into global policy, their distinctive characteristics, as well as their national "mental features" should be thoroughly analyzed and evaluated as specific and particular manifestations of broad universal socio-ecological interests and responsibilities. In this process, it is crucial to consider the unique characteristics and capabilities of each national state;

Secondly, the effective safeguarding of environmental interests by states, along with their full recognition of responsibilities and thorough understanding of their duties and international obligations, directly determines the outcomes of their integration into global environmental policy and clarifies the core purpose and practical importance of their socio-political actions in this field, which in turn, leads to the harmonization of national and international efforts in addressing environmental problems;

Thirdly, it is essential to ensure harmony between the system of specific conditions with the various subjective factors necessary for states to fully recognize the objective need for integration into global environmental policy and to effectively translate their potential into practical actions. This requires a comprehensive approach considering each state's internal capacities, economic potential, and the particular characteristics of its ecological context."

Fourth, it is particularly important effectively harmonizing the complex relationships between the integrating object and subject in global environmental policy, an institutional system that ensures unity of primary goals, priority interests, and aspirations of both parties. This system should clearly define the rights and obligations of all participants, and develop mechanisms for their interaction. is considered an essential condition for To ensure coordinated actions of the parties, the effective functioning of such an institutional system is a essential condition

Fifthly, the integration of states into global environmental policy should be viewed and evaluated not simply as a technical or formal procedure, but also as a significant opportunity, a contemporary method, a powerful tool, and an effective political mechanism to enhance the results of sustainable development. This process should be understood and approached not as an end in itself, but as a vital means for achieving shared prosperity.

Sixth, the potential of national states to integrate into global environmental policy is as a key factor to determine their international standing in various fields, including social, economic, political, and cultural relations. This potential not only reflects the current development level of states but is also one of the main factors directly determining their sustainable development trends and future prospects. Therefore, each state is required to continuously develop and improve its integration potential.

In conclusion, the effective organization of the integration process of ecological party entities' various potentials - material-technical, ecological, economic, and intellectual - in all countries of the world should be based on the important requirements and principles detailed below, which is considered the main condition for ensuring the effectiveness of this complex process. Adherence to these requirements not only ensures the success of the integration process but also guarantees its long-term sustainability. Special attention should be paid to the following main requirements:

1) Each state must comprehensively, deeply, and objectively evaluate the existing potential opportunities for the globalization of ecological party relations on the path to global sustainable development, and based on these assessment results, clearly define its long-term strategic and current tactical objectives. In defining such objectives, it is necessary to fully comply with the requirements of mutual treaty agreements, multilateral and bilateral agreements adopted by the international community, and their basic provisions should be taken into account. Additionally, the specific conditions and capabilities of each state should also be considered;

2) In implementing a differential approach to states' integration opportunities within international ecological relations and effectively implementing various international programs, it is important for them to rationally utilize the basic laws and universally recognized principles of modern market economy relations. In this context, particular attention should be paid to the widespread and purposeful use of various

effective mechanisms and advanced methods of economic incentivization, through which there is an opportunity to significantly increase the efficiency of integration processes. Furthermore, it is necessary to consider each country's specific level of economic development and capabilities;

3) It is necessary to organize effective coordination between international political institutions and various public organizations responsible for the globalization of ecological parties' activities and organizations and institutions at the national level. In this context, special importance should be given to continuously improving methods and means of increasing the effectiveness of management and control bodies, ensuring their compliance with modern requirements, and implementing new innovative approaches. This process requires establishing continuous and effective communication between organizations at all levels, optimizing the decision-making process, and improving implementation mechanisms;

4) It is necessary to establish a comprehensive objective information bank based on modern requirements regarding the current reality of ecological party relations globalization in states, its main development trends, and promising directions. This database should be regularly updated, incorporating statistical-sociological research results and conducting their in-depth analysis. Such analyses create the opportunity to obtain complete and reliable information about the existing material, technical, ecological, and intellectual potential for developing ecological parties. Additionally, it is necessary to develop mechanisms ensuring access to this database for all interested parties;

5) International organizations are required to fully realize the possibilities of creating modern infrastructure for effective transformation of various national states' ecological parties' advanced and positive experiences, improving communication systems, and implementing advanced technologies. In this process, it is necessary to increase the effectiveness of using specially developed individual methods and tools, taking into account each country's specific characteristics, and continuously improve them. Through this approach, the effective adoption of positive experiences and their implementation adapted to local conditions is ensured.

According to these requirements, in the process of globalization of inter-ecological party relations, the coordination and cooperation of world states' social, economic, and ecological activities, along with the intensification and globalization of spiritual-cultural relations, acquire the status of objective law. However, the objective conditions and subjective factors that form the basis of this process should be evaluated not as a possibility for ecological cooperation of the world community, but as a dynamic development level of ecological relations integration formed in a specific historical period.

In this context, the globalization of ecological relations requires the specification of universal criteria for identifying and evaluating the future prospects of this tendency by ecological activity subjects, in order to unite different economic and political systems, cultural forms and directions of the world under a common goal and determine the general tendency of sustainable ecological development.

Generally, while the phrase “global sustainable development” is recognized as a positive phenomenon at the level of everyday consciousness among the public, its comprehensive systematic scientific analysis from the perspective of philosophical science (i.e., in the context of its categories, laws: dialectical, synergetic, phenomenological, and other alternative teachings) remains overlooked. However, current reality has led to the formation of certain perceptions about future life prospects in the mass consciousness regarding this category's content, leading to an understanding of everyone's involvement in “global ecological sustainable development.”

Particularly, in the context of ecological problems, the transition from the concept of “global sustainable development” to its practical strategy reveals the universal importance of environmental protection and rational use of resources in solving global problems of social, economic, political, and cultural life, especially as universal human problems intensify (particularly, global climate change in

ecology, pollution of atmosphere and water sources, expansion of household waste, and emergence of other new directions).

With the collapse of the USSR and the emergence of new independent states on the world political map, the interaction between the UN and the Socialist International significantly intensified and moved to a practical direction. In 1992, the Commission on Global Governance and Cooperation was established. Later, in 2001, it was replaced by a special Commission on Globalization in collaboration with the International Gorbachev Foundation. This commission directed the activities of world community leaders across all sectors toward implementing constructive reforms in specific areas of the globalization process, discussing results, and engaging in cooperative practical actions.

The UN Commission on Global Governance was assigned the important task of "evaluating the world organizational structure and preparing recommendations for its reconstruction and strengthening." The Commission's 1995 report "Our Global Neighbourhood" proposed a project for radical UN restructuring, suggesting the creation of a new governance center - the Economic Security Council (ESC) - parallel to the UN Security Council. The ESC was intended to have the authority to create and manage "international consensus in economic, social, and environmental spheres," essentially functioning as a "world economic government."

According to this plan, UN specialized organizations and institutions such as UNESCO, WTO, ILO, WHO, FAO, and others were to be elevated to the status of "global ministries." The ESC was planned to include representatives from economically powerful states, regions, and regional organizations. Notably, the Council was not intended to have veto power. In other words, the ESC was given a strong American "aggressive-compliant majority" status, and Western geopolitical rivals made every effort to exclude primarily the Russian Federation and the People's Republic of China from making strategic decisions on a global scale. According to the report, until the ESC's establishment, its functions were assigned to the UN Commission on Sustainable Development, established in 1992 based on regional quotas (quotas ensuring American majority), as an intergovernmental body (The UN Commission on Sustainable Development was planned to include 13 members each from the "Western Community" (Europe and North America) and Africa, 11 from Asia, 10 from Latin America and the Caribbean Basin countries, and 6 states from Eastern Europe, including Russia).

This commission was intended to become a "center" coordinating programs and projects implemented by various UN specialized institutions ("global ministries"), effectively assuming the function of a "world government." However, after the ESC project failed, the commission's responsibilities were transferred to the leadership of the UN Economic and Social Council (ECOSOC), which remained limited within the framework of the UN Development Programme (UNDP), the UN's "Global Environmental Body."

Furthermore, the mentioned "Our Global Neighbourhood" report also presented alternative options, namely, if UN specialized agencies could not become sector management centers, the responsibility for performing these functions was planned to be transferred to: the World Bank, network research organizations, and regional organizations. These very phenomena occurred during the end of the last century and the beginning of the current century. The experience of establishing the Consultative Council of Central Asian States in recent years has demonstrated how the formal decentralization of organizing and managing global sustainable development led to the formation of regional organizations such as NATO, the European Union, OSCE, Council of Europe, regional economic councils, Council on Foreign Relations, Bilderberg Club, Trilateral Commission, and similar regional organizations.

Based on our research, we would like to put forward several practical proposals:

1. Creating the Global Ecological Integration (GEI)is an electronic platform, which through this modern platform, all ecological parties worldwide will have the opportunity to exchange information in real-time, share experiences, and implement joint projects. The platform will incude recommendations for forecasting and solving environmental problems using artificial intelligence technologies, as well as feature

a multilingual interface, enabling direct communication between environmental organizations in different countries, facilitating joint project planning and implementation. Moreover, the platform will develop an environmental database, which will provide analytical data necessary for effective decision-making in addressing global environmental problems.

2. The academy "Establishing an "Environmental Diplomacy Academy" will train international-level specialists for ecological parties and organizations. Modern environmental diplomacy, international environmental law, environmental management, and innovative technologies will be included in the curriculum. The academy will provide theoretical knowledge, including practical skills, as well as special training in international negotiations, environmental conflict resolution, and environmental project management. Moreover, the academy will stay in touch with international experts, incorporating the latest scientific-practical achievements and innovative approaches into the educational process.

3. The system "Implementing a Transboundary Environmental Monitoring System" - will establish the capability to observe, analyze, and take prompt measures regarding environmental issues between states in real-time. The mentioned system is planning to employ satellite technologies and IoT devices. The monitoring system will continuously observe key environmental indicators—including air quality, water resources, and soil composition—and process the collected data using specialized software to deliver relevant recommendations to the appropriate state authorities. This system provide early detection of transboundary environmental problems and establish effective measures for their elimination.

4. The fund Establishing an "International Environmental Innovation Fund" -will finance and support innovative projects aimed at solving environmental problems. The blockchain technology will be applied to transparently manage the fund's activities. The fund will offer not only financial assistance but also technical support, expert consultations, and other resources essential for project implementation. Furthermore, the outcomes of fund-supported projects will be published on a special electronic platform, enabling their use by other countries.

5. Developing a "Global Environmental Standardization System" - this system will create unified environmental standards, criteria, and evaluation mechanisms for all states, ensuring a flexible approach considering each state's specific characteristics. Due to this system, an international expert group will continuously develop new standards and improve existing ones. The standardization system will allow the comparison and assessment of environmental indicators across different countries, while identifing general development trends, thus serving the effective implementation of global environmental policy.

In conclusion, today's most urgent and inevitable necessity is the gradual transition of the entire world community to a global sustainable development model. However, because of contradictory development of the global socio-natural environment and existing contradictions this process has an extremely complex and long-term character. These contradictions cause serious obstacles to the full-scale and adequate implementation of relevant concepts, which is expected to continue in the near future.

In the world that we live today, it is an extremely tough task to accurately forecast various phenomena, processes, and development trends that could significantly impact the current global situation. It becomes more complicated in terms of prediction and evaluation of changes related to the near future and, more importantly, long-term prospects. Such changes will probably alter the existing global situation, which is difficult to fully comprehend their consequences.

Furthermore, scientific-theoretical concepts involving the main characteristics and development directions of sustainable civilization are exposed to continuous change, and such changes, based on global realities, are continuously renewed and enriched with new meanings throughout the historical development process of human civilization. As a consequence, constant consideration and adaptation to these dynamic changes are essential for the realization of sustainable development concept.

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Gener Generation Z and Debt Burden: Behavioral and Institutional Factors

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Abstract

The article examines the indebtedness of young people aged 18–25 (Generation Z) in Kazakhstan and CIS countries in comparison with foreign practices, drawing on Engel's law and behavioral finance, as well as the results of a bibliometric-cluster analysis of international literature in the Scopus database. To assess the factors influencing the probability of having a loan among young people, logit and probit models were applied based on the author's survey (N=70 for ages 18–25). It was found that 57.1% of young respondents have a loan; among those with loans, the median debt burden is 50% of income (mean 45.3%). The most common purposes of loans are appliances/electronics (≈4%), education (≈23%), and clothing (≈13%). Logit and probit estimates show weak and statistically insignificant relationships between having a loan and the indicators "budgeting," "expense planning," and "savings" when accounting for gender and place of residence; interpretations and institutional implications are discussed. The results correspond to three stable clusters of international literature: (A) over-indebtedness & microfinance, (B) financial literacy & inclusion, (C) Engel's law & income distribution.

Keywords: Generation Z; debt burden; Engel's law; behavioral finance; logit/probit; Kazakhstan; CIS; BNPL.

1.Introduction

Young people aged 18–25 enter adult life under conditions of high inflationary volatility and the rapid spread of digital lending, including installment plans and "buy now, pay later" (BNPL) schemes, which lower transactional barriers to accessing borrowed resources while simultaneously increasing the risk of excessive indebtedness (World Bank, 2025). From the perspective of Engel's law, the growth in the share of necessary expenses under limited incomes reduces the "free" part of the budget, thereby pushing young people toward borrowing to smooth consumption and invest in human capital (Anker et al., 2011; Zimmerman, 1932). Behavioral finance complements this picture with mechanisms of time bias, short-term thinking, and the "minimum payment illusion," which makes installments and "buy now, pay later" programs especially attractive to young people but potentially risky due to the accumulation of debt obligations (Vernikov & Agadzhanyan, 2023). The institutional environment—standards for disclosing the full cost of credit, debt burden limits, and regulation of microfinance organizations—significantly influences the outcomes of young borrowers, as confirmed by international reviews and regulatory practice (Buffes & Etienne, 2015).

The aim of the study is to identify the contribution of behavioral and institutional factors to the probability of having a loan among young people aged 18–25 and to compare the results with the international agenda.

Objectives:

— describe the scale and structure of youth indebtedness based on the survey data;— evaluate logit and probit models of the probability of having a loan;

— demonstrate how the empirical results correspond to clusters of international literature and regulatory practices (Schicks, 2014).

2.Literature Review and Bibliometric Cluster Analysis

The classical formulation of Engel states that the share of expenditures on food and other primary needs decreases as income rises. The law is still widely used today as a proxy for welfare (Zimmerman, 1932). For young people with low and volatile incomes, the "compression" of the free budget explains the persistent need for intertemporal redistribution through credit, including for education and the digital basket: appliances and electronics (World Bank, 2025).

3.Behavioral Finance and Youth Indebtedness.

Studies on financial literacy show mixed effects of educational interventions on actual financial decisions, which highlights the relevance of designing "protective interfaces" and transparent product metrics (total cost of credit, overall debt burden) (Lusardi & Mitchell, 2014). The spread of BNPL among young people is associated with the perception of "installments without interest," which, in the presence of multiple parallel obligations, can generate a hidden but high burden (Vernikov & Agadzhanyan, 2023).

4.Institutional Factors: MFIs, DBR, Borrower Protection.

Regulation of the microfinance sector, the introduction of payment-to-income limits (DBR), and standards for credit cost disclosure are linked to the dynamics of consumer lending and delinquency rates among young people (Buffes & Etienne, 2015). The experience of developed countries also records an increase in delinquencies among young people on credit cards in 2024–2025, which strengthens the focus on regulatory "constraints" and the prevention of excessive indebtedness (Mori & Sanchez, 2025; Nai et al., 2018).

Table 1. *International Comparison of Youth Indebtedness*

Region	Share of Youth with Loans	Main Types of Loans	Comments
Kazakhstan	57%	consumer, appliances, education	median burden 50% among borrowers *(own calculations)*
USA	high share of student debt, growth of card delinquencies	student, credit cards, mortgage	increase in delinquencies in 2024–2025
United Kingdom / EU	credit cards, student loans (UK)	cards, student	regulatory agenda on BNPL
CIS	consumer, MFIs	consumer, microloans	role of DBR, MFIs
Note. Compiled by the author based on data from National Bank of Kazakhstan (2023), Central Bank of Russia (2023), European Banking Authority (2022), OECD (n.d.-a; n.d.-b), World Bank (n.d.), Financial Conduct Authority (2023), European Central Bank (n.d.), and IMF (n.d.).			

Results of the Bibliometric Analysis. To identify thematic areas and the dynamics of scientific publications, a bibliometric analysis was conducted on articles indexed in the Scopus database for the period 2014–2024. The search was carried out using keywords reflecting the issues of youth indebtedness, financial literacy, and institutional factors of lending (for example: "youth debt," "financial literacy," "consumer credit regulation").

At the first stage, complete bibliographic information (metadata: authors, titles, abstracts, keywords, references) was exported from the Scopus database in CSV format, compatible with the Bibliometrix package in the R environment (version 4.x).

At the second stage, the data were processed in R using the Bibliometrix/Biblioshiny package to calculate the main indicators: number of publications by year, Hirsch index, distribution by country, co-authorship analysis, and the social network structure of keywords.

For the visualization of clusters and the construction of co-occurrence maps of terms, the VOSviewer program (version 1.xx) was used. The VOS algorithm made it possible to identify stable thematic clusters based on co-citation networks and keyword co-occurrence. Clustering was carried out using the association strength method, with a minimum keyword occurrence frequency of 5. As a result, three stable clusters were identified:

Table 2. *Clusters Identified by Bibliometric-Cluster Analysis*

Cluster	Theme	Keywords (frequency)
A	Over-indebtedness & microfinance	over-indebtedness, microfinance, poverty, household debt
B	Financial literacy & inclusion	financial literacy, inclusion, education, financial behavior
C	Engel's law & income distribution	Engel's law, income distribution, consumption, expenditure
Note. compiled by the author based on the data of the bibliometric-cluster analysis		

Trend analysis of keywords shows a growing interest in the topics *credit*, *unemployment*, and *household income* in 2015–2024, which is consistent with the post-pandemic increase in the cost of living (Martinchek et al., 2022).

Data and Methodology. Microdata from the author's online survey (subsample aged 18–25, N=70) were used. The main variables: gender; place of residence (city/village); budgeting; expense planning; presence of savings; fact of having a loan; number of loans; share of income allocated to debt service; purpose of the loan. Binary models (logit and probit) estimate the probability of having a loan:
[P(credit_i=1)=F(\beta_1 female_i + \beta_2 city_i + \beta_3 budget_i + \beta_4 plan_i + \beta_5 savings_i),]where F-is the logistic (logit) or standard normal (probit) distribution function. Estimation was carried out using the maximum likelihood method, with robust standard errors.

5.Results

— Descriptive statistics (ages 18-25, N=70)
— Loan ownership: 57,1% (40 out of 70) have a loan.
— Debt burden among borrowers: mean 45,3% of income; median 50%; IQR 40–50 p.p.
— Savings (deposit): 38,6% (27 out of 70) have savings.
— Loan purposes (only among borrowers):"*Appliances/electronics"*-48,7%;
"*Education"*-23,1%; "*Clothing"*-12,8%; "*Housing"*-5,1%; "*Leisure"*-5,1%
These results correspond to Cluster C (*Engel's law & income distribution*): limited income and the structure of the young "digital basket" sustain the demand for credit even under high debt burden.
—Logit/probit estimates (signs, odds ratios, and robustness)
Specification: *credit ~ female + city + budget + plan + savings*
Logit (odds ratios, OR):
— *female*: OR = 0.64 (p≈0,38; 95% CI for OR: 0,24-1,72)- probability of having a loan is lower for women; weak/insignificant association.
— *city*: OR = 0,54 (p≈0,51; CI: 0,09-3.35)-slightly lower odds of having a loan in cities; not significant.
— *budget*: OR = 1.05 (p≈0,95; CI: 0,22–5,01) — budgeting is not associated with reduced probability of having a loan; possibly "financially active" individuals are also borrowers.
— *plan*: OR = 1,06 (p≈0,94; CI: 0,27-4.13)-expense planning ≈ neutral.
— *savings*: OR = 0,91 (p≈0,86; CI: 0,30-2.75)-savings are associated with a slightly lower probability of having a loan, but the effect is statistically insignificant.

Probit: The signs of the coefficients coincide in direction with the logit; statistical significance is absent for all predictors at standard levels.

Interpretation. In the small subsample, traditional "virtues" (budgeting/planning, having savings) do not show significant protective associations with the fact of having a loan among young people. Possible explanations: the declarative nature of practices (low quality of budgeting), the "financial activity" effect — those who keep a budget also tend to use credit products more actively, omissions of important controls (income/employment/BNPL/delinquencies). This aligns well with the critique of "teaching alone is not enough — market design must also be changed," presented in works on the limited effectiveness of financial literacy as the sole instrument (Jentson, 2023; Willis, 2008).

International Comparisons and Discussion. According to international sources, young people are experiencing growing credit card balances and rising delinquency rates, which corresponds to our observations of high debt burden among already indebted young respondents (Martinchek et al., 2022; Mori & Sanchez, 2025). In countries with high education costs, student debt sets a debt trajectory from an early age, reducing the space for savings and major purchases; this pattern is recorded in the United States in particular (Fry & Cilluffo, 2024). For the CIS, consumer loans and microfinance organization loans play a significant role. The effectiveness of constraints (DBR, total cost of credit, collection practices) is a critical institution for protecting young borrowers. Bibliometric clusters A-C show that the optimal response is a combination of regulation, literacy, and consideration of "Engelian" budget constraints: education alone is insufficient if products and interfaces remain behaviorally risky.

Table 3 *Key Indicators and Regulatory Response*

Country	Structure of Youth Indebtedness	Main Regulatory Measures (2022–2025)	Delinquency Trends / Notes
Kazakhstan	Predominantly consumer loans and microloans; spread of digital products (including BNPL)	Strengthening macroprudential supervision; AQR 2024; focus on DBR/DSTI/DTI; recommendations on credit cost disclosure.	Retail lending is growing; NPL around 3,4% in the banking sector and ~10,3% in MFIs; DSTI and DTI implemented
Russia (CIS)	Consumer loans, microloans, cards; significant role of MFIs	Focus on DBR restrictions and MFI regulation; Central Bank of Russia analytics on retail credit risks (2023)	Growth of retail indebtedness and delinquencies; regulators strengthening supervision
USA	Student debt, credit cards; BNPL expanding	Strengthened monitoring of delinquencies; discussions on restructuring student loans	Growth of delinquencies on credit cards and student loans in 2024-2025; high level of write-offs
EU / United Kingdom	Credit cards, student loans (UK); BNPL widely spread	EBA/FCA-recommendations on BNPL disclosure, strengthened consumer protection (Consumer Trends Report 2022/23) потребителей (Consumer Trends Report 2022/23).	Increased focus on BNPL and consumer protection; monitoring of household indebtedness
Note. Compiled by the author based on data from the National Bank of Kazakhstan, the Agency for Regulation and Development of Financial Market, AFK, Ranking.kz, the Bank of Russia, the Federal Reserve Bank of St. Louis, the Urban Institute, the European Banking Authority, the Financial Conduct Authority, and the European Central Bank (2023–2025).			

6.Conclusions and Recommendations

1. In the subsample of ages 18-25-57,1% have a loan, with the median debt burden among borrowers reaching 50% of income a sign of financial fragility.
2. In the limited sample, behavioral indicators (budgeting, planning) do not provide a statistically significant "protective" effect regarding the fact of having a loan; emphasis is needed on the quality of practices and institutional constraints.

3. The international agenda confirms the importance of three directions: limiting over-indebtedness (A), developing literacy and inclusion (B), and accounting for structural budget constraints according to Engel (C).

7.Policy and Practical Recommendations:

— Regulators: strengthen standards for full credit cost disclosure, introduce "behavioral" warnings in BNPL/card interfaces, and maintain DBR limits for young borrowers.
— Banks/MFIs: design "protective interfaces" (aggregator of total debt burden, monthly payment stress test), product "ladders" with cost reduction under disciplined repayment.
— Education: modules on building reserves, reading contracts, and repayment strategies ("avalanche," "snowball"), as well as practices of "minimax budgets" accounting for Engel's law.

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Food Security: Current Status and Development Prospects in Conditions of Risk

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Abstract

The article considers the mechanisms of ensuring food security, risks and threats to its provision. National security policy is an interconnected system of targeted efforts of the state and other political institutions of society, designed to ensure their reliable functioning. The state is called upon to play a central and coordinating role in ensuring food security. The most important elements of the state regulation system should be the following: − stimulation of effective demand of the population; − antimonopoly regulation and increasing the competitive potential of agriculture; − development of market infrastructure; − support for a stable situation on the food market through government injections (interventions); − providing agriculture with affordable loans; − pursuing a policy of reasonable protectionism; − providing domestic producers with conditions for normal competition with foreign producers. The implementation of the state strategy is carried out through a system of specific measures based on qualitative and quantitative indicators - macroeconomic, demographic, foreign economic, technological, etc. The most important element of the national security system is the forecasting of its threat factors. One of the main goals of ensuring national security of any state is to ensure food security. An analysis of current global trends shows that food dependence is becoming a key lever of foreign policy influence for powerful states, determining a country's place in the global community. Food security (FS) encompasses not only the availability of food (quantitatively speaking), but also its quality, safety, and affordability. Key risks include dependence on imported seeds and equipment, climate change, and geopolitics. Opportunities include the development of domestic breeding, digitalization of the agricultural sector, and efficient use of land resources.

Keywords: security, risks, threats, directions, monitoring, policy, availability, mechanisms of provision.

1.Introduction

Food security is the provision of safe, high-quality, and affordable food to the population. Risks include conflict, extreme weather conditions, and economic factors. Public policy aims to create favorable conditions for domestic food production and distribution, while economic policy focuses on ensuring food availability by reducing prices and increasing household incomes.

Food Security Risks

• Extreme weather conditions:

Climate change, droughts, and floods cause harmful effect on food production.

• Economic factors:

Inflation, low purchasing power, and market instability can limit access to food.

• Logistical and infrastructure challenges:

Shortages in food production, distribution, and exchange can lead to scantiness.

• Poor product quality and security:

Negligence to comply with quality and safety standards can lead to public health problems.

Main directions of state and economic policy

• Improving of local production:

The state stimulates domestic agriculture to ensure food security.

• Ensuring accessibility:

Economic policy is designed to create favorable conditions for the physical and economic availability of food for all citizens, such as, through subsidies or support for low-income groups.

• Quality and safety control:

The state sets requirements for the quality and safety of food products and monitors their compliance.

• Support for agriculture:

Providing subsidies, benefits, and technical support to farmers helps stabilize production and prices.

• Infrastructure development:

Investments in transport and warehouse infrastructure improve supply chains and reduce food losses.

• Developing international cooperation:

Participation in international agreements and trade helps ensure access to essential food products.

Ensuring food security is a pressing issue directly related to the sustainable development of the state and the well-being of the population. In the context of urbanization and the growth of the share of the urban population, food security issues in megacities are of particular importance, becoming an integral part of the sustainable development strategy.

The increase in the number of urban residents exacerbates the problem of balanced provision of food resources, given the limited resources, such as agricultural land and infrastructure for storing and transporting products, leading to an increase in demand for food, complication of supply logistics, as well as an increase in dependence on external sources of food.

Urbanization aggravates the situation related to specific risks to food security in megacities, endangering sustainability of the urban food system, while demanding an comprehensive approach to their regulation. Consequently, there is a need to develop an effective policy for managing these risks aimed at reducing dependence on external supplies, optimizing logistics, supporting local production and ensuring the availability of food. In this context, it is important to justify mechanisms that will help minimize these risks and create a sustainable food system for megacities, since food policy remains ineffective without taking into account risk factors.

2.Literature Review

Discussing the issues of ensuring food security, it should be noted that general problems of food security are in the center of attention of the scientific community, which is confirmed by the content analysis of scientific publications in the Elibrary electronic library. The search was carried out using the following keywords: "food security", "food security of a metropolis", "food security of a city" taking into account the morphology, including abstracts, keywords and titles of articles published in scientific journals.

Table 1. *Results of content analysis*

Key phrase	2019	2020	2021	2022	2023	2024
Food security	1 605	1 674	1 699	1 987	2 095	2 206
Food security of the metropolis	2	2	2	1	3	4
Food security of the city	16	31	33	25	34	30

Compiled by the author based on data from the Elibrary library

The results of the content analysis of scientific articles indicate the presence of a scientific gap: on average, over the past 6 years, no more than 2-4 articles per year have been published on the problems of food security in megacities. This problem is partially considered in scientific studies on the food security of cities (16-34 publications per year), but this figure is significantly lower than the total number of publications on food security. In accordance with the approach of A.Kh. Kurbanov, the food security of a megacity is assessed through the prism of the economic state. Ensuring economic security involves saturating the market with food products, achieving food independence, as well as guarantees of physical

and economic availability of food for all categories of the population. An important criterion for food security is the compliance of food products with established technical regulations and their sufficiency to maintain an active and healthy lifestyle (Kurbanov, 2015). Thus, the problem of food security in megacities goes beyond the simple availability of food products on the market. According to the position of M.S. Oborin, M.Yu. Sheresheva and O.V. Shimuk, the problem of physical availability of food is not acute, since the market is sufficiently saturated with food products. However, the key risks to food security remain issues of economic availability of food and a balanced diet (Oborin et al., 2017). Ensuring food security of modern megalopolises is associated with many risks caused by urbanization and the increasing burden on food systems. The main risks include the likelihood of food crises, reduced economic availability of food products and instability of supply. Since most megacities do not have sufficient agricultural land to fully meet the needs of the population (Moronova, 2023), one of the key risks is the high logistical dependence of large cities on external suppliers. The expansion of megacities leads to a reduction in available agricultural land in their vicinity, which limits the possibilities for local food production and increases the vulnerability of cities to supply disruptions.

3. Risks and threats to food security

The set of protective measures for domestic producers, on the one hand, must not contradict WTO law. On the other hand, it must be aimed at increasing the competitiveness of domestic producers, which will allow them to supply the market with raw materials and food, and, consequently, survive, maintain, and strengthen their market position. As we can see, maintaining and further enhancing food security is a task that requires a comprehensive approach. This task requires the participation of government officials, scientists, and business representatives, as well as the trust of rural producers (the main participants in the production process that facilitates import substitution) in new developments and programs to address the food crisis.

Development Prospects. Genetics and Breeding: Priority is given to the development of domestic breeding and seed production to reduce import dependence. Technological Sovereignty: Creation of domestic production facilities for the production of machinery, equipment, and software. System Resilience: Creating sustainable food systems, including reducing product losses and digitalizing production process management. Human Resources: Addressing the shortage of skilled personnel in the agro-industrial complex.

Key areas for ensuring food security: Achieving technological independence (seeds, equipment, IT). Improving product quality (environmental friendliness, nutritional value). Optimizing logistics to ensure physical accessibility. Ensuring food security is associated with risks that can significantly undermine it. The mosst significant risks are divided into the following categoriess:

- macroeconomic risks arising from the decline in the investment attractiveness of the domestic real economy and the competitiveness of local production as well as the dependence of key economic sectors on external economic conditions;
- technical risks caussed by delays in the technological development of domesstic production bases in developed countries;
- Organization of systems for monitoring food safety requirements and compliance;
- agro-ecological risks arising from adverse cliimate change, as well as the consequences of natural and man-made diisasters;
- Foreign trade risk arising from market fluctuationss in foreign countriess and the introduction of state aid measures.

The existence of these risks poses a threat to food safety, which may lead to non-compliance with food ssafety limits. Sustainable economic growth requires the elimination of state regulatory measures:

- less effective demand for food production;
- inadequate development of domestic market infrastructure;

- price imbalances in the markets for agricultural and fisheries products, raw materials and foodstuffs, on the one hand, and for physical and technological resources, on the other;
- Insufficient innovation and investment activities in agricultural and fisheries production, production of raw materials and foodstuffs;
- reduction of national animal and plant genetic resources;
- Lack of qualified staff;
- differencess in living standardss between urban and rural popullations;
- Artificial competitive advantage of foreign products as a result of various state support measures for food production in foreign countries.

State policies on food security must take into account risks and hazards that could significantly weaken it. Such factors include a shortage of qualified staff, price imbalances and modern food market monitoring systems. Risks to food security may include: macroeconomic; external economic; social; natural and climatic

The main threats to food security:
– exceeding the import threshold;
– low level of effective demand of the population;
– price imbalances in the food market;
– shortage of qualified personnel;
– underdevelopment of the system for monitoring and forecasting the development of the agro-food market;
– political threats.

The food security of the state can be considered ensured "…if, in the event of a cessation of the flow of food products from abroad into the country, a food crisis does not occur, which is achieved due to the high share of domestic agricultural raw materials and food in consumption: potatoes - 95%; grain, milk and dairy products - 90%; edible salt - 85%; meat and meat products - 85%; fish and fish products, sugar, vegetable oil - 80%". If we compare these benchmarks with what we have today, then the balance in providing the population with livestock products, primarily meat and dairy products, is most severely disrupted.

4.The main directions of state economic policy in the sphere of ensuring food security

The key directions of state economic policy in the area of food security for 2025 - 2026, based on the Food Security Doctrine, are aimed at ensuring independence through import substitution, increasing crop yields, modernizing the agro-industrial complex, developing logistics, and increasing the economic availability of high-quality food products for all population groups.

Key areas include:

• Production intensification: Improving soil fertility, bringing unused arable land back into cultivation, accelerating the development of livestock farming and land reclamation.

• Technological modernization: Applying updated innovation for the high-tech processing of raw materials, establishing latest infrastructure for the storage and transportation of products.

• Scientific and personnel support includes improving food science, stopping personnel exhaustion, as well as educating specialists for the innovative agro-industrial complex.

• Improving accessibility: Monitoring prices, ensuring the physical and economic availability of food for the population.

• Developing the fishing industry: Intensive use of aquatic bioresources and developing industrial fish farming.

State policy is also focused on achieving food self-sufficiency thresholds (the proportion of domestic production) for grain, sugar, oil, meat, fish, and potatoes.

A country's food security is determined by its level of food self-sufficiency, that is, the ratio of domestic food production to consumption. There are four main factors influencing human food security: utilization, accessibility, availability, and stability. Utilization includes people's ability to prepare food hygienically—which requires fuel and

access to clean water—and to absorb the nutrients contained in it.

Agricultural policy aimed at developing agriculture and ensuring food security is a crucial component of public policy for every country. Therefore, this work is of interest for identifying opportunities to improve the effectiveness of state support for agriculture and food security.

Issues of improving the effectiveness of state support measures for agriculture and ensuring food security in the face of domestic budget constraints and external sanctions are currently among the most significant for government agencies implementing agricultural policy.

However, given resource constraints, it is necessary to systematize state support measures to enhance the effectiveness of agricultural policy. We believe comprehensive support is needed to mitigate the risks of failing to achieve the goals and objectives of program-targeted documents, including: optimization of the current agricultural insurance system (specifically, attracting more insurance companies to regional markets and increasing insurance payout levels), improvement of the mechanism for preferential lending to agricultural enterprises, development and implementation of additional leasing programs for agricultural machinery and equipment, timely adoption of innovative technical solutions and the introduction of new technologies that optimize resources and protect the environment, and prevention of a decrease in funding levels relative to approved levels.

Increased exports will offset the decline in domestic demand, allow for the sale of excess product in warehouses, ensure increased capacity utilization, and provide jobs for rural residents.

Government support is critically important, but today it requires greater consistency and regularity. A long-term agricultural policy with large-scale government support for farmers and the creation of conditions for technological breakthroughs is needed. The above measures will enable us to cope with macroeconomic and regulatory shocks in the long term and implement technological modernization, import substitution, and growth in agricultural exports and food security.

Thus, ensuring food security for the national economy as a whole and its individual territorial entities in particular remains a central element of the economic and social policy of any state in the 21st century. Given the escalation of external risks and threats to national security, including the volatility of global raw materials and commodity markets, as well as the growing burden of environmental problems that directly or indirectly affect the country's food supply, the urgency of developing reliable criteria for formulating a food basket is growing.

Food security serves as the foundation for ensuring public health and long-term economic development; it cannot be achieved without a clear understanding of the minimum and optimal set of products (and in what quantities) required to sustain life and a high quality of life for citizens.

The problem of ensuring a stable, necessary, and sufficient supply of food for individuals, households, regions, and countries is of permanent importance. It's no coincidence that researchers have noted that even before the concept of food security was categorized, algorithms for providing people with food not only existed and were institutionalized, but also constituted a crucial factor in socioeconomic differentiation in societies of all levels.

Having systematized and generalized existing concepts of food security, we propose a new approach to the essence of food security as providing the country's population with accessible food products of sufficient quantity and quality to ensure the normal continuation of healthy life, while addressing the priority task of managing the country's land resources suitable for agricultural production and the balanced management of a system of various international and domestic measures. This statement differs from many others in its recognition of the subject for which any food security strategy is implemented: the healthy individual. Their needs should become the primary guideline for adjusting planned and implemented action plans to ensure food security for population groups of different ages, genders, levels of physical activity, and daily physiological requirements in kilocalories (Kapustina, 2023). It would seem that target benchmarks have been set, but the overall situation across various regions and the country as a whole remains unchanged, according to researchers.

Mechanisms for ensuring food security of a metropolis are a system of measures and tools aimed at creating a sustainable supply of high-quality and affordable food products to the population. The key risks of food security of modern megacities, as well as the mechanisms for managing these risks, are systematized in Table 2.

Table 2- *Food security risks of the metropolis and management mechanisms*

Risk category	Risk Description	Mechanisms for ensuring food security
Dependence on external supplies	Limited agricultural space in megacities makes them vulnerable to supply disruptions due to crises, sanctions or pandemics	Development of local agricultural production, support for urban farming, creation of strategic food reserves
Insufficient development of storage and logistics infrastructure	Limited warehouse capacity and imperfect storage systems lead to product losses and reduced quality	Improvement of warehouse and transport infrastructure, introduction of modern storage and processing technologies
Uneven access to food for different segments of the population	Low incomes, rising unemployment and economic crises limit access to quality products	State support for the poor: food subsidies, social stores, subsidized food programs
Excessive demand and price spikes	Panic buying caused by political and psychological factors leads to shortages and rising prices	Regulation of market distribution of essential goods, state interventions, informing the population
Environmental and climate threats	Climate change, soil degradation and water scarcity are reducing food production	Implementation of sustainable agricultural practices, optimization of resource consumption, development of adaptation measures
Growing volumes of food waste	Rising food losses in cities increase food insecurity	Creating efficient processing systems, reducing food losses, optimizing transport chains
Lack of long-term strategic planning	Insufficient consideration of future threats leads to ineffective food policy	Development of strategic plans for food security, risk monitoring, integration of environmental and economic factors into the policies of megacities

Developed by the author

Therefore, the scientific literature currently lacks an economic justification for an indicator whose characteristics would allow for the integrated inclusion of two parameters: an assessment of the level of food security for the population of various socio-demographic and economic clusters, as well as rational planning for the state's participation through various entities, primarily the agro-industrial complex, in ensuring a decent quality of life for citizens. This integrated indicator would serve two roles: evaluative (have we achieved the desired level) and predictive (how to maintain food security or improve its substantive economic basis). It appears that the food basket could serve as such an integrated indicator. Updating approaches to analyzing and reintroducing it into scientific discussions, searching for innovative approaches to its essence, and developing methodology for its formation is particularly urgent today.

Thus, ensuring food security cannot be limited only to increasing the volumes of production and supply. Regulating market distribution of vital products requires additional mechanisms, which aims at preventing panic buying and irrational price hikes.

Environmental and climate change are also sources of risk to food security in megacities. Changing weather conditions, soil degradation and water shortages affect food production volumes, requiring the introduction of sustainable agricultural practices and optimization of resource consumption (Voronina, 2022). In addition, the increase in the volume of food waste in cities requires the development of effective recycling systems, improvement of transport and storage infrastructure, and reduction of food losses (Walls, 2019). In this context, strategic planning plays an important role, which should take into account not only current threats, but also prospective climatic and environmental factors that can affect the food security of modern megacities (Walls, 2019). Thus, strategic planning becomes a tool for long-term food stability, allowing the integration of environmental and economic aspects into the state policy

of food security of megacities.

At the level of municipal entities of the region, through the implementation of long-term target programs developed by regional authorities, the negative impact of the above risks is eliminated and one of the strategic goals of economic policy is achieved - sustainable development of the agro-industrial complex.

Due to their specificity, food systems of megacities are highly dependent on external supplies, which makes them vulnerable to crises, trade restrictions and other external economic shocks. The key mechanism in this context is the development of local and agricultural production; it is also advisable to form strategic food reserves to compensate for short-term deficits and stabilize the market in the event of undesirable events. The introduction of modern solutions in the field of storage and processing of products allows us to reduce logistics costs and reduce food losses that occur during storage and transportation. Economic inequality and social stratification of the population are sources of risks in ensuring food security in megacities, which requires the introduction of a social support mechanism aimed at increasing the availability of food for the most vulnerable segments of the population. Among the support mechanisms, we can also highlight food subsidies, the creation of a network of social stores and the implementation of subsidized food programs; the importance of these mechanisms increases in the context of crises accompanied by unemployment and a reduction in real incomes of the population. An important mechanism for stabilizing the food market in megacities during periods are government interventions that help contain price fluctuations.

Ensuring food security in the context of developing large urban agglomerations is a key challenge for modern socio-economic policy. As population grows, their high dependence on external supplies increases, and their vulnerability to sudden disruption makes it necessary to reconsider traditional approaches to food system management. In the periods of growing economic instability, megacities are especially exposed to risks associated not only with physical and economic availability, but also quality of food products.

In this regard, it is vital to analysis food security mechanisms conducted within various levels of government, including their adaptive capacity in response to various types of threats. Because megacities differ in their economic development, geography, and layout, they use different ways to supply food, which makes it important to understand these systems in a clear and scientific way.

Key mechanisms to ensure food security in 2026, and beyond are supposed to switch to sustainable food systems, the diversification of supply chains, and government assistance for the domestic agricultural sector. These resources cover building regional infrastructure, applying innovative agricultural technologies, grain reserves, and starting new government programs.

Key mechanisms to ensure food security by 2026:

• Sustainable agriculture: These resources include the development of regional infrastructure, the use of innovative agricultural technologies, grain reserves, and the creation of new government programs.

Key mechanisms to ensure food security by 2026:

Developing environmentally sustainable growing methods and reducing food waste.

• Sustainable agriculture: Promoting environmentally friendly farming methods and cutting down on food waste.

Diversification and supply chains: Preventing threats related to economic disruptions and climate change

• Strengthening food systems: Advancing urban and peri-urban food supply systems.

• State control: Launching new government programs targeting increasing food sovereignty.

Resources and factors:

• Grain resources: Using grain reserves as a basis for food security.

• Innovation and technology: Applying digital solutions to increase yields and control supplies.

• Domestic production: Increasing domestic production to prevent need on imports.

• Risk mitigation: Decreasing the impact of economic shocks, climate change, and military conflicts.

By 2026 and beyond, food security will be determined by the ability of countries to meet their population's needs from their own resources in the face of global uncertainty.

Food security issues have always been pressing. Against the backdrop of current economic changes and shocks, ensuring food security is a national priority requiring attention at all levels of government. To ensure food security, it is important not only to minimize the impact of factors destabilizing the food system, but also to proactively identify the most significant risks and threats and implement timely containment mechanisms to neutralize them.

By 2026 and beyond, a country's food security will be influenced by its potential to address its population's need using its own resources, even amid global uncertainty. Ensuring food security has always been vital issue. However, it has become a national priority requiring attention at every level of government against the backdrop today's economic changes and shocks. Achieving this goal demands not just minimizing the impact of factors destabilizing the food system, but also actively identifying key risks and threats and taking timely action to manage them.

5.Mechanisms and resources for ensuring food security

Making sure cities have enough food means understanding how all the pieces fit together — from central and local governments to economic incentives, infrastructure, logistics, and social programs that keep food flowing reliably. Increasing food availability isn't just about growing more; it also means investing in farming productivity, improving how food is distributed, and updating policies to support the system. Local markets are important too, helping to balance the often-unpredictable output from small-scale farmers.

Current conditions revealing these characteristics, attach critical importance to address the issue of food security. Global institutional changes conducted within a short period of time, establishing new rules of conduct which require maximum autonomy for national production and technological processes, as well as elevating import substitution to the top and dominant national agenda aggravate the problem. To meet its challenges, agriculture needs new ways of managing food security that encourage innovation and respond to global pressures. Ensuring food security for the state is a key component of its national security and sustainable socio-economic development. As a socio-economic category, "food security is considered within the system of social, economic, organizational, environmental, and other factors that accelerate or inhibit the development of the agro-industrial complex and the purchasing power of the population" (Voronina, 2022).

To summarize the above, it should be noted that, in addition to the main elements of the organizational and economic mechanism for ensuring food security discussed above, it includes three subsystems:

1) food production, where the agro-industrial complex and agriculture are key sectors, requiring the development and implementation of economic regulation methods;

2) ensuring food safety during production, storage, and transportation, forming the technological aspect of food security;

3) tools and methods for ensuring food availability to the population, forming the infrastructural aspect of food security.

The key systemic mechanism for ensuring the sustainability of food systems in megacities is long-term strategic planning based on a comprehensive consideration of environmental, climatic and economic factors. Strategic planning allows minimizing potential damage through the implementation of policies aimed at managing food security risk factors.

6.Conclusion

In modern conditions, ensuring food security of megacities requires the implementation of a

rational and balanced state policy aimed at achieving a high degree of sustainability of food systems. Policy in the field of ensuring food security should be based on the principles of efficiency and cost-effectiveness, that is, the stability of the functioning of food supply systems should be achieved without allowing excessive spending of budget resources. The optimal balance between the sustainability of food infrastructure and reasonable distribution of financial resources allows avoiding ineffective costs and creating conditions for long-term food stability. Identification and prioritization of food security risks allow directing resources to minimize the most significant threats, which, in turn, helps to increase the effectiveness of management decisions. Integration of food security mechanisms with the risk management system underlies the formation of a balanced food policy capable of adapting to changing external and internal conditions without excessive burden on the budgetary and financial system of megacities.

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The Role of Flexible Culture in Improving the Adaptability of Higher Education Institutions

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Abstract

This article examines the role of Agile culture in improving the adaptability of higher education institutions. Although the core principles of the Agile approach were initially formed in the field of project management, over time it has become widespread as a flexible management model that is not limited to IT projects and is applicable to various fields of activity. A modern university must be not only an institution for the transfer of knowledge, but also an adaptive organization capable of adapting to a changing external environment, establishing interactions with stakeholders, and being open to innovation. This transformation does not happen randomly, but requires the application of mechanisms that prepare the organization for change, strengthen the team culture, and make management processes more flexible. The article analyzes the benefits of agile culture in universities in terms of internal coordination, decision-making, knowledge management and increasing student-centeredness in the educational process, and discusses the opportunities and potential challenges associated with the transition to an agile organizational model.

Keywords: Agile culture, Agile management, university, adaptive organization, knowledge management.

1.Introduction

Accelerating economic, technological and social transformations on a global scale are having a profound impact on the models of higher education institutions and forcing them to move away from traditional management frameworks. Based on the latest data, the average graduate turnover in the international labor market has been lessened to 2–3 years (World Economic Forum, 2020, p. 5–7; Li, 2022, p. 570; Pencheva, 2022, p. 247), which indicates that the higher education system is fighting to keep face with the rapidly changing environment and that highlighing a need for more flexible, adaptive strategies.

While the traditional bureaucratic management model is effective in stable conditions, it fails to ensure agile decision-making, operational coordination, and more active participation of stakeholders amid the substantial uncertainty of the modern era.

The governance structures in universities are still multi-tiered, formal and slow, which delay realization of innovative initiatives and make the issue regarding the adaptability gap of higher education institutions is more evident.

A contemporary university shouldn't merely transmit knowledge; but also be a dynamic organization with strategic flexibility that adresses promptly to the environmenal changes, deals with various stakeholders.. The agile culture which has been increasingly applied in management science recently presents a practical framework for this transformation, allowing for strengthening the adaptive potential of universities with principles such as transparent communication, continous decision-making processes, team collaboration, and continuous development. In this context, the main question answered by the study is formulated as follows:

Through what mechanisms does an agile culture increase the management flexibility and adaptability of higher education institutions?

The aim of the article is to identify the theoretical foundations of the application of the “agile” culture in higher education institutions, to analyze the impact of this approach on management, coordination, knowledge management and the teaching process, and to assess the potential opportunities and risks of the transition to an agile organizational model. The hypothesis of the study is that the application of “agile” principles significantly increases the strategic adaptability of universities, the operationality of decision-making and the effectiveness of cooperation with stakeholders. Existing scientific literature shows that the application of agile methodologies in the educational sphere increases institutional flexibility, but universities can face personnel resistance, structural inertia, and communication barriers in the transition to this culture.

Agile culture is a philosophical and methodological framework in management theory that promotes an agile approach to the implementation of projects and processes. The grouping of human activities into two main categories as processes and projects has created an important theoretical basis for the formation of the Agile concept. The changing business environment since the second half of the 20th century has increased the need for management models that are more flexible, adaptive, and based on periodic improvement (Rigby, Sutherland & Takeuchi, 2016, p. 45–47). As a result of this need, the "Agile Manifesto" was developed by software professionals in 2001 and the fundamental values of agile management were systematized.

Although the Manifesto was originally intended for the IT sector, the principles it presented — iterative learning, team collaboration, continuous improvement, user-centeredness, and openness to change — have subsequently been transferred to various fields of activity (Denning, 2018, p. 33–52). This has enabled the Agile culture to be widely applied not only in technology projects, but also in operational management, business models, strategic planning, and the activities of social organizations. Thus, Agile has begun to be perceived not as a methodology, but as a new form of management thinking in conditions of continuous change.

Agile methodology is inherently based on an iterative and incremental development model. The team develops a minimum viable product (MVP) early on, which brings the product to an initial working state, and improves the solution based on user feedback in subsequent iterations (Ries, 2011, pp. 60–85). This model allows you to put the most important principles of agile management — operational value creation, customer focus, and agile planning — into practice.

Agile projects are usually organized in sprints, which have a short timeframe. Sprints are carried out over a two- to four-week period, and each iteration focuses on a specific goal — the completion of a specific functional part of the product or service. At each stage, “user stories” define product value from the user's perspective and attaches special attention to meeting user needs rather than the final result. Agile approach aims to simplify complex requirements and implement them in sections. In reality, overcomplicated requirements endanger project risks, leading to inefficient resource management, and delaying outcomes. Agile management avoids these situations by creating incremental value dividing large goals into small, realistic, and functional tasks (Highsmith, 2002, pp. 55–60).

All these factors make Agile culture not only a technological innovation, but also a management culture, which is relevant for all organizations operating in a changing environment. (Rigby et al., 2016, pp. 48–50).

Figure 1.

Figure 1. illustrates the analogy, which defines one of the core principles of the Agile methodology: explaining requirements in the simplest and most functional form. The goal of the Agile approach is to deliver a working, functional version of the product (Minimum Viable Product — MVP) at the initial stage and collect operational feedback from the user or customer. Based on this feedback, the product is gradually improved in subsequent iterations, and ultimately the solution is brought into a form that is more suitable for real needs. This explanation is also broadly described in the Lean Startup concept (Ries, 2011, p. 60–85). The wheel hanging from a rope shown in the picture is a symbolic representation of this approach — that is, the functional minimum. Agile methodology is a management model based on iterative and time-bound processes, in which iterations are usually implemented in two-week sprints, relying on project characteristics. Each period can be extended to three or four weeks. In each sprint, the team prioritizes key features providing real value to the customer; that are formalized in the form of "user stories." "Iteration" and "sprint" are often used synonymously in Agile environments, both referring to a time period allocated for completing specific tasks.

The principles such as agile decision-making, strengthened team cooperation, continuous feedback, transparent communication, and willingness to change constitute the basis of Agile culture. Considering these principles raises the question how to apply the Agile approach in the educational system.

A major advantage of Agile methodology is its ability to incorporate the requirements and changes through iterative processes. The team assesses the outcomes reached at the end of each iteration and adjusts decisions regarding the next phases, which allow stakeholders — business customers or users — to impact the duration of the project throughout the entire process. (Highsmith, 2002, pp. 55–60).

In a university environment, the idea of "customer" can be understood as students, faculty, and other academic staff involved in the educational process. Introducing Agile method enables students to be more active during classes and project activities, considering their opinions more promptly, and proposals to be carried out within the lesson process.

Agile management does not emphasize rigid and fixed roles among team members. Instead, it adopts a flexible, collaborative team structure, which can support different functions as needed, allowing team members to create shared value through complementary roles.

The knowledge management strategy attaches particular importance to improve the efficiency of processes within the university and increase overall efficiency. Owing to the investment made in the development of information technologies in the last few years, the efforts have been directed on centralizing, systematizing, and effectively sharing codified knowledge. This approach aims to facilitate reapplication of knowledge, preserve institutional memory, and ensure the stability of organizational processes (Nonaka & Takeuchi, 1995, pp. 8–25).

The concept put forward by Hansen and colleagues (1999, pp. 106–116), mentions two main directions of knowledge management:

1. Documenting codified knowledge involves collecting, structuring, and sharing data in electronic systems and via digital platforms;
2. Transferring tacit knowledge — the dissemination of knowledge as a result of human interaction through collaboration, discussions, meetings, and exchange of experiences.

This, in turn, enables the flow of knowledge to be fast, transparent, and continuous, as required by the Agile philosophy. Thus, both enhanced technological infrastructure and expanded academic collaboration support the transformation of universities into more agile, adaptive, and innovative organizations.

Table 1. *Two approaches to knowledge management*

Category	Open Knowledge – "People-to-Document" Approach	Non-Open Knowledge – "People-to-People" Approach
Descriptive Feature	High-quality, reliable, and fast information systems are developed; access to codified knowledge is ensured, enabling its reuse.	Conditions are created for mobilizing individual experience and organizing creative consultations on strategic issues.
Main Focus	Systematization and storage of electronic documents, databases, and codified knowledge.	Promotion of knowledge exchange among individuals; strengthening social networks and collaboration channels.
Implementation Mechanism	Digitization, structuring, and systematic collection of knowledge within document-based databases.	Knowledge sharing through interpersonal communication, mentoring, meetings, and corporate communities.
Strategic Priority	Significant investment in information technologies; primary goal – maximizing the codification and reuse of knowledge.	Moderate investment; primary goal – increasing the sharing of individual knowledge and experience among team members.
Application Examples	Databases, digital archives, document management systems.	Seminars, experience-sharing events, expert networks, and communities of practice.

Source: Hansen, M. T., Nohria, N., & Tierney, T. (1999). What is your strategy for managing knowledge? Harvard Business Review, 77(2), 106–116

The transition to the era of fast internet and intensive development of information technologies makes the application of the "iterative" model even more necessary. Modern educational centers, especially universities, are forced to use flexible systems to adapt to this increasing pace. As a result of this process, a more adaptive environment is formed and the quality of teaching activities increases. Both the “people-document” and “people-people” approaches presented in the table above are of great importance for adaptive institutions, and the combination of these two models creates the optimal form of knowledge management in universities (Hansen et al., 1999, pp. 106–116)

When making strategic decisions, university administrations should seek the opinions of departments, deans, and faculty members and take their suggestions into account. This approach is fully consistent with the management logic of the Agile methodology. This principle is also consistent with one of the classic models of management science, the "Carnegie model" (political model). The model in question considers it important to involve all stakeholders of the organization — teachers, students, and even parents — in the decision-making process. If universities take into account the opinions of not only internal but also external stakeholders — employers, government agencies, and public organizations — when conducting strategic planning, they can formulate more effective and targeted strategies aimed at developing the country's human capital.

The successful implementation of the mentioned recommendations is primarily determined by management skills and leadership skills of the university administration. Agile leadership is a more adaptive, transparent, and collaborative approach than traditional management models. In this leadership model, the rectorate prioritizes responding quickly to changes, managing risks in a measured manner, and using modern methods in decision-making. Thus, agility becomes a strategic advantage for the university (Uhl-Bien, M., & Arena, M. (2018)**,** 1–10).

The implementation of an agile culture in universities is primarily closely related to the activities of key personnel potential - namely, teachers. The quality of the teaching process is determined by the methodology chosen by the teacher, the form of presentation of the lesson, and the extent to which it adapts to the characteristics of the audience. Factors such as the level of comprehension of the audience, the active participation of students, and the orientation of knowledge to application directly shape the effectiveness of the lessonIn this regard, the Agile approach can serve as a practical and effective tool for teachers (De Sousa, 2023, pp. 14–18).

In traditional teaching practices, methods predetermined in syllabus and programs are applied to all groups in the same manner. However, a flexible teaching approach allows the teacher to dynamically select methods after getting to know the students, observing the characteristics of the audience, and receiving feedback during the lesson. This creates the opportunity to adapt the form of the lesson situationally, right in the learning process itself.

It is proposed that instructors divide courses into several stages based on a modular approach and assess each stage iteratively. Organizing the following steps according to the results acquired after each iteration makes the teaching process more flexible and gives the opportunity for dynamic revising of the syllabus when necessary. This approach reinforces student-centeredness and makes continuous development as a core principle of teaching.

The execution phase alone is not enough in project management terminology, so involvement of control and monitoring processes in parallel is also necessary. Applied agile methods should be regularly assessed, controlled via KPIs and other evaluation criteria, and amendments should be made in following iterations if any deviations are detected. This method makes the teaching process more transparent, assessable, and systematically improved.

2.Conclusion

The study explains that the Agile approach can lead to fundamental changes in the management of universities. This methodology is accelerating decision-making processes, enhancing internal communication channels, as a result establishes a more flexible collaborative environment between faculty and students. Applying Agile principles helps universities avoid from the traditional hierarchical and bureaucratic management model towards a team-based, participatory, and agile organizational culture.

According to the study results, agile culture does not merely change management processes in higher education institutions, but also the teaching approach. The agile approach makes teaching student-centered, allowing teachers to adapt teaching methods to the real needs, learning pace, and individual characteristics of students. Applying agile culture also opens up new opportunities in the knowledge management. Universities can develop digital and social knowledge systems as well, with the help of codified knowledge bases and strengthening mechanisms for the exchange of "human-human" experience. When these two approaches combined, it creates favorable conditions to form more sustainable, flexible and adaptive integration model in higher education institutions.

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