

JAROSŁAW WENANCJUSZ PRZYBYTNIOWSKI
PAWEŁ DZIEKAŃSKI

PERCEPTION OF GREEN TRANSFORMATION
AMONG STUDENTS
IN THE ŚWIĘTOKRZYSKIE REGION



**Perception of Green Transformation
Among Students in the Świętokrzyskie Region**

**Jarosław Wenancjusz Przybytniowski
Paweł Dziekański**

**Perception of Green Transformation
Among Students in the Świętokrzyskie Region**



Poznań 2026

Recenzja wydawnicza
dr hab. Ruth Taplin, prof. UW
dr hab. Grzegorz Drozdowski, prof. UJK

Projekt okładki:
Wydawnictwo Rys

© Copyright by Jarosław Wenancjusz Przybytniowski
© Copyright by Paweł Dziekański

© Copyright by Wydawnictwo Rys

Wydanie I
Poznań 2026

ISBN 978-83-68668-49-0

DOI 10.48226/978-83-68668-49-0



Wydawnictwo Rys
ul. Kolejowa 41
62-070 Dąbrówka
tel. 600 44 55 80
e-mail: tomasz.paluszynski@wydawnictworys.com
www.wydawnictworys.com

Contents

Introduction.....	7
Chapter 1.	
Green transformation: global conditions and analysis of opportunities and challenges in the region (using the example of the Świętokrzyskie Voivodeship).....	13
1.1. Global impulses and political frameworks of green transformation.....	13
1.2. Dimensions of Green Transformation.....	14
1.3. Barriers and Threats in the Implementation of Green Transformation.....	17
1.4. Opportunities for the region in the context of green transformation.....	19
Chapter 2.	
Green transformation in a region with specific conditions.....	23
2.1. Theoretical frameworks of regional transformation.....	23
2.2. The role of local awareness in the success of transformation.....	26
2.3. Local ecological challenges as a manifestation of global trends.....	29
2.4. Regional conditions of the świętokrzyskie voivodeship in the light of a multi-level perspective.....	31
Chapter 3.	
Local Sustainable Development in the Context of Green Transformation.....	41
3.1. Conceptual foundations of green transformation.....	41
3.2. Key elements and function of sustainable development.....	44
3.3. Local dimension of sustainable development and building resilience.....	47
Chapter 4.	
Traps of Ecological (Green) Transformation: Analysis of Risks for the Regional Economy and Society.....	51
4.1. Economic and market risks.....	51
4.2. Social and justice traps.....	53
4.3. Institutional and political risks.....	55
Chapter 5.	
Social Acceptance, Resistance, and Regional Development Trajectories: An Implementation Perspective on JT.....	61
5.1. Dynamics delaying transformation: psychosocial barriers and conflicts of interest...	61
5.2. The Requirement of justice: architecture of social acceptance.....	63
5.3. Regional development trajectories: alignment with mlp specificity.....	66
Chapter 6.	
Descriptive statistics and data normality analysis.....	73
6.1. Descriptive statistics – characteristics of data distribution.....	74
6.2. Perceptions, knowledge, and attitudes of students toward green transformation in global and regional contexts.....	83
6.3. The region’s shrinking potential and the spiral of regression.....	87
6.4. Cumulative mechanisms of spatial polarization and their implications for regional development.....	92

Chapter 7.	
Awareness and Understanding of the Green Transformation	97
7.1. Analyses of green transformation perception	97
7.2. Level of awareness and understanding of the concept of green transformation	99
7.3. Differentiation of perception based on socio-demographic characteristics	106
7.4. Differentiation of green transformation perception by socio-demographic characteristics	124
7.5. Determinants of knowledge and perception of the green transition among the younger generation.....	127
Chapter 8.	
Access to knowledge and environmental education	131
8.1. Determinants of environmental education among students in the context of the green transition.....	131
8.2. Perception of environmental education and sustainable development activities among students.....	133
8.3. Awareness and barriers in accessing knowledge on green transformation	162
8.4. Between declared awareness and real barriers – determinants of social acceptance of green transformation among Polish academic youth	193
Chapter 9.	
Perception of costs, benefits, and social impacts of green transformation	199
9.1. Perception of costs and benefits of green transformation among students	199
9.2. Perception of economic costs, benefits, and risks of social inequality of the green transition in the assessment of students in the Świętokrzyskie region...	204
9.3. Perception of costs, benefits, and the risk of social inequalities of the green transition in the assessment of students in the Świętokrzyskie Voivodeship.....	219
9.4. Costs, benefits, and social justice of green transformation in students' perception – demographic determinants, knowledge, and ecological awareness ..	229
9.5. Perception of costs, benefits, and the risk of social inequalities in the green transformation among students of the Świętokrzyskie Voivodeship	235
Summary	239
Reference	243
List of figures	253
List of tables.....	255

Introduction

Contemporary science and global policy unanimously recognize that the climate crisis, loss of biodiversity, and increasing environmental degradation constitute unprecedented civilizational challenges. In the face of these threats, the concept of green transformation (Green Transition), understood as a fundamental restructuring of social, economic, and technological systems toward a sustainable low-emission economy and circular economy, has become a global imperative. This process, whose frameworks are defined, among others, by the European Green Deal and the United Nations Sustainable Development Goals (SDGs), requires coordinated actions at all levels – from international agreements to local communities.

Although the goals of the green transition are universal (e.g., decarbonization and achieving climate neutrality), the effectiveness of their implementation depends decisively on reception and implementation at the regional and local levels. At this level, macroeconomic and political strategies collide with specific social, economic, and cultural conditions, as well as bureaucratic and financial barriers. In the regional context, local awareness and the perception of challenges related to the transformation thus become key elements. Understanding the role of human capital in adapting to ecological changes requires precise measurement tools. In studies on the Świętokrzyskie Voivodeship, the authors emphasize the utility of taxonomic methods in assessing ecological order and the spatial diversification of the natural environment (Przybytniowski, Dziekański, 2019).

In this monograph, it is assumed that academic youth – as future management personnel, the driving force of innovation, and a key segment of civil society – represents a critical group for the green transformation process. Students, being recipients and potential creators of new technologies and social models, have the greatest influence on shaping regional resilience to negative phenomena such as demographic shrinkage or economic regression spirals. Understanding their perspective is essential for designing effective educational and strategic interventions at the regional level.

In this context, the Świętokrzyskie Voivodeship serves as an interesting research field. It is a region with specific economic conditions (including mining and construction industries), social and demographic characteristics, where transformational challenges may be perceived differently than in metropolitan regions.

Aim and research questions:

The main objective of this study is a comprehensive identification and analysis of the perception of green transformation challenges among students from the Świętokrzyskie Voivodeship. The study focuses on assessing their level of awareness, identifying key transformational barriers and opportunities, and under-

standing how students link global ecological imperatives with local implications in their region.

Achieving the main objective translates into the following specific research questions (R.Q.):

1. R.Q. global trends and local interpretation – how are global green transformation trends understood and interpreted by students from the Świętokrzyskie Voivodeship, taking into account their local experiences and informational context?
2. R.Q. Access to knowledge and ecological education – what are the key barriers and facilitators in access to knowledge about ecological transformation for students in the region, and how does this affect their attitudes and level of ecological education?
3. R.Q. costs, benefits, and social consequences – how do students assess the costs and benefits associated with implementing green transformation, and do they recognize its impact on potential social inequalities in their region?
4. R.Q. local dimension and regional resilience – how do students perceive the role of local actions and initiatives in transformation, particularly in the context of building regional resilience to negative demographic and economic phenomena?
5. R.Q. linking challenges – to what extent do students identify a direct connection between global ecological trends and specific local challenges (e.g., air quality, waste management), and how does this perception shape their readiness for engagement?

Research hypotheses:

Based on literature analysis and preliminary exploratory research, the following hypotheses (H) were formulated:

1. H1 (awareness and understanding) – students from the Świętokrzyskie Voivodeship exhibit general awareness of global green transformation trends (e.g., climate change, pollution), but their understanding of these trends is more superficial than in-depth, and the direct linking of global challenges with local environmental and economic problems in their region is often overlooked.
2. H2 (Access and Education) – Limited access to personalized, practical knowledge about green transformation and insufficient ecological education in formal and informal systems constitute significant barriers to deepening students' awareness, despite their positive assessment of the importance of acquiring such knowledge.
3. H3 (Costs and Inequalities) – Students perceive the costs of green transformation as high compared to its direct, short-term economic benefits, which poses a significant barrier to their acceptance and support; at the same time, there is awareness of potential social inequalities resulting from the implementation of these changes in the region.

The conclusions drawn from this analysis are intended to provide empirical foundations for formulating strategic recommendations for local authorities, educational institutions, and economic entities in the Świętokrzyskie Voivodeship,

aimed at effectively involving academic youth in processes of building a sustainable and resilient regional future.

The study focuses on the role of human capital – understood as knowledge, skills, competencies, and attitudes – in the context of the effectiveness of initiatives related to green transformation (Green Transition) and building regional resilience. The key subject of analysis is the perception, understanding, and active shaping of ecological changes by the student population of the Świętokrzyskie Voivodeship. The aim is to identify mechanisms and factors conditioning the effectiveness of these processes, as well as to analyze perceived benefits, costs, and barriers to transformation implementation.

The research process was carried out based on standard research stages:

1. Research preparation – defining the objective, selecting methodology, defining the population and variables.
2. Data collection – conducting a survey as the primary tool.
3. Data processing and presentation: Statistical grouping, counting, and visualization of results (series, tables, charts).
4. Statistical analysis and inference – conducting descriptive analysis and inference based on collected data.

The study was quantitative and conducted using the CAWI (Computer-Assisted Web Interview) method with a structured questionnaire. The questionnaire, developed and subjected to substantive consultations by the author, was designed to collect respondents' opinions and assessments regarding the role of human capital in adaptation to green transformation, the effectiveness of ecological changes, and the perception of associated costs, benefits, and barriers. The study was conducted: March–May 2024.

The target population (Table 1) consists of Generation Z students (persons born in 1997–2012) studying at higher education institutions in Poland. Due to the research objective, the focus was primarily on students associated with the Świętokrzyskie Voivodeship. Non-probability sampling was applied, using purposive selection technique. Inclusion criteria were: student status at the time of the survey and belonging to Generation Z. The analysis is based on a sample of N=207 fully completed questionnaires. The majority of respondents are women (127 persons, i.e., 61.35%). Men constitute a minority (80 persons, i.e., 38.65%). In terms of age, the group is relatively young, with the highest numbers in the ages of 20 years (24.64%), 21 years (22.22%), and 22 years (23.19%). These three categories together account for approximately 70% of the studied population. Persons aged 23 years and older constitute a smaller portion of the sample (total 29.95%).

The majority of respondents are second-cycle students (49.51%), with a dominance of part-time mode (30.20%). First-cycle students constitute the second-largest group (50.49%), with a predominance of full-time mode (26.73%). The total number of students in this analysis is 207. The last category considered in the analysis of

the studied population was place of residence. The vast majority of respondents come from rural areas (116 persons, i.e., 58.00%). Persons living in cities constitute 32.00% of the sample, while residents of mixed areas ('city-village') form the smallest group of respondents, reaching 10.00%. The total number in this category is 200, suggesting that 7 persons (207-200) were not included in this division.

It should be noted that the dominant population consisted of respondents from Generation Z, which accounts for 90.82% of all respondents (188 persons). This is typical for first- and second-cycle students in Poland, where the majority fall within the age range of 19–25 years. Generation Z consists mainly of young adults (20–22 years account for over two-thirds of this cohort). Among them, there is a large group of part-time students (first- and second-cycle), which may suggest combining studies with professional work. The group "over 25 years old," which can be attributed to older Millennials (Generation Y) or occasionally Generation X, is a minority and constitutes 9.18% of the sample (19 persons). The presence of this group is natural and may result from continuing education (e.g., after a break) or choosing part-time studies by professionally active persons.

In summary, the studied student population consists predominantly (90.82%) of representatives of Generation Z – young adults aged 20–22 years. This group is characterized by a clear predominance of women (over 61%) and rural origins (58%). Academically, second-cycle part-time students dominate, which is characteristic of a young cohort combining studies with work.

Table 1. Demographic Structure of Respondents by Gender, Age, Year and Mode of Study, and Place of Residence (N = 207)

Category	Class / Value	Number	Percentage
Gender	Female	127	61.35%
	Male	80	38.65%
	Total	207	100.00%
Age	20 years	51	24.64%
	21 years	46	22.22%
	22 years	48	23.19%
	23 years	30	14.49%
	24 years	13	6.28%
	Over 25 years	19	9.18%
	Total	207	100.00%

Category	Class / Value	Number	Percentage
Student Status	First-cycle full-time	54	26.73%
	First-cycle part-time	48	23.76%
	Second-cycle full-time	39	19.31%
	Second-cycle part-time	61	30.20%
	Total	202	100.00%
Place of Residence	City	64	32.00%
	Village	116	58.00%
	City–Village	20	10.00%
	Total	200	100.00%

Source: Own elaboration based on conducted research

Due to the categorical nature of most demographic variables and the results of normality tests, the analysis employed descriptive statistics and non-parametric statistical methods. This approach is consistent with the research practice used in assessing disparities in the state of the natural environment of the Świętokrzyskie region, where synthetic measures are utilized to objectify ecological phenomena (Przybytniowski, Dziekański, Michalski, 2020).

Calculations for descriptive statistics were performed to characterize the distributions of quantitative variables (e.g., knowledge level, engagement indicators). The following were determined:

1. Arithmetic mean (a measure of central tendency).
2. Standard deviation (a measure of dispersion).
3. Coefficient of variation (V), which allowed for a percentage comparison of variability between different variables.
4. Skewness and Kurtosis (to evaluate the shape of the distribution).
5. Confidence intervals for means (typically at $p = 0.05$).

Due to the lack of data normality (confirmed by Kolmogorov-Smirnov, Lilliefors, and Shapiro-Wilk tests, where $p < 0.05$) and the categorical nature of most variables, parametric statistical methods (i.e., Pearson correlation, Student's t-test, or ANOVA) were rejected. Consequently, only non-parametric statistical methods were used to verify hypotheses and examine relationships between variables:

1. Chi-square test of independence – used to examine the relationship between two qualitative variables (nominal or ordinal), e.g., between place of residence and level of pro-ecological engagement (Yule, 1900; Cramér, 1946; Cohen, 1988).

$$\chi^2 = \sum_{i=1}^k \sum_{j=1}^k \frac{(n_{ij} - \hat{n}_{ij})^2}{\hat{n}_{ij}} \chi^2 = \sum_{i=1}^k \sum_{j=1}^k \frac{(n_{ij} - \hat{n}_{ij})^2}{\hat{n}_{ij}} \quad (1)$$

where:

n_{ij} – observed counts,

\hat{n}_{ij} – theoretical counts.

The test statistic, under the assumption of true H_0 , follows a χ^2 distribution with $(k-1) \cdot (n-1)$ degrees of freedom (df).

The adopted significance level (p) for analyses was 0.05.

2. Mann-Whitney U test – applied to compare distributions of a quantitative variable in two independent groups (e.g., comparing knowledge level between women and men), being a non-parametric equivalent of the Student's t-test.
3. Kruskal-Wallis test – applied to examine differences between medians of a quantitative variable in more than two independent groups (e.g., comparing perceptions of transformation costs depending on study status). This test is a non-parametric equivalent of one-way ANOVA.
4. Spearman's rank correlation coefficient (ρ) – used to examine monotonic (not necessarily linear) relationships between two variables when their distributions are not normal. This coefficient is a non-parametric equivalent of the rejected Pearson correlation.

For examining linear relationships between two quantitative variables with distributions close to normal (if such a situation occurred after transformation or for selected variables), the parametric Pearson correlation coefficient would be adopted.

The adopted significance level for all analyses was 0.05. When $p < 0.05$ was obtained, the null hypothesis (H_0) was rejected in favor of the alternative hypothesis (H_1).

Statistical analyses were performed using Statistica v13.3 software.

The literature review revealed a wide range of studies on global trends and local actions. However, there is a clear gap in detailed research that comprehensively links global transformation trends with local awareness and student perception in a specific, less-studied region such as the Świętokrzyskie Voivodeship (Zaręba, Ziemiańska, 2020).

Existing studies often focus on global perspectives, general society, or agglomerations. There is a lack of research analyzing how the young generation (students) from a region with specific conditions identifies challenges, understands their local manifestations, and perceives transformation barriers and opportunities.

This study aims to fill this gap. Analysis of responses to research questions (e.g., Q1: "How well does your environment understand the importance of green transformation?", Q5: "How do you assess your level of knowledge about ecological transformation?") will allow for a detailed determination of the level of awareness and understanding among students.

This combination of global perspective with local experience, filtered through the prism of a young, educating social group in a specific region, constitutes an original contribution to the literature and will provide valuable data for local authorities and educational institutions, supporting transformation in Poland.

Chapter 1.

Green transformation: global conditions and analysis of opportunities and challenges in the region (using the example of the Świętokrzyskie Voivodeship)

1.1. Global impulses and political frameworks of green transformation

The current green transformation constitutes one of the most dynamic and fundamental processes in global policy and economy, redefining civilizational development paradigms (Sachs, 2015). Its driving force stems both from growing awareness of existential climate and environmental threats and from the conviction of the economic and social possibility of building a more sustainable and resilient future (Stern, 2007). Global political and technological frameworks set directions that have profound implications for national strategies and local economies worldwide. The catalyst for global green transformation is international agreements and political initiatives that provide frameworks for national emission reduction strategies and sustainable development (Keohane & Victor, 2011). This transformation is a comprehensive process of transitioning from a fossil fuel-based economy and linear model (“take-make-dispose”) to a low-emission economy and circular economy (CE), requiring massive investments in renewables, energy efficiency, and digital innovations.

A key document in this regard is the Paris Agreement (2015), whose primary goal is to limit the increase in average global temperature well below 2°C relative to pre-industrial levels. For Europe, the key strategy is the European Green Deal (2019), which aims to make the continent climate-neutral by 2050 (European Commission, 2019). Implementation is supported by the “Fit for 55” package and the Recovery and Resilience Facility (RRF), which serves as a key source of transformation financing. Global trends are expressed in several key sectors: energy transformation and renewables (IEA, 2023), the circular economy (Geissdoerfer et al., 2017), and the transport sector, which is undergoing dynamic electrification and seeking alternative fuels.

For Europe, the key strategy is the European Green Deal (EGD, 2019), which aims to make the continent the first climate-neutral by 2050 (European Commission, 2019). EGD implementation is based on a comprehensive package of regulations and financial instruments, including:

1. The “Fit for 55” package – a set of legislative proposals aimed at achieving at least 55% reduction in greenhouse gas emissions by 2030 (compared to 1990 levels);
2. The Recovery and Resilience Facility (RRF) – supports large-scale green investments, serving as a key source of transformation financing in member states.

Global green transformation trends are expressed in profound ecological changes in several key economic sectors (IEA, 2023):

1. Energy transformation and renewables represent the most dynamic area of transformation, characterized by rapid development and cost reduction of renewable energy sources (RES), especially photovoltaics and wind energy. Investments in energy storage technologies and the development of smart grids are growing in parallel (Sioshansi (ed.), 2012; Kirchherr, Reike, & Hekkert, 2017).
2. The circular economy (CE) represents a radical departure from the traditional linear “take–make–dispose” model toward waste minimization, focusing on reuse, recycling, and regeneration (Geissdoerfer, Savaget, Evans, 2017).
3. The transport sector is undergoing transformation through dynamic vehicle electrification and the development of low-emission mobility, seeking alternative fuels (e.g., green hydrogen and ammonia). These trends are complemented by the smart cities concept, which integrates digital technologies with ecological solutions, creating energy-efficient and low-emission urban environments. In hard-to-decarbonize sectors (aviation, shipping), alternative fuels (e.g., green hydrogen and ammonia) are being sought.

Economically, the transformation generates new markets and jobs and focuses on decoupling – the potential for economic growth unrelated to increasing natural resource consumption (Hickel, Kallis, 2020). Socially, it has the potential for significant improvement in quality of life through pollution reduction (Haines, 2017). Strategically, the transformation increases state energy security (Kruyt et al., 2009). Nevertheless, the transformation may involve initial costs for consumers and require adaptation of entrenched consumption habits.

1.2. Dimensions of Green Transformation

Green transformation is a multidimensional concept, encompassing fundamental changes in economic, social, and technological systems (D’Amato et al, 2017; D’Amato & Korhonen, 2021; D’Amato, 2021; Merino-Saum et al., 2019). For the Świętokrzyskie Voivodeship, a region with a rich industrial history related to raw material extraction and construction materials, it constitutes both a significant challenge and a substantial opportunity. Local challenges are associated with the inertia of traditional sectors and the need for structural restructuring of energy-intensive industry (Domański, 2022ab; Adamowicz, 2021a; 2021b; Borys, 2016a; 2016b).

For the Świętokrzyskie Voivodeship, a region with a rich industrial history, particularly related to raw material extraction (e.g., limestones, gypsums) and production of construction materials, green transformation constitutes both a significant challenge and a substantial opportunity. Local challenges are associated with strong inertia of traditional sectors and the need to create alternative development paths through: education and raising social awareness, the necessity of

transforming traditional industrial sectors, and developing the potential of renewable energy sources. Green transformation constitutes a structural challenge for the Świętokrzyskie region, resulting from the need to restructure energy-intensive construction materials industry (cement plants, lime plants) and the need to manage water resources in the face of increasingly frequent droughts. At the same time, the region, thanks to significant RES potential and location, has unique adaptive potential. It must be implemented in accordance with the normative paradigm of just transition (JT), which is a sine qua non condition for its long-term acceptance and social stability (ILO, 2015: <https://www.ilo.org>; update date: 08.11.2025). This concept goes beyond mere restructuring of employment in the coal industry, becoming an overriding goal of EU climate policies (embedded in EGD and EU funds for green transformation).

In the social dimension, a critical but often overlooked aspect is transport poverty. The Świętokrzyskie region faces significant communication exclusion in many peripheral areas. As noted in regional analyses, green transformation — particularly the push for electromobility — without a simultaneous improvement and decarbonization of public transport, may deepen social inequalities. If the transition focuses solely on private electric vehicles, it risks marginalizing lower-income groups who lack access to expensive technology and adequate charging infrastructure, thus exacerbating “mobility poverty” (Urge-Vorsatz et al., 2020).

Therefore, the transformation must follow the paradigm of JT. Theoretically, it is based on three pillars of justice:

1. Distributive justice, involving equal distribution of benefits (e.g., clean air, cheap energy) and mitigation of negative effects (e.g., risks of energy poverty, job losses) for the most vulnerable groups.
2. Procedural justice, related to including local communities in decision-making processes regarding allocation of funds and choice of investments, key to minimizing local resistance (NIMBY) and building trust.
3. Corrective/restorative justice, involving repair of historical and environmental damages (e.g., reclamation of post-industrial areas in the Świętokrzyskie Voivodeship).

The success of implementing local transformation projects is directly dependent on social acceptance (Wüstenhagen et al., 2007). A key contribution of Wüstenhagen and colleagues was organizing and expanding the previously often too narrow understanding of social acceptance and proposing a three-dimensional model of acceptance, which serves to identify where exactly the problem lies: in technology, policy, or community (Table 2).

Table 2. Three dimensions of acceptance

Dimension of acceptance		Definition	Examples in the context of GT
I	Socio-political acceptance	Acceptance of policies, technologies, and institutions related to GT at national or regional level.	Acceptance of EGD, subsidy systems, or national climate targets.
II	Market acceptance	Acceptance of products by consumers and investors.	Willingness to purchase EVs, PV panels, or green bonds
III	Local acceptance	Acceptance of specific investments in a particular location.	Lack of opposition to a wind farm or biogas plant nearby

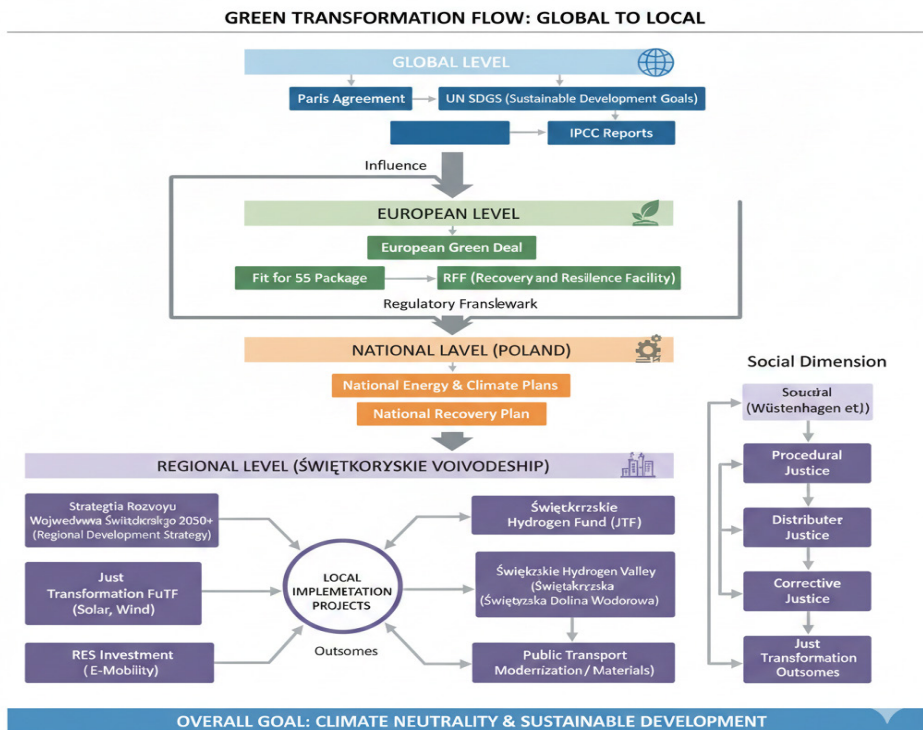
Source: Own elaboration based on Wüstenhagen et al. (2007, pp. 2683-2691).

This model is methodologically important because:

1. It separates NIMBY, allowing distinction between local acceptance and broader socio-political acceptance.
2. It emphasizes justice, linking local acceptance with procedural and distributive justice.
3. It connects dimensions, informing that local success depends on an appropriate base in policy and technology dimensions.

The structural dependencies between global climate objectives and their regional implementation in the Świętokrzyskie Voivodeship are presented in the diagram below (Figure 1). As shown in the figure, the success of local implementation projects depends not only on top-down regulatory frameworks but also on the social dimension, including distributive and procedural justice.

Figure 1. Green transformation flow: from global impulses to local implementation



Source: Own elaboration based on: European Commission (2019); Development Strategy of the Świętokrzyskie Voivodeship 2030+ (Strategia Rozwoju Województwa Świętokrzyskiego 2030+, 2020); Wüstenhagen et al. (2007).

1.3. Barriers and Threats in the Implementation of Green Transformation

The complex process of energy and climate transformation, although determined by global impulses, encounters significant obstacles at the local implementation level, particularly in social and political spheres (IPCC, 2022; Khan et al., 2022). Effective implementation requires not only overcoming social resistance but also ensuring the consistency and stability of the decision-making apparatus.

At the social level, the NIMBY syndrome remains a primary barrier to RES projects (Wüstenhagen et al., 2007). From a political perspective, a lack of long-term coordination and regulatory instability (Midttun, 2018a) weakens investor confidence. In the Świętokrzyskie Voivodeship, these issues are compounded by

high initial costs for SMEs and the risk of stranded assets in traditional, energy-intensive industries.

Technologically, energy grid limitations act as a “bottleneck” — the current infrastructure often cannot accept new distributed RES capacities (Wiśniewski & Koćmirowska, 2023ab). Furthermore, the deficit of qualified personnel in the green jobs sector may slow down the implementation of innovative solutions, especially in the less urbanized parts of the region.

Social challenges of transformation:

Barriers of a social nature focus on acceptance of costs, risks, and direct impact of new investments on the quality of life of local communities (Sovacool, Drupady, 2018). The most visible problem is the NIMBY syndrome (Not In My Back Yard). This phenomenon manifests in local protests against RES projects, such as wind farms or biogas plants, despite general acceptance of the idea of energy transformation. Opposition is often motivated by aesthetic concerns, acoustic nuisance, or potential decline in property values in the immediate vicinity of the investment (Wüstenhagen, Wolsink, Bürer, 2007). Equally important is the risk of energy poverty. The costs of green transformation, especially in its initial phase (e.g., infrastructure investments, energy price increases), may lead to increased energy poverty, particularly affecting lower-income households. Formulating and implementing effective, targeted protection mechanisms and JT programs is an ethical and political imperative (Urge-Vorsatz et al., 2020).

Political-institutional conditions:

The effectiveness of the transformation is directly dependent on the quality of political coordination and long-term strategic consistency (OECD, 2023: <https://www.oecd.org>; update date: 08.11.2025). A key challenge is political fragmentation and lack of coordination. As research indicates, insurance constitutes a key form of ecological risk transfer, which allows for financial stabilization of local governments in the face of unforeseen consequences of climate change (Przybytniowski, Dziekański, Kusto, 2024). The transformation process requires the involvement of many actors and levels of governance – from global to local. The lack of a lasting, cross-party political consensus on the key directions of transformation, as well as insufficient coordination between individual levels of administration, significantly slows down the decision-making process (Kettl, 2015). Furthermore, regulatory and institutional instability is demotivating. Frequent changes in legal frameworks and support programs, including the instability of guaranteed tariff systems or subsidy mechanisms, weaken investor confidence (both private and individual). The lack of regulatory predictability leads to the withholding of long-term investments (Midttun, 2018b).

Nevertheless, awareness of these institutional gaps forces public intervention aimed at strengthening coordination mechanisms and establishing long-term legal frameworks to reduce investment risk and increase social trust.

Economic and financial barriers:

Implementing green technologies requires significant financial resources. The primary barrier is high initial investment and infrastructure modernization costs, often inaccessible to small and medium enterprises (SMEs) and local governments. At the same time, transformation involves the risk of stranded assets, i.e., premature withdrawal of fossil fuel-based assets. This can lead to financial losses and social conflicts in regions traditionally dependent on these sectors. Additionally, regulatory and price uncertainty is a deterring factor. Energy price volatility and unclear or frequently changing legal regulations (e.g., connection conditions, distance act) discourage private investors from long-term transformation projects.

Technological and infrastructural barriers:

There are also key technical bottlenecks. Energy grid limitations are common – transmission and distribution infrastructure is often not adapted to accepting large, distributed RES capacities, requiring costly modernizations or rejection of connection applications. Related to this is the need for storage technology development. Instability of energy production from sources like wind or sun requires further development and commercialization of efficient and cheap energy storage systems (e.g., batteries, hydrogen) for system stabilization. The last but significant challenge is the deficit of personnel and know-how. Lack of qualified specialists (engineers, installers, advisors) in green technologies constitutes a real bottleneck in implementing innovative solutions, especially in less urbanized regions.

Successful regional implementation of green transformation, including in the Świętokrzyskie Voivodeship, is a comprehensive process requiring a holistic and interdisciplinary approach. Success depends on the ability to actively manage social conflict and ensure that transformation benefits are fairly distributed.

1.4. Opportunities for the region in the context of green transformation

Green Transformation is a driver of investments that can break the traditional inertia of the Świętokrzyskie region. According to the Development Strategy of the Świętokrzyskie Voivodeship 2030+, the region aims to increase its energy self-sufficiency and innovation potential.

A flagship example of technological opportunity is the Świętokrzyskie Hydrogen Valley. This initiative, based on a regional hydrogen cluster, aims to utilize RES for “green hydrogen” production. This is a strategic chance for the region’s energy-intensive industry (e.g., cement plants) to decarbonize and for the transport sector to introduce hydrogen-powered public fleets, addressing both emission targets and communication exclusion.

Economic opportunities include the inflow of funds from the Just Transition Fund (EU funds for green transformation) and RRF. These funds support the creation of “green jobs” in RES sectors and energy consulting (Domański, 2022ab). Moreover, the region can leverage its natural assets (Świętokrzyski National Park) for sustainable ecotourism, strengthening the brand of a clean and innovative region.

Economic and investment opportunities:

The most important opportunity is the inflow of structural and investment funds. Regions with traditional industrial structures have priority access to the EU funds for green transformation, funds under the National Recovery Plan (NRP), and EU cohesion policy. These funds constitute capital necessary for implementing key projects, such as reclamation of post-industrial and post-mining areas, transforming them into green areas or new investment zones, as well as investments in renewable energy sources (RES), which will reduce energy costs for local enterprises. In parallel, transformation favors the creation of new, high-tech sectors. Innovative value chains emerge, particularly related to energy storage technologies (batteries, hydrogen), smart energy management systems (smart grids), and development of the circular economy (CE), which is particularly important for the construction materials industry (innovative recycling). In the context of European regulations, the decarbonization requirement forces local companies, such as cement plants, to invest in energy-efficient processes and advanced CCS/CCU technologies (carbon capture and utilization), which, although initially costly, lead to long-term industrial competitiveness growth by reducing operating costs and independence from expensive CO₂ emission allowances.

Social and market opportunities:

Green transformation is primarily an opportunity to enhance human capital and improve career prospects. Dynamic creation of “green” jobs (Green Jobs) occurs – in RES sectors (installers, service technicians), energy consulting, and environmental engineering. This process allows diversification of the local labor market and reduction of dependence on traditional, shrinking industries. A key support element is competency enhancement programs (reskilling/upskilling), financed from EU funds for green transformation, enabling professional retraining of workers from traditional sectors and minimizing the risk of structural unemployment. Moreover, improvement in quality of life and public health is a direct social benefit. Replacing old energy sources and industrial decarbonization translates into reduced air pollution (smog), directly lowering treatment costs and improving residents’ overall health.

Technological and innovative opportunities:

Transformation creates potential for the region to become a hub of innovation in selected green niches. The need to implement innovative solutions favors tech-

nology transfer and cooperation in R&D (Research and Development) between local universities (e.g., Kielce University of Technology) and enterprises. This can lead to the emergence of technology clusters focused on green construction, recycling materials, or energy storage technologies. In turn, increasing building energy efficiency through massive thermal modernization of public and private facilities (supported e.g., by the “Clean Air” program) not only reduces maintenance costs but also strongly stimulates the local construction sector. Finally, development of smart transport is an opportunity for modernizing urban mobility, including development of electric vehicle charging infrastructure and potentially hydrogen transport.

Environmental and image opportunities:

The last dimension of opportunities is the possibility of using the region’s natural assets to create a new, sustainable brand. The unique values of the Świętokrzyskie Mountains and Świętokrzyski National Park can be effectively used for developing ecotourism and sustainable tourism, characterized by high profitability and less sensitivity to economic fluctuations. Conducting active transformation and striving for environmental cleanliness contributes to strengthening the region’s brand – positioning Świętokrzyskie as a clean and innovative region improves its attractiveness for foreign investors and young residents valuing sustainable development. Ultimately, transformation actions ensure improvement in the state of natural resources, including active protection and regeneration of forests, waters, and soils, which is crucial for the region’s long-term resilience to climate change.

In summary, the analysis of global conditions and political frameworks (EGD, Paris Agreement) proves that green transformation is an inevitable and structured process. For the Świętokrzyskie Voivodeship, this transformation constitutes a balance of benefits and costs, where key barriers (NIMBY, initial costs) must be balanced by strategically utilized opportunities (EU funds for green transformation, CE, and ecotourism). The effectiveness of this transformation in the region depends on the ability of local authorities and communities to manage social conflict and implement the principle of JT, which will be analyzed in detail in subsequent chapters.

The analysis conducted in this chapter demonstrates that the green transformation is a multidimensional process, driven by global climate imperatives and structured by comprehensive political frameworks such as the Paris Agreement and the European Green Deal. For a region with a deep industrial heritage like the Świętokrzyskie Voivodeship, this transition represents a fundamental paradigm shift – moving from a resource-intensive, linear economy toward a low-emission, circular model.

The key conclusions from this chapter highlight a dualism of challenges and opportunities:

1. Strategic drivers – the influx of dedicated funding (EU funds for green transformation, RRF) and initiatives like the Świętokrzyskie Hydrogen Valley provide

the necessary fuel for decoupling economic growth from environmental degradation.

2. Critical barriers – the regional path is hindered by significant “bottlenecks,” including infrastructural limitations (power grids), the risk of stranded assets in the cement and lime industries, and social challenges such as transport poverty and the NIMBY syndrome.
3. The necessity of justice – the transition cannot be purely technical; its long-term viability depends on the JT framework, ensuring distributive, procedural, and restorative justice for the local community.

While chapter 1 established the “what” and “where” of the transformation – identifying the global impulses and the specific regional context – it also revealed that technical and financial solutions alone are insufficient. The persistence of social resistance and institutional inertia suggests that the transformation is a complex socio-technical shift.

To understand how these global pressures interact with local structures and why certain innovations succeed while others fail, it is necessary to apply a deeper theoretical lens.

Therefore, Chapter 2 will move from the descriptive analysis of trends to a systemic perspective, utilizing the Multi-Level Perspective (MLP) framework to explore the dynamics between global “landscapes,” regional “regimes,” and local “niches”.

Chapter 2.

Green transformation in a region with specific conditions

2.1. Theoretical frameworks of regional transformation

The green transformation is increasingly analyzed in scientific literature not as a linear technical change, but as a socio-technical transition that requires deep structural reorganization (Bachtler et al., 2017). This process is fundamental to building tailored regional resilience – the ability of a local system to not only withstand environmental shocks but to proactively adapt its economic and social structures to new global paradigms (Markard et al., 2012, pp. 955-967):

1. Post-industrial regions – these areas face the challenge of path dependency. Historical success in traditional sectors (e.g., mining) often leads to regional lock-ins, where existing infrastructure and institutional mindsets resist change. Transformation here acts as a revitalization strategy to break the “regression spiral” by creating green jobs and attracting sustainable investments (Rogge & Reichardt, 2016).
2. Agricultural regions – transformation is viewed through the water-food-energy nexus. The focus is on integrating biological cycles with technological innovations, such as biogas and RES-based smart irrigation, to ensure food security while mitigating climate-induced droughts (Antrop, 2004).
3. Urban regions – these serve as laboratories for the Smart City concept. The goal is to integrate digital technologies with ecological management, focusing on transport decarbonization and building energy efficiency (Dirks et al., 2018ab).

To clarify these differences, the following table summarizes the transformation focus across these archetypes (Table 3).

Table 3. Comparison of transformation priorities by region type

Region type	Primary driver	Key technology	Main barrier
Post-industrial	Economic diversification	Hydrogen, CCS/CCU)	Path dependency / stranded skills
Agricultural	Resource circularity	Biogas, smart irrigation	Dispersed infrastructure
Urban	Quality of life / efficiency	Smart grids, e-mobility	Density / high energy demand

Source: Own elaboration based on Bachtler et al. (2017) and Rogge & Reichardt (2016).

Understanding these regional nuances is essential for designing and implementing green transformation that is not only effective but also just and adapted to local conditions. This allows regional development in a sustainable way, counteracting negative effects of uncontrolled suburbanization and environmental degradation, while offering revitalization strategies for shrinking cities.

For scientific analysis of complex, long-term changes such as green transformation, the multi-level perspective (MLP) is often used (see Geels, 2002). This model assumes that socio-technical transformation occurs through interactions between three levels:

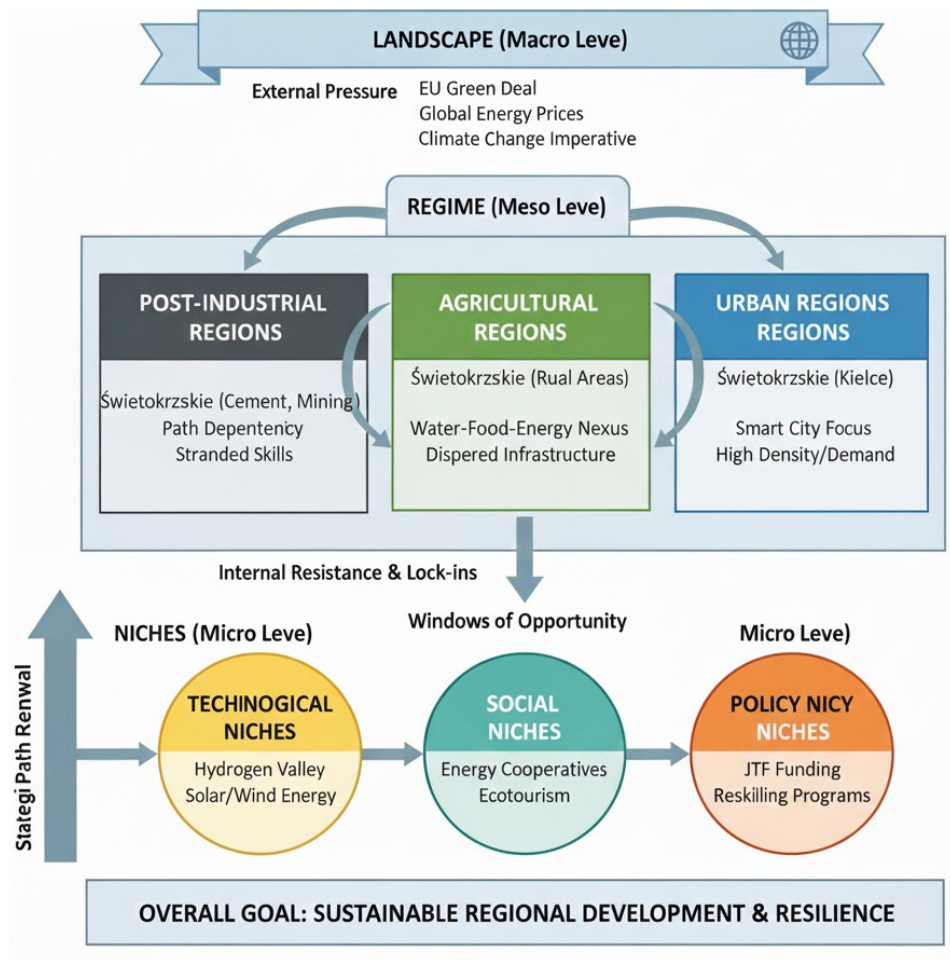
1. Landscape – external macro-forces not directly controlled but exerting strong pressure (e.g., global Paris Agreement, EGD, rising CO₂ prices). These forces constitute an external imperative for change for the region.
2. Regime (socio-technical regime) – dominant, entrenched technological, institutional, and economic system (e.g., fossil fuel-based economy, traditional cement and mining industry in the Świętokrzyskie Voivodeship). The regime resists transformation (inertia).
3. Niches – local, bottom-up technological and social innovations (e.g., energy cooperatives, ecotourism development, green innovations in SMEs). Niches are drivers of change and constitute local laboratories for sustainable solutions.

The logic of regional transformation involves a “pincer movement”: landscape pressure weakens the regime’s stability from above, while innovative niches provide the viable alternatives to replace it from below.

Strategic path renewal:

The integration of regional typologies into the MLP framework reveals that transformation is a localized process of path renewal (Hassink, 2010ab). In the Świętokrzyskie context, the ‘Landscape’ provides the window of opportunity, but the ‘Regime’ acts as a filter. Therefore, regional policy must act as a bridge, ensuring that ‘Niches’ are not isolated experiments but are systematically integrated into the evolving regional economic structure, thereby overcoming the structural inertia described in the regional lock-in model (Figure 2).

Figure 2: Integrated framework: regional archetypes within the multi-level perspective (MLP)



Source: Own elaboration based on: Geels (2011); Bachtler, Begg, & Wislade (2017); and Hassink (2010ab).

The figure above illustrates the intersection of regional archetypes within the Multi-Level Perspective. While Landscape pressures (such as the European Green Deal or global energy price volatility) are universal and act as external shocks to all systems, the response of the Regime is not uniform.

In the Świątokrzyskie Voivodeship, the regime’s resistance is heavily dictated by its historical path dependency. For instance:

1. In industrial zones (e.g., around cement plants), the regime relies on heavy infrastructure and specialized labor, making it more resistant to change due to “stranded skills.”
2. In agricultural zones, the regime is characterized by dispersed land ownership, requiring different institutional adjustments for bio-energy adoption.

Furthermore, the success of Niches is determined by their strategic alignment with local structural conditions. A niche like “Green Hydrogen” (Hydrogen Valley) has a higher chance of scaling if it directly addresses the decarbonization needs of the existing industrial regime while utilizing landscape-level financial support (EU funds for green transformation).

2.2. The role of local awareness in the success of transformation

Local awareness of global challenges related to green transformation is a key success factor (Geels, 2014ab). Residents’ and local communities’ readiness to accept changes is directly related to understanding the complexity of global trends, such as climate change. A dissonance is often observed: global problems are generally known, but their direct connection to daily life is often unnoticed, constituting a significant barrier.

Table 4: Dimensions of local awareness and their impact on transformation

Dimension	Focus area	Transformation impact
Cognitive	Knowledge of climate change and European Green Deal policies.	Foundation for rational support; counteracts misinformation and fake news.
Affective	Emotional connection to local nature, health, and quality of life.	Drives personal engagement and willingness to change long-standing habits.
Conative	Readiness to adopt RES technologies or support local green taxes.	Direct fuel for niche implementation (e.g., joining energy cooperatives).
Institutional	Trust in local government, EU financial tools, and fair fund distribution.	Determines the level of NIMBY (resistance) vs. PIMBY (community support).

These dimensions directly inform the construction of the survey instrument used in the empirical part of the study.

Source: Own elaboration based on Wolsink (2018) and Geels (2014).

Identification of global-local connection:

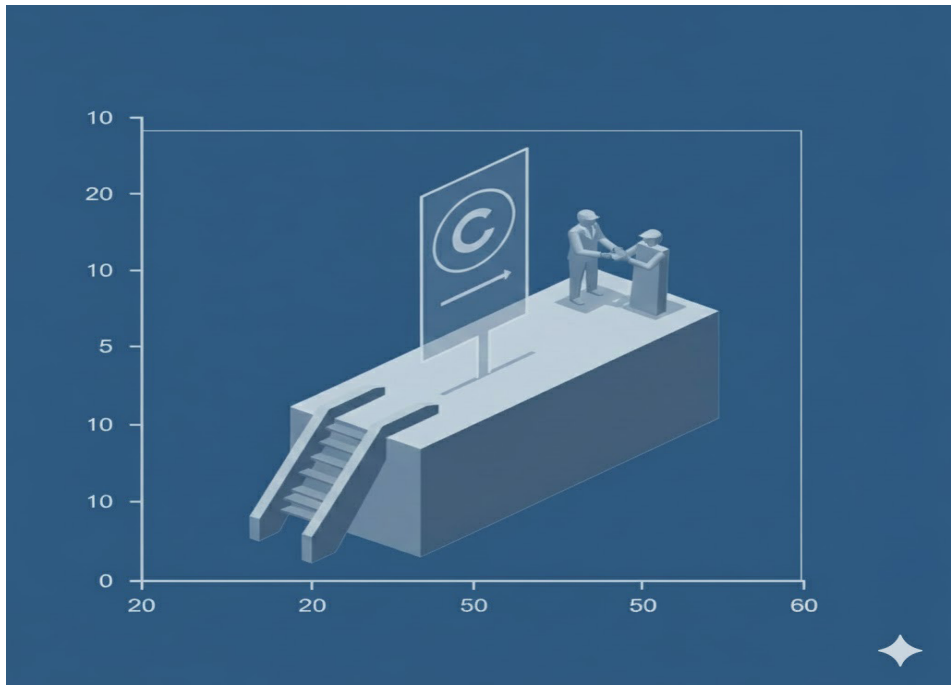
A key element is the ability to perceive a direct connection between global problems and their local manifestations – a process known as localization of the landscape. For residents of the Świętokrzyskie Voivodeship, abstract global temperature increases are less motivating than the tangible observation of regional droughts affecting local crops or intense precipitation causing flash floods in urbanized areas.

When residents perceive smog not just as a local nuisance, but as a symptom of an outdated global energy paradigm, their support for decarbonization shifts from passive to active. This “sense of place” transforms global mandates into local responsibilities.

The process by which global transformation goals translate into local reality is not immediate; it follows a cascading logic of social acceptance, as illustrated in Figure 3. This mechanism consists of five critical stages that determine the success or failure of regional initiatives:

1. Global Landscape Awareness — the foundational stage where residents acknowledge macro-scale pressures, such as the climate crisis or international decarbonization mandates (e.g., the Paris Agreement).
2. Local Impact Perception – this is the “localization” of the landscape. Awareness is strengthened when abstract global data is linked to tangible regional phenomena, such as water scarcity in the Świętokrzyskie agricultural zones or air quality issues in industrial hubs.
3. Policy Legitimacy – at this stage, the community evaluates whether international and national frameworks (like the EU funds for green transformation) are fair and necessary for their specific region. Without trust in these policies, the process stalls.
4. Knowledge of Local Initiatives – this involves specific awareness of regional projects, such as the development of the “Hydrogen Valley” or local heat pump subsidy programs.
5. Community Engagement – the final stage represents the shift from passive acceptance to active participation. Successful navigation through these stages effectively minimizes NIMBY (Not In My Backyard) sentiments and fosters PIMBY (Please In My Backyard) attitudes, which are essential for the scaling of innovative niches.

Figure 3. The cascading mechanism of local acceptance for green transformation



Source: Own elaboration based on Geels (2014ab) and Wolsink (2018).

Understanding the impact of international policies:

It is also important to understand how international policies (European Commission, 2019: date: 10.11.2025) translate into specific requirements, investments, or opportunities in the municipality or county. Awareness of the impact of these programs on emission standards, access to funds for thermal modernization, or RES development plans is crucial. When residents see concrete benefits from global decisions, their acceptance and engagement significantly increase.

Knowledge and acceptance of local initiatives:

The last aspect is assessment of knowledge and acceptance of local initiatives (construction of photovoltaic farms, subsidy programs for heat pumps, expansion of bicycle paths). It is necessary to examine attitudes toward these projects – whether they are perceived as beneficial or encounter resistance (NIMBY). High level of acceptance is a strong indicator of deeper awareness of global challenges and readiness for action.

2.3. Local ecological challenges as a manifestation of global trends

The green transformation at the regional level is not merely an administrative requirement but a response to the “localization of the landscape.” Local awareness of global challenges acts as the “social glue” that binds technical solutions with community support (Geels, 2014ab). However, the primary obstacle remains psychological distance — the tendency of residents to perceive climate change as a remote threat. Bridging this gap requires framing local ecological issues as direct manifestations of global systemic shifts.

The Global-Local environmental nexus:

The transition requires a shift from perceiving ecological issues as isolated incidents to seeing them as part of a global structural change. This is best illustrated by the following key areas:

1. Air quality (Smog) – smog is often the most tangible local driver for change. However, for a successful transition, residents must link it to the global energy paradigm. Understanding that poor air quality is a symptom of fossil fuel dependency – rather than just a weather-related nuisance – legitimizes investments in energy efficiency and decarbonization (Janssen et al., 2011).
2. Waste management – this area serves as the gateway to the Circular Economy (CE). Daily segregation habits are the micro-foundation of a global trend toward resource decoupling. Perceiving waste not as “trash” but as a “secondary resource” is crucial for regional sustainability.
3. Sustainable transport – everyday struggles with congestion and emissions are local manifestations of an outdated transport regime. The development of bicycle paths and e-mobility must be framed as part of the global mobility transformation (Sorensen, 2015).

To better understand these connections, the following table maps local challenges to their global drivers and the desired regional response (Table 5).

Table 5. Mapping local challenges to global trends

Local challenge	Global manifestation	Regional strategic response
Smog / air quality	Fossil fuel-based energy regime	Thermal modernization & RES subsidies
Linear waste model	Global resource depletion	Circular economy & industrial symbiosis
Congestion / emissions	Internal combustion engine (ICE) dominance	Public transport & e-mobility infrastructure
Water scarcity	Global climate change impacts	Smart irrigation & small-scale retention
Local challenge	Global manifestation	Regional strategic response

Source: Own elaboration based on Janssen et al. (2011) and Sorensen (2015).

The local dimension of transformation is crucial for its global success, as real change implementation occurs at the community level (Sorensen, 2015):

1. Role of local governments and participation – local governments, being closest to residents, serve as system integrators within MLP. On one hand, they are responsible for implementing landscape policies (e.g., distribution of EGD/EU funds for green transformation), on the other – they must manage regime resistance (e.g., spatial conflicts, bureaucracy). However, the key role is supporting niches and achieving effective social participation, which is a sine qua non condition for success. Active societal participation, especially in planning RES investments, is key to minimizing social conflicts and preventing NIMBY phenomenon, directly strengthening regional social resilience to changes.
2. Building resilience – the local dimension builds resilience to global shocks (climate change, energy crises). Investments in local RES and circular economy reduce dependence on external supplies and systems, preventing region shrinkage.
3. Local barriers and opportunities:
 - a) barriers – social resistance (NIMBY), lack of resources (financial and human), bureaucratic barriers. This resistance weakens social resilience and can drive the regression spiral.
 - b) opportunities – proximity of problems favors local social innovations (energy cooperatives, food banks).

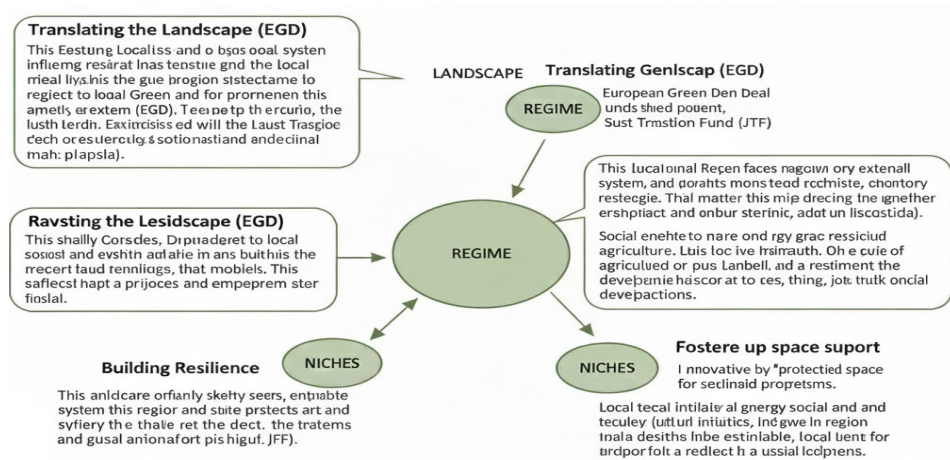
The success of the transformation in regions like Świętokrzyskie depends on the balance between barriers and opportunities. While social resistance and lack of human capital (stranded skills) act as significant hurdles, the proximity of problems often favors rapid social innovation. Bottom-up movements can become laborato-

ries for sustainable solutions, allowing for the testing and scaling of innovations before they are implemented at a national level (Raman et al., 2025 pp. 1-20).

As shown in Figure 4, the local government acts as a system integrator within the Multi-Level Perspective. Its position is strategic:

1. From above (Landscape) – it translates global and EU imperatives (like the European Green Deal) into local investment plans.
2. Against the regime – it must navigate and overcome institutional inertia, such as bureaucratic barriers and established industrial interests that resist change.
3. From below (Niches) – it provides the necessary “protected space” for niches to grow, supporting local initiatives like energy clusters or social innovations that eventually replace the old regime.

Figure 4. Local government as a system integrator within the MLP framework



In Figure 4: Total government assume gorenens on System Intestan muticuis. MLP rwithie role an ilccerates the system, the MLP Franspematoint integratori, Lces a susths corned undaturs an a longustin in stritlial coral elssontable, lne lusilewæ toll det for of the secure al abey loruaf moled. Eoninal guntem, wveslinen's ort the successinites yob trananog; intlesioole r oa successsue, transfoural system, rede molasiter suram at a regiistiny enusforming an tepiune foroportwitis for regional path renewal.

Source: Own elaboration based on Sorensen (2015) and Raman et al. (2025).

2.4. Regional conditions of the świętokrzyskie voivodeship in the light of a multi-level perspective

The Multi-Level Perspective (MLP) constitutes an effective analytical framework for understanding the complexity of transformation in the Świętokrzyskie Voivodeship (Geels, 2002; 2011). This region is characterized by a unique di-

chotomy: on one hand, historical embedding in mining and heavy industry; on the other, high natural and agricultural potential. Applying MLP allows for defining the dominant system, external forces, and directions of desired innovations, preventing the risk of the voivodeship's degradation to the status of a "place that doesn't matter" (Rodriguez-Pose, 2018).

Landscape. external pressure:

The landscape includes macro-forces exerting pressure on regime change but not directly controlled by regional authorities:

1. European Green Deal (EGD) and EU Climate Policy – constituting the main decarbonization imperative, forcing a departure from high-emission industries (energy and cement sectors). The establishment of the EU funds for green transformation is a direct landscape response to the risk of regime disintegration.
2. Global energy shocks – instability in fossil fuel markets and energy price increases enhance the economic rationality of investments in local RES, acting as a powerful incentive to break inertia.
3. Social and image pressure – growing ecological awareness (especially regarding smog) and ESG reporting requirements create external transparency and a mandate for change for companies operating in the region.

Socio-technical regime: dominance and inertia:

The regime is the entrenched dominant system posing the greatest resistance to transformation, which must be destabilized under pressure. In the Świętokrzyskie region, this regime struggles with so-called regional lock-ins (Hassink, 2010b):

1. Dominance of Traditional Industry – regional inertia is rooted in mining and cement plants. As indicated by the data in table 6, the high share of "brown" employment generates a risk of creating marginalized "lagging regions" (Rodriguez-Pose, 2018). This dominance is often supported by strong local institutional ties that prioritize the status quo over radical change.

Table 6. Sensitivity indicators of the socio-technical regime in the świętokrzyskie voivodeship

Indicator	Świętokrzyskie	National average (Poland)	Analytical conclusion
Industrial Energy Consumption (kWh/capita)	~2,800	~1,950	High energy intensity of the regime (cement, minerals).
Economy Emissivity (kg CO ₂ / 1,000 PLN GDP)	~0.85	~0.62	Higher dependence on fossil fuels than the national average.
Employment in „Brown” Sectors (%)	~12%	~8%	High risk of „stranded skills” and structural unemployment.
Regional Innovation Index (Rank)	12 / 16	–	High barriers for niche technologies to enter the mainstream.

Source: Own elaboration based on Statistics Poland (GUS, 2023) and World Bank reports on coal/ industrial regions.

2. The challenge of “Stranded Skills” – a key element of regime resistance is not just the physical infrastructure, but the people. As depicted in the “Institutional & Social Bonds” node of Figure 5, there is a real threat that the specialized competencies of workers (e.g., mining machinery mechanics) may become obsolete. Without rapid reskilling, the region risks losing its human capital, as workers with “stranded skills” are unable to transition into the green niches described later in this chapter.

The Figure 5 delineates the mechanisms of regional lock-in that obstruct the green transition in carbon-intensive industrial hubs. It demonstrates a path-dependent cycle where established industrial structures create a feedback loop reinforcing the current socio-economic state.

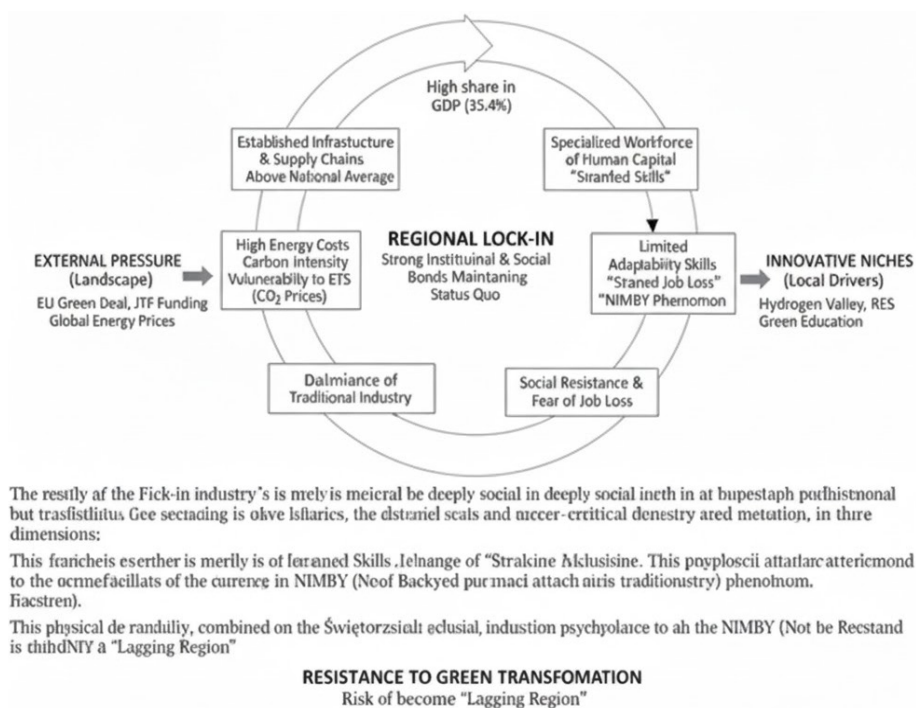
Key analytical points:

- 1) Human capital obsolescence – the model identifies the emergence of “stranded skills.” High workforce specialization within traditional sectors leads to limited adaptability, fostering social resistance and fear of economic displacement.
- 2) Socio-Institutional Inertia – strong institutional bonds and the maintenance of the *status quo* trigger the NIMBY (Not in My Backyard) phenomenon. This creates a barrier between external pressures (e.g., EU Green Deal, ETS

pricing) and the emergence of innovative niches like Hydrogen Valleys or RES-based education.

- 3) Risk of regional marginalization – the core of the problem lies in the inability to pivot from traditional industry dominance to sustainable alternatives. Without breaking this cycle, the region faces a high risk of becoming a “Lagging Region,” characterized by structural stagnation and loss of competitiveness in the low-emission global economy.

Figure 5. Resistance to green transformation



Source: Own elaboration based on Hassink (2010a), Rodriguez-Pose (2018).

3. Infrastructure and Spatial Planning – regime stability is further maintained by outdated power grids and entrenched high-emission habits. This physical dependency, combined with the psychological attachment to traditional industry, facilitates the occurrence of the NIMBY (Not In My Backyard) phenomenon, where local communities resist green investments (e.g., wind farms) due to perceived threats to the existing social order.

Innovative niches: local driver of change:

Niches are local technological and social innovations that have the potential to undermine regime stability:

1. RES technological niches – the development of photovoltaics, biogas plants, and projects like the Świętokrzyskie Hydrogen Valley act as laboratories for modern energy.
2. Social and educational niches – students, as “brokers of change,” constitute a critical niche. Their role involves transferring the new socio-technical paradigm to local administration and SMEs, which is crucial for the long-term success of the green transformation.

Confirmation of this are statistical data in the multi-level perspective – MLP (Table 7).

Table 7. Świętokrzyskie Voivodeship

MLP Element	Statistical Indicator	Value/Trend (authentic data)	Conclusions for Transformation
Regime (industrial inertia)	Share of industry and construction in voivodeship GDP	35.4% (2024 data, higher than national average 32%)	Confirms strong regime embedding in traditional high-emission sectors (cement, mineral processing, production), generating stranded assets and structural unemployment risk.
Regime (emissivity)	Economy emissivity (CO2 emission intensity per GDP unit in Świętokrzyskie Voivodeship)	Above national average (e.g., in 2023 8-10% higher)	Indicates high energy intensity of regional regime, making it particularly vulnerable to landscape pressure (ETS/CO2 price increase).
Landscape (financial pressure)	EU funds allocation – EU funds for green transformation for the region)	Allocated EU funds for green transformation for 2021-2027 make Świętokrzyskie Voivodeship the second region in Poland in terms of allocation	Confirms external landscape pressure (EU) and recognition of the region as critical for EU funds for green transformation are intended for mitigating regime effects and developing niches.

MLP Element	Statistical Indicator	Value/Trend (authentic data)	Conclusions for Transformation
Niches (RES potential)	Share of RES in electricity production balance	Growth from 12% in 2021 to ~18% in 2024 (mainly photovoltaics)	Indicates dynamic scaling of technological niches (mainly prosumer). Points to region potential for breaking regime resistance in energy.
Niches (human capital)	Number of students in GT-related fields (e.g., environmental protection, renewable energy, environmental engineering)	~15-20% increase in student numbers in 2022-2024	Confirms students' role as niche – local human capital ready for adaptation and creating “green professions”, crucial for lasting regime breakthrough.

Source: Own elaboration based on data from the Central Statistical Office (GUS), Ministry of Funds and Regional Policy (EU funds for green transformation), Energy Market Agency (ARE), and regional institutions (2024–2025).

The above data clearly illustrate MLP interactions in the Świętokrzyskie Voivodeship:

1. The regime is strong but costly – high industry share and emissivity prove the regime is deeply entrenched but expensive to maintain in light of climate policies.
2. The landscape is transformative – allocated EU funds for green transformation constitute strategic fuel for financing niches (e.g., through training and economic diversification) and thus controlled disruption of regime stability.
3. Niches are active – dynamic RES share growth (mainly photovoltaics) and increasing interest in green study fields indicate local technological and social innovations are present and constitute strategic potential for region-wide scaling.

The previous scientific analysis, based on the Multi-Level Perspective (MLP) framework, allowed precise embedding of global transformation impulses (Chapter I) in the structural context of the Świętokrzyskie Voivodeship (Chapter II). It was shown that the region is under strong landscape pressure (EGD, EU funds for green transformation) to depart from the dominant and costly regime based on high-emission industry. At the same time, active bottom-up niches (RES, human capital, ecotourism) were identified, constituting strategic potential for breaking inertia.

A key conclusion from the MLP analysis is that while transformation impulses and resources come from the global level (landscape), its real effectiveness and durability depend on process management at the local level. This necessity results

directly from JT principles (Chapter I), requiring social acceptance, procedural and distributive justice, and neutralization of barriers (NIMBY, competency deficit) identified in Chapter II.

Regional transformation thus boils down to the question of a development model that will allow local governments to effectively scale niches under strong regime resistance conditions.

Therefore, in chapter three, the authors move from structural analysis to normative and strategic framework. Focusing on the concept of local sustainable development, the next chapter will analyze how a holistic approach to economic, environmental, and social dimensions can constitute an operational strategy for regional and local authorities in Świętokrzyskie, enabling effective use of EU funds for green transformation resources and lasting achievement of green transformation goals.

The theoretical framework presented in this chapter, based on the Multi-Level Perspective (MLP), provides a comprehensive lens through which the green transformation of a region can be understood. The analysis indicates that the transition is not merely a technical shift but a complex socio-technical process involving three interactive levels: the Landscape (global pressures), the Regime (stable but rigid local structures), and Niches (local innovations).

The key findings of this chapter can be synthesized as follows:

1. The power of localization – the transformation’s success depends on bridging the “psychological distance” by framing global climate goals as solutions to tangible local problems, such as air quality and resource management.
2. The integration role – as illustrated in the cascading mechanism (Figure 4) and the integrator model (Figure 5), the local government occupies a pivotal position. It must simultaneously implement top-down mandates and nurture bottom-up social innovations while overcoming the inertia of the existing socio-economic regime.
3. Social resilience – building regional resilience requires shifting from passive acceptance to active community engagement. Reducing NIMBY sentiments through transparent participation is essential for transforming potential social resistance into a driver for regional growth.

In conclusion, the green transformation of a region – such as the Świętokrzyskie Voivodeship – requires a synchronized approach where institutional support meets community awareness. This theoretical foundation sets the stage for the subsequent empirical analysis of regional strategies and their alignment with these global-local dynamics.

The second chapter provided a theoretical and structural deep dive into the mechanics of regional change, utilizing the Multi-Level Perspective (MLP) as the primary analytical lens. The transition in the Świętokrzyskie Voivodeship has been redefined not as a simple policy implementation, but as a complex socio-technical struggle between entrenched systems and emerging innovations.

The key findings of this chapter emphasize three critical dimensions:

1. The structural conflict: The region is currently locked in a “pincer movement.” While the Landscape (EU climate mandates, EU funds for green transformation) exerts irresistible pressure from above, the local Regime – deeply rooted in energy-intensive mineral processing and cement production – exhibits significant inertia. This is manifested through “stranded skills” and institutional path dependency.
2. The localization of awareness – success depends on the cascading mechanism of acceptance (Figure 3). It was established that bridging the “psychological distance” is essential; residents support the green transition only when global climate goals are translated into local benefits, such as improved air quality or regional water security.
3. The local government as integrator – as shown in the integrator model (Figure 4), local authorities are the linchpin of the transformation. They must manage regime resistance (bureaucracy, NIMBY) while creating “protected spaces” for Niches – such as the Świętokrzyskie Hydrogen Valley or prosumer energy clusters – to scale and eventually replace the old regime.

The statistical indicators (Table 7) confirm that while the regime is costly and high-emissive, the niches are rapidly growing, particularly in the RES sector and green human capital. However, the theoretical identification of these forces is only the first step.

To move from structural analysis to actionable regional policy, we must define the normative framework that governs these changes at the municipal and county levels. Therefore, Chapter 3 will transition from the “how” of socio-technical transitions to the “what” of strategic implementation. It will explore the concept of Local Sustainable Development, analyzing how economic, environmental, and social pillars can be integrated into an operational strategy that empowers local governments to effectively utilize JT resources and achieve long-term regional resilience.

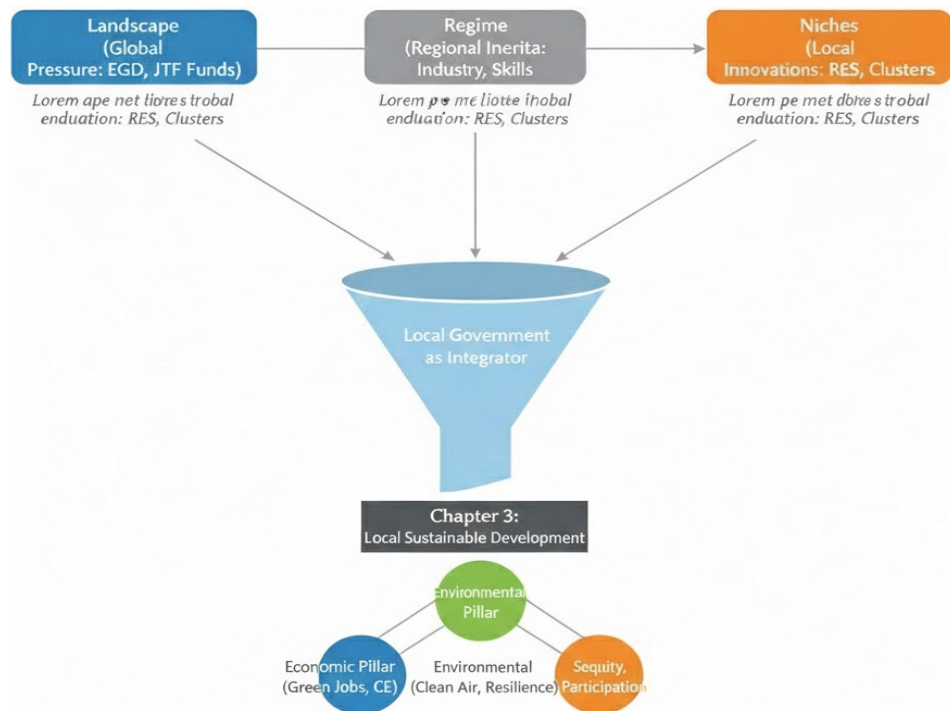
Figure 6 illustrates the strategic “funneling” process through which the theoretical components of the Multi-Level Perspective (MLP) are filtered and transformed into the practical pillars of Local Sustainable Development.

The mechanism consists of three distinct stages:

1. Input stage (MLP Framework) – landscape pressures – represents external forces such as the European Green Deal, EU funds for green transformation, and global climate mandates that provide both the necessity for change and the financial resources:
 - a) regime inertia – symbolizes the resistance of entrenched regional structures (e.g., the energy-intensive mineral and cement industries in Świętokrzyskie) that must be destabilized or restructured,
 - b) niche innovations – represents bottom-up initiatives (e.g., the Hydrogen Valley, energy cooperatives) that offer the technological and social solutions ready for scaling.

2. Integration stage (Local Government as a Processor) – In the center of the funnel, the Local Government acts as the primary system integrator. This stage represents the “operational bridge” where abstract global pressures and innovative niches are confronted with regional constraints. It is here that policy-making translates theoretical potential into administrative action.
3. Output stage (Local Sustainable Development) – the result of this process is the realization of a localized sustainable development model, structured around three mutually reinforcing pillars:
 - a) Economic pillar – focused on creating green jobs, increasing industrial energy efficiency, and diversifying the regional economy.
 - b) Social pillar – centered on community acceptance, distributive justice, and mitigating issues like transport or energy poverty.
 - c) Environmental pillar – aimed at tangible local improvements, such as air quality restoration, water retention, and the protection of the region’s natural ecosystems.

Figure 6. Conceptual bridge: operationalizing MLP dynamics into local sustainable development pillars



Source: Own elaboration based on Geels (2011), Sorensen (2015), and the Development Strategy of the Świętokrzyskie Voivodeship 2030+.

The synthesis of the “Regional Lock-in” model (Figure 6) and the “Conceptual Bridge” (Figure 5) provides a comprehensive framework for transitioning from structural diagnosis to actionable regional policy. While figure 6 illustrates the stagnation cycle, figure 5 defines the funneling mechanism required to overcome it.

Key synthesis points:

1. Overcoming regime inertia – Figure 6 identifies high energy costs and specialized “stranded skills” as core components of regional resistance. Within the MLP framework (Figure 5), these represent the “Regime Inertia” that must be destabilized. For regions like Świętokrzyskie, this means leveraging external landscape pressures (EU Green Deal) to decouple the economy from carbon-intensive mineral and cement industries.
2. The Local government as the operational bridge – the “Integration Stage” in Figure 5 is the missing link in the lock-in cycle. By acting as a system integrator, local governments can channel the “Innovative Niches” identified in Figure 6 (e.g., Hydrogen Valleys) into formal administrative strategies, effectively bypassing the NIMBY phenomenon and social fear of job loss.
3. From vulnerability to resilience – the transition from the input stage (external pressures) to the output stage (Local Sustainable Development) aims to transform a “Lagging Region” into a resilient ecosystem. Success is measured by the integration of the three pillars: diversifying the economy, ensuring distributive justice (mitigating energy poverty), and ecological restoration, thereby replacing the self-reinforcing loop of decline with a model of sustainable growth.

Chapter 3.

Local Sustainable Development in the Context of Green Transformation

The previous chapters have solidified the understanding of green transformation as a multi-level process – from global impulses and political frameworks (Chapter 1) to a theoretical analysis of socio-technical dynamics in a region with specific conditions, such as the Świętokrzyskie Voivodeship (Chapter 2). It has been demonstrated that the effectiveness of the transformation depends not only on landscape pressures and the potential of niches, but above all on the ability of local authorities to integrate these forces amid strong industrial regime inertia. Chapter 3 shifts the focus from structural analysis to the normative and strategic dimension, concentrating on the concept of local sustainable development as an operational model that enables municipal and county governments to effectively utilize EU funds for green transformation resources and durably achieve the goals of a green economy. In this way, green transformation ceases to be an abstract imperative and becomes a holistic strategy balancing economic, social, and environmental dimensions at the level closest to residents.

3.1. Conceptual foundations of green transformation

Sustainable Development constitutes the overriding principle, philosophical foundation, and fundamental paradigm guiding the entire green transformation process. It is commonly defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987). This concept, popularized internationally through the UN 2030 Agenda (UN, 2015), is inherently holistic. It moves beyond mere environmental protection by integrating three interrelated and equivalent pillars: the economic, the social, and the environmental (Borys, 2015). The essence of sustainable development in the modern era is not the halting of economic progress, but its radical reorientation toward respecting planetary boundaries while ensuring intergenerational equity.

In the specific context of green transformation, this principle serves as a strategic compass that indicates the direction of structural changes. It guarantees that all actions taken for decarbonization, the greening of the economy, and building long-term green resilience are consistent and serve the common good (Murray, Skinner, & Story, 2017; Gutiérrez, 2022ab). For regional and local authorities, particularly in industrial hubs with specific structural challenges like the Świętokrzyskie Voivodeship, this requires a decisive transition from theoretical discourse to an operational management model, as synthesized in Table 8.

Achieving intergenerational justice, however, is impossible without adopting realistic ecological frameworks. A key concept supporting the environmental pillar is that of Planetary Boundaries. This framework, introduced by the Stockholm Resilience Centre team (Rockström et al., 2009), identifies nine global environmental processes – including climate change and biodiversity loss – that regulate the stability and resilience of the Earth system. These boundaries define a “safe operating space” for humanity. As noted by scientists, exceeding these boundaries in several critical areas increases the risk of sudden, non-linear, and irreversible environmental changes (Steffen et al., 2015). The latest assessment confirms that seven out of nine boundaries have now been breached, with ocean acidification newly identified as transgressed, further heightening the risk of irreversible changes (Sakschewski et al., 2025).

Table 8. Operationalizing sustainability pillars in local governance

Pillar	Strategic objective	Local level instruments (e.g., EU funds for green transformation/FST)
Environmental	Protection of life-support systems	Thermal modernization, RES development, and blue-green infrastructure.
Economic	Building green competitiveness	Support for SMEs in Circular Economy (CE) and green innovation.
Social	Ensuring social cohesion	Reskilling programs for coal-sector workers and social dialogue.

Source: Own elaboration based on Borys (2005) and Jachimowski (2024ab).

In the transformation context, planetary boundaries constitute an absolute ecological imperative. This means that all economic development, including the implementation of new green transformation technologies, must operate within these biophysical limits to ensure long-term green resilience (Berkes et al., 2002). To effectively bridge the gap between these ecological limits and fundamental social needs, the transformation must follow the Doughnut Economics logic (Raworth, 2017). This model suggests that the goal is to bring humanity into the “doughnut” – a space where social foundations are met without overshooting the planetary ceiling (Figure 7).

The integration of the social pillar within this ecological framework is realized through the overriding principle of JT. This concept, which historically originated from North American trade union movements (Stark, Gale, & Murphy-Gregory, 2023ab), has gained global priority status, particularly within the framework of the European Union’s climate policy. Just Transition recognizes that the transition

to a low-emission economy generates significant social costs, such as the loss of traditional jobs in carbon-intensive sectors. These costs must be actively managed to prevent the deepening of regional inequalities and social exclusion (International Labour Organization [ILO], 2015).

As an operational strategy, the main goals of JT are:

1. Mitigating negative socio-economic effects – ensuring targeted support for vulnerable regions and industrial sectors through retraining programs and strategic investments in “green” jobs.
2. Participation and democratic dialogue – guaranteeing the active inclusion of workers, local communities, and marginalized groups in the decision-making processes regarding their future.

In this way, JT serves as a critical tool for achieving intragenerational equity. It ensures that the ecological transformation is not only environmentally effective and compliant with planetary boundaries but also socially acceptable, just, and beneficial at the local level closest to the residents.

Figure 7. Conceptual model of local green transformation



Source: Own elaboration based on Raworth (2017) and Rockström et al. (2009).

3.2. Key elements and function of sustainable development

The direction of green transformation, understood as a comprehensive and multi-faceted systemic change process, is determined by several fundamental elements of sustainable development. These elements do not function in isolation; rather, they create a coherent, mutually reinforcing, and resilient structure for strategic action. This structure is essential for navigating the complexities of transitioning from a resource-intensive economy to one based on circularity and climate neutrality.

The integration of dimensions and systemic resilience:

The first and perhaps most critical element is the integration of dimensions, often referred to as the “triple bottom line” or the three pillars of sustainability. This requires achieving a dynamic and precarious balance between economic growth, environmental protection (including the critical preservation of biodiversity), and social justice (Borys, 2015). In the contemporary research paradigm, the key to successful transformation is the decisive shift away from fragmented, sectoral thinking toward a truly systemic approach. In such a model, every economic decision is rigorously assessed for its potential long-term social and environmental impacts (Costanza et al., 2017).

This integration is fundamental for building environmental resilience. Neglecting any single aspect – for example, pursuing aggressive industrial decarbonization while ignoring the social costs of job losses – weakens the entire system’s ability to survive, adapt, and eventually regenerate. As demonstrated in regional studies, a lack of balance frequently leads to deep-seated social conflicts and public resistance to green investments. These tensions, in turn, act as significant barriers that slow down or even permanently prevent the implementation of necessary environmental reforms and infrastructure projects.

Resource efficiency, innovation, and the circular model:

The second pillar of this structure is **resource efficiency and the circular economy**. This involves the radical optimization of natural resource use, the minimization of waste and pollution at the source, and the active promotion of recycling and cascading reuse. This concept is inextricably linked to the Circular Economy (CE) – a regenerative model designed to eliminate the very concept of “waste” through superior product design, keeping materials in use at their highest value, and actively regenerating natural systems (MacArthur Foundation, 2015).

Reducing a region’s dependence on limited, virgin resources and lowering waste output directly translates into increased environmental resilience. By reducing the cumulative pressure on local and global ecosystems, the risk of key resource depletion is significantly mitigated (Murray, Skene, & Haynes, 2017).

Closely following this is the element of innovativeness, which serves as a cross-cutting catalyst for all sustainability dimensions. The operational role of these innovations, categorized by their systemic, economic, and social functions, is synthesized in Table 9. As shown, the development and implementation of cutting-edge technologies – such as advanced Renewable Energy Sources (RES), high-capacity energy storage, and zero-emission transport – act as the primary engines of transformation, providing the technical substrate for deep decarbonization.

Table 9. Operational elements of sustainable development in transformation

Key element	Strategic objective	Role in green transformation
Systemic integration	Dynamic balance of 3 pillars	Prevents „rebound effects” and sectoral conflicts.
CE & efficiency	Decoupling growth from resource use	Minimizes ecological footprint and builds resource security.
Social innovation	New collaborative business models	Enhances local community resilience and market adaptability.

Source: Own elaboration based on Borys (2015) and Jaffe et al. (2002).

However, as indicated in Table 9, innovation must be understood in a broad, non-linear sense: it encompasses not only technical progress (e.g., next-generation photovoltaic cells) but also social and institutional innovation. This includes new collaborative business models, green bonds, community-led energy sharing systems, and participatory governance structures. These multi-dimensional innovations do more than solve current ecological problems; they build the adaptive capacity of both natural and human systems. By fostering market adaptability and community resilience, they allow for a more agile and effective response to emerging climate threats and the socio-economic shocks associated with the dismantling of old industrial regimes (Jaffe, Newell, & Stavins, 2002).

Participation and the axiom of intergenerational responsibility:

A guarantee of the transformation’s legitimacy is **social participation**. This involves the active and meaningful inclusion of citizens, entrepreneurs, and academic communities in decision-making processes at every level. Participation is particularly crucial for the JT principle, as it provides the only viable mechanism for identifying and mitigating local costs and risks before they escalate (ILO, 2015). An engaged and aware society is not only more resilient to the disruptions caused by change but is also more likely to co-create and accept new solutions that strengthen environmental protection (Pawłowska, Chmiel, & Szmelter-Jarosz, 2025ab).

Finally, the entire structure is underpinned by the axiom of intergenerational responsibility. This is the fundamental assumption of sustainable development, determining its long-term, non-transient character. It dictates that current actions cannot compromise the ability of future generations to meet their own needs (WCED, 1987). In the context of green transformation, this responsibility is operationalized through:

1. Long-term investments – prioritizing durable, life-cycle-oriented solutions over temporary, short-term fixes.
2. Reduction of ecological debt – implementing radical greenhouse gas emission cuts and halting biodiversity loss to ensure that the biosphere remains resilient to global shocks.

The strategic integration of these operational values is reflected in the specific functions that sustainable development performs within the transformation process. These functions, which serve as the primary goals for regional policy-making, are detailed in Table 10.

Table 10. Functions of sustainable development as a transformation goal

Function	Description	Mechanism of action
Comprehensive-ness	Ensuring a holistic perspective	Avoids „green blindness” and narrow focus on single metrics.
Legitimatization	Building social mandate	Through dialogue and equitable distribution of benefits.
Resilience building	Strengthening adaptive capacity	By maintaining biodiversity and diverse economic bases.

Source: Own elaboration based on Halsnæs & Shukla (2008ab) and Michalik & Zieliński (2024ab).

As illustrated in Table 10, the overarching function of sustainable development in this context is to ensure that decarbonization and environmental changes are not seen as ends in themselves. Instead, they are the means to achieve a more stable, just, and above all, resilient society (Halsnæs & Shukla, 2008ab; Cervantes, 2021). The mechanism of temporal stability is particularly vital for regional planning, as it explicitly protects the interests of future inhabitants against the potential “stranded assets” or ecological degradation left by current industrial transitions.

Adopting this perspective helps avoid “green blindness,” a phenomenon where an obsessive focus on one ecological indicator, such as CO² emissions, leads to the neglect of other critical factors such as water quality, soil health, or social equity (Michalik & Zieliński, 2024ab; Pomponi & Moncaster, 2017). By ensuring comprehensiveness (Table 10), the framework of sustainable development prevents the transformation from creating

new ecological weak points while solving old ones, thereby securing a holistic and durable transition for the region.

3.3. Local dimension of sustainable development and building resilience

The principle of sustainable development gains particular importance at the local level, where socio-economic challenges and ecological opportunities are most tangible and immediate. Local sustainable development is not merely a subsidiary element of global policy; it is a fundamental pillar for the overall effectiveness of the green transformation (Sachs, 2015). It constitutes a powerful, methodical tool for building the socio-economic resilience of regions and minimizing their vulnerability to global shocks, ranging from supply chain disruptions to the direct impacts of climate change.

Local governments as system brokers:

In the context of socio-technical transitions, local sustainable development serves as a mechanism used by local governments, acting as “system brokers,” to scale niche innovations and manage the dismantling of the high-emission regime. This approach, which integrates economic, environmental, and social pillars, is essential for legitimizing transformation policies. For instance, niche technologies such as geothermal investments must be implemented in accordance with the principles of JT (the social pillar) to minimize local resistance – often manifested as the NIMBY (Not In My Backyard) phenomenon – and to prevent a structural return to regime inertia.

This integration requires a holistic approach through three core dimensions, which collectively establish the framework for regional stability. The strategic objectives of these dimensions and their specific roles in building localized resilience are synthesized in Table 11.

Table 11. Pillars of local sustainability in resilience building

Dimension	Key local objective	Resilience mechanism
Environmental	Decentralized energy & resource efficiency	Reduces vulnerability to global energy price shocks and water scarcity.
Social	Social capital & JT	Enhances community cohesion and mandate for difficult structural reforms.
Economic	Diversification & circular business models	Decreases dependence on single-industry regimes and volatile raw materials.

Source: Own elaboration based on Sachs (2015) and Borys (2015).

As demonstrated in table 11, the practical implementation of these dimensions translates into specific adaptive capacities:

1. The environmental dimension – this involves the implementation of low-emission technologies, small-scale RES development, and rational resource management (water, energy). As indicated in table 11, focusing on decentralized energy and efficiency serves as a comprehensive guide for transformation, helping to avoid “green blindness” while significantly reducing vulnerability to global energy price shocks and climate-induced water scarcity.
2. The social dimension (JT) – this focus is on ensuring access to ecological education, promoting sustainable lifestyles, and engaging local communities in decision-making. Crucially, the mechanism of building social capital ensures that the benefits of transformation are distributed equitably, thereby strengthening the community’s mandate for even the most difficult structural reforms.
3. The economic dimension – this concerns the creation of “green jobs,” supporting local green innovations, and building a regional economy based on sustainable sectors. By promoting circular business models and diversification (Table 11), local governments can decrease regional dependence on single-industry regimes and volatile raw material markets, prioritizing long-term stability over short-term extraction.

Regional specificity and strategic adaptation: the case of Świętokrzyskie:

In the context of regional specificity, such as the Świętokrzyskie Voivodeship, local sustainable development is the primary vehicle for building environmental resilience. This region, characterized by rich natural resources and a simultaneous legacy of heavy industrial challenges, must find a strategic balance to increase its adaptive capacity. The practical manifestation of this balance involves a shift toward local low-emission infrastructure, the development of ecotourism in regional mountain ranges as a viable industrial alternative, and the introduction of Circular Economy (CE) principles within local SMEs to reduce vulnerability to raw material shortages (Table 12) (Szczech-Pietkiewicz & Czerniak, 2024ab).

Table 12. Practical implementation areas of local sustainability

Regional Context	Focus Areas	Practical Examples
Post-industrial	Land reclamation & Green re-industrialization	Transforming old mines into geothermal centers or hydrogen hubs.
Agricultural	Agroecology & Short supply chains	Promoting organic farming and local food security markets.
Urban	Smart-city & Blue-green infrastructure	Sustainable transport, smart grids, and urban heat island reduction.

Source: Own elaboration based on Szczech-Pietkiewicz & Czerniak (2024ab).

Ultimately, these local actions compose a mosaic of the global green transformation, leading to the construction of comprehensive regional resilience. Such development allows regions to move toward energy self-sufficiency, greater food security, and the creation of integrated communities better prepared for unforeseen crises. The analysis confirms that for the Świętokrzyskie Voivodeship, Local Sustainable Development is a *sine qua non* condition for breaking high-emission regime inertia. However, the transition from a fossil-fuel regime to a sustainable model is fraught with significant risks, even with the support of the EU funds for green transformation. Strategic planning must actively consider factors that could thwart this reorientation. These potential failures, categorized as “transformation traps,” are summarized in Table 13.

Table 13. Strategic risk factors in local green transformation

Risk type	Description	Consequence
Stranded assets	Devaluation of infrastructure tied to old regimes.	Economic loss and regional financial instability.
Energy poverty	Rising costs for vulnerable households.	Loss of social mandate and increased inequality.
NIMBY phenomenon	Local resistance to green infrastructure.	Delays in scaling innovative niches (e.g., wind/solar).
Decoupling failure	Inability to separate growth from resource use.	Continued environmental degradation despite „green” labels.

Source: Own elaboration based on Halsnæs & Shukla (2008ab) and Michalik & Zieliński (2024ab).

As local actions move from ethical postulates to operational reality, the focus must shift toward risk mitigation. Chapter 4 will provide a detailed analytical assessment of these ecological (green) transformation traps. Identifying these critical decision points is necessary to ensure that the Świętokrzyskie Voivodeship remains within the boundaries of a safe and just path, avoiding the systemic threats that accompany rapid structural change.

Chapter 4.

Traps of Ecological (Green) Transformation: Analysis of Risks for the Regional Economy and Society

Ecological transformation, understood as a fundamental change in economic and social paradigm aimed at achieving climate neutrality and sustainable development, is a strategic necessity in the face of climate crisis (European Commission, 2019: update date: 16.11.2025). Nevertheless, this process, particularly in regional context, is fraught with a series of significant systemic and operational risks that, if ignored or mismanaged, can lead to undesirable macroeconomic consequences and social disintegration (OECD, 2020: update date: 16.11.2025). This chapter analyzes key transformation traps, focusing on their impact on the economy and society at the regional level.

This chapter adopts a risk-based analytical framework, distinguishing economic, social, and institutional traps as mutually reinforcing dimensions of regional vulnerability.

4.1. Economic and market risks

Deindustrialization, structural unemployment, and the effect of “Forgotten Regions” The most serious and direct risk is stranded assets and resulting deindustrialization and mass structural unemployment in regions (e.g., mining, energy, metallurgical) strongly dependent on high-emission industries (Michalik & Zieliński, 2024a). Decommissioning high-emission assets (e.g., mines, coal power plants, cement plants) without prior adequate planning leads to loss of economic capital (stranded assets) and human and social capital, causing:

1. Skill obsolescence – workers’ specific qualifications suddenly become unsellable (stranded skills/non-transferable skills), generating high social and economic costs related to mass retraining (reskilling) and upskilling needs.
2. Social catastrophe – at local level, spiral economic decline, collapse of enterprises linked to the main industry, decline in regional budget revenues, and consequently – emergence of “forgotten regions” dominated by frustration, apathy, and open opposition to transformation, blocking further reforms (OECD, 2020; Bickerstaff & Walker, 2003).

Competency gap and innovation bottlenecks:

Transformation effectiveness is directly linked to availability of specialized human capital. Ecological transformation requires fundamental reorientation of education and training systems to meet demand for “green professions” (e.g.,

energy storage specialists, circular economy engineers) (Cedefop, 2021: update date: 16.11.2025). Otherwise:

1. Education system inefficiency – if regional universities and vocational training systems are not sufficiently flexible and quick in adapting programs, a critical competency gap emerges.
2. Investment barrier – lack of appropriate personnel acts as a key entry barrier for new innovative investments in green technologies and circular economy sectors, slowing economic diversification and maintaining unemployment despite global specialist shortage (Kozera-Kowalska, 2024).

Table 14 categorizes these competency risks to highlight the mismatch between current labor supply and future demand.

Table 14. Matrix of competency gaps and labor market risks

Risk category	Industrial transition point	Strategic bottleneck	Socio-economic impact
Human capital	Shift from extractive industries to tech-heavy RES (Renewable Energy Sources).	Shortage of certified „Green-Collar” technicians.	Structural unemployment in high-emission hubs.
Innovation	Transition from linear to circular production models.	Lack of regional R&D staff specialized in LCA.	Stagnation of regional SME competitiveness.
Educational	Curriculum lag in regional vocational schools.	Slow institutional response to market signals.	„Brain Drain” as youth migrate to leading tech hubs.

Source: Own elaboration based on Cedefop (2021) and Kozera-Kowalska (2024).

Financial barriers and the “Two-Speed Regions” trap:

Green transformation implementation requires significant long-term investments (e.g., power grid modernization, zero-emission public transport development). Regions with poor financial condition, low external fund absorption capacity, and insufficient creditworthiness may not be able to meet these challenges (PWC, 2022: <https://ungc.org.pl>; update date: 16.11.2025).

As a result, disparity deepening may occur, i.e., lack of appropriate redistribution and support mechanisms may deepen disparities between rich and poorer regions. This leads to perpetuating the developmental gap and preventing achievement of EU territorial and social cohesion goals, creating two-speed regions in access to sustainable solutions, as detailed in Table 15.

Table 15. Comparison of transformation capacity: prosperous vs. lagging regions

Transformation factor	Prosperous/leader regions	Lagging/at-risk regions	Risk outcome
Capital mobility	High access to Green Bonds & private equity.	Dependence on shrinking local tax bases & state subsidies.	Financial trap – inability to fund large-scale infrastructure.
Absorptive capacity	High administrative competence in EU grants.	Limited staff for complex green project management.	Cohesion trap – funds flow to regions that need them least.
Energy infrastructure	Resilient, modern, and decentralized.	Obsolete, centralized, and prone to energy poverty.	Energy trap – higher utility costs for vulnerable households.

Source: Own elaboration based on PWC (2022) and OECD (2020) data.

The culmination of these factors can be summarized as a systemic risk model, where the inability to synchronize economic, human, and financial capital leads to a permanent exclusion of certain regions from the benefits of the green paradigm shift.

4.2. Social and justice traps

The green transformation process, although necessary, generates serious social and equity risks that, if ignored, can thwart its goals and cause social and political destabilizations.

Energy poverty and social inequalities

Introducing transformation, although reducing living costs in the long term through efficiency and cheap renewable energy, may lead to a significant increase in household financial burdens in the short and medium term. Rising CO2 emission fees (e.g., the EU ETS system), heating system modernization costs, or higher prices of ecological products may significantly burden household budgets (Bouzarovski & Petrova, 2015). This phenomenon leads to two main structural problems, which are synthesized in the context of social stratification in Table 16.

Table 16. Social stratification and the “Entry Barrier” in green transformation

Socio-economic Group	Ability to Invest	Long-term Impact	Risk Status
High-income	High (Thermal retrofitting, PV, EV)	Reduction in operational costs; asset appreciation.	Beneficiaries
Low-middle income	Low (Financial „lock-in” in legacy systems)	Exposure to rising carbon taxes and fuel prices.	Vulnerable / Excluded

Source: Own elaboration based on Bouzarovski & Petrova (2015) and Michalik & Zieliński (2024ab).

As detailed in the table above, the primary issue is:

1. Increased adaptation costs, constituting an unfair burden distribution problem. Most affected are low- and middle-income households unable to bear one-time high investment costs necessary for adaptation. This refers to expenses for:
 - a) building thermal modernization,
 - b) replacing heating sources (e.g., from “dirty boilers” to modern heat pumps or district heating).
 Lack of support results in a green transformation entry barrier, deepening property and infrastructure disparities.
2. Energy poverty, defined as the inability to provide a minimum energy standard (e.g., adequate heating, cooling, cooking energy) at an affordable price, may intensify as a result of poorly managed transformation. The consequences are far-reaching (Michalik & Zieliński, 2024b; Bouzarovski & Petrova, 2015), manifesting through:
 - a) deepening social inequalities – increasing distance between transformation beneficiaries and losers (persons living in industrial regions, miners, elderly),
 - b) political destabilization – feeling of injustice and “transformation cost” constitute fertile ground for populism and radical political moods, where parties promising a return to cheaper conventional energy gain popularity.

Spatial Conflicts and Local Resistance (NIMBY):

The location of infrastructure investments key to transformation (e.g., wind farms, large-area photovoltaic installations, transmission networks) generates land-use conflicts, often referred to as the NIMBY (Not In My Backyard) phenomenon (Wolsink, 2009). Local resistance constitutes a serious obstacle to the pace of transformation and manifests in several dimensions, which are categorized in Table 17.

Table 17. Matrix of NIMBY resistance dimensions

Dimension of conflict	Primary driver	Specific risk factor
Environmental/visual	Subjective risk perception	Landscape degradation and aesthetics.
Economic/material	Perceived loss of wealth	Real estate value decline.
Health/safety	Lack of technical knowledge	Noise pollution and electromagnetic fields.
Procedural	Perceived marginalization	Top-down imposition of projects without consultation.

Source: Own elaboration based on Wolsink (2009) and Pasqualetti (2011).

Analysis of the dimensions presented in Table 17 reveals two critical operational risks:

1. Lack of local acceptance and external burdens. Concerns often result from subjective risk perception and a lack of full knowledge, causing:
 - a) landscape degradation,
 - b) property value decline,
 - c) noise and health fears,
 - d) exclusion from the decision-making process.
2. Project blocking and inertia risk. Ineffective management of these conflicts leads to investment paralysis. Key blocking factors are:
 - a) lack of transparency,
 - b) insufficient social consultations often being a mere formality,
 - c) lack of fair benefit distribution (e.g., profit shares not reaching directly affected residents).

As a result, resistance can lead to administrative blockades and long-term legal battles, critically slowing the entire transformation. Effectively overcoming NIMBY requires moving toward a participation-based transformation model, ensuring trust and fair participation in benefits (Pasqualetti, 2011).

The culmination of these factors suggests that without a robust social framework, the ecological transition remains vulnerable to systemic rejection.

4.3. Institutional and political risks

Action fragmentation and political instability:

Ecological transformation is a long-term process (20–30 years) requiring strategic consistency and cross-party political consensus beyond election cycles (European Commission, 2019; update date: <https://eur-lex.europa.eu>; 16.11.2025). Government

changes, short-sighted political approach, and ideological divisions lead to regulatory instability, lack of funding continuity, and public resource waste. This in turn undermines investor (capital is “skittish”) and societal trust, delaying not only transformation pace but also discouraging private investments (Kozera-Kowalska, 2024).

Greenwashing and loss of credibility (reputational and systemic risk):

Greenwashing should be analytically differentiated into a micro-level phenomenon (corporate greenwashing), involving misleading environmental claims by individual enterprises, and a macro-level phenomenon (systemic greenwashing), in which financial markets and public institutions reproduce misleading sustainability signals, thereby generating cumulative risks for the credibility and effectiveness of the green transformation.

A serious threat is the risk of “green brainwashing” (greenwashing), i.e., declaring pro-ecological and sustainable actions that are in reality facade or have no real environmental impact (Delmas & Burbano, 2011). This phenomenon, initially concerning industrial enterprise marketing communication, has now become systemic risk. M.A. Delmas and V.C. Burbano (2011) describe this phenomenon as “discrepancy between declared and actual enterprise environmental activity.” These authors indicate that greenwashing occurs when an enterprise presents itself as ecological without undertaking real actions in this regard. Lyon and Montgomery (2015) expand this definition, indicating that greenwashing is deliberate communication actions aimed at creating false or exaggerated image of organization as sustainable or environmentally responsible when these actions have no coverage in actual operational or investment policy.

Table 18 synthesizes the mechanisms of greenwashing and their impact on capital allocation.

Table 18. Mechanisms of greenwashing and systemic consequences

Strategy type	Definition and context	Systemic consequence
Misinformation	Deliberately misleading customers and investors (Delmas & Burbano, 2011).	Capital misallocation; slowing actual economic transformation.
Hidden trade-off	Focusing on one positive aspect while hiding negatives (Koch & Denner, 2025).	Distorted environmental impact assessment.
Vagueness	Using general terms like “ecological investing” without data.	Erosion of sustainable finance market credibility.
Greencrowding	Joining non-binding industry initiatives to avoid criticism.	Systemic reputational risk for the entire sector.

Source: Own elaboration based on Delmas & Burbano (2011) and Koch & Denner (2025).

As indicated, by deliberately misleading customers and investors, greenwashing directs capital to wrong places, slowing actual economic transformation and reducing action effectiveness (Delmas & Burbano, 2011). The systemic dimension of the phenomenon justifies treating it not as reputational problem but as real systemic risk for credibility of the entire sustainable finance market (Koch & Denner, 2025).

Key to credibility rebuilding – effective counteraction requires combining rigorous regulatory frameworks (e.g., Green Claims Directive), internal sector self-control, and continuous empirical monitoring. Trust can be rebuilt only through transparency, auditability, and ESG data standardization (required by SFDR, Taxonomy, and CSRD), as well as introducing unified product labeling systems based on objective criteria (Koch & Denner, 2025).

Abuse strategies and systemic consequences are based on:

1. Hidden Trade-off – focusing on one positive product aspect (e.g., low-emission car) while hiding negative consequences (e.g., high-energy battery production) (Koch, Denner, 2025).
2. Lack of Proof and Vagueness – using general unverified terms like “ethical fund” or “ecological investing” without data verification possibility (Koch, Denner, 2025).
3. Greencrowding and Greenhushing – joining general non-binding industry initiatives (greencrowding) or deliberately concealing sustainable development progress (greenhushing) to avoid criticism.

By deliberately misleading, greenwashing directs capital to wrong places, slowing actual economic transformation. The systemic dimension of the phenomenon justifies treating it not as reputational problem but as real systemic risk for market credibility (Chen & Chang, 2013).

Regulatory remedial measures:

An integrated EU regulatory system plays a key role in limiting greenwashing, enforcing consistency between marketing claims and actual ESG policy (Chen & Chang, 2013; Koch & Denner, 2025). As shown in the regulatory logic below:

1. SFDR Regulation and EU Taxonomy – introduce disclosure obligations and scientific criteria defining what is “environmentally sustainable”.
2. CSRD Directive – requires applying “double materiality” perspective and transparent action documentation.
3. Green Claims Directive (GCD) – in the future to impose auditable confirmation obligation for every pro-environmental declaration.

Trust in transformation can be rebuilt only through transparency and publication of sustainable development assessment methodology and introducing uniform labeling systems based on objective criteria.

In response to key transformation challenges, especially deindustrialization risk and deepening regional disparities, the EU established the Just Transition Fund

(JTF). This is the most important financial instrument of the Just Transition pillar, designed within EU Cohesion Policy for 2021-2027 to mitigate social, economic, and environmental effects of transitioning to climate neutrality (Regulation (EU) 2021/1056:eu; update date: 17.11.2025).

Table 19 illustrates how the JTF addresses specific regional challenges.

Table 19. Just Transition Fund (JTF) intervention logic

Intervention area	Targeted risk	JTF financing mechanism
Labor market	Unemployment & skill obsolescence	Reskilling and upskilling programs for „green competencies”.
Economic growth	Deindustrialization	Diversification of regions and GreenTech SME investments.
Social justice	Energy poverty	Revitalization and thermal modernization projects.

Source: Own elaboration based on Regulation (EU) 2021/1056 and PWC (2022).

JTF main goal is supporting territories most affected by decarbonization challenges. JTF directly responds to identified transformation traps through financing (Chen & Chang, 2013):

1. Counteracting unemployment – supports economic diversification of regions, creation of new innovative GreenTech and SME enterprises, and RES investments.
2. Filling competency gap – JTF funds are allocated to mass retraining (reskilling) and upskilling programs, enabling workers from emission industries to acquire “green competencies” (PWC, 2022: update date: 16.11.2025).
3. Social support – the fund supports revitalization of degraded social infrastructure and projects helping combat energy poverty through supporting thermal modernization.

Therefore, a key requirement for obtaining JTF support is developing Territorial Just Transition Plans (TJTP) by regions. These plans are strategic documents that must detail the decarbonization path and investment needs. The TJTP creation requirement enforces long-term strategic planning and participation of various stakeholders, aimed at building broad consensus and minimizing social resistance.

In summary, green transformation is inevitable and necessary, but its success at regional level is not guaranteed. It is conditioned by active and strategic management of identified risks. The process of transitioning to sustainable economy must be just transition, i.e.:

1. Thoughtful and strategic, based on long-term strategies (TJTP) beyond political terms.

2. Participatory, requiring genuine social dialogue and including local communities in decision-making (to counteract NIMBY).
3. Financially supported and with appropriate regulations ensuring protection mechanisms (like JTF) for most vulnerable groups (combating energy poverty) and innovative financing and transparency (combating greenwashing).

Only such comprehensive and holistic approach predicting and addressing transformation traps – from deindustrialization through energy poverty and spatial conflicts to competency deficits and credibility loss due to greenwashing – will allow full utilization of its potential – transforming regions into dynamic ecological and resilient centers of innovation and development.

This chapter complements the analytical framework, moving from imperative and model (Chapters I-III) to identification and categorization of transformation traps. It was indicated that green reorientation success in a region with strong industrial regime, such as the Świętokrzyskie Voivodeship, is not guaranteed but conditioned by strategic management of three critical risk groups:

1. Economic, i.e., deindustrialization, stranded assets phenomenon, and structural unemployment resulting from skill obsolescence (stranded skills).
2. Social (related to social justice), associated with energy poverty increase and spatial conflicts (NIMBY) resulting from lack of participation and unfair benefit distribution.
3. Institutional, referring to greenwashing as systemic risk undermining market credibility and leading to improper capital allocation, and regulatory instability.

The comprehensive analysis proves that green transformation in a region with specific conditions (MLP) is an inevitable process driven by external imperatives (landscape/EGD) and supported by the JTF. The key to success lies in local governments' (system broker) ability to implement Local Sustainable Development as a methodical tool for scaling innovative niches and simultaneously managing regime disintegration risk.

For the Świętokrzyskie Voivodeship, this means:

1. Long-term planning (TJTP), involving adherence to Just Transition and Participation principles to minimize NIMBY and prevent energy poverty.
2. Human capital investments, related to prioritizing reskilling and upskilling programs (supported by JTF) to minimize competency gap and avoid social catastrophe related to deindustrialization.
3. Transparency and regulations, referring to actively applying EU legal frameworks (Taxonomy, CSRD) to build trust, counteract greenwashing, and attract private capital necessary for financing regime transition.

Only such comprehensive and strategic approach actively predicting and addressing identified traps can transform transformation risks into lasting opportunities for creating a dynamic ecological and resilient regional innovation center.

The comprehensive analysis of transformation traps presented in Chapter 4 has demonstrated that the transition to a climate-neutral economy is not merely a technical or environmental shift, but a complex socio-political challenge. The identified risks – ranging from economic deindustrialization and stranded skills to the profound threats of energy poverty and institutional greenwashing – form a systemic barrier that can paralyze regional development if not addressed through strategic management.

While Chapter 4 categorized what can go wrong (the “traps”), it also introduced the Just Transition Fund (JTF) and Territorial Just Transition Plans (TJTP) as institutional safeguards designed to mitigate these risks. However, as the analysis of the NIMBY phenomenon and spatial conflicts suggests, the success of these safeguards depends less on their financial volume and more on their social legitimacy and the local capacity for implementation.

This leads directly to the core focus of Chapter 5, which moves from the theoretical and categorical identification of risks to the implementation perspective. The transition between these chapters is marked by three critical shifts in focus:

1. From Passive Risk to Active Acceptance: While Chapter 4 identified social resistance as a trap, Chapter 5 explores the mechanisms of social acceptance as a proactive driver of regional stability.
2. From Institutional Frameworks to Local Trajectories: Chapter 4 discussed global and EU-level regulations; Chapter 5 examines how these are filtered through the specific socioeconomic fabric of the Świętokrzyskie Voivodeship and other industrial regions.
3. From Strategic Planning to Multi-level Governance: Building on the institutional risks discussed in Section 4.3, the next chapter analyzes how local governments act as “system brokers” to scale innovative niches while navigating the disintegration of the old industrial regime.

By understanding the “traps” of Chapter 4, we can now evaluate the Regional Development Trajectories in Chapter 5 through a more critical and realistic lens, ensuring that the Just Transition is not only planned but effectively anchored in social and political reality.

Chapter 5.

Social Acceptance, Resistance, and Regional Development Trajectories: An Implementation Perspective on JT

This analytical chapter serves as a bridge between theoretical model and practical implementation requirements of green transformation (GT). The aim is to define mechanisms through which psychosocial and endogenous factors related to region conditions determine GT success or failure. The analysis focuses on the relationship between social acceptance and JT as overriding conditions for legitimization and effectiveness of regional strategies.

5.1. Dynamics delaying transformation: psychosocial barriers and conflicts of interest

Social resistance constitutes the most serious implementation trap, undermining assumptions about rationality and automatic acceptance of long-term benefits. In the strategic management of regional transition, resistance is not a monolithic phenomenon but a result of overlapping cognitive, economic, and cultural layers.

Economic and cognitive sources of delay:

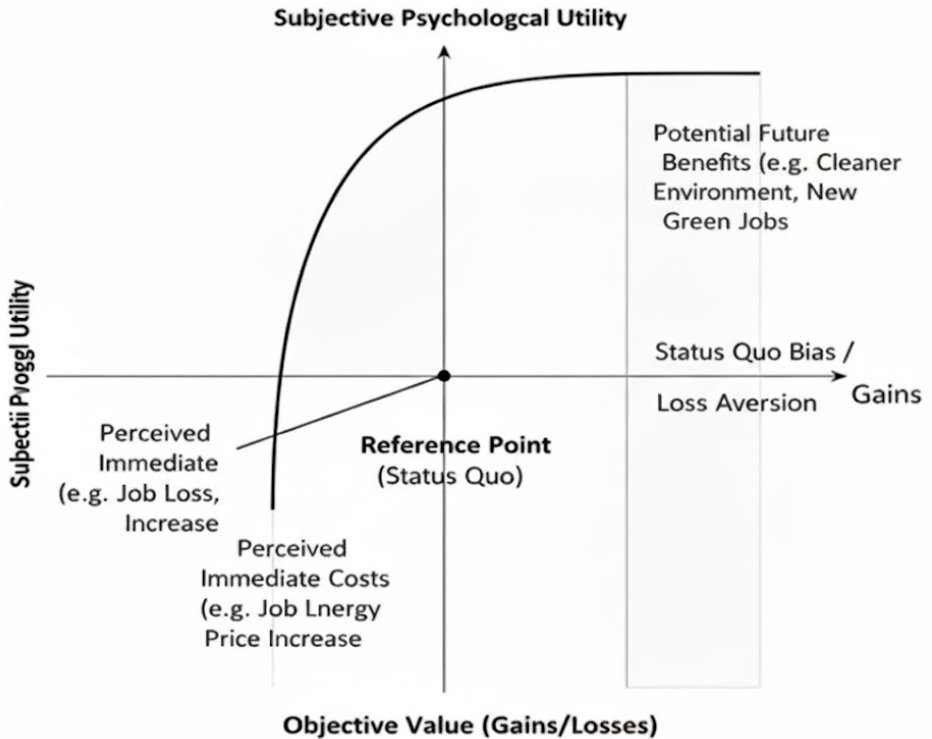
In the context of Chapter 5.1, the fundamental barrier to Green Transformation is the cognitive bias known as loss aversion. Fundamental social resistance originates in the temporal and psychological imbalance between costs and benefits. Individuals and communities focus on direct tangible costs, while long-term benefits are perceived as uncertain and distant. This phenomenon, known as Status Quo Bias, is further complicated by the mechanism of loss aversion. It implies that the perceived disadvantage of moving away from the current state is significantly greater than the perceived advantage of the new, albeit more sustainable, state.

As illustrated in Figure 8, the psychological impact of potential losses (e.g., job security, traditional status) is significantly higher than that of equivalent potential gains. The diagram demonstrates that the utility curve is steeper for losses than for gains, which explains why the transformation narrative often fails when it only promotes future environmental stability. In the GT context, this means that the fear of immediate loss – such as energy price increases or the decommissioning of local industry – must be actively managed through compensatory policies to shift the community's position on the utility curve.

The asymmetry presented in the model above explains why even economically rational arguments regarding the lower costs of renewable energy often fail to gain traction in industrial hubs. The psychological “weight” of losing a known

livelihood is cognitively processed as a threat to survival, which triggers defensive mechanisms rather than exploratory or adaptive behaviors. To effectively “move” the residents’ reference point from the origin (0,0), policy intervention must reduce the perceived steepness of the loss through immediate, tangible proof-of-concept projects that provide alternative status and security.

Figure 8. The value function of loss aversion in the context of green transformation



Source: Own elaboration based on Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk.

In regional context, this resistance is strengthened by a multi-dimensional set of endogenous factors:

1. Risk of identity and heritage loss – occurring in regions with a strong historical industrial regime (Chapter II), transformation is perceived as a threat to work culture and collective identity, generating opposition beyond economic calculation. The “miner” or “steelworker” identity is deeply rooted in the social

- fabric; thus, decarbonization is often interpreted as a delegitimization of the community's historical contribution to national development.
2. Digital polarization – in the digitalization era, social media algorithms create information bubbles and favor disinformation. This phenomenon intensifies attitude polarization and undermines trust in institutional knowledge sources, escalating external greenwashing risk. Information asymmetry allows radical groups to exploit the fear of loss, presenting the Green Deal as an elitist project detached from local realities.
 3. Institutional distrust and exclusion feeling – social resistance escalates when transformation is perceived as an externally imposed process by unknown or distrusted entities (e.g., EU institutions, central authorities). Low trust in public institutions and political elites causes even transparent and beneficial messages to be interpreted as manipulation. In historically marginalized regions or those affected by previous restructuring traumas (e.g., post-industrial), this exclusion and procedural injustice feeling becomes a strong predictor of opposition to any radical changes. As a result, disinformation (point 2) more easily finds fertile ground in low social capital environments, where the lack of “bridge” institutions prevents the absorption of new development paradigms.

Conflicts of interest and systemic lobbying:

Resistance is also shaped by organized interest groups. Economic entities linked to the high-emission regime conduct lobbying and disinformation actions aimed at delaying GT implementation, which constitutes a major institutional risk (Chapter 4). This process is often described as “regime inertia,” where established actors use their political and economic influence to protect sunk costs in carbon-intensive infrastructure.

The complexity of this conflict requires local governments to act as system brokers capable of transparent management of conflicting narratives and interests. To counteract decision-making paralysis, regional authorities must move beyond traditional administrative roles and become mediators who can align the needs of the industrial legacy with the requirements of the green niche. This requires the creation of “safe spaces” for negotiation where the fear of loss can be addressed through concrete, auditable, and just transition plans.

5.2. The Requirement of justice: architecture of social acceptance

Social acceptance in the context of green transformation (GT) is not a static state of public approval, but a dynamic and multi-layered function of participation, transparency, and the subjective and objective perception of transformation justice. In a monographic approach, this architecture must be viewed as a complex institutional design that internalizes social externalities of the economic shift.

Participation as legitimization mechanism

Active citizen inclusion in decision-making processes – moving decisively beyond “tokenism” and symbolic consultations – is an ontological necessity for building co-responsibility and a genuine sense of agency. Within the regional ecosystem, this participation serves as a diagnostic and therapeutic tool for managing the structural anxieties discussed in Section 5.1.

1. Spatial conflict management (NIMBY) – relying on participatory spatial planning (e.g., deliberative citizen panels, deep-dive workshops) is the most effective tool for managing local resistance to infrastructure investments. By including residents in the early stage of RES niche location, authorities can neutralize the *Not-In-My-Backyard* risk (Chapter IV). This process transforms residents from “objects of investment” into “subjects of planning,” reducing information asymmetry and perceived threat levels.
2. Role of social capital – strong social capital, characterized by high levels of generalized trust and active cooperation networks, constitutes a strategic endogenous regional resource. It acts as a shock absorber for the negative effects of change, fostering an environment where social innovations can be tested and implemented with lower transaction costs.
3. Procedural justice – beyond immediate spatial management, a critical acceptance requirement is ensuring procedural justice. It refers to citizens’ perception that the decision-making process is transparent, neutral, and inclusive. When individuals believe their voices are treated with due respect and that information access is symmetric, institutional trust is strengthened. This remains true even when distributive outcomes are unfavorable (e.g., an unpopular infrastructure location). Procedural justice is the primary antidote to administrative paternalism, which often triggers radical resistance.

To synthesize these elements, Table 20 categorizes the levels of social engagement required for a stable architecture of acceptance.

Table 20. Levels of social participation and their impact on GT legitimization

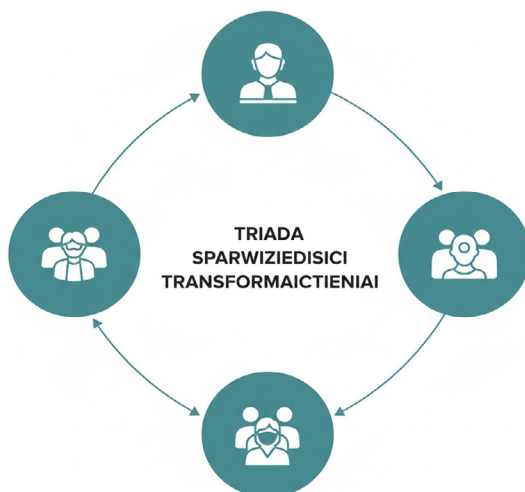
Level of Participation	Character of Interaction	Impact on Social Acceptance	Strategic Outcome
Consultative	Top-down information; gathering opinions.	Passive acceptance; high risk of „hidden” NIMBY.	Minimal legal compliance.
Deliberative	Structured dialogue (citizen panels); consensus building.	High legitimization; reduction of loss aversion.	Mitigated spatial conflicts.
Co-creative	Joint decision-making on niche investments (e.g., energy co-ops).	Active prosumership; local agency.	High regional resilience.

Source: Own elaboration based on Wolsink (2009) and Pasqualetti (2011).

Just transformation as a strategy axis:

The JT concept serves as the fundamental ethical and implementation filter for all green transformation (GT) actions. It represents a paradigm shift from purely technocratic management to a values-based developmental model. In the regional context, JT is not merely a social safety net, but a prerequisite for structural stability. It requires a holistic, integrated approach to three distinct yet overlapping dimensions of justice, as illustrated in Figure 9.

Figure 9. The triad of just transition: distributive, procedural, and corrective justice



Source: Own elaboration.

As presented in figure 9, the success of the regional strategy depends on the equilibrium between:

1. Distributive justice – focusing on the equitable allocation of costs and benefits (who pays for the transition and who reaps the rewards).
2. Procedural justice – ensuring the fairness of the processes through which these decisions are made.
3. Corrective (Restorative) justice – proactively addressing historical injustices and environmental burdens in post-industrial regions (e.g., land reclamation, health compensation).

This means the transformation burden cannot deepen existing inequalities. Strategic JT implementation requires:

1. Loss compensation – directing JTF investments into robust reskilling programs and the creation of “green-collar” jobs. This is a direct response to the stranded

skills risk and acts as a psychological stabilizer against the loss aversion curve discussed in figure 8.

2. Addressing inequalities – implementing targeted mechanisms for green solution access (e.g., deep thermal modernization subsidies, preferential loans for RES) for the lowest-income groups. This neutralizes the energy poverty risk and ensures that distributive justice is not merely a theoretical claim but a material reality.

Building trust and influence: role of leaders and social niches:

Social acceptance is also a result of social innovations and modeling actions. Local leaders (change ambassadors) and non-governmental organizations play a key role as credible intermediaries (system brokers) between the rigid state administration and the local residents.

Scaling exemplary niches involves a “social proof” mechanism. Technology acceptance (e.g., local RES farms or biogas plants) is significantly higher when citizens witness tangible local effects (proof-of-concept) and derive direct financial benefits (e.g., through energy communities, municipal dividends, or profit shares). This move from abstract global climate goals to local material gains is crucial for:

1. Translating theoretical transformation benefits into real material and psychosocial gains.
2. Combating the loss aversion barrier by providing immediate, observable offsets.
3. Building a local-level sense of agency, transforming “forgotten regions” into centers of the new ecological paradigm.

Only through such a robust architecture – where justice is auditable and participation is substantive – can the green transformation avoid the trap of social rejection and political destabilization.

5.3. Regional development trajectories: alignment with mlp specificity

Effective Green Transformation (GT) implementation requires approach diversification according to specific regional conditions, analyzed through the Multi-Level Perspective (MLP) framework. The MLP lens allows for a nuanced understanding of how regional landscapes and regimes interact with emerging technological and social niches. Table 21 serves as a foundational decision-making matrix, mapping these interactions onto concrete developmental paths.

Table 21. Diversification of approaches according to specific regional conditions

Region type / specificity	Strategic MLP challenge	Development path/investment vector
Post-industrial (e.g., Świętokrzyskie)	Managing industrial regime heritage and stranded assets risk.	Diversification and Revitalization: Transforming post-industrial areas into green niches (RES, CE, green-tech). Necessity of mass workforce retraining.
Agricultural and peripheral	Emission reduction from agricultural sector and landscape (biodiversity) protection.	Agroecology and Resilience: Development of sustainable agriculture, biogas systems, and agrotourism. Building food system resilience.
Urban and metropolitan	Innovation and capital concentration (niche and locomotive role).	Decarbonization and Smart City: Development of sustainable transport and Smart grids. CE implementation in waste management and construction.

Source: Own elaboration based on conducted theoretical research.

Table 21 effectively maps the specificity of three dominant area types faced by regions (such as Świętokrzyskie Voivodeship combining post-industrial, agricultural, and urban elements), assigning them adequate strategic challenges and investment vectors.

Trajectory I: Post-industrial regions (Świętokrzyskie Voivodeship):

The post-industrial sector must confront strong resistant regime heritage (Chapter II). The primary strategic challenge (MLP) lies in the fact that the existing socio-technical regime – built around heavy industry and centralized energy – is characterized by significant carbon lock-in. A key problem is stranded assets risk and accompanying stranded skills (Chapter IV). These assets, although physically present (e.g., mines, smelters, cement plants), lose economic value in the new climate model, creating a “valuation vacuum” that can destabilize regional balance sheets.

The development path for such areas focuses on diversification and revitalization. This means strategic transformation of post-industrial areas into green niches (RES, CE), directly responding to regime challenges. Mass workforce retraining (reskilling/upskilling) necessity is here a key Just Transition (JT) element neutralizing structural unemployment risk. Revitalization must be understood not just as physical renovation of brownfields, but as a systemic re-injection of innovative capital into degraded economic tissues.

Trajectory II: Agricultural and peripheral regions of Świętokrzyskie Voivodeship:

In these areas, the strategic challenge (MLP) shifts to the landscape level (Chapter II), focusing on biodiversity protection and agricultural sector emission limitation. Unlike the industrial regime, the agricultural challenge is fragmented across numerous smaller actors, making coordination more complex. Climate risks (e.g., droughts, floods) directly affecting food systems must also be considered as external landscape pressures.

The development path prioritizes agroecology and resilience. The development of sustainable agriculture and biogas systems (using organic waste) are concrete innovative niches contributing to emission reduction and local energy production. Including agrotourism strengthens the local economy and builds resilience to macroeconomic shocks by diversifying the rural income base and preserving the natural landscape as a competitive asset.

Trajectory III: Urban regions of Świętokrzyskie Voivodeship:

Urban areas function as Transformation Locomotives (niches), concentrating capital, innovations, and human resources. The strategic challenge (MLP) is utilizing this potential for large-scale decarbonization while simultaneously minimizing pollution and congestion (social/health risk). Cities act as the “incubation chambers” for the socio-technical niches that will eventually challenge the dominant industrial regime.

The development path vector is Decarbonization and Smart City. The development of sustainable transport and Smart Grids maximizes efficiency through data-driven management. Circular Economy (CE) implementation in construction and waste management is crucial for reducing raw material dependence and building an innovation-based competitive advantage, effectively decoupling urban growth from resource exhaustion.

Application conclusion:

Table 21 provides a decision-making model for regional authorities. Its substantive value lies in three core dimensions:

1. Intervention alignment – indicates that interventions financed (e.g., from EU funds for green transformation) must be sectorally differentiated rather than uniform. A “one size fits all” approach fails to address the unique path dependencies of industrial versus agricultural clusters.
2. Strategic risk valuation – MLP challenges (regime, landscape, niches) are a strategic translation of Chapter IV risks (e.g., stranded assets = managing regime heritage).
3. Indicating integrated niches – all development paths indicate the necessity of developing technological and social niches (e.g., agroecology, CE) to break regime resistance.

This model is thus consistent with the concept of building Regional Resilience through managing a region-specific challenge portfolio and resource allocation toward sustainable development.

Competitive advantage and CE:

Regardless of trajectory, a key element of building regional resilience and competitive advantage is the Circular Economy (CE). CE is a model minimizing dependence on critical raw material imports (landscape risk) through maximizing resource efficiency, product redesign, and re-manufacturing development. By internalizing material loops, regions can insulate themselves from global supply chain shocks.

Including peripheries: regional cohesion:

To maintain regional cohesion, transformation must avoid deepening disparities between centers (metropolises) and peripheries. This requires strategic planning ensuring:

1. Technology and knowledge transfer from centers to smaller centers.
2. Decentralization of green investments and supporting local supply chains (e.g., food, energy) so benefits are felt throughout the administrative area.

Green transformation can succeed only when strategically embedded in sustainable risk management and social legitimization. This requires a triad of actions:

1. Risk-action integration: Addressing psychosocial and economic barriers (P19 vs. P23) through JT strategies.
2. Participatory design: Recognizing residents as change co-creators rather than mere recipients to neutralize spatial resistance (NIMBY).
3. Holistic investments: Moving from emission reduction to building resilient and resource-efficient (CE) regional ecosystems utilizing regional specificity to create new niches.

Further analysis focuses on empirical modeling to quantify the influence strength of individual variables (e.g., knowledge, gender, place of residence) on social acceptance (e.g., P23 – concerns about inequalities), allowing the formulation of specific policy recommendations.

Trajectory financing and monitoring requirement:

Effective implementation of diversified regional development trajectories (Table 21) requires not only strategic planning but also effective public and private capital allocation. In the region context, key financing tools remain European Funds (including EU funds for green transformation) and national support programs.

Contradictory requirement (niche financing) – financing must be designed to support innovative niches (e.g., agroecology, CE) against dominant regime inertia, requiring readiness for higher investment risk at early development stages. This necessitates a shift from conservative lending to “mission-oriented” regional finance.

Effectiveness monitoring (Accountability), involving maintaining social legitimization and institutional trust is introducing robust result-oriented monitoring indicators. These indicators must go beyond traditional economic measures (e.g., GDP) to capture the multi-dimensional nature of regional resilience and justice. To address this need, Table 22 provides a comprehensive framework for evaluating the success of the green transformation across three strategic dimensions: social equity, systemic robustness, and innovation capacity.

Table 22. Regional GT Monitoring Framework: Beyond GDP

Indicator category	Key metrics	Strategic purpose
Distribution indicators	Energy poverty rates; Number of workers reskilled; P19 vs. P23 perception gaps.	Assessing Just Transition and social equity.
Resilience indicators	% RES in regional energy mix; CE share in value chains; Air quality (PM2.5/PM10).	Measuring environmental and systemic robustness.
Innovation indicators	Number of green-tech SMEs; Patent filings in CE; JTF fund absorption in niches.	Tracking the growth of regional ecological niches.

Source: Own elaboration.

Establishing such indicators is necessary to verify the hypothesis that diversified investments translate into actual regional resilience building and increased social acceptance. This comprehensive monitoring ensures that the transformation remains on its intended path, adjusting to the evolving landscape pressures and regime shifts within the Świętokrzyskie Voivodeship.

Chapter 5 has provided a comprehensive architectural framework for the implementation of Green Transformation (GT) through the lens of JT. By bridging the gap between theoretical Multi-Level Perspective (MLP) models and the practical realities of regional governance, several critical conclusions have been established:

1. The Primacy of psychosocial barriers – it has been demonstrated that social resistance is not merely a lack of information but a deeply rooted cognitive response driven by loss aversion and Status Quo Bias (Figure 7). The perceived steepness of potential losses in industrial regimes creates a “lock-in” effect that requires proactive compensatory policies rather than just technological incentives.
2. Justice as a legitimization engine – the transition from technocratic management to a values-based model is centered on the triad of distributive, procedural, and

corrective justice (Figure 8). The analysis confirms that social acceptance is a dynamic variable that depends on the transparency of decision-making and the tangible mitigation of risks like energy poverty and stranded skills.

3. Diversified trajectories – the study established that a “one-size-fits-all” approach is insufficient. For the Świętokrzyskie Voivodeship, success depends on aligning specific investment vectors—revitalization for post-industrial hubs, agroecology for peripheral areas, and smart-city innovations for urban centers—to ensure regional cohesion and resilience.
4. The requirement for new metrics – finally, the chapter introduced a shift from traditional economic indicators toward a multi-dimensional monitoring framework (Table 22). By prioritizing distribution, resilience, and innovation indicators, regional authorities can move toward an accountability model that justifies the higher risks associated with niche financing.

Transition to chapter 6 while chapter 5 established the qualitative and structural requirements for acceptance, the following section moves into the quantitative verification of these theoretical constructs. To move from the general “Architecture of Acceptance” to specific policy recommendations, it is necessary to analyze the actual attitudes, concerns, and demographic correlations within the study population.

Chapter 6 initiates this empirical phase by providing a rigorous diagnostic of the collected data. Before testing the causal relationships between variables such as the perception of inequality (P23) and the general support for transformation (P19), we must first establish the statistical characteristics of the dataset. This involves a detailed look at descriptive statistics to identify trends and a formal analysis of data normality to determine the appropriate parametric or non-parametric tools for the subsequent modeling of regional development trajectories.

Chapter 6.

Descriptive statistics and data normality analysis

This chapter serves as the methodological and descriptive foundation for the empirical part of the monograph, providing the necessary basis for subsequent inferential analyses. Its primary objective is the presentation and in-depth interpretation of descriptive statistics, alongside non-parametric inference for both demographic and research variables. These variables measure the perceptions, knowledge levels, and attitudes of students toward the Green Transformation (GT) across both global and regional dimensions, with a specific focus on the Świętokrzyskie Voivodeship.

Data collection was executed using a quantified survey instrument, structured to capture three critical domains of the transition process:

1. Cognitive Awareness (variables: P1, P2, P5, P11).
2. Environmental and Social Influence (variables: P3, P4, P8, P17).
3. Perception of Implications (variables: P6, P7, P15, P18, P19, P23).

By synthesizing these domains, the chapter delivers a comprehensive profile of respondent consciousness. Furthermore, the analysis includes a rigorous verification of the data distribution's normality – a fundamental prerequisite for selecting the appropriate inferential statistical methods and ensuring the validity of the final policy recommendations derived from the study.

Structure of the empirical foundation:

To maintain the monographic depth, the following table maps the research variables to the theoretical constructs discussed in Chapter 5.

Table 23. Operationalization of research variables in the survey instrument

Domain	Variables	Research focus	Relation to chapter 5
Cognitive awareness	P1, P2, P5, P11	Level of technical and ecological knowledge.	Niche development capacity.
Environmental influence	P3, P4, P8, P17	Impact of social norms and institutional trust.	Social Capital & procedural justice.
Perceived implications	P6, P7, P15, P18, P19, P23	Evaluation of risks, costs, and benefits.	Loss aversion & distributive justice.

Source: Own elaboration.

The verification of distribution normality, as presented in the subsequent sections, determines whether the “architecture of acceptance” identified in the previous

chapter can be generalized through parametric testing or requires the more robust approach of non-parametric modeling.

6.1. Descriptive statistics – characteristics of data distribution

The analysis of descriptive statistics covering demographic and perceptual variables related to the green transformation reveals significant diversification in the structure of the studied sample and its attitudes toward environmental issues. The variable “Gender” is characterized by the least variability, indicating a relatively stable and homogeneous distribution of this trait, while “Age” is characterized by much higher dispersion, confirming the diversity of generational cohorts participating in the study. The variables “Student” and “Place of Residence” show moderate variability and positive skewness, which may reflect a predominance of individuals associated with the academic environment and a more frequent origin from rural and urban areas than from mixed-character territories.

Regarding the substantive variables concerning the green transformation, the mean values range from 1.7 to 3.3, indicating a moderate level of knowledge and environmental awareness. The lowest mean value concerning the understanding of the definition of ecological transformation suggests that respondents do not yet possess a clear and established conceptual apparatus in this area. At the same time, higher means regarding the assessment of one’s own understanding of the need to adapt to climate change and the perception of the positive effects of green actions evidence growing awareness and openness to transformation processes. Moderate coefficients of variation and a predominance of negative kurtosis suggest flattened response distributions, reflecting a wide diversity of opinions while maintaining an absence of extreme tendencies.

Interpreting the results in light of environmental economic theory, sustainable development, and information asymmetry models, it can be stated that cognitive and educational capital remains a key factor conditioning the adaptation process to the green transformation. The positive skewness of variables concerning barriers and positive aspects of access to knowledge may indicate uneven access to information, consistent with concepts of information asymmetries affecting the functioning of green technology markets. The results highlight the need for intensifying educational and communication efforts and differentiating educational messaging depending on the age and socio-educational status of respondents. They thus constitute a solid basis for formulating regional and institutional strategies supporting the development of ecological competencies in society (Table 24).

Table 24. Descriptive statistics of variables regarding green transformation and demographic characteristics of respondents

Descriptive statistics	Arithmetic mean	Variance	Standard deviation	Coefficient of variation	Skewness	Kurtosis
Gender	1.386	0.238	0.488	0.352	0.470	-1.797
Age	2.831	2.413	1.553	0.549	0.583	-0.593
Student	2.530	1.395	1.181	0.467	-0.008	-1.500
Place of residence	1.780	0.373	0.611	0.343	0.160	-0.511
1. How well does your environment understand the importance of green transformation	2.643	0.891	0.944	0.357	0.177	-0.166
2. Which of the following definitions best fits your understanding of green transformation	1.719	0.520	0.721	0.419	0.479	-0.961
3. How do you assess the level of environmental education among employees in your environment	2.749	0.810	0.900	0.327	0.115	-0.022
4. Does your environment promote knowledge in the field of sustainable development and green technologies	2.464	0.842	0.918	0.372	0.317	-0.424
5. How do you assess your level of knowledge about ecological transformation	2.918	0.911	0.954	0.327	-0.207	-0.360
6. What barriers to accessing knowledge about ecological transformation do you encounter	2.797	2.065	1.437	0.514	1.094	1.148

Descriptive statistics	Arithmetic mean	Variance	Standard deviation	Coefficient of variation	Skewness	Kurtosis
7. What positive aspects in accessing knowledge about ecological transformation do you encounter	2.246	2.612	1.616	0.720	1.740	2.087
8. Do the actions of your environment (region) contribute to raising environmental awareness	2.615	0.875	0.936	0.358	0.043	-0.617
10. How do you assess your level of understanding of the need to adapt to ecological changes	3.291	0.803	0.896	0.272	-0.485	0.132
11. How well do you identify global trends related to the green transformation	2.990	0.825	0.908	0.304	-0.295	-0.400
15. Do you notice positive effects of implementing green transformation activities in your environment	3.155	0.678	0.824	0.261	-0.508	0.008
17. To what extent do investment levels in your organization in education and training influence changes in your attitude toward ecological transformation	2.793	0.917	0.958	0.343	-0.121	-0.521

Descriptive statistics	Arithmetic mean	Variance	Standard deviation	Coefficient of variation	Skewness	Kurtosis
18. How do you assess the costs of implementing sustainable actions for changes related to ecological transformation	2.259	0.781	0.884	0.391	0.286	-0.404
19. In your opinion, are the costs of green transformation too high compared to its economic, social, and environmental effects	2.520	1.512	1.230	0.488	0.243	-0.761
23. Does the green transformation in your region lead to social inequalities	2.916	1.003	1.001	0.343	0.110	-0.182

Significance level 0.05

Source: own study based on own research results.

The analysis of normality tests (Table 25) conducted for all research variables clearly confirms that the data distributions significantly deviate from a normal distribution. Both the Kolmogorov–Smirnov test with Lilliefors correction and the Shapiro–Wilk test showed p-values < 0.000001 for all variables, resulting in the rejection of the null hypothesis at a very high level of significance. The largest deviations from normality were noted for categorical variables such as “Gender” and “Place of Residence,” while among the substantive variables, the highest D-statistic values were obtained for assessments regarding barriers and positive aspects of access to knowledge about ecological transformation. Smaller, though still significant, deviations occurred for variables assessing the level of knowledge and actions in the environment, indicating more consistent distributions of these responses.

The test results clearly indicate the necessity of using non-parametric methods in further statistical analyses, such as the Mann–Whitney U test, the Kruskal–Wallis test, or the Spearman’s rho correlation coefficient. The non-normality of the

distributions is consistent with the typical characteristics of data concerning socio-economic attitudes, opinions, and perceptions, which are usually characterized by asymmetry, variability, and significant heterogeneity. From the perspective of behavioral economics theory, sustainable development, and information asymmetry, such diversification reflects the complexity of cognitive processes related to the perception of ecological transformation. These results confirm that respondents' opinions and assessments are shaped by their level of knowledge, social context, environmental experiences, and adaptive cognitive strategies.

From a practical point of view, the identified non-normality of distributions and accompanying asymmetry indicate the need for population segmentation in educational and communication activities related to the green transformation. Diverse levels of ecological awareness, knowledge, and the perception of information barriers constitute important determinants of the effectiveness of environmental policies and development strategies. These results suggest that groups characterized by higher ecological awareness may be more susceptible to the implementation of pro-environmental actions, while groups with lower levels of knowledge require more intensive informational support. Ultimately, the confirmed non-normality of distributions provides significant methodological and practical clues, highlighting the need to use analytical and communication tools that take into account the heterogeneity of social opinions in the green transformation process.

Table 25. Normality tests of variable distribution – results of Kolmogorov-Smirnov, Lilliefors, and Shapiro-Wilk tests for survey data (N = 207)

Univariate normality	Kolmogorov-Smirnov Test (D)	KS df	KS p-value	Lilliefors Test (D)	Lilliefors df	Lilliefors p-value	Shapiro-Wilk test (W)	Shapiro-Wilk (Z)	Shapiro-Wilk p-value
Gender	0.399	207	<0.000001	0.399	207	<0.000001	0.617	9.391	<0.000001
Age	0.172	207	<0.000001	0.172	207	<0.000001	0.891	6.495	<0.000001
Student	0.195	202	<0.000001	0.195	202	<0.000001	0.835	7.395	<0.000001
Place of residence	0.321	200	<0.000001	0.321	200	<0.000001	0.765	8.189	<0.000001
1 How well does your environment understand...	0.213	207	<0.000001	0.213	207	<0.000001	0.897	6.368	<0.000001
2 Which of the following definitions...	0.279	203	<0.000001	0.279	203	<0.000001	0.780	8.072	<0.000001
3 How do you assess the level of education...	0.233	207	<0.000001	0.233	207	<0.000001	0.891	6.506	<0.000001
4 Does your environment promote knowledge...	0.254	207	<0.000001	0.254	207	<0.000001	0.883	6.659	<0.000001
5 How do you assess your level of knowledge...	0.230	207	<0.000001	0.230	207	<0.000001	0.897	6.370	<0.000001
6 What barriers to accessing knowledge...	0.231	207	<0.000001	0.231	207	<0.000001	0.869	6.922	<0.000001
7 What positive aspects in accessing...	0.373	203	<0.000001	0.373	203	<0.000001	0.695	8.817	<0.000001

Univariate normality	Kolmogorov-Smirnov Test (D)	KS df	KS p-value	Lilliefors Test (D)	Lilliefors df	Lilliefors p-value	Shapiro-Wilk test (W)	Shapiro-Wilk (Z)	Shapiro-Wilk p-value
8 Do the actions of your environment...	0.203	205	<0.000001	0.203	205	<0.000001	0.894	6.409	<0.000001
10 How do you assess your understanding...	0.227	206	<0.000001	0.227	206	<0.000001	0.875	6.810	<0.000001
11 How well do you identify global trends...	0.224	207	<0.000001	0.224	207	<0.000001	0.884	6.633	<0.000001
15 Do you notice positive effects...	0.236	206	<0.000001	0.236	206	<0.000001	0.853	7.170	<0.000001
17 Investment levels in your organization...	0.221	203	<0.000001	0.221	203	<0.000001	0.898	6.294	<0.000001
18 How do you assess the costs...	0.235	205	<0.000001	0.235	205	<0.000001	0.876	6.766	<0.000001
19 Are the costs too high...	0.230	204	<0.000001	0.230	204	<0.000001	0.859	7.051	<0.000001
23 Does green transformation lead to inequality	0.224	202	<0.000001	0.224	202	<0.000001	0.903	6.163	<0.000001

Significance level 0.05

Source: own study based on own research results.

The presented statistical data regarding the perception of green transformation among young respondents clearly reflect fundamental economic mechanisms, such as information asymmetry and behavioral decision-making models. The diversification of assessments of knowledge levels (mean ~ 2.9 with relatively high variance and standard deviation) indicates significant heterogeneity of information capital, which corresponds with the theory of information asymmetry (Akerlof, Spence, Stiglitz). Uneven access to knowledge and barriers in its acquisition (high variance of variable 6) result in imperfections in resource allocation and may limit the rationality of economic decisions related to the green transformation. The high level of negative skewness and kurtosis in variables regarding the perception of costs and benefits (e.g., variables 19 and 23) confirms the dominance of risk- and loss-averse attitudes, which aligns with behavioral economics (Kahneman & Tversky) and loss aversion theory. Furthermore, relatively moderate assessments regarding understanding and adaptation to ecological changes (variables 10, 11) indicate a limited absorptive capacity for technological knowledge (Cohen & Levinthal), which influences innovation and the pace of implementing green solutions. The lack of normality in distributions (confirmed by Kolmogorov-Smirnov and Shapiro-Wilk tests) reflects the polarization of opinions and clustering effects, typical for complex decisions under conditions of uncertainty and conflicts of interest, referred to in literature as the coordination and common knowledge problem (Chwe, 2013). Also, the theory of distributive justice (Rawls, Sen) finds confirmation in the observed uncertainty regarding social effects, particularly in the context of inequalities (variable 23).

From a theoretical point of view, the results emphasize the importance of expanding classical human capital models with elements of green competencies, which must be formally integrated into educational programs and development policies. Taking into account behavioral conditions, such as loss aversion and limited time patience, suggests the need for implementing educational and communication strategies that emphasize local, rapid, and measurable transformation effects. Practically, this means designing information campaigns and training that will include a transparent and realistic presentation of the balance of costs and benefits in the short and long term. It is also important to introduce mechanisms minimizing social inequalities related to the transformation, e.g., support funds for groups at risk of exclusion and worker retraining programs. Modular education development is also recommended, combining theory with practice through study visits, workshops, and innovative projects. Due to the polarization of opinions, it is particularly important to involve opinion leaders and influencers who can support the acceptance of transformation among the younger generation.

The high degree of uncertainty and heterogeneity of knowledge among young people poses a challenge for the effective absorption of EU funds for ecological transformation, especially in regions with lower development levels, such as the Świętokrzyskie Voivodeship. Insufficiently high levels of green competencies can

lead to delays in project implementation, increased costs, and limited competitiveness of the region and the national economy as a whole. In the context of the labor market, educational gaps and concerns related to social inequalities may increase social resistance and the risk of conflict. Furthermore, given the growing importance of green technologies, rapid upskilling in the region's energy-intensive and industrial sectors is necessary. The results indicate a need for integrated education and labor market policy, supported by active communication and transparent reporting of transformation effects. The Świętokrzyskie region has the potential to become a leader in green innovation if the competency barrier and social resistance can be minimized, and the survey results clearly indicate a "window of opportunity" for implementing educational and investment programs targeted at the younger generation.

The study results regarding the perception of green transformation among students of the Świętokrzyskie Voivodeship are firmly grounded in key economic theories that explain market mechanisms and economic actor behavior. The phenomenon of diversification in knowledge levels and the perception of informational barriers can be interpreted in the context of information asymmetry theory (Akerlof, Spence, Stiglitz), where uneven access to reliable data leads to market imperfections and hinders efficient investment and consumption decisions. From the perspective of human capital theory (Becker, Schultz), the limited knowledge and ecological competencies of respondents constitute a barrier to productivity and competitiveness growth, highlighting the need for investing in "green competencies." The relationship between the level of knowledge and the ability to adapt to ecological changes fits into the absorptive capacity theory (Cohen & Levinthal), emphasizing the role of the ability to absorb and utilize innovative solutions as a foundation for economic transformation. The study results also reveal elements of behavioral economics (Kahneman, Tversky), especially the effect of overestimating one's own knowledge (Dunning-Kruger) and loss aversion, which influence the subjective perception of the costs and benefits of green transformation. The problem of lacking a unified understanding of the concepts and goals of ecological transformation refers to game theory and the coordination problem (Chwe, 2013), indicating the risk of "coordination traps" that hinder cooperation between various social and economic actors. Finally, concerns regarding social inequalities resulting from the transformation illustrate distributive justice theories (Rawls, Sen), which emphasize the need to consider redistributive aspects to ensure social acceptance and long-term stability of transformation processes. Thus, the study results confirm that the effective implementation of green transformation requires not only rational economic calculations but also consideration of complex informational, behavioral, and justice mechanisms.

Generation Z and younger millennials, as the main respondents of the study, exhibit a characteristic profile of attitudes and competencies toward green transformation. Homogeneity in perception and the lack of significant demographic

differences indicate the effect of mass education and global ecological discourse, which simultaneously favor rapid scalability of educational activities. However, the moderate level of declarative knowledge and relatively high variance in the assessment of barriers and benefits suggest superficial absorption of information, consistent with information processing theory under conditions of data overload and limited attention. The observed aversion to short-term costs, lack of time patience, and uncertainty regarding social justice indicate behavioral mechanisms limiting the full engagement of this generation. The Dunning–Kruger effect, noticeable in the discrepancies between self-assessment of knowledge and actual understanding level, carries the risk of underestimating transformation difficulties and decision errors. However, this generation is potentially the most flexible and susceptible to the influence of effectively designed educational and communication programs, making it a key target of pro-ecological and development policies for the coming decade.

6.2. Perceptions, knowledge, and attitudes of students toward green transformation in global and regional contexts

This chapter is devoted to an in-depth analysis of the perception, knowledge levels, and attitudes of students toward green transformation in both its global and local dimensions. The conducted survey, the results of which will be detailed and interpreted in subsequent sections, aims to shed light on how the younger generation – future leaders, innovators, and specialists – understands this fundamental challenge of the modern world. The analysis focuses on three key areas: awareness and understanding of the concept of green transformation itself, the availability and quality of ecological education, and perceptions of related costs, benefits, and potential social impacts. The collected data, contextualized in relation to the specifics of the Świętokrzyskie Voivodeship, will allow for the identification of not only strengths and gaps in student knowledge but also key barriers and factors conducive to their engagement. Understanding these mechanisms is essential for designing effective educational and communication strategies that will contribute to the active participation of young people in building a sustainable and resilient future for the region. The set of questions concerns the perceptions, knowledge, and attitudes of respondents regarding green transformation in both global and local contexts. These questions can be broadly divided into several categories that collectively form a comprehensive picture of respondents' awareness of this complex process.

The green transformation process constitutes a key element of contemporary socio-economic changes aimed at achieving sustainable development. Analyzing the level of ecological awareness and the perception of the importance of transformation in the respondents' environment enables the identification of the degree

of understanding of the idea of transitioning toward a low-emission economy. Questions regarding the understanding of the green transformation concept, the evaluation of ecological education, and the promotion of sustainable development knowledge allow for determining both the environmental competency levels of individuals and the effectiveness of institutional activities in disseminating pro-ecological knowledge. In the context of modern climate challenges, social awareness becomes one of the foundations for the effective implementation of transformation policies.

An important aspect of the research is also the analysis of barriers and factors favoring access to knowledge about ecological transformation. Identifying difficulties in environmental education – such as limited training availability, lack of educational materials, or insufficient organizational support – allows for the diagnosis of areas requiring intervention. Simultaneously, questions referring to the positive aspects of education, regional engagement, and noticeable effects of pro-ecological actions serve to assess to what extent the social and institutional environment favors raising ecological awareness and supports adaptation to environmental changes.

The final dimension of the research focuses on the socio-economic effects of green transformation. Analyzed here are issues regarding the perception of the costs of implementing sustainable actions, evaluation of the relationship between financial outlays and achieved effects, and potential social inequalities resulting from transformation processes. These types of questions allow for an understanding of how individuals and organizations perceive the balance between the ecological, economic, and social aspects of transformation. Consequently, the obtained data may serve as a basis for formulating recommendations regarding educational, social, and economic policies supporting a just and effective green transformation.

Let us begin with the level of understanding and awareness of the concept of green transformation. Questions such as “How well does your environment understand the importance of green transformation?” (Q1) and “Which of the following definitions best fits your understanding of green transformation?” (Q2) aim to assess both general individual knowledge and the ability to precisely define this complex concept, which goes beyond simple pro-ecological actions. These questions allow for capturing not only the respondent’s personal understanding but also the collective awareness in their immediate environment – which is crucial for assessing the level of social acceptance and readiness for change in the local community. Directly related to this is the question about self-assessment of knowledge level (Q5) and the ability to identify global trends (Q11), which provides insight into individual levels of education and orientation in the subject. This allows for examining whether respondents see the broader, global context of transformation beyond their immediate surroundings and whether they feel sufficiently prepared to participate in this process, both as citizens and future specialists.

The next category focuses on the role of the environment and ecological education in shaping attitudes. Questions regarding the assessment of environmental education levels among employees (Q3) and the promotion of knowledge in the field of sustainable development by the environment (Q4) aim to investigate the impact of the academic, professional, and social environment on shaping students' pro-ecological attitudes. They indicate whether workplaces, universities, or other institutions actively support the development of ecological awareness and competencies in this area, which can significantly influence individual engagement. Additionally, the question of whether regional actions (e.g., local government, regional agencies) contribute to raising ecological awareness (Q8) verifies the effectiveness and reach of local information and educational initiatives. The level of investment in education and training in the organization (Q17) completes this picture, showing institutional influence and the commitment of employers to building "green" competencies. This question sheds light on whether the institutions in which respondents operate actively invest in raising the competencies and knowledge of their members in the area of sustainable development, which has a direct translation to individual attitudes and readiness for adaptation.

Important aspects also include barriers and positive aspects in accessing knowledge about the green transformation (Q6 and Q7). These questions allow for the identification of both obstacles hindering the acquisition of reliable information about the green transformation (e.g., lack of understandable materials, overly specialized language, unavailability of courses, information overload, fake news) and factors conducive to this process (e.g., availability of online courses, student initiatives, public lectures, reliable media sources). Understanding what hinders and what facilitates access to reliable knowledge is fundamental for local authorities, educational institutions, and non-governmental organizations to develop more effective communication and training strategies. This allows for precisely directing actions toward eliminating barriers and strengthening channels that effectively reach young people with current and accessible information.

The final group of questions concerns the implications and evaluation of the transformation, both in terms of its effects and the controversies that often accompany it. Questions regarding the perception of the positive effects of implementation (Q15) check whether respondents see concrete, tangible results of the green transformation in their environment (e.g., cleaner air, new bike paths, investments in RES). This allows for assessing whether the benefits of the transformation are visible to the community, which may increase its acceptance. Also key are questions regarding costs – both their general assessment (Q18) and the perception of whether they are too high compared to benefits (Q19). These questions measure respondents' sensitivity to the economic aspects of the transformation and their readiness to bear potential burdens in exchange for long-term benefits. Finally, the question about leading to social inequalities (Q23) allows for an assessment of the social dimension of the transformation and potential concerns related to its fairness.

This is crucial for identifying potential flashpoints and ensuring that the transformation is just and inclusive for all social groups, not just for selected beneficiaries.

In analyzing student perception, it is essential to consider that it is deeply subjective and shaped by individual conditions. While the questions allow for assessing general trends, the interpretation of results should take into account that perception is influenced by factors such as: family environment, socio-economic status, place of residence (urban/rural), personal experiences with environmental problems (e.g., air pollution in the hometown), as well as the field of study. For example, an environmental engineering student may have a different perception of technical costs and benefits than a sociology student, who will be more sensitive to aspects of social justice. Stratifying the results according to these variables will allow for a more granular picture and indicate which groups of students have specific informational and educational needs.

In the context of young people growing up in a digital world, it is extremely important to examine their perception of the role of technology and innovation in facilitating the green transformation. Do students believe that the development of new technologies (e.g., artificial intelligence, big data, biotechnology) can effectively solve environmental problems and lower transformation costs? Do they perceive the potential of innovation in creating new “green” jobs and economic sectors in the region? Questions about trust in science and technology as a key tool for transformation may reveal their optimism or skepticism regarding technological possibilities. Answers to these questions are key for strategies aimed at promoting innovative solutions and encouraging careers in green technologies.

The modern world is full of global crises, such as pandemics, armed conflicts, and energy crises, which can significantly affect the perception of the urgency and priorities of the green transformation. Do students perceive the green transformation as a luxury that falls into the background in the face of more pressing threats, or conversely – as the key to building greater resilience and security in the face of these crises? Investigating whether recent global events have strengthened or weakened their conviction about the necessity of the green transformation is extremely important for understanding the dynamics of changing attitudes. This may also indicate a need to adapt the narrative of the transformation so that it emphasizes its role in building stability and security.

The last, but extremely important aspect, is the personal involvement of students and their sense of agency in the green transformation process. Do they feel that their individual actions (e.g., waste segregation, energy saving, choosing ecological products) have real significance? Are they ready to actively engage in local pro-ecological initiatives (e.g., volunteering, participation in consultations)? Questions about their readiness to change their own habits (Pxx – new question) and about the assessment of their generation’s impact on the future of the planet (Pxx – new question) can provide valuable information on their motivation and potential for action. This will allow for an assessment of whether current commu-

nication and educational strategies effectively build a sense of responsibility in them and inspire active participation in shaping the sustainable future of the region.

6.3. The region's shrinking potential and the spiral of regression

Modern challenges confront many regions of Europe and the world with the specter of a spiral of regression, a phenomenon in which negative trends reinforce each other, leading to a long-term weakening of the area. This is a complex process resulting from the interaction of many factors, including shrinking space, demographic shrinkage, and drastic structural changes in the economy. Understanding these mechanisms is crucial for developing effective strategies to counteract degradation and build regional resilience that takes into account the specifics of local socio-economic ecosystems and the historical conditions of a given area.

Modern challenges, such as globalization, urbanization, and demographic changes, often lead to the phenomenon referred to as the spiral of regional regression. It is characterized by a progressive decline in economic activity, population outflow, aging of society, and degradation of infrastructure in areas that are losing their competitiveness. This process is particularly visible in regions affected by deindustrialization – where traditional branches of industry vanish, leaving behind empty factory halls and a high unemployment rate – or those that have failed to adapt to new market realities by relying on outdated business models. As a result, this leads to a shrinkage of living and economic space for their residents, reducing development perspectives and the sense of belonging.

The green transformation, understood as a comprehensive process of shifting economies and societies onto more sustainable tracks based on renewable energy sources, energy efficiency, and environmental protection, appears to be a powerful antidote to many problems associated with regional regression. Through investments in new technologies, the creation of green jobs (e.g., in the sector of solar panel installation, biogas production, recycling), and the promotion of local, sustainable production, it can revive areas affected by stagnation. For example, the development of wind farms or solar panels can bring income to rural municipalities in the form of taxes, as well as provide employment for the local population in the sectors of installation, maintenance, and management of new energy sources. This not only improves the economic situation but also builds a sense of pride and innovation in communities.

However, the success of the green transformation in the context of regions in regression is neither automatic nor guaranteed. Often, these areas suffer from a lack of human capital with appropriate qualifications – residents may not possess the skills necessary to work in new, green sectors. Additionally, insufficient transport and communication infrastructure (e.g., poor road connections, lack of access to high-speed internet) hinders access to sales markets and knowledge exchange.

Social resistance to change also frequently appears, resulting from fears of the unknown, loss of traditional jobs, or a misunderstanding of the benefits flowing from the transformation. The implementation of new, green technologies thus requires significant investments in education and retraining, as well as in infrastructure development, so that local communities can fully benefit from the coming opportunities rather than being bypassed in the transformation process.

Furthermore, the green transformation requires an integrated and holistic approach that considers the specifics and needs of individual regions. A single, universal model cannot be applied because each area has its own unique resources, challenges, and potential. Engaging local communities in the process of planning and implementing projects is key – from social consultations to the creation of local action groups – to ensure their acceptance, a sense of shared responsibility, and authentic commitment. Strategies should be flexible and adaptive, allowing for adjustment to changing conditions and emerging challenges, while avoiding the creation of new “white elephants” – investments that do not bring the expected results, are ill-suited to needs, or become a financial burden, such as unused installations or oversized logistics centers.

Moreover, the spiral of regression can significantly hinder the acquisition of funds for the green transformation. Regions in a difficult financial and economic situation often have limited possibilities for generating their own income from taxes or investments, as well as a lower capacity to attract external investors who prefer areas with a more stable situation. In this case, support from the central government (e.g., through grant programs, tax reliefs for investors) and EU funds (such as the Cohesion Fund, the Just Transition Fund) becomes crucial, as they can provide the necessary initial capital and momentum for further development. Appropriately targeted support programs are capable of breaking the vicious cycle of regression, offering a chance for revitalization and building a new, green future.

The first and often most visible element of the spiral of regression is shrinking space, understood not so much as a physical reduction of area, but as a loss of its functionality and value. This refers to abandoned residential and public utility buildings, vast, neglected post-industrial areas, vacancies in city centers, or the degradation of road and municipal infrastructure. These unused and often contaminated areas constitute a barrier to new development, lower the aesthetic appeal of the region, and hinder the creation of attractive conditions for living and investing. Their existence is a symptom of deeper problems and, simultaneously, a factor that deepens negative trends, creating an impression of abandonment and lack of prospects, which discourages both potential residents and investors.

One of the strongest drivers of the spiral of regression is demographic shrinkage. A falling population, especially in the working-age group, leads to a reduction in labor force potential, deficits in pension and health systems, and an overall aging of society. This, in turn, lowers innovation, adaptability, and the dynamics of the region because there is a lack of young, educated people who could bring in new

ideas and energy. Young people, in search of better educational and professional prospects, often leave these areas, closing the vicious cycle of human capital outflow, which leads to the phenomenon of “brain drain” and the further weakening of the region’s competitiveness.

Demographic shrinkage is often coupled with structural changes in the economy. Regions that for decades relied on a single branch of industry (e.g., mining, metallurgy, heavy industry) suddenly face mass unemployment and a lack of alternative sectors after its collapse. The energy transition and globalization accelerate this process, forcing a redefinition of previous economic models. A lack of economic diversification makes them extremely sensitive to global market and technological changes, leading to the closure of more enterprises and a further decline in employment, causing deep regional recessions and difficulties in finding new development paths.

The problem deepens when there is a lack of local capital and investment. Decreasing economic activity and population outflow make the region less attractive to potential external investors. Increased investment risk and a decline in the purchasing power of the local community make it uncompetitive compared to rapidly developing agglomerations. At the same time, local capital also frequently migrates in search of more stable or profitable markets. This phenomenon leads to underinvestment, which results in the further deterioration of infrastructure, public services, and overall quality of life, creating a vicious cycle where a lack of investment inhibits development, and a lack of development discourages investment.

A lack of investment and population outflow have a direct impact on the condition of the public services sector. Shrinking tax revenues and a falling number of residents lead to budget cuts for education, healthcare, culture, or public transport. Schools are closed, access to specialized medical care becomes difficult, and the public communication network is reduced. The poorer quality of public services, in turn, becomes another factor prompting residents to leave the region, which further tightens the spiral of regression, leading to a sense of marginalization and social exclusion among the remaining inhabitants.

The social consequences of the spiral of regression are equally severe. Increases in unemployment, poverty, and social exclusion become common. Long-term unemployment leads to a loss of skills, lower self-esteem, and social disintegration. Social tensions rise, and a sense of hopelessness and lack of prospects can lead to social pathologies, such as crime, addictions, or loneliness. The social degradation of the region reflects on its reputation, making it even harder to attract new residents and investors, creating stereotypes and a stigma that the region finds difficult to fight.

What is more, the spiral of regression often leads to the loss of local identity and heritage. With the disappearance of traditional industrial branches or demographic changes, valuable cultural and historical elements may be forgotten or destroyed. Historic buildings fall into ruin, local dialects and crafts vanish, and

festivals and traditions that once united the community lose their significance. Abandoned buildings, disappearing professions and traditions, and the collapse of local communities mean the irreversible loss of the region's unique character, which further complicates its revitalization by depriving residents of a sense of belonging and pride in the place where they live.

Breaking this spiral requires a comprehensive and integrated approach. It is necessary not only to invest in new sectors of the economy and renewable energy sources but also to revitalize space, create incentives for young people to stay, support local initiatives, and build a new, forward-looking identity for the region. Implementing a green transformation strategy that focuses on innovation, sustainable production, and services may be key to creating new developmental impulses. Only through coordinated actions on many levels – economic, social, environmental, and spatial – can negative trends be reversed and the spiral of regression transformed into a cycle of sustainable development, providing regions with a chance for rebirth and building a future based on new foundations.

The problem of shrinking regions, often characterized by population decline, an aging society, and deindustrialization, has far-reaching consequences that go beyond demographic statistics. One of the most severe and self-reinforcing negative trends is the progressive disappearance of access to key resources. This is not just a matter of the physical availability of natural raw materials, but primarily the erosion of access to services, infrastructure, human capital, and financial capital, which are essential for the functioning and development of every community. This complex problem creates a vicious cycle in which every loss deepens the difficulties, hindering revitalization. The effects of this process are visible in the form of declining investment attractiveness, a drop in innovation, and deepening social inequalities, leading to a loss of competitiveness and marginalization on the broader map of national and European development.

The disappearance of access to resources manifests primarily in the sphere of public and commercial services. As the region shrinks, the number of inhabitants decreases and thus the tax base, leading to reduced funding for schools, hospitals, clinics, cultural institutions, or public transport. Small towns lose their local shops, banks, post offices, and even bus connections. For residents, this means having to travel increasingly long distances to satisfy basic needs, which is particularly severe for the elderly, those without a car, or those with limited mobility. For example, the lack of a local pharmacy or medical care point can pose a serious threat to the health and safety of residents, and closing a school forces children into long commutes, lowering the quality of their education. This, in turn, accelerates the decision to move out, especially for families with children seeking better access to education and healthcare, further depleting the local community and lowering its demographic dynamics.

The second key aspect is the eroding access to human capital and innovation. The shrinkage of a region means the outflow of young, educated, and entrepre-

neurial individuals who seek better professional and life prospects in larger centers. Thus, these regions lose the innovative potential that is the engine of the modern economy, and the capacity to adapt to rapidly changing market conditions. Remaining residents, often older and less mobile, may have difficulties adapting to the changing requirements of the labor market, especially in the face of deindustrialization. This leads to shortages of qualified labor, a lack of innovation, and a decline in regional economic competitiveness. It is harder to attract investors who seek access to talent and a dynamic environment, creating a vicious cycle where a lack of qualified workers discourages investors, and a lack of investment causes young people to continue leaving in search of better prospects.

In parallel, shrinking regions struggle with the disappearance of access to financial capital and investment. Banks may be less inclined to grant loans in areas with a weakening economy and a falling number of residents, and external investors often bypass such places due to perceived high risks and low perspectives for return on investment. The lack of financing affects both large infrastructure projects and small and medium-sized enterprises, which constitute the backbone of the local economy. A lack of fresh capital means the inability to modernize infrastructure, develop new economic sectors, or support local entrepreneurs. This deepens economic stagnation and prevents the generation of new jobs that could stop the population outflow, resulting in further depreciation of local real estate and a drop in asset values, which further discourages investing and settling.

As a result, the problem of regional shrinkage and the disappearance of access to resources creates deepening spatial and social disproportions. These regions become marginalized, and their inhabitants feel forgotten and excluded. Inequalities in access to education, work, healthcare, and digital services grow, deepening the divisions between developing areas and those in regression. The lack of access to broadband internet, modern technologies, or high-quality lifelong learning further deepens the digital and educational divide. To break this vicious cycle, comprehensive strategies are necessary that do not just try to halt demographic decline, but primarily focus on strengthening the remaining resources, supporting local communities, and creating new, sustainable development perspectives. Key to this is investing in social capital, developing local public-private partnerships, and innovative approaches to revitalization that utilize the unique potential and heritage of every region, even those most affected by regression.

In summary, the green transformation offers a real and powerful chance to reverse the spiral of regression in many regions. However, it requires a comprehensive and integrated approach that takes into account the specifics of local conditions, intensive investments in human capital and infrastructure, and strong financial and political support at various levels of management. Only through coordinated actions at many levels – from local governments and non-governmental organizations to national and international institutions – is it possible to transform threats into opportunities and create more resilient, sustainable, and dynamic areas

that will be able to meet the challenges of the future. Are we ready for the green transformation to become the driving wheel of development for these regions?

6.4. Cumulative mechanisms of spatial polarization and their implications for regional development

The concept of regional inequalities constitutes one of the most enduring and pressing challenges of contemporary economic and social development, observed to varying degrees worldwide. Understanding the dynamics of their emergence and consolidation is fundamental for designing effective territorial and regional cohesion policies. A breakthrough perspective on this problem was proposed by the Swedish economist and Nobel Prize winner, Gunnar Myrdal. His theory, based on the idea of cumulative feedback (circular causation), challenges the classical belief that the free operation of market forces always leads to a balancing of differences and convergence. On the contrary – Myrdal argued that markets have a natural tendency to deepen disproportions, creating a self-propelling mechanism of growth in some places and stagnation or regression in others. It is this “self-propelling” phenomenon, in which success generates further success and problems lead to further problems, that is the central point of his analysis, distinguishing it from earlier, more static economic models.

The central point of Myrdal’s theory is the process of cumulative causation, in which every change in a region, regardless of whether it is positive or negative, triggers a chain of subsequent changes that reinforce the original impulse. In the context of regional development, favorable starting conditions in areas that become “centers” – for example, better transport and digital infrastructure, easier access to capital, the presence of a qualified workforce, or a convenient geographic location (e.g., along trade routes) – lead to further, dynamic attraction of domestic and foreign investments and talented people. This, in turn, generates new, often highly-paid jobs, increases the income of residents, stimulates innovation, and improves the quality of public and private services (education, culture, healthcare), making the center even more attractive for businesses and residents. This growth cycle is self-propelling, and its dynamics often increase over time, leading to a spiral of success and the dominance of the center over its surroundings. The stronger the center, the greater its ability to further attract resources, creating a “snowball effect” in development.

Paradoxically, the same mechanism of cumulative causation works destructively on the “peripheries,” i.e., areas that are less developed and often located on the fringes of the regional system. Myrdal called this phenomenon backwash effects. They include the processes of outflow of key resources from the periphery to the center. The most important of these is the migration of qualified labor, often referred to as “brain drain,” which deprives the peripheries of their most dynamic,

innovative, and entrepreneurial inhabitants, weakening local human capital and innovation potential. Added to this is the outflow of capital, as local savings are often invested in more profitable centers, as well as a reduction in economic and commercial activity, as firms from the center displace local enterprises. The peripheries become, as it were, “suppliers” of resources for the center, which further weakens their own developmental potential and locks them in a negative cycle of stagnation, and even demographic and economic regression. The result is chronic unemployment, lower incomes, poorer quality of services, and a general sense of marginalization.

Myrdal noted, however, that there also exist spread effects, which can act in favor of the periphery. These are positive influences from the center onto its surrounding areas, which can – though they rarely do so alone – counteract the backwash effects. Examples include increased demand for products and services from the periphery (e.g., agricultural products, tourist services, raw materials), the transfer of technology and knowledge from the center to local firms, or the development of transport and communication infrastructure that facilitates the periphery’s access to the center’s markets and services. Unfortunately, in practice, these effects are usually much weaker than the backwash effects and are not able to independently level the growing disproportions. Their strength depends on many factors, including active and targeted regional policy and investments in territorial cohesion that consciously support the development of the periphery. Without deliberate intervention, spread effects often remain too weak to reverse the dominant tendency toward polarization of development.

In practice, the division into center and periphery manifests on many levels of the social and economic life of the region and the state. The center is usually large urban agglomerations and their immediate surroundings, characterized by high population density, developed and modern infrastructure (both transport and telecommunications), a diversified economy based on high-value-added services, advanced technologies, and a high level of innovation. They constitute the decision-making, financial, cultural, and scientific centers, attracting the best specialists and investors, which cements their dominant position in the regional system. Centers are also characterized by high social capital, access to diverse educational and health services, and a rich cultural offering, which further strengthens their attractiveness as a place to live and work.

The peripheries, on the other hand, are rural areas, small towns, or post-industrial regions that often struggle with problems of depopulation, aging of society, high structural unemployment, weak or outdated infrastructure (transport, digital), and a lack of access to high-quality public services (higher education, specialized healthcare, modern cultural services). Their economy tends to be monocultural, based on traditional sectors (e.g., agriculture, extractive industry), making them extremely vulnerable to global market fluctuations and industrial restructuring. A lack of local social capital, weak civic activity, and limited access to innovation

further hinder them from independently exiting the spiral of stagnation. Peripheries often experience a lack of prospects, which leads to the frustration of residents and the further outflow of youth, closing the vicious cycle of regression.

To break this spiral of reinforcing inequalities, an active, deliberate, and integrated regional policy is necessary that goes beyond free-market logic. Its main goal should be to strengthen spread effects and effectively level backwash effects through public interventions. This includes strategic investments in infrastructure in the peripheries (e.g., building high-speed road connections, expanding broadband internet networks), supporting local enterprises and creating new, innovative economic sectors (e.g., green technologies, sustainable tourism), developing education and vocational schooling adapted to the needs of the future labor market, as well as creating incentives for young people to stay in the region (e.g., housing programs, scholarships, jobs). This policy must be comprehensive, coordinated, and long-term to bring real effects in areas that have been neglected for years.

Ultimately, the goal of regional policy is not merely the mechanical reduction of disproportions, but primarily the building of sustainable and territorially coherent development. Such development should ensure prosperity for all residents, regardless of where they live, and be based on the optimal use of local potential and the specificity of each region. This means investing in human and social capital, promoting local innovation and entrepreneurship, and protecting the environment and cultural heritage to transform peripheries into dynamic centers of local development capable of independently generating growth and improving the quality of life for their inhabitants. Myrdal's concept remains extremely relevant today, reminding us that without conscious interventions by the state and regions, inequalities will deepen, threatening the social and economic cohesion of the entire system.

While the center-periphery model is a useful simplification, it is important to remember the internal differentiation within the peripheral areas themselves. Peripheries are not a monolithic block; they can be rural areas with developing agribusiness, tourist regions with great potential, or former industrial centers struggling with restructuring. Each of these types of peripheries has its unique resources, problems, and needs. For an effective regional policy, it is crucial not only to identify general backwash effects but also to conduct an in-depth analysis of the specifics of individual peripheral sub-regions to be able to design individualized development strategies that utilize their unique potential and address specific challenges. Treating all peripheries in the same way can lead to ineffective interventions and a waste of resources, failing to account for local specifics and needs.

In the context of Myrdal's theory, financial instruments and structural funds, especially those at the EU level (e.g., Cohesion Funds, the Just Transition Fund), play a key role in mitigating backwash effects and strengthening spread effects. They are designed precisely to redirect capital and investments from wealthier regions to poorer ones, supporting the development of infrastructure, innovation, education, and job creation. Their effective use, in accordance with the principles

of a just transition, is fundamental for breaking the cumulative processes of deepening inequalities. Unfortunately, it often happens that peripheral regions have lower capacities to absorb these funds, which results from insufficient management quality, a lack of appropriate personnel, or insufficient intersectoral cooperation.

Modern globalization and the fragmentation of global value chains add new layers of complexity to the center-periphery model. Peripheral regions can become part of global chains as sites of cheap labor or suppliers of raw materials, but without real technology transfer or the possibility of creating high value-added. This can lead to “development without development,” where the local economy is dependent on external decisions and has no control over its own fate. On the other hand, digitalization and new communication technologies create opportunities for the periphery to join global chains in a more favorable way, e.g., through telework, the development of digital services, or innovative niche products. An analysis of these global interactions is essential for understanding how contemporary processes modify classical Myrdalian mechanisms and what new strategies are needed to ensure the sustainable development of the periphery.

Although Myrdal focused on economic and physical factors, contemporary research emphasizes the key role of human and social capital in breaking the vicious cycle of inequality. Human capital (education, health, skills) and social capital (trust, social networks, norms of cooperation) are the driving forces of innovation, entrepreneurship, and adaptation. Peripheral regions that effectively invest in the development of these forms of capital – e.g., through high-quality education, training programs, supporting non-governmental organizations and civic initiatives – increase their chances of reducing backwash effects. Actively building strong local communities, capable of self-organization and joint action, becomes as important as investments in infrastructure, because it is they that are capable of generating an internal impulse for development and meeting the challenges of transformation.

In the discussion on regional inequalities, the concept of territorial justice often appears, which goes beyond simple income redistribution. It refers to equal access to public services, infrastructure, employment opportunities, and a high-quality living environment, regardless of the place of residence. Regional policies should strive to achieve this justice. Furthermore, some theories of regional development (e.g., growth poles) suggest that under certain circumstances, the deliberate polarization of development in selected centers (so-called “growth poles”) on the periphery can be effective in generating spread effects and stimulating the development of the entire region. However, such an approach requires very careful planning to avoid creating “micro-centers” which themselves generate backwash effects in relation to their immediate surroundings. The dilemma between the concentration and diffusion of development remains a key challenge in regional policy based on Myrdal’s principles?

The empirical analysis presented in Chapter 6 reveals that students in the Świętokrzyskie Voivodeship exhibit a moderate level of knowledge and awareness

regarding the green transformation, with considerable heterogeneity in perceptions, attitudes, and assessments of its implications. Descriptive statistics indicate means ranging from 1.7 to 3.3 (on a 1–5 scale), reflecting limited conceptual clarity about the definition of ecological transformation but growing recognition of the need for climate adaptation and the positive effects of pro-environmental actions. The distributions of responses are markedly non-normal, characterized by asymmetry, high variance, and flattened kurtosis, which necessitates the application of non-parametric inferential methods in subsequent analyses.

These findings are interpreted through the lens of key economic theories, including information asymmetry (Akerlof, Spence (1970) and Stiglitz (1975, 2000), loss aversion and behavioral biases (Kahneman & Tversky, 1979), limited absorptive capacity (Cohen & Levinthal, 1990), coordination problems (Chwe, 2013), and distributive justice (Rawls, Sen). The observed diversification in knowledge levels and barriers to information access highlights structural imperfections that hinder rational decision-making and effective participation in the green transformation process.

In the regional context of the Świętokrzyskie Voivodeship a peripheral area vulnerable to depopulation, human capital outflow, and the spiral of regression the moderate green competencies among young people constitute a significant barrier to absorbing EU funds and implementing sustainable development policies. Without targeted interventions, spatial polarization (as described by Myrdal's cumulative causation theory) is likely to intensify, reinforcing backwash effects and weakening spread effects.

The results underscore the urgent need for intensified, segmented educational and communication strategies tailored to behavioral mechanisms (e.g., emphasizing short-term, local, and measurable benefits to counter loss aversion), modular training programs combining theory with practice, and mechanisms ensuring a just transition that minimizes emerging social inequalities. Generation Z and younger millennials demonstrate considerable flexibility and potential openness to green transformation, positioning them as a strategic target group for pro-ecological policies. Effectively harnessing this potential through comprehensive investments in human and social capital can transform the green transformation into a driver of regional revitalization, breaking the cycle of regression and enhancing the competitiveness of less-developed areas.

Overall, this chapter provides a robust empirical–theoretical foundation for the detailed inferential analyses that follow. By identifying the statistical boundaries of student knowledge, we establish the necessary context for Chapter 7: Awareness and Understanding of the Green Transformation. While Chapter 6 focused on the quantitative distribution of competencies, the upcoming section will deconstruct the subjective “Awareness and Perception” of these processes. This transition allows for a deeper exploration of how theoretical barriers such as the identified information gaps – manifest in the specific mental models and value systems of the respondents, ultimately shaping the social acceptance of green policies in the region.

Chapter 7.

Awareness and Understanding of the Green Transformation

7.1. Analyses of green transformation perception

The analysis of student perception is a key element in understanding the dynamics of the green transformation at the local level. The following section aims to present and interpret the survey results in detail, focusing on three key areas: awareness and understanding of the green transformation, access to knowledge and environmental education, and the perception of costs, benefits, and social impacts. Each of these areas will be discussed in the context of data obtained from students in the Świętokrzyskie Voivodeship, allowing for the identification of both strengths and existing gaps in their perception. Through this analysis, it will be possible to outline a comprehensive picture of how future generations of leaders and specialists perceive one of the most significant challenges of the modern world. This understanding is essential for designing effective educational and communication strategies that will contribute to the active engagement of young people in building a sustainable and resilient future for the region.

The first area of analysis is the level of awareness and understanding of the concept of green transformation among students. The study aimed to verify how well respondents and their social environment define and interpret this complex phenomenon, which extends beyond simple pro-ecological actions. Specifically, responses regarding general understanding (Q1) and the identification of the most accurate definition among the options provided (Q2) will be analyzed to assess the depth of their comprehension. It will also be examined whether students perceive the green transformation solely as an environmental aspect (e.g., just planting trees) or if they understand its complex links with the economy (e.g., innovation, new jobs) and society (e.g., social justice, participation).

The goal is to delve into the level of knowledge and interpretation of the green transformation among respondents, both in terms of their personal understanding and their perception of their surroundings. The objective is to obtain a comprehensive picture of how respondents comprehend and relate to a phenomenon as complex as the green transformation. The analysis covers key aspects such as the general understanding of the meaning of transformation (Question 1), the ability to align personal definitions with the concept of green transformation (Question 2), and a subjective assessment of one's own knowledge regarding ecological changes (Question 5). These elements form the basis for assessing the depth and consistency of the respondents' awareness.

It will also be important to compare their self-assessment of knowledge levels (Q5) with their actual ability to identify global trends related to the transformation (Q11). Such an analysis will determine whether students possess solid theoretical foundations and whether they can link global environmental challenges with their local manifestations and consequences in the Świętokrzyskie Voivodeship. Particular attention will be paid to the convergence or divergence between what students declare and their actual knowledge of specific aspects of the green transformation, such as industrial decarbonization, circular economy principles, or sustainable agriculture. The conclusions from this section will be crucial in determining whether education in green transformation should focus on basic definitions and concepts or on deepening the understanding of its complex aspects and practical implications.

Additionally, the study enters the area of understanding the need for adaptation to ecological changes (Question 10) and the ability to identify global trends related to the green transformation (Question 11). These questions are vital because they allow us to verify whether respondents not only possess general knowledge but can also recognize and name specific phenomena and challenges that are integral parts of the ecological transformation. For example, can they identify concepts such as the circular economy, the development of renewable energy sources, or sustainable transport? Comparing self-assessed knowledge with the real ability to identify these trends is of key importance. It allows for an assessment of whether the respondents' subjective sense of knowledge is actually supported by concrete information and the ability to recognize global processes, or if it is merely a superficial belief.

Ultimately, this segment aims to establish whether students in the Świętokrzyskie Voivodeship possess sufficient knowledge to actively and consciously participate in the green transformation process, both as citizens and as future specialists or leaders. Understanding their perception of the fundamental assumptions of this transformation is essential for designing effective educational programs that not only inform but also inspire action and build a sense of agency. Gaps in understanding may indicate a need to intensify information and educational activities focused on clearly presenting the benefits and challenges associated with the green transformation, tailored to regional specificities and context.

Beyond general understanding, it is important to delve into the perception of the individual pillars of the green transformation, which are crucial for its complexity. The study should examine to what extent students understand and distinguish concepts such as: energy transformation (transition to RES), digitalization as a transformation tool, the circular economy (recycling, reuse), sustainable transport, or biodiversity protection. Are all these aspects equally understandable and prioritized by them? Or is their awareness concentrated on one or two areas while ignoring others? Identifying these "blind spots" in their knowledge is crucial for designing precise educational interventions that fill gaps and ensure a holistic approach to transformation.

A key element of a true understanding of the green transformation is the perception of the interconnections between its various aspects, rather than treating them as isolated actions. Do students understand that investments in renewable energy sources can affect the stability of the power grid, and that the development of sustainable transport affects air quality and urban planning? Do they perceive that the circular economy involves not only recycling but also product innovation and new business models? Examining whether students can analyze systemically, perceiving the green transformation as a network of dependencies rather than a set of detached initiatives, will allow for an assessment of their capacity for strategic thinking and complex environmental and social problem-solving.

Examining this local awareness is crucial because tangible examples from one's own environment can most strongly influence engagement and the feeling that the green transformation is not a distant phenomenon, but a real process happening here and now. A lack of awareness of local successes may weaken motivation and faith in the reality of change. The synthetic picture obtained from the analysis of all these questions will allow for the determination of how deep and consistent the respondents' awareness is regarding the complex ecological processes occurring both globally and in their immediate surroundings. The results of this study are extremely important as they can point to potential knowledge gaps and identify specific educational needs. Consequently, the data obtained will serve to develop more effective and targeted information and promotion strategies regarding the green transformation, which is crucial for increasing social engagement in these necessary changes.

7.2. Level of awareness and understanding of the concept of green transformation

Data analysis regarding self-assessment and perception of knowledge related to the green transformation indicates a moderate level of awareness in the studied population (Table 26). Respondents most often rate the understanding of the importance of green transformation in their environment as average (40.58%), while only slightly more than 15% considered it good or very good. In the context of understanding the concept of green transformation itself, the dominant definitions perceive it as a process (43.84%) and as development (40.39%), indicating a basic level of knowledge but also some interpretative ambiguity.

Self-assessment of one's own knowledge about ecological transformation fluctuates around average (42.03%) and good (24.64%), testifying to a moderate sense of competence in this area. Regarding the understanding of the need to adapt to ecological changes and the identification of global green transformation trends, respondents show a slightly higher level of self-assessment, with 44.17% rating themselves as understanding this need well or very well, and 30.92% declaring

good or very good recognition of global trends. Such results signal that while awareness and knowledge of the green transformation are present, the depth and precision of interpretation leave room for development, indicating the necessity for further educational and informational actions.

From an economic perspective, the presented results have significant implications for green transformation processes and adaptation to climate challenges. The moderate level of self-assessed knowledge and understanding of ecological transformation among respondents indicates a potential risk of insufficient human capital readiness to meet the requirements resulting from the implementation of sustainable development policies and investments in green technologies. Low precision in understanding and the variety of interpretations of the concept of green transformation can lead to a fragmented approach to implementing pro-ecological practices, which consequently may delay the absorption of EU funds and the effectiveness of actions at the level of enterprises and institutions. In the context of a dynamically changing regulatory environment and increasing requirements for environmental responsibility, building high-quality and aware human capital becomes a key factor in maintaining competitiveness and the sustainable development of the national economy. Given the above, the results emphasize the need for systematic and comprehensive educational programs that will strengthen ecological competencies and increase the adaptive capacity of employees and consumers to the challenges of the green economy transformation.

Table 26. Perception and self-assessment of knowledge regarding green transformation – analysis of respondent answers

Question / Class		Very Poor	Poor	Average	Good	Very Well	Total
1. How well does your environment understand the meaning of green transformation?	Count	23	67	84	27	6	207
	Percentage	11.11	32.37	40.58	13.04	2.90	100.00
Class		It is a process	It is development	It is global	–	–	–

Question / Class		Very Poor	Poor	Average	Good	Very Well	Total
2. Which of the following definitions best fits your understanding of green transformation?	Count	89	82	32	–	–	203*
	Percentage	43.84	40.39	15.76	100,00	–	100.00
Class		Very Poor	Poor	Average	Good	Very Well	–
5. How do you rate your level of knowledge on ecological transformation?	Count	17	46	87	51	6	207
	Percentage	8.21	22.22	42.03	24.64	2.90	100.00
10. How do you rate your level of understanding of the need to adapt to ecological changes?	Count	8	26	81	80	11	206*
	Percentage	3.88	12.62	39.32	38.83	5.34	100.00
11. How well do you identify global trends related to green transformation?	Count	12	46	85	60	4	207
	Percentage	5.80	22.22	41.06	28.99	1.93	100.00

*Note: Slight variations in total 'Count' may result from missing data in specific survey questions.
Source: Own elaboration based on research results.

The analysis of descriptive statistics regarding self-assessed knowledge and the perception of green transformation indicates a diverse yet generally moderate level of awareness in the studied sample. The mean score for understanding the significance of green transformation in the respondents' environment is 2.64 (on a 1–5 scale), which indicates an assessment within the bounds of average knowledge, though with relatively high variability (coefficient of variation 35.7%), suggesting an uneven perception of this issue among those surveyed. The lowest mean (1.72) pertains to the choice of a definition for green transformation, illustrating a certain ambiguity and dispersion in the understanding of the term. On the other hand, self-assessment of the level of knowledge on ecological transformation and the understanding of the need to adapt to ecological changes are at higher levels, 2.92 and 3.29 respectively, with lower variability, indicating a more unified belief

among respondents regarding their own competencies in these areas. The identification of global trends related to the green transformation achieves a mean close to 3.0, confirming moderate awareness of the importance of these processes on the international stage. Overall, these results signal a need to deepen knowledge and develop uniform definitions and conceptual frameworks to more effectively communicate and implement the green transformation.

From an economic perspective, the obtained descriptive statistics highlight key challenges in building the ecological competencies necessary for the effective implementation of sustainable development policies and green transformation. The moderate level of self-assessed knowledge and the variation in perception indicate a fragmented understanding of key concepts, which may limit the ability of employees and managers to make informed investment and operational decisions in a low-carbon economy. The lack of uniform and consistent definitions of green transformation, confirmed by the low mean score for this variable, suggests the necessity of standardizing knowledge and disseminating clear educational messages that can increase the efficiency of pro-ecological technology implementations. Consequently, an unreflective or superficial level of knowledge poses a potential threat to the absorption of EU funds and adaptation to environmental regulations, which may lower the competitiveness of the Polish economy in the global market. These results point to the need for strategic investment in environmental education, at both formal and informal levels, to effectively develop human capital capable of supporting economic transformation aligned with climate goals (Table 27).

Table 27. Assessment of knowledge level and perception of green transformation based on descriptive statistics analysis

Variable	Mean	Std. Dev.	Coeff. of Variation
1. How well does your environment understand the meaning of green transformation?	2.642512	0.943928	0.357208
2. Which of the following definitions best fits your understanding of green transformation?	1.719212	0.720956	0.419353
5. How do you rate your level of knowledge on ecological transformation?	2.917874	0.954305	0.327055
10. How do you rate your level of understanding of the need to adapt to ecological changes?	3.291262	0.895856	0.272192
11. How well do you identify global trends related to green transformation?	2.990338	0.908377	0.303771

Source: Own elaboration based on research results.

The results of the tests for the normality of the distribution of key variables for assessing awareness and understanding of the green transformation clearly indicate the rejection of the hypothesis of a normal distribution of this data. Both the Kolmogorov-Smirnov (K-S) test and the Lilliefors test showed statistical significance at the $p < 0.01$ level for all analyzed variables, confirming significant deviations from a normal distribution. Additionally, the Shapiro-Wilk (W) test yielded values significantly below 1, and its significance level was also $p = 0.000000$, confirming the lack of normality. These results suggest that the distribution of ratings regarding environmental perception, understanding of the definition of green transformation, self-assessment of knowledge about ecological transformation, as well as the understanding of the need for adaptation to ecological changes and identification of global trends, is characterized by a strong deviation from a typical Gaussian distribution. Consequently, further statistical analyses of this data set should be conducted using non-parametric methods, which will allow for obtaining reliable and credible results in the context of studying these specific variables.

From an economic perspective, establishing the lack of normality in the distribution of key indicators of knowledge and perception of the green transformation has significant methodological and practical implications. The non-normality of distributions indicates the heterogeneity of attitudes and levels of awareness in the studied population, which may stem from a diversity of experiences, education levels, or access to information. In practice, this means that educational and communication policies should be addressed with consideration for diverse target groups to more effectively close knowledge gaps and increase the adaptability of economic entities to green transformation requirements. Furthermore, the necessity of using non-parametric methods in empirical analyses confirms that straightforward statistical generalizations could lead to erroneous conclusions and, consequently, less effective interventions. Correct identification of the distribution and adequate modeling of the data are key to formulating accurate strategic recommendations that directly impact the ability of the Polish economy to implement sustainable solutions and maintain competitiveness in the face of global climate challenges (Table 28).

Table 28. Results of normality tests for key variables regarding awareness and understanding of the green transformation

Variable	N	Max D	K-S (p)	Lillief. (p)	W	p
1. How well does your environment understand the meaning of green transformation?	207	0.212771	p < .01	p < .01	0.896942	0.000000
2. Which of the following definitions best fits your understanding of green transformation?	203	0.279182	p < .01	p < .01	0.779608	0.000000
5. How do you rate your level of knowledge on ecological transformation?	207	0.229942	p < .01	p < .01	0.896849	0.000000
10. How do you rate your level of understanding of the need to adapt to ecological changes?	206	0.227313	p < .01	p < .01	0.874536	0.000000
11. How well do you identify global trends related to green transformation?	207	0.224050	p < .01	p < .01	0.884364	0.000000

Source: Own elaboration based on research results.

The empirical analysis presented in this chapter indicates that the level of awareness and understanding of the green transformation among students in the Świętokrzyskie Voivodeship remains moderate, accompanied by considerable variation in individual assessments, attitudes, and cognitive abilities. The results confirm that respondents most often perceive the green transformation intuitively, without clear grounding in consistent conceptual or theoretical frameworks.

At this point, it is important to make a significant conceptual distinction. Respondents' statements suggest that the term "green transformation" is sometimes equated with both a "process" and a "development." From a scientific perspective, this distinction is crucial. A process denotes a sequence of structural, institutional, and technological changes, whereas development implies a normative improvement in quality economic, social, or environmental. A lack of awareness of this difference can lead to erroneous expectations of public policies, where any ecological change is automatically interpreted as a welfare improvement, regardless of its short-term social costs.

Particularly interesting from a cognitive standpoint are the results comparing subjective self-assessment of knowledge (Q5) with the objective ability to identify trends related to the green transformation (Q11). The observed discrepancy between high self-assessment and limited accuracy of responses can be interpreted in light of the Dunning-Kruger effect, a cognitive bias in which individuals with low levels of knowledge overestimate their competencies. This phenomenon is strongly supported by behavioral economics and information asymmetry theory, indicating that limited cognitive awareness constitutes a real barrier to rational participation in transformational processes.

The obtained response distributions are characterized by significant asymmetry, high variability, and flattened kurtosis, confirming the heterogeneity of attitudes and perceptions within the studied group. Non-parametric tests revealed statistically significant differences between variables ($p < 0.001$), confirming the high reliability of the results and the validity of the adopted analytical methodology.

Interpreting the findings in a regional context, it should be emphasized that the Świętokrzyskie Voivodeship functions as a peripheral region, vulnerable to depopulation, human capital outflow, and the mechanisms of cumulative causation described by Myrdal. In such a setting, a low or fragmented level of ecological awareness among the younger generation has far more serious consequences than in metropolitan regions. Limited knowledge weakens the capacity to absorb EU funds, hinders the implementation of sustainable development policies, and increases the risk of long-term socio-economic stagnation.

In this context, not only human capital understood as the stock of individual knowledge and skills but also social capital, encompassing trust, cooperation, and readiness for collective action, is of key importance. The green transformation is not an individual process it requires coordination, social acceptance, and mechanisms for the fair distribution of costs and benefits. Deficiencies in social capital can therefore effectively block even well-designed technological or financial interventions.

At the same time, the results indicate that Generation Z and younger millennials exhibit relatively high cognitive flexibility and potential openness to pro-environmental changes. This makes them a strategic target group for public policies, provided that appropriately designed educational and communication instruments are employed. It is particularly important to account for behavioral mechanisms, such as loss aversion, by emphasizing short-term, local, and measurable benefits arising from the green transformation.

In summary, this chapter provides a solid empirical and theoretical foundation for further analyses. Identifying the limits of knowledge, cognitive biases, and regional conditions allows for a better understanding of how the green transformation is perceived by young residents of a peripheral region. This serves as a direct introduction to the next chapter, which will analyze in detail the awareness, perception, and mental models of respondents, shaping the social acceptance of ecological policies in the Świętokrzyskie Voivodeship.

7.3. Differentiation of perception based on socio-demographic characteristics

The analysis of the level of understanding regarding the significance of the green transformation in relation to the socio-demographic characteristics of the respondents revealed varied results (Table 29). Among genders, women more frequently declared a lower level of understanding (very poor and poor: 30.44%) compared to men (13.04%), while men more often rated their understanding as good or very good (11.18% versus 6.76% among women). In the age groups, the perception of an average understanding dominated, with the largest age group (20–22 years) showing moderate diversification in ratings. From the perspective of student status, part-time second-cycle (Master's) students more frequently declared better understanding (good and very good: 5.45%) than first-cycle (Bachelor's) students. Regarding place of residence, respondents living in rural areas predominantly rated their understanding as average (27.5%), and the level of "very good" understanding was higher here (2.5%) than in the urban group, where "very good" declarations were absent. The results indicate significant differentiation in the perception of the green transformation depending on demographics, which should be considered when planning educational and communication activities. The prevalence of lower ratings among women and rural residents may indicate a need for targeted educational interventions aimed at equalizing differences in ecological awareness.

From an economic perspective, the differentiation in the level of understanding of the green transformation based on socio-demographic characteristics is a significant factor influencing the effectiveness of implementing low-emission development strategies. Low self-assessment of knowledge among women and rural residents may lead to a decrease in the adaptive potential of these groups in the process of economic transformation, which in turn may translate into regional and sectoral inequalities. Incorporating these differences into educational and investment policies is crucial for building the human capital necessary for the absorption of green transformation funds and the effective implementation of technological innovations. Directing support toward demographically less aware groups will enable increased inclusivity in transformation processes, which is essential for ensuring the lasting competitiveness of the Polish economy in the face of global climate and regulatory challenges.

The statistical analysis of the relationship between the level of understanding of the green transformation and the socio-demographic characteristics of the respondents was conducted using Chi-square tests, correlation coefficients, and uncertainty indicators. The results indicate that only in the case of the relationship between the level of understanding and the gender of the respondents did a marginal tendency toward dependence occur (Pearson's $\chi^2 = 8.12$, $df = 4$, $p = 0.087$; Likelihood Ratio tests $p > 0.05$), and the Spearman rank correlation coefficient ($r = 0.181$; $p = 0.009$) confirmed the statistical significance of this link at the $\alpha < 0.01$

level. The interpretation of this result suggests that gender may have a moderate influence on the perception of the green transformation, which corresponds with the earlier observation of differences in self-assessed knowledge between women and men. For the remaining demographic variables age ($p = 0.191$), student status ($p = 0.554$), and place of residence ($p = 0.141$) the tests showed no statistically significant relationships, and the correlation coefficients were near zero, indicating a lack of association between these traits and the level of understanding. Additionally, uncertainty indicators confirm a moderate degree of independence between the studied variables, suggesting that demographic factors other than gender do not play a significant role in shaping the perception of this issue.

Table 29. Level of understanding of the importance of green transformation according to socio-demographic characteristics of respondents

Category	Very Poor	% Very Poor	Poor	% Poor	Average	% Average	Good	% Good	Very Well	% Very Well	Total	% Total
Gender												
Female	16	7.73	47	22.71	50	24.15	11	5.31	3	1.45	127	61.35
Male	7	3.38	20	9.66	34	16.43	16	7.73	3	1.45	80	38.65
Age												
20 years	8	3.86	11	5.31	22	10.63	8	3.86	2	0.97	51	24.64
21 years	4	1.93	21	10.14	17	8.21	2	0.97	2	0.97	46	22.22
22 years	7	3.38	10	4.83	24	11.59	6	2.90	1	0.48	48	23.19
23 years	1	0.48	14	6.76	12	5.80	3	1.45	0	0.00	30	14.49
24 years	2	0.97	3	1.45	4	1.93	4	1.93	0	0.00	13	6.28
Over 25	1	0.48	8	3.86	5	2.42	4	1.93	1	0.48	19	9.18
Student Status												
Full-time 1st Cycle	4	1.98	20	9.90	20	9.90	8	3.96	2	0.99	54	26.73
Full-time 2nd Cycle	10	4.95	11	5.45	21	10.40	5	2.48	1	0.50	48	23.76
Part-time 1st Cycle	5	2.48	13	6.44	17	8.42	4	1.98	0	0.00	39	19.31
Part-time 2nd Cycle	4	1.98	23	11.39	23	11.39	9	4.46	2	0.99	61	30.20
Residence												
Urban	4	2.00	26	13.00	23	11.50	11	5.50	0	0.00	64	32.00
Rural	14	7.00	30	15.00	55	27.50	12	6.00	5	2.50	116	58.00
Urban-Rural	3	1.50	8	4.00	6	3.00	3	1.50	0	0.00	20	10.00

Source: Own elaboration based on research results.

From an economic perspective, these results highlight the importance of considering gender differences in educational and communication activities regarding the green transformation. Despite the lack of significant dependencies regarding age, student status, or place of residence, the demonstrated link with gender indicates the need to adapt educational programs and information campaigns to more effectively engage and support women in the process of acquiring knowledge about ecological transformation. Such a targeted approach can contribute to reducing competency and social gaps that might limit the effectiveness of sustainable development policy implementation. In the context of economic transformation, effective knowledge transfer and awareness-building among all social groups, with particular emphasis on gender differences, are key to mobilizing the human capital necessary to achieve the goals of a low-emission and climate-resilient economy. Failing to utilize the potential of any social group may result in reduced innovation and competitiveness for the Polish economy on the international stage (Table 30).

Table 30. Analysis of the relationship between the level of understanding of the green transformation and respondents' socio-demographic characteristics (gender, age, student status, place of residence) – results of Chi-square tests, correlation, and uncertainty coefficients

No.	Specification	Statistics	Value	Result
1	Understanding significance (5) x Gender (2)	Pearson chi2	8.123158	p = .08717
		Likelihood Ratio chi2	8.046173	p = .08990
		Kendall's tau b & c	b = .1669218	c = .1923966
		Spearman Rank R	.1807805	p = .00914
		Uncertainty Coeff.	X = .0144655	Y = .0291319
2	Understanding significance (5) x Age (6)	Pearson chi2	25.28615	p = .19070
		Likelihood Ratio chi2	27.03974	p = .13415
		Kendall's tau b & c	b = .0126365	c = .0118439
		Spearman Rank R	.0145389	p = .83529
		Uncertainty Coeff.	X = .0486125	Y = .0386183
3	Understanding significance (5) x Student Status (4)	Pearson chi2	10.70959	p = .55396
		Likelihood Ratio chi2	11.37588	p = .49701
		Kendall's tau b & c	b = .0053027	c = .0050975
		Spearman Rank R	.0060644	p = .93174
		Uncertainty Coeff.	X = .0210874	Y = .0205041

No.	Specification	Statistics	Value	Result
4	Understanding significance (5) x Residence (3)	Pearson chi2	12.24196	p = .14073
		Likelihood Ratio chi2	14.18567	p = .07705
		Kendall's tau b & c	b = -.017155	c = -.015900
		Spearman Rank R	-.019833	p = .78044
		Uncertainty Coeff.	X = .0268045	Y = .0389366

Source: Own elaboration based on research results.

The analysis of the distribution of green transformation definitions among respondents indicates a significant differentiation in the perception of this concept depending on demographic traits such as gender, age, student status, and place of residence. The most frequently chosen definition was “green transformation as a process” (43.84% of the total), particularly noted by women (30.05% of the total sample) and rural residents (27.55%). The definition of “green transformation as development” was most often selected by full-time 1st and 2nd cycle students and rural residents, which may indicate a greater awareness of the developmental nature of the transformation in this group. The definition of “green transformation as a global phenomenon” was chosen relatively less frequently (15.76%), and its distribution shows a slightly higher percentage among urban residents (7.65%) and individuals over 25 years old. These results suggest that the concept of green transformation is perceived by respondents in a multidimensional way; however, an understanding of this process as a dynamic, long-term phenomenon clearly dominates, which aligns with academic definitions and political strategies. Demographic differences indicate the necessity for individualizing educational messaging, tailoring it to the specific perceptions of various social groups to increase communication effectiveness and engagement in the transformation process.

From an economic perspective, the diversification of the definitional understanding of the green transformation has significant implications for educational and communication strategies supporting the implementation of sustainable development policies. Different perceptions of the transformation may influence levels of acceptance and motivation to participate in pro-ecological actions at both individual and organizational levels. It is particularly important to consider differences arising from place of residence and educational status, which will allow for better targeting of training programs and information campaigns. In the context of the green economy, effective human capital management requires understanding that the perception and interpretation of fundamental concepts of ecological transformation vary within the population, which may affect the pace and effectiveness of implementing innovations and environmental regulations. Consequently, adapting educational tools and messages to socio-demographic specifics will contribute to increasing green competencies and the competitiveness of the Polish economy in global climate challenge conditions (Table 31).

Table 31. Definitions of green transformation according to demographic characteristics

Category	It is a process	% Total	It is development	% Total	It is global	% Total	Total	% Total
Gender								
Female	61	(30.05%)	44	(21.67%)	19	(9.36%)	124	(61.08%)
Male	28	(13.79%)	38	(18.72%)	13	(6.40%)	79	(38.92%)
Age								
20 years	21	(10.34%)	25	(12.32%)	5	(2.46%)	51	(25.12%)
21 years	15	(7.39%)	23	(11.33%)	8	(3.94%)	46	(22.66%)
22 years	18	(8.87%)	24	(11.82%)	6	(2.96%)	48	(23.65%)
23 years	17	(8.37%)	7	(3.45%)	5	(2.46%)	29	(14.29%)
24 years	7	(3.45%)	2	(0.99%)	3	(1.48%)	12	(5.91%)
Over 25	11	(5.42%)	1	(0.49%)	5	(2.46%)	17	(8.37%)
Student Status								
Full-time 1st Cycle	21	(10.61%)	25	(12.63%)	8	(4.04%)	54	(27.27%)
Full-time 2nd Cycle	17	(8.59%)	27	(13.64%)	3	(1.52%)	47	(23.74%)
Part-time 1st Cycle	20	(10.10%)	11	(5.56%)	8	(4.04%)	39	(19.70%)
Part-time 2nd Cycle	29	(14.65%)	17	(8.59%)	12	(6.06%)	58	(29.29%)
Residence								
Urban	23	(11.73%)	24	(12.24%)	15	(7.65%)	62	(31.63%)
Rural	54	(27.55%)	50	(25.51%)	11	(5.61%)	115	(58.67%)
Urban-Rural	8	(4.08%)	7	(3.57%)	4	(2.04%)	19	(9.69%)

Source: Own elaboration based on research results.

The results of statistical tests regarding the relationship between understanding the definition of green transformation and the demographic characteristics of respondents showed varied dependencies with different levels of significance (Table 32). The analysis of Pearson's Chi-square tests and Likelihood Ratio (NW) tests indicates that statistically significant differences were observed only in the case of the variables "age" ($\text{Chi}^2 = 21.47$; $\text{df} = 10$; $p = 0.018$) and "student status" ($\text{Chi}^2 = 13.10$; $\text{df} = 6$; $p = 0.041$), suggesting that the perception of the definition of green transformation is linked to the stage of education and the age group of the respondents. In contrast, the relationships between the understanding of the definition and gender ($p = 0.134$) and place of residence ($p = 0.120$) were not statistically significant. Spearman's rank correlation indicators and Kendall's tau b and c coefficients confirm the moderately low strength of these dependencies, indicating a weak tendency for systematic associations. It is also noteworthy that the analysis of uncertainty coefficients confirms a relatively small level of shared information between the variables. These results suggest that while age and student status influence differences in the interpretation of the green transformation, other demographic traits play a smaller role, which may indicate a need to concentrate educational efforts on specific age and educational groups to increase the consistency of understanding regarding the key concepts of ecological transformation.

From an economic perspective, the findings regarding the differentiation in understanding the green transformation depending on age and educational status are crucial for designing effective human capital development strategies in a low-emission economy. Differences in perception may influence adaptability and readiness to implement pro-ecological innovations, especially among young personnel who represent the future of the labor market. Effectively equalizing these educational differences requires targeted training activities, which directly translates into the ability of enterprises and institutions to absorb new technologies and meet regulatory requirements, such as the EU taxonomy or CBAM mechanisms. The limited role of other demographic variables, such as gender or place of residence, indicates the universal nature of educational challenges in the context of the green transformation, confirming the need for a broad, systemic approach to environmental education and competency development across the entire professionally active population.

The analysis of the distribution of responses regarding self-assessment of the level of knowledge on ecological transformation indicates a differentiation in perception depending on the socio-demographic characteristics of the respondents. In the group of women, ratings in the average and good range dominated (totaling over 42%), while as many as 4.35% of female respondents rated their knowledge as very poor. Among men, the percentage of average and good ratings was lower, which may indicate a slightly lower level of self-assessment in this group. In the context of age, the highest level of positive ratings (good, very good) was observed in the 21-year-old group (6.76%), while the lowest was among people over 25,

which may result from differences in educational and professional experience. Student status also affects self-assessment full-time second-cycle students showed the highest share of positive ratings, while those in part-time studies more often declared poor and average ratings. Place of residence influences the perception of knowledge, where respondents from urban areas showed higher rates of positive self-assessment compared to rural residents, who more frequently rated their knowledge as very poor or poor. Such differentiation indicates the significant importance of environmental factors and the availability of educational resources in shaping ecological competencies.

Table 32. Results of statistical tests for the relationship between the understanding of the definition of green transformation and demographic characteristics of respondents

No.	Specification	Statistics	Value	Result
1	Understanding significance (5) x Gender (2)	Pearson chi2	4.022263	p = .13384
		Likelihood Ratio chi2	4.045375	p = .13230
		Kendall's tau b & c	b = .1070223	c = .1161882
		Spearman Rank R	.1121953	p = .11100
		Uncertainty Coeff.	X = .0097791	Y = .0149078
2	Understanding significance (5) x Age (6)	Pearson chi2	21.47247	p = .01803
		Likelihood Ratio chi2	24.36456	p = .00669
		Kendall's tau b & c	b = -.065325	c = -.068941
		Spearman Rank R	-.076757	p = .27639
		Uncertainty Coeff.	X = .0588978	Y = .0357789
3	Understanding significance (5) x Student Status (4)	Pearson chi2	13.10031	p = .04147
		Likelihood Ratio chi2	13.66605	p = .03360
		Kendall's tau b & c	b = -.043425	c = -.044230
		Spearman Rank R	-.048760	p = .49513
		Uncertainty Coeff.	X = .0339062	Y = .0250910
4	Understanding significance (5) x Residence (3)	Pearson chi2	7.320387	p = .11990
		Likelihood Ratio chi2	7.201151	p = .12563
		Kendall's tau b & c	b = -.092132	c = -.080279
		Spearman Rank R	-.099579	p = .16494
		Uncertainty Coeff.	\$X = .0181026	Y = .0203403

Source: Own elaboration based on research results.

From an economic point of view, these results highlight the importance of investing in educational programs tailored to demographic specificities that take into account the diversity of needs and knowledge levels of individual social groups. Particularly important is the support for the development of ecological competencies among rural residents and part-time students, where lower self-assessment rates are observed, which may translate into a lower readiness to implement pro-ecological innovations. Increasing ecological knowledge and awareness among these groups is key to the effective adaptation of enterprises to the requirements of ecological transformation and to increasing the competitiveness of the Polish economy in the face of growing environmental regulations and global low-emission trends. Furthermore, bridging knowledge deficits promotes equal development opportunities between regions and sectors, which is essential for sustainable economic and social growth (Table 33).

Table 33. Assessment of the level of knowledge about ecological transformation depending on demographic characteristics

Category	Very Poor	% Very Poor	Poor	% Poor	Average	% Average	Good	% Good	Very Well	% Very Well	Total	% Total
Gender												
Female	9	4.35%	27	13.04%	55	26.57%	33	15.94%	3	1.45%	127	61.35%
Male	8	3.86%	19	9.18%	32	15.46%	18	8.70%	3	1.45%	80	38.65%
Age												
20 years	5	2.42%	10	4.83%	23	11.11%	11	5.31%	2	0.97%	51	24.64%
21 years	4	1.93%	7	3.38%	21	10.14%	13	6.28%	1	0.48%	46	22.22%
22 years	4	1.93%	13	6.28%	19	9.18%	12	5.80%	0	0.00%	48	23.19%
23 years	2	0.97%	11	5.31%	10	4.83%	5	2.42%	2	0.97%	30	14.49%
24 years	2	0.97%	0	0.00%	4	1.93%	7	3.38%	0	0.00%	13	6.28%
Over 25	0	0.00%	5	2.42%	10	4.83%	3	1.45%	1	0.48%	19	9.18%
Student Status												
Full-time 1st Cycle	5	2.48%	12	5.94%	25	12.38%	11	5.45%	1	0.50%	54	26.73%
Full-time 2nd Cycle	5	2.48%	7	3.47%	21	10.40%	14	6.93%	1	0.50%	48	23.76%
Part-time 1st Cycle	3	1.49%	6	2.97%	16	7.92%	12	5.94%	2	0.99%	39	19.31%
Part-time 2nd Cycle	4	1.98%	20	9.90%	23	11.39%	13	6.44%	1	0.50%	61	30.20%
Residence												
Urban	3	1.50%	15	7.50%	26	13.00%	16	8.00%	4	2.00%	64	32.00%
Rural	12	6.00%	28	14.00%	48	24.00%	26	13.00%	2	1.00%	116	58.00%
Urban-Rural	2	1.00%	2	1.00%	10	5.00%	6	3.00%	0	0.00%	20	10.00%

Source: Own elaboration based on research results.

Statistical test results indicate a lack of statistically significant relationships between the self-assessment of the level of knowledge about ecological transformation and the basic demographic characteristics of the respondents, such as gender, age, student status, or place of residence. Pearson's χ^2 test for individual variables showed p-values significantly above the adopted significance level ($p > 0.05$), meaning that differences in knowledge assessments are not linked to the analyzed demographic categories. Furthermore, Kendall's tau and Spearman's rank coefficients confirm the absence of strong correlations between the variables, and uncertainty indicators suggest a low value of predictability of one variable based on another. Consequently, it can be stated that the level of self-assessment of knowledge about ecological transformation is relatively independent of the demographic characteristics of the studied group, which may suggest an even distribution of knowledge and its perception across different segments of the studied student population.

From an economic perspective, the lack of statistically significant differences in the self-assessment of ecological knowledge divided by demographic characteristics indicates a potentially balanced level of ecological awareness among young people, regardless of their gender, age, or living environment. This situation creates a basis for designing uniform, national educational programs and information campaigns that can effectively reach a wide spectrum of recipients without the need for specialized adaptation to specific demographic groups. However, in the context of building the human capital necessary for the realization of ecological transformation goals, it remains essential to focus efforts on raising actual knowledge and competencies, not just its subjective assessment, to meet the requirements of the dynamically changing labor market and environmental regulations. Such an approach is key to the effective implementation of ecological innovations and maintaining the competitiveness of the economy against global climate challenges (Tabel 34).

Table 34. Statistical test results for the relationship between the assessment of the level of knowledge about ecological transformation and demographic characteristics

No.	Specification	Statistics	Value	Result
1	Knowledge level assessment (5) x Gender (2)	Pearson chi2	1.339932	p = .85456
		Likelihood Ratio chi2	1.323153	p = .85744
		Kendall's tau b & c	b = -.044054	c = -.050970
		Spearman Rank R	-.047796	p = .49404
		Uncertainty Coeff.	X = .0023646	Y = .0047906
2	Knowledge level assessment (5) x Age (6)	Pearson chi2	22.12454	p = .33379
		Likelihood Ratio chi2	26.39095	p = .15328
		Kendall's tau b & c	b = .0016744	c = .0015753
		Spearman Rank R	.0029130	p = .96677
		Uncertainty Coeff.	X = .0471632	Y = .0376917
3	Knowledge level assessment (5) x Student Status (4)	Pearson chi2	9.282683	p = .67861
		Likelihood Ratio chi2	8.931217	p = .70879
		Kendall's tau b & c	b = -.018896	c = -.018234
		Spearman Rank R	-.023391	p = .74107
		Uncertainty Coeff.	X = .0164460	Y = .0160978
4	Knowledge level assessment (5) x Residence (3)	Pearson chi2	7.439265	p = .49006
		Likelihood Ratio chi2	8.120690	p = .42177
		Kendall's tau b & c	b = -.044845	c = -.042000
		Spearman Rank R	-.050580	p = .47691
		Uncertainty Coeff.	X = .0149584	Y = .0222895

Source: Own elaboration based on research results.

The analysis of the distribution of ratings for the level of understanding of the need to adapt to ecological changes divided by demographic characteristics indicates a diversification in the perception of this issue among respondents. The largest percentage of respondents indicated an “average” rating (approximately 39.32% of the total), suggesting a moderate level of awareness in the studied group. Women declared a higher level of understanding (ratings of “well” and “very well”) more often than men, while the distribution of responses regarding age and student status shows relative uniformity, with a slight increase in positive ratings among older age groups and second-cycle students. Rural residents declared slightly higher levels of understanding than urban residents, which may indicate a greater awareness

of the need to adapt to ecological changes in environments more dependent on natural resources. Overall, the results indicate a moderate level of understanding of the need for adaptation, but with clear room for educational activities aimed at raising ecological awareness among young people.

The level of understanding of the need to adapt to ecological changes is crucial for the effective implementation of sustainable development policies and economic transformation toward a green economy. A higher level of awareness among rural residents may indicate a natural interest in adaptation in regions with greater contact with nature and agriculture, which is important for securing local production systems against the effects of climate change. Conversely, the moderate level of knowledge across the entire group of respondents signals a need to intensify ecological education, which should be aimed at increasing the adaptive capacity of society, especially in the context of the growing requirements of an economy based on sustainable development principles. In the long term, increasing adaptive competencies will contribute to building a more resilient and innovative economy capable of meeting the challenges of global environmental changes (Table 35).

Table 35. Assessment of the level of understanding of the need to adapt to ecological changes (5) depending on demographic characteristics

Category	Very Poor	% Very Poor	Poor	% Poor	Average	% Average	Good	% Good	Very Well	% Very Well	Total	% Total
Gender												
Female	5	(2.43%)	11	(5.34%)	55	(26.70%)	49	(23.79%)	7	(3.40%)	127	(61.65%)
Male	3	(1.46%)	15	(7.28%)	26	(12.62%)	31	(15.05%)	4	(1.94%)	79	(38.35%)
Age												
20 years	2	(0.97%)	4	(1.94%)	17	(8.25%)	25	(12.14%)	3	(1.46%)	51	(24.76%)
21 years	0	(0.00%)	7	(3.40%)	21	(10.19%)	13	(6.31%)	5	(2.43%)	46	(22.33%)
22 years	2	(0.97%)	5	(2.43%)	18	(8.74%)	22	(10.68%)	0	(0.00%)	47	(22.82%)
23 years	2	(0.97%)	2	(0.97%)	15	(7.28%)	9	(4.37%)	2	(0.97%)	30	(14.56%)
24 years	1	(0.49%)	3	(1.46%)	3	(1.46%)	6	(2.91%)	0	(0.00%)	13	(6.31%)
Over 25	1	(0.49%)	5	(2.43%)	7	(3.40%)	5	(2.43%)	1	(0.49%)	19	(9.22%)
Student Status												
Full-time 1st Cycle	2	(1.00%)	6	(2.99%)	21	(10.45%)	20	(9.95%)	5	(2.49%)	54	(26.87%)
Full-time 2nd Cycle	1	(0.50%)	3	(1.49%)	21	(10.45%)	21	(10.45%)	2	(1.00%)	48	(23.88%)
Part-time 1st Cycle	3	(1.49%)	4	(1.99%)	18	(8.96%)	13	(6.47%)	1	(0.50%)	39	(19.40%)
Part-time 2nd Cycle	2	(1.00%)	12	(5.97%)	20	(9.95%)	25	(12.44%)	1	(0.50%)	60	(29.85%)
Residence												
Urban	3	(1.51%)	9	(4.52%)	23	(11.56%)	23	(11.56%)	6	(3.02%)	64	(32.16%)
Rural	4	(2.01%)	13	(6.53%)	48	(24.12%)	48	(24.12%)	2	(1.01%)	115	(57.79%)
Urban-Rural	0	(0.00%)	4	(2.01%)	7	(3.52%)	7	(3.52%)	2	(1.01%)	20	(10.05%)

Source: Own elaboration based on research results.

Statistical test results (Table 36) indicate that respondents' level of understanding regarding the need to adapt to ecological changes does not show statistically significant dependencies with characteristics such as gender ($p = 0.24$), student status ($p = 0.41$), or place of residence ($p = 0.36$). However, in the case of age, a weak but statistically significant negative correlation was observed (Spearman $r = -0.14$, $p = 0.045$). This suggests that younger respondents declare a higher level of understanding of the need for ecological adaptation than older individuals. Other Kendall correlation coefficients and χ^2 test results confirm the lack of significant links between the assessment of understanding and the analyzed socio-demographic variables. Thus, age appears to be the only demographic factor in this study that slightly influences the perception of ecological adaptation needs.

Understanding the need for ecological adaptation is a key element in preparing society for the economic transition toward sustainable development. The lack of significant differences in the perception of adaptation between genders, places of residence, and student status indicates the relative universality of this issue within the studied population. The significant negative correlation with age may suggest that younger generations are more aware of ecological challenges and more willing to engage in adaptive actions, which is a positive signal for the future of an economy based on ecological innovation. These results emphasize the need for targeted educational programs, particularly aimed at older age groups, to increase their awareness and preparation for active participation in the green transformation of the economy.

Understanding the need for adaptation to ecological changes is a key element in preparing society for the economic transformation toward sustainable development. The lack of significant differences in perception based on gender, residence, or student status indicates the relative universality of this issue within the studied population. The significant negative correlation with age may suggest that younger generations are more aware of ecological challenges and more willing to engage in adaptation activities, which is a positive signal for the future of an economy based on eco-innovation. These results highlight the need for targeted educational programs, specifically directed at older age groups, to increase their awareness and preparation for active participation in the green transformation of the economy.

Table 36. Results of statistical tests regarding the assessment of the level of understanding of the need for adaptation to ecological changes depending on demographic characteristics

No.	Specification			
1	10. How do you assess your level of understanding of the need for adaptation to ecological changes (5) x Gender (2)	chi2	df	p
	Pearson's chi2	5.479307	df=4	p=.24155
	M-L chi2 (Maximum Likelihood)	5.365514	df=4	p=.25181
	Kendall's tau b & c	b=-.044404	c=-.050146	
	Spearman's rank R	-.047647	t=-.6813	p=.49644
	Uncertainty coefficient	X=.0101887	Y=.0195616	X Y=.01340
2	10. How do you assess your level of understanding of the need for adaptation to ecological changes (5) x Age (6)	chi2	df	p
	Pearson's chi2	22.77614	df=20	p=.29992
	M-L chi2 (Maximum Likelihood)	26.54478	df=20	p=.14856
	Kendall's tau b & c	b=-.116820	c=-.107456	
	Spearman's rank R	-.139977	t=-2.019	p=.04478
	Uncertainty coefficient	X=.0504065	Y=.0380712	X Y=.04338
3	10. How do you assess your level of understanding of the need for adaptation to ecological changes (5) x Student status (4)	chi2	df	p
	Pearson's chi2	12.44146	df=12	p=.41091
	M-L chi2 (Maximum Likelihood)	11.92091	df=12	p=.45205
	Kendall's tau b & c	b=-.080046	c=-.075246	
	Spearman's rank R	-.092870	t=-1.316	p=.18976
	Uncertainty coefficient	X=.0235281	Y=.0215801	X Y=.02251

No.	Specification			
4	10. How do you assess your level of understanding of the need for adaptation to ecological changes (5) x Place of residence (3)	chi2	df	p
	Pearson's chi2	8.782700	df=8	p=.36096
	M-L chi2 (Maximum Likelihood)	9.504933	df=8	p=.30150
	Kendall's tau b & c	b=-.010361	c=-.009469	
	Spearman's rank R	-.011317	t=-.1589	p=.87395
	Uncertainty coefficient	X=.0188318	Y=.0261675	X Y=.02190

Source: Own study based on research results.

An analysis of the distribution of scores regarding the identification of global trends related to green transformation indicates differences in perception depending on demographic characteristics. Women more often than men declare an average (26.57% vs. 14.49%) or good level of understanding (18.84% vs. 10.14%). Among those surveyed by age, the highest percentage of “good” and “very good” ratings appears in the 20–22 age groups, while the lowest awareness is shown by respondents over 25.

In the context of student status, the highest level of trend identification is declared by part-time second-cycle (Master's) students. Regarding residence, respondents from both cities and villages show varying levels of perception, with a higher percentage of rural residents declaring a “good” rating. These results indicate a diversified level of awareness of global ecological trends, which may be significant for designing targeted educational and communication activities (Table 37).

Table 37. Assessment of the level of identification of global trends related to green transformation by demographic characteristics

Category	Very Poor	% Very Poor	Poor	% Poor	Average	% Average	Good	% Good	Very Well	% Very Well	Total	% Total
Gender												
Female	4	(1.93%)	26	(12.56%)	55	(26.57%)	39	(18.84%)	3	(1.45%)	127	(61.35%)
Male	8	(3.86%)	20	(9.66%)	30	(14.49%)	21	(10.14%)	1	(0.48%)	80	(38.65%)
Age												
20 years	5	(2.42%)	11	(5.31%)	19	(9.18%)	15	(7.25%)	1	(0.48%)	51	(24.64%)
21 years	1	(0.48%)	15	(7.25%)	18	(8.70%)	10	(4.83%)	2	(0.97%)	46	(22.22%)
22 years	2	(0.97%)	11	(5.31%)	19	(9.18%)	15	(7.25%)	1	(0.48%)	48	(23.19%)
23 years	4	(1.93%)	3	(1.45%)	14	(6.76%)	9	(4.35%)	0	(0.00%)	30	(14.49%)
24 years	0	(0.00%)	2	(0.97%)	7	(3.38%)	4	(1.93%)	0	(0.00%)	13	(6.28%)
Over 25	0	(0.00%)	4	(1.93%)	8	(3.86%)	7	(3.38%)	0	(0.00%)	19	(9.18%)
Student Status												
Full-time 1st Cycle	4	(1.98%)	15	(7.43%)	17	(8.42%)	17	(8.42%)	1	(0.50%)	54	(26.73%)
Full-time 2nd Cycle	2	(0.99%)	12	(5.94%)	21	(10.40%)	11	(5.45%)	2	(0.99%)	48	(23.76%)
Part-time 1st Cycle	2	(0.99%)	6	(2.97%)	18	(8.91%)	13	(6.44%)	0	(0.00%)	39	(19.31%)
Part-time 2nd Cycle	4	(1.98%)	12	(5.94%)	26	(12.87%)	18	(8.91%)	1	(0.50%)	61	(30.20%)
Residence												
Urban	4	(2.00%)	20	(10.00%)	25	(12.50%)	14	(7.00%)	1	(0.50%)	64	(32.00%)
Rural	5	(2.50%)	23	(11.50%)	46	(23.00%)	41	(20.50%)	1	(0.50%)	116	(58.00%)
Urban-Rural	2	(1.00%)	2	(1.00%)	11	(5.50%)	3	(1.50%)	2	(1.00%)	20	

Source: Own study based on research results.

Conducted statistical analyses indicate that no statistically significant relationships were found between the identification of global green transformation trends and demographic characteristics such as gender ($\chi^2 = 5.48$; $p = 0.2415$), age ($\chi^2 = 16.97$; $p = 0.6551$), and student status ($\chi^2 = 6.97$; $p = 0.8596$). Similarly, the level of understanding of the need for ecological adaptation showed no significant differences depending on the place of residence ($\chi^2 = 8.78$ $p = 0.3610$).

Spearman's rank correlation coefficients and Kendall's tau b and c coefficients confirm the lack of strong links between the variables and demographic traits. These results suggest that the perception of these aspects of green transformation is relatively uniform across the various socio-demographic groups in the studied sample. This uniform perception can promote social cohesion and better cooperation between different segments of society in the process of economic transformation toward sustainable development (Table 38).

Table 38. Statistical analysis of the relationship between the assessment of identifying global trends related to green transformation and the level of understanding of the need for adaptation to ecological changes relative to demographic characteristics

No.	Specification			
1	11. How well do you identify global trends related to green transformation (5) x Gender (2)	chi2	df	p
	Pearson's chi2	5.479891	df=4	p=.24150
	M-L chi2 (Maximum Likelihood)	5.372263	df=4	p=.25119
	Kendall's tau b & c	b=-.110469	c=-.126771	
	Spearman's rank R	-.119145	t=-1.718	p=.08728
	Uncertainty coefficient	X=.0099817	Y=.0194508	X Y=.01319
2	11. How well do you identify global trends related to green transformation (5) x Age (6)	chi2	df	p
	Pearson's chi2	16.96669	df=20	p=.65514
	M-L chi2 (Maximum Likelihood)	19.23411	df=20	p=.50666
	Kendall's tau b & c	b=.0597713	c=.0557773	
	Spearman's rank R	.0717857	t=1.0305	p=.30400
	Uncertainty coefficient	X=.0357372	Y=.0274702	X Y=.03106

No.	Specification			
3	11. How well do you identify global trends related to green transformation (5) x Student status (4)	chi2	df	p
	Pearson's chi2	6.970669	df=12	p=.85955
	M-L chi2 (Maximum Likelihood)	7.646273	df=12	p=.81213
	Kendall's tau b & c	b=.0344661	c=.0330687	
	Spearman's rank R	.0396433	t=.56108	p=.57537
	Uncertainty coefficient	X=.0144991	Y=.0137818	X Y=.01413
4	10. How do you assess your level of understanding of the need for adaptation to ecological changes (5) x Place of residence (3)	chi2	df	p
	Pearson's chi2	8.782700	df=8	p=.36096
	M-L chi2 (Maximum Likelihood)	9.504933	df=8	p=.30150
	Kendall's tau b & c	b=-.010361	c=-.009469	
	Spearman's rank R	-.011317	t=-.1589	p=.87395
	Uncertainty coefficient	X=.0188318	Y=.0261675	X Y=.02190

Source: Own study based on research results.

7.4. Differentiation of green transformation perception by socio-demographic characteristics

The conducted correlation analysis revealed statistically significant relationships between selected aspects of perception, knowledge, and adaptation to the green transition. The strongest positive correlation was observed between the assessment of understanding the need to adapt to ecological changes and the ability to identify global trends related to the green transition ($r = 0.463$, $p < 0.05$). Furthermore, significant positive correlations occurred between the assessment of the level of knowledge regarding the ecological transition and the understanding of the need for adaptation ($r = 0.420$, $p < 0.05$), as well as between the perception of how well the environment understands the significance of the green transition and the ability to identify global trends ($r = 0.362$, $p < 0.05$). It is also worth noting that the correlations between defining the green transition and other variables were not statistically significant. These results indicate links between knowledge, awareness, and adaptive capacity in the context of the green transition, highlighting that a better understanding of the subject fosters more effective adjustment to ecological changes.

Knowledge and understanding of issues related to the green transition, as well as awareness of the need to adapt to ecological changes, are crucial for the effec-

tive implementation of sustainable development strategies in the economy. Strong correlations between knowledge and adaptive capacity indicate that education and communication regarding the green transition can directly influence the readiness of society to undertake pro-ecological actions. In the context of the economy, raising the level of ecological awareness and knowledge promotes greater efficiency in implementing technological innovations and environmentally friendly practices, which translates into increased competitiveness, reduction of costs associated with environmental degradation, and the achievement of climate goals at national and international levels. Therefore, investments in ecological education and the development of adaptive competencies are of fundamental importance for the transformation of the economy towards sustainability (Table 39).

Table 39. Correlation analysis between perception, knowledge, and adaptation to the green transition

Specification	1. How well your environment understands the meaning of green transition	2. Which of the following definitions best fits your understanding of green transition	5. How do you assess your level of knowledge on ecological transition	10. How do you assess your understanding of the need to adapt to ecological changes	11. How well do you identify global trends related to green transition
1. Environment understanding	1.000000	0.062402	0.306812	0.300405	0.361701
2. Definition fit	0.062402	1.000000	0.056820	0.112458	-0.043240
5. Knowledge level	0.306812	0.056820	1.000000	0.419995	0.294075
10. Adaptation understanding	0.300405	0.112458	0.419995	1.000000	0.462898
11. Trend identification	0.361701	-0.043240	0.294075	0.462898	1.000000

Marked correlation coefficients are significant at $p < .05000$.

Source: Own study based on own research results.

The analysis of correlation coefficients between demographic variables (gender, age, student status, and place of residence) and various aspects of perception and knowledge about the green transition indicated a lack of statistically significant relationships in the studied sample dataset. The values of the correlation coefficients were low and oscillated around zero, which proves a weak or non-existent relationship between demographic variables and the assessment of understanding the significance of the green transition, the definition of the transition, the level of knowledge on this subject, the understanding of the need to adapt to ecological changes, and the identification of global trends related to the green transition. The highest, though still small, coefficient was recorded for gender in relation to the assessment of how well the environment understands the significance of the green transition ($r = 0.181$); however, it did not exceed the threshold of statistical significance. These results suggest that demographic factors in the studied group do not have a significant impact on the level of awareness and perception of the green transition.

The lack of significant correlations between demographic variables and knowledge/perception of the green transition indicates that ecological awareness and the level of knowledge about the green transition are not conditioned by characteristics such as age, gender, student status, or place of residence. In the context of the economy, this means that educational and communication activities regarding the green transition should be conducted universally, without the need for strong segmentation based on demographics. Such a result emphasizes the need for systematic, broad access to information and educational programs that can affect the entire population regardless of demographic group. Consequently, improving overall awareness and knowledge can effectively support adaptation processes and pro-ecological innovations, which are of key importance for the sustainable development of the economy (Table 40).

Table 40. Correlation coefficients between demographic variables and the perception and knowledge of the green transition

Specification	Gender	Age	Student	Place of residence
1. Environment understanding	0.180780	0.014539	0.006064	-0.019833
2. Definition fit	0.112195	-0.076757	-0.048760	-0.099579
5. Knowledge level	-0.047796	0.002913	-0.023391	-0.050580
10. Adaptation understanding	-0.047647	-0.139977	-0.092870	-0.011317
11. Trend identification	-0.119145	0.071786	0.039643	0.126538

Marked correlation coefficients are significant at $p < .05000$.

Source: Own study based on own research results.

7.5. Determinants of knowledge and perception of the green transition among the younger generation

The study conducted among students of the Świętokrzyskie Voivodeship revealed a moderate level of self-assessment of knowledge about the green transition, as well as significant diversification of assessments in this area. This phenomenon can be understood in the context of the information asymmetry theory proposed by Akerlof, Spence (1970), and Stiglitz (1975; 2000). Imperfect and unevenly distributed knowledge in the population results in individuals having different information capital, which leads to inefficiencies in market resource allocation mechanisms and hinders conscious consumer and investment decision-making. Simultaneously, from the perspective of human capital theory (Becker, Schultz), low and uneven knowledge constitutes a limitation in the development of green competencies, which are key to the future productivity and competitiveness of the economy. Strong positive correlations between the level of knowledge and the ability to adapt to ecological changes ($r \approx 0,42-0,46$) fit into the framework of Schumpeter's theory of technological change and the concept of "absorptive capacity" (Cohen & Levinthal, 1990), indicating that the ability to assimilate and use new information and technologies is a necessary condition for innovative transformation processes.

The lack of significant demographic differences in the perception and knowledge of the green transition can be explained by the theory of homogeneity of preferences in young cohorts and the effect of mass higher education, which confirms the growing homogenization of ecological attitudes among Generation Z and young millennials. In turn, the dispersion and low precision of the definition of the green transition point to a classic coordination problem in game theory and the issue of "common knowledge" (Chwe, 2013), where the lack of a common, precise understanding of concepts limits the ability to effectively cooperate and undertake coordinated actions in the economy. Finally, a higher level of self-assessment of one's own readiness to adapt than of actual knowledge can be interpreted through the lens of the Dunning and Kruger (1999) effect, especially in the version adapted to ecology, where excessive cognitive optimism leads to an underestimation of transition challenges and costs, which carries significant implications for policy and strategic planning.

The research results indicate the need to expand classic human capital models by a specific dimension of "green competencies," which should be formally included in national qualification frameworks and higher education curricula as mandatory and transversal modules. From the perspective of absorptive capacity theory, confirmed in the context of ecological transformation, it is recommended to introduce layered education: starting from basic concepts and definitions, through the analysis of global trends and systemic connections, up to the development of adaptive and innovative skills. In practical terms, there is a risk of a middle-level

awareness trap, where superficial knowledge does not translate into effective decisions or actions. Therefore, short, intensive online courses (MOOCs) focusing on the most important pillars of the green economy, such as the circular economy (CE), renewable energy sources (RES), EU taxonomy, or CBAM mechanisms, are proposed. The lack of significant demographic diversification allows for the scaling of such programs at the national level, which recommends the preparation of a nationwide educational campaign “Green Competencies 2030” organized jointly by the Ministry of Climate and universities. The strong link between knowledge and adaptation emphasizes the high efficiency of investment in ecological education, which justifies the allocation of EU funds (e.g., FENG, FERS) with mandatory monitoring of effects in the form of increased absorptive capacity in longitudinal studies.

In the context of the economy of the Świętokrzyskie region and Poland as a whole, the low precision of knowledge and a moderate level of awareness of the green transition among young cadres create a real risk of low absorption of EU funds allocated for 2021–2027, including funds from the National Recovery Plan (KPO). The Świętokrzyskie Voivodeship has significant financial resources (approx. 1.4 billion EUR) for ecological transformation, however, insufficiently prepared personnel may lead to unsuccessful investments and suboptimal project efficiency. Furthermore, the dynamic development of the green economy and the increase in demand for qualifications in this area, with a projected 70–80% of new jobs requiring a medium or higher level of green competencies, places the region and the country in the face of labor market challenges. High costs of internal training or the need to bring in qualified workers from abroad may limit the competitiveness of local enterprises. This is particularly important in a region with a strongly industrialized character, such as Świętokrzyskie, where carbon-intensive sectors, such as cement plants or metallurgy, require rapid decarbonization and the implementation of innovative technologies (e.g., CCS). The lack of aware and competent managerial and technical staff may slow down this process and increase its costs. At the same time, due to the lack of significant demographic differences, the region has a unique “window of opportunity” to quickly raise the level of green competencies in the entire young generation. The implementation of pilot educational programs in the Świętokrzyskie Voivodeship has the potential for full replication in other regions of Poland, which may contribute to a leap in competencies and strengthen the competitiveness of the entire economy.

The study, covering mainly representatives of Generation Z and the youngest millennials, confirms the key characteristics of this generation in the context of the green transition. The homogeneity of ecological attitudes is the result of a unified global discourse and mass education in Poland, which eliminates traditional demographic divisions related to gender, age, or place of residence. The moderate level of declarative knowledge, but low conceptual precision, reflects the dominant way of assimilating information by Generation Z, often superficial and emotional,

shaped by social media and popular information platforms. A significant observation is the strong correlation between actual knowledge and the ability to adapt, indicating pragmatism and readiness for action, provided that reliable and systemic educational content is provided. Simultaneously, the Dunning–Kruger (1999) effect and the culture of self-confidence in social media generate the risk of overestimating one’s own competencies, which may lead to an inadequate assessment of transformation challenges. Finally, the lack of clear gender differences testifies to positive changes in terms of inclusiveness and social equality, which constitutes a good basis for the implementation of sustainable development policies.

The conducted study of the perception of the green transition among students of the Świętokrzyskie Voivodeship can be interpreted in the light of several fundamental economic theories that explain the mechanisms of perceiving costs, benefits, and investment and consumption decisions. Above all, the high assessment of costs associated with implementing ecological activities and the uncertainty as to their long-term effects corresponds to the transaction cost theory (Williamson, Coase, 1985), which indicates that information and coordination barriers and systemic risks affect the efficiency and acceptance of innovation. From the point of view of behavioral economics, a clear aversion to short-term losses compared to distant benefits (loss aversion, Kahneman & Tversky, 1979) explains the imbalance in perception, where students feel costs more clearly than potential gains, which hinders decisions favoring the transition. In the context of distributive justice and the concept of “just transition” (Rawls, Sen), concerns about the increase in social inequalities indicate the importance of the perceived fairness of the distribution of costs and benefits, which is a condition for the legitimization of transformation policies. Additionally, the moderately positive assessment of ecological effects with a simultaneous strong focus on costs reflects the classic problem of insufficient internalization of external effects, emphasized in environmental economics theory, and requires the use of fiscal and regulatory instruments (e.g., Pigou taxes, ETS systems). Finally, the results indicate the presence of hyperbolic discounting in intertemporal decisions, which makes it difficult to accept distant benefits and emphasizes the need for strategies that take into account psychological time barriers. In summary, the integration of classical and behavioral economic theories allows for a better understanding of the mechanisms shaping the attitudes of young people towards the green transition, indicating the need for a multifaceted approach in educational and communication policies.

In conclusion, the study indicates that Generation Z and young millennials constitute a strategic target group for fast and effective educational interventions. The implementation of such actions in the coming years is a necessary condition to prevent the consolidation of a competency gap that could inhibit the absorption of EU funds and slow down the development of a low-emission economy in Poland. Thus, investments in precise, systemic ecological education are not only an educational challenge but also a key element of the country’s development strategy for the next decade.

Research conducted among students in the Świętokrzyskie Voivodeship revealed a complex picture of green transition perception. Statistical analysis (Table 28) showed that the distribution of knowledge assessments and understanding of ecological processes deviates from a normal distribution (Shapiro-Wilk test, $p < 0.05$), indicating a strong polarization of attitudes within the study group. Although the dominant way of defining the green transition is to perceive it as a long-term process (43.84%) and development (33%), the conceptual precision of respondents remains at a moderate level.

The analysis of socio-demographic differentiation (Section 7.3) provided significant insights regarding the inclusivity of the transformation process. A “gender gap” was observed – women were statistically more likely to declare a lower level of understanding of the subject (30.44% negative ratings) than men (13.04%), which was confirmed by the Spearman test ($r = 0.181$; $p = 0.009$). At the same time, it was shown that age ($p = 0.018$) and student status ($p = 0.041$) significantly differentiate the way the transition is defined, with younger cohorts more often identifying it with positive economic development. Interestingly, in the area of detailed self-assessment of substantive knowledge and identification of global trends (Tables 33–37), demographic differences vanished. This suggests that while psychological barriers and self-confidence are correlated with gender or age, real knowledge deficits are systemic and affect the entire studied population to a similar extent.

The key finding of this chapter is the strong interdependence between knowledge and adaptive capacities. A clear positive correlation ($r \approx 0.42 - 0.46$) was recorded between the level of substantive competence and the readiness to implement ecological changes. This result, interpreted through the lens of the theory of information asymmetry (Stiglitz, 1975, 2000) and the Dunning-Kruger (1999) effect, points to the risk of a “middle-level awareness trap” – respondents exhibit high optimism regarding their own adaptive capacity, which may not be backed by the hard competencies necessary to operate low-emission technologies.

Chapter 8.

Access to knowledge and environmental education

8.1. Determinants of environmental education among students in the context of the green transition

The second phase of the analysis focuses on the accessibility and quality of environmental education, as well as the structural barriers and facilitators in accessing knowledge regarding the green transition. The empirical results address research questions concerning the assessment of environmental education levels within the students' immediate environment (Q3) and the institutional activity in promoting sustainable development and green technologies (Q4). The objective is to quantify the extent to which the academic and extra-university environments determine pro-ecological attitudes and the development of specialized competencies. This assessment is fundamental for measuring the efficiency of current educational policies and for calibrating future strategic interventions.

Particular emphasis is placed on identifying barriers to information access (Q6) and the corresponding facilitators (Q7). Analyzing these factors allows for a verification of whether current communication channels – including university curricula, specialized seminars, workshops, and social campaigns – are effective or require structural optimization. Identified barriers may include the lack of accessible, non-technical materials, high entry costs for specialized knowledge (e.g., proprietary courses, limited mentoring), or time constraints resulting from competing academic obligations. Conversely, facilitators include the availability of Open Educational Resources (OERs), Massive Open Online Courses (MOOCs), and grassroots student initiatives. Mapping these “pain points” and success drivers is essential for the strategic targeting of educational resources.

Furthermore, the analysis evaluates the impact of regional policy instruments on ecological awareness (Q8) and the level of organizational investment in specialized training (Q17). These variables allow for an objective assessment of whether local authorities and institutions (universities, enterprises, local governments) are effectively engaged in pro-ecological education and whether their outputs are perceived as credible and authentic by the student population. Identifying entities recognized as reliable sources of knowledge is critical for developing communication strategies that bridge existing knowledge gaps and reinforce pro-ecological behaviors among future labor market participants.

In the digital paradigm, it is necessary to examine the utilization of social media platforms (Facebook, Instagram, TikTok) and influencer-led communication as primary data sources on the green transition. The research evaluates the perceived credibility and cognitive value of these channels. It further investigates

the respondents' ability to distinguish between verified data and "greenwashing" or disinformation. Given the high reach of these platforms among the studied cohort, understanding the dynamics of information flow is vital for designing high-impact communication strategies that utilize the preferred formats of the younger generation.

Environmental education is defined here not only as theoretical knowledge but as the acquisition of "green competencies" required by the evolving labor market. The study measures the demand for specific skills (e.g., energy management, environmental auditing, RES operation, sustainable agriculture) and evaluates the adequacy of university offerings (internships, laboratories, research projects). Correlating acquired knowledge with perceived career trajectory is essential for understanding the drivers of student motivation. This analysis highlights the gap between market demand for specialized human capital and the current regional educational output.

The study also considers the impact of student participation in co-creating educational curricula and transition-related initiatives. It verifies whether students are active stakeholders in course design and research agendas. Measuring the level of engagement in campus-based pro-ecological initiatives (Qxx) and the perceived influence on the educational model allows for an assessment of the institutional flexibility of the academic environment. Shifting the role of students from passive recipients to active contributors is a key variable in increasing the relevance of educational programs.

Finally, the analysis incorporates the field of study (e.g., technical, natural, social, or human sciences) as a differentiating variable for knowledge levels and perceptions of the green transition. It tests whether engineering students demonstrate higher technical proficiency in RES technologies, while social science students exhibit better understanding of the "just transition" framework. Identifying gaps resulting from a lack of interdisciplinarity in curricula allows for the design of specialized support modules. This approach ensures a comprehensive understanding of green transition challenges, regardless of the primary educational path.

The findings from this section provide a basis for the evidence-based design of educational programs and information campaigns. Identifying specific knowledge access barriers facilitates the creation of personalized learning modules, including gamified e-learning and practical technical workshops. Moreover, identifying high-trust regional practices allows for their replication and the establishment of "best practices" in environmental education. The ultimate objective is the systematic building of durable competencies and the intensification of youth engagement in the green transition process.

In summary, the identified determinants highlight the critical role of institutional and digital knowledge flow channels in shaping students' competency capital. Recognizing the barriers to accessing reliable information serves as a starting point for a detailed analysis of the subjective reception of these processes, which

will be discussed in section 8.2. perception of environmental education and sustainable development activities among students, focusing on the assessment of the effectiveness of local pro-ecological initiatives.

8.2. Perception of environmental education and sustainable development activities among students

The study focuses on evaluating ecological competencies and the promotional activity of knowledge regarding sustainable development among academic staff, employees, and the work and study environment. The analysis considers whether the environment constitutes an effective source of education and inspiration for pro-ecological actions. Furthermore, barriers and facilitators in accessing knowledge on the ecological transition are identified, allowing for the design of effective educational interventions. It is also essential to examine the perception of the impact of regional initiatives on raising environmental awareness and to assess the relationship between investments in education and training and shifts in attitudes toward the green transition. This multidimensional approach enables a comprehensive analysis of the individual and systemic determinants of environmental education, providing a basis for developing educational strategies that support sustainable development and socio-economic transformation.

The conducted analysis indicates a diversified level of assessment regarding environmental education among employees and activities promoting sustainable development and green technologies in the respondents' environment. The majority of study participants rated the level of environmental education as average (44.93%), while a clear minority rated it as good (14.49%) or very good (2.90%). A similar distribution occurred in the assessment of activities promoting knowledge of sustainable development, where 43% indicated a weak level of promotion, and only 14.5% indicated a good or very good level. Regarding barriers to accessing knowledge, the most frequently cited were difficulties in understanding technical issues (30.43%) and a lack of time for learning (31.88%). A significant barrier was also the lack of available knowledge sources (16.43%). Conversely, among the positive aspects of knowledge access, the availability of educational materials (35.96%) and the increase in social awareness (45.32%) predominated. Other factors, such as support from government institutions, the timeliness of information, or media openness, were mentioned less frequently. The assessment of the impact of investment in education and training on attitudes toward the ecological transition was distributed similarly, with a prevalence of average (39.90%) and weak (26.60%) ratings, indicating a moderate impact of these activities on changing attitudes.

These results point to significant needs for improving the quality and accessibility of environmental education, particularly regarding the simplification of materials and their better adaptation to recipients to mitigate barriers resulting

from technical difficulties and lack of time. They also emphasize the necessity of increasing activities promoting knowledge of sustainable development and green technologies in various environments, especially where the perception of these activities is low. The identified barriers and positive aspects can serve as guidelines for designing more effective educational programs that take into account the participants' constraints and utilize existing resources and positive social experiences. It is also crucial to increase investment in training and improve its promotion to strengthen the impact of these actions on attitudes toward the green transition.

From the perspective of economic theory, particularly behavioral economics and the economics of education, the results highlight the impact of information accessibility and quality on individuals' decisions regarding pro-ecological actions. Cognitive barriers, such as the difficulty in understanding technical materials, are related to the concept of bounded rationality, where individuals have limited capacities to process complex information, affecting their behavior. Furthermore, human capital theory indicates that investments in education and training have the potential to increase knowledge and change attitudes, which in effect can lead to more effective participation in the green transition. However, the moderate impact of investments on attitudes indicates the need to optimize educational programs to better meet the recipients' needs and foster real behavioral changes. Finally, the results also refer to information theory and information asymmetry, where limited access to reliable and accessible knowledge sources may inhibit rational investment and consumption decisions in the area of sustainable development, which is significant for public policies and economic development strategies (Table 41).

Table 41. Results concerning the assessment of environmental education, barriers, positive aspects, and the impact of the environment and investment on ecological awareness

Category / Response	Count	%	Category / Response	Count	%
3. Level of environmental education			4. Environment promotes knowledge		
very weak	16	7.73	very weak	27	13.04
weak	62	29.95	weak	89	43.00
average	93	44.93	average	61	29.47
good	30	14.49	good	28	13.53
very good	6	2.90	very good	2	0.97
Total	207	100	Total	207	100

Category / Response	Count	%	Category / Response	Count	%
6. Barriers in access to knowledge			7. Positive aspects		
Lack of available sources	34	16.43	Availability of materials	73	35.96
Difficult technical content	63	30.43	Increase in awareness	92	45.32
Lack of time	66	31.88	Availability of training	5	2.46
Lack of practical examples	20	9.66	Institutional support	8	3.94
Lack of educational support	10	4.83	Diversity of examples	6	2.96
Complexity of the problem	7	3.38	Timeliness of information	11	5.42
Uncertainty of the future	7	3.38	Media openness	8	3.94
Total	207	100	Total	203	100
8. Does the region raise awareness?			17. Do investments affect attitudes?		
very weak	24	11.71	very weak	20	9.85
weak	70	34.15	weak	54	26.60
average	74	36.10	average	81	39.90
good	35	17.07	good	44	21.67
very good	2	0.98	very good	4	1.97
Total	205	100	Total	203	100

Source: Own study based on own research results.

The conducted statistical analyses present basic descriptive measures for selected variables regarding environmental education, barriers and positive aspects of knowledge access, and the impact of investment on attitudes toward the ecological transition. Mean assessment values range from 2.25 to 2.80 on a five-point scale, indicating a moderate level of positive assessment for both environmental education and activities promoting sustainable development. The highest mean was recorded for the question concerning barriers to accessing knowledge (2.80), signaling that respondents experience significant difficulties in this area. Conversely, the lowest mean is shown for positive aspects of knowledge access (2.25), which may indicate a limited number or weaker perception of these aspects by respondents. Standard deviations oscillate around 0.9 for most variables, suggesting a moderate dispersion of ratings within the study group. An exception is the variable regarding positive

aspects of knowledge access, where the standard deviation is 1.62, indicating greater variability in opinions. Coefficients of variation (the ratio of standard deviation to the mean) confirm this trend, showing the greatest spread of ratings in positive aspects (0.72) and barriers (0.51).

These results indicate the need to concentrate efforts on reducing barriers to accessing knowledge about the ecological transition, which is key to increasing the efficiency of education and the promotion of pro-ecological behaviors. High variability in opinions on positive aspects suggests that respondents' experiences are diverse, which may stem from varying degrees of accessibility and quality of educational materials and institutional support. Furthermore, moderate ratings of the impact of educational investment on attitudes indicate the possibility of improving training programs to better motivate and engage participants in the green transition process. In practice, this may necessitate adjusting the content and format of training to the specific needs of different recipient groups.

From the perspective of economic theory, particularly human capital theory, the results underscore the vital role of investment in education as a mechanism increasing the potential of individuals' knowledge and skills in the context of the green transition. The diversification of assessments of barriers and positive aspects reflects information asymmetry and varying levels of access to educational resources, which may affect the efficiency of economic decisions related to ecological behaviors. High variability in the perception of positive aspects of knowledge access can be interpreted as an effect of diversified social capital and resources in the respondents' environment, which is consistent with the theory of social networks in economics. Finally, the moderate impact of investment on attitudes aligns with behavioral economics, where changes in attitudes require not only access to information but also motivation and appropriate incentives, which should be included in educational and environmental policies (Table 42).

Table 42. Descriptive statistics concerning environmental education and access to knowledge about the ecological transition

Variable	Mean	Standard deviation	Coefficient of variation
Q3 How do you assess the level of environmental education among employees in your environment?	2.748792	0.900208	0.327492
Q4 Does your environment promote knowledge in sustainable development and green technologies?	2.463768	0.917675	0.372468
Q6 What barriers in accessing knowledge about the ecological transition do you encounter?	2.797101	1.437160	0.513803
Q7 What positive aspects in accessing knowledge about the ecological transition do you encounter?	2.246305	1.616261	0.719520
Q8 Do the actions of your environment (region) contribute to raising ecological awareness?	2.614634	0.935561	0.357817
Q17 To what extent does the level of investment in education and training in your organization affect changes in your attitude toward the ecological transition?	2.793103	0.957798	0.342916

Source: Own study based on own research results.

The conducted normality tests – Kolmogorov-Smirnov (K-S), Lilliefors, and Shapiro-Wilk (W) – indicate that the distributions of ratings for all analyzed variables differ significantly from a normal distribution ($p < 0.01$). The values of the Maximum D test statistics range from 0.20 to 0.37, and the Shapiro-Wilk W statistics for each variable are below critical values, confirming the rejection of the hypothesis of distribution normality.

This means that the data have an asymmetrical distribution or exhibit other deviations from the classic normal distribution, which is typical in social research, particularly in surveys of a subjective nature concerning attitudes.

The lack of normality in the data distribution requires the use of statistical analysis methods robust to deviations from normality, such as non-parametric tests (e.g., rank tests, Spearman’s correlation coefficient). This will allow for a more reliable interpretation of the relationships between variables and an assessment of the significance of differences between groups. Furthermore, the asymmetry of

the distributions may indicate a diversification of respondents' opinions, as well as the presence of extreme attitudes toward environmental education and pro-ecological actions in the environment, which is significant for practitioners planning educational and communication strategies.

From the standpoint of economic theory, the non-standard distribution of ratings may reflect the heterogeneity of the population in terms of access to educational resources and differences in human capital. Deviations from normality may result from inequalities in the distribution of knowledge and ecological awareness, which is consistent with human capital theory and the economics of inequality. Furthermore, the fact that the distribution is asymmetrical suggests that barriers and limitations may exist in the population, causing a significant portion of respondents to have limited access to knowledge or unfavorable educational experiences, which should be considered when designing interventions and policies supporting the green transition (Table 43).

Table 43. Results of normality tests (K-S, Lilliefors, Shapiro–Wilk) for variables related to environmental education and the green transition

Variable	N	Max D	K-S (p)	Lillief. (p)	W	p
Q3 Level of environmental education	207	0.233087	p < .01	p < .01	0.890560	0.000000
Q4 Environment promotes knowledge	207	0.253738	p < .01	p < .01	0.883055	0.000000
Q6 Barriers in access to knowledge	207	0.231303	p < .01	p < .01	0.868901	0.000000
Q7 Positive aspects	203	0.373369	p < .01	p < .01	0.695429	0.000000
Q8 Region raises awareness	205	0.202936	p < .01	p < .01	0.894054	0.000000
Q17 Investments affect attitudes	203	0.220979	p < .01	p < .01	0.898195	0.000000

Source: Own study based on own research results.

In summary, the statistical evidence confirms that while institutional efforts exist, their perceived impact is currently hindered by significant cognitive and structural barriers. The research findings carry significant practical implications for the formulation of organizational and regional policies regarding environmental education and ecological transformation. The moderate to high level of investment in education and training suggests that further strengthening these activities may

contribute to a deeper and more conscious acceptance of ecological transformation among employees and local communities. Furthermore, it is essential to leverage the positive aspects of knowledge access, which dominate respondent perceptions, to design effective educational and information campaigns. Concurrently, identifying barriers allows for the targeting of corrective actions aimed at eliminating obstacles to the widespread dissemination of knowledge. In practice, it is recommended to develop cross-sectoral cooperation, including the engagement of local administrations, enterprises, and educational institutions, to increase the effectiveness of pro-ecological and educational initiatives.

From the perspective of economic theory, these results can be interpreted within the framework of human capital theory and the economics of sustainable development. Investments in education and training are treated as investments in human capital that increase individual efficiency and the capacity to adapt to technological and environmental changes (Becker, 1964). Moreover, positive attitudes toward ecological transformation, fostered by education, can lead to the internalization of the costs and benefits of sustainable development, which is critical for the effective functioning of market and non-market mechanisms in environmental protection (Stiglitz, 2000). In light of the theory of public goods, raising ecological awareness in the region serves as a public good requiring coordination and support from state institutions and social organizations. Finally, the analysis of knowledge access barriers aligns with the theory of asymmetric information (Akerlof, 1970), where imperfect access to information constitutes an obstacle to optimal decision-making by individuals and organizations, potentially delaying the effective implementation of green technologies and practices in the context of ecological transformation.

In the context of the green transition, a particularly vital role is played by understanding how students – as future professional cadres and conscious citizens – perceive and internalize knowledge about sustainable development and ecology. The conducted analyses aim to deepen this issue by examining the influence of demographic factors and the interrelationships between various aspects of ecological perception. The analysis of survey responses enables the identification of potential gaps in environmental education, existing barriers to information access, and areas that positively influence the raising of ecological awareness among students.

Examining the dependence of the perception of promoting sustainable development knowledge on the type of university (public vs. private) and the field of study allows for an assessment of how the academic environment – through resources, curricula, or pedagogical approaches – influences the reception of pro-ecological initiatives. Detecting differences in perception between students of different universities or disciplines may indicate the need to adapt educational and communication strategies to the specificities of individual institutions and fields of study. For example, technical fields may require different promotional tools and communication formats than the humanities.

Equally important is investigating the relationship between the perception of regional actions for raising ecological awareness and the general level of understanding of the green transition in the student's environment, while also accounting for the influence of the place of residence prior to studies (urban vs. rural). Such an approach allows for the evaluation of the effectiveness of local and regional initiatives and indicates whether there is a need to tailor actions to regional specificities, considering differences in resource availability, education, or environmental challenges characteristic of urban and rural areas.

An essential element of the study is also the analysis of barriers and positive aspects in accessing knowledge about ecological transformation. Categorizing responses and examining their interconnections allows for the identification of student groups who simultaneously face numerous obstacles and have limited access to supportive information sources. Furthermore, correlating the general level of understanding of the subject with the most frequently reported barriers and positive aspects enables the pinpointing of key areas requiring intervention and those that should be developed as effective elements of environmental education (Table 44).

The collected data and their analysis provide valuable guidance for educational policymakers, academic institutions, and social organizations. They allow for the design and implementation of effective actions to improve access to reliable ecological knowledge, strengthen social awareness, and more effectively support the green transition in various academic and regional environments.

Statistical analysis of the dependence between the assessment of the environmental education level of employees and selected demographic characteristics of respondents (gender, age, student status, and place of residence) revealed no statistically significant relationships. In all four comparisons, both the Pearson chi-square test values and the Likelihood Ratio (NW) chi-square test values yielded p-values exceeding the significance level $\alpha = 0.05$ (for gender $p = 0.64$; age $p = 0.72$; student status $p = 0.51$; place of residence $p = 0.72$). Low values of Kendall's and Spearman's rank coefficients (ranging from -0.02 to 0.06) indicate a lack of monotonic associations between variables, while very low uncertainty coefficients demonstrate that demographic variables explain only a minimal fraction of the variance in assessments. These results prove that the perception of the environmental education level of employees is homogeneous and does not depend on basic socio-demographic characteristics, suggesting that this assessment is similarly low regardless of gender, age, residence, or academic status.

The obtained results are of significant importance for the regional economy as they indicate a widespread, systemic deficit in ecological competencies among employees, independent of the demographic structure of society. A uniformly low assessment of environmental education levels implies that human resources in the region are insufficiently prepared for the requirements of the green transition, including the implementation of low-emission technologies, environmental innovations, and circular economy principles. A lack of ecological competencies

Table 44. Assessment of the level of environmental education among employees by demographic characteristics of respondents

Category	Very Weak	% of total	Weak	% of total	Aver-age	% of total	Good	% of total	Very good	% of total	Total	% of total
Gender												
Female	11	(5.31%)	37	(17.87%)	58	(28.02%)	19	(9.18%)	2	(0.97%)	127	(61.35%)
Male	5	(2.42%)	25	(12.08%)	35	(16.91%)	11	(5.31%)	4	(1.93%)	80	(38.65%)
Age												
20 years	5	(2.42%)	18	(8.70%)	17	(8.21%)	10	(4.83%)	1	(0.48%)	51	(24.64%)
21 years	2	(0.97%)	11	(5.31%)	27	(13.04%)	6	(2.90%)	0	(0.00%)	46	(22.22%)
22 years	3	(1.45%)	11	(5.31%)	25	(12.08%)	7	(3.38%)	2	(0.97%)	48	(23.19%)
23 years	4	(1.93%)	9	(4.35%)	13	(6.28%)	3	(1.45%)	1	(0.48%)	30	(14.49%)
24 years	1	(0.48%)	6	(2.90%)	3	(1.45%)	2	(0.97%)	1	(0.48%)	13	(6.28%)
Over 25	1	(0.48%)	7	(3.38%)	8	(3.86%)	2	(0.97%)	1	(0.48%)	19	(9.18%)
Student Status												
Full-time 1st Cycle	4	(1.98%)	18	(8.91%)	21	(10.40%)	10	(4.95%)	1	(0.50%)	54	(26.73%)
Full-time 2nd Cycle	4	(1.98%)	10	(4.95%)	25	(12.38%)	9	(4.46%)	0	(0.00%)	48	(23.76%)
Part-time 1st Cycle	3	(1.49%)	15	(7.43%)	15	(7.43%)	5	(2.48%)	1	(0.50%)	39	(19.31%)
Part-time 2nd Cycle	5	(2.48%)	18	(8.91%)	29	(14.36%)	5	(2.48%)	4	(1.98%)	61	(30.20%)
Residence												
Urban	8	(4.00%)	19	(9.50%)	28	(14.00%)	7	(3.50%)	2	(1.00%)	64	(32.00%)
Rural	6	(3.00%)	35	(17.50%)	52	(26.00%)	19	(9.50%)	4	(2.00%)	116	(58.00%)
Urban-Rural	1	(0.50%)	8	(4.00%)	8	(4.00%)	3	(1.50%)	0	(0.00%)	20	(10.00%)

Source: Own study based on own research results.

across broad groups of employees may limit the ability of enterprises to adapt to climate regulations, reduce the efficiency of utilizing EU funds, and weaken the competitiveness of the regional economy. These findings underscore the necessity of introducing wide-ranging, systemic educational and training initiatives covering both the public and private sectors to ensure the adequate human capital necessary to accelerate transition processes toward a low-emission economy.

Analysis of the response distributions indicates that, regardless of demographic characteristics, the majority of respondents rate the promotion of sustainable development knowledge and green technologies as weak or average. Broken down by gender, the answers “weak” and “average” dominate among both women (25.60% and 19.81%) and men (17.39% and 9.66%), with marginal participation of positive ratings (“good” and “very good”). A similar distribution is observed across age groups, where “very weak,” “weak,” and “average” responses constitute the vast majority, particularly among those aged 20–22, who collectively generate over 70% of negative or moderate ratings. A comparable response structure is also seen among students of varying status – both 1st and 2nd cycle, full-time and part-time – where “weak” and “average” ratings prevail, especially in the 2nd cycle part-time group (25.7% negative and 10.4% average indications). Place of residence also does not clearly differentiate ratings, although rural residents more frequently indicate negative responses (27.5% “weak”), while urban and transitional area residents somewhat more often provide moderate ratings. Overall, the data indicate that the promotion of sustainable development knowledge is perceived as insufficient in most analyzed groups, suggesting a widespread information deficit and low visibility of educational activities in this area (Table 45).

Table 45. Relationship between the assessment of employees’ environmental education level and respondents’ demographic characteristics

No.	Specification	Test	Statistic	df	p
1	Q3 Assessment level x Gender	chi2	2.519124	df=4	p=.64121
		LR chi2 (NW)	2.464700	df=4	p=.65097
		Kendall tau b/c	b=.02538 / c=.02884		
		Spearman R	.0273608	t=-.39189	p=.69554
		Uncertainty coeff.	X=.00457 / Y=.00892		X Y=.00605
2	Q3 Assessment level x Age	chi2	15.98459	df=20	p=.71758
		LR chi2 (NW)	16.96421	df=20	p=.65530
		Kendall tau b/c	b=-.01553 / c=-.01435		
		Spearman R	-.018881	t=-.2704	p=.78714

No.	Specification	Test	Statistic	df	p
3	Q3 Assessment level x Student Status	chi2	11.23526	df=12	p=.50887
		LR chi2 (NW)	12.29669	df=12	p=.42216
		Kendall tau b/c	b=-.02187 / c=-.02078		
		Spearman R	-.025283	t=-.3577	p=.72097
		Uncertainty coeff.	X=.02331 / Y=.02216		X Y=.02722
4	Q3 Assessment level x Place of Residence	chi2	5.340597	df=8	p=.72063
		LR chi2 (NW)	5.702169	df=8	\$p=.68055
		Kendall tau b/c	b=.04922 / c=.04530		
		Spearman R	.0554005	t=.78075	p=.43588
		Uncertainty coeff.	X=.01093 / Y=.01565		X Y=.01287

Source: Own study based on own research results.

The obtained results are of significant importance for the regional and national economy, as they point to an insufficient level of promotion of sustainable development knowledge among the young generation, who will constitute critical human capital for the public and private sectors in the near future. Negative or moderate ratings in nearly all demographic groups testify to the limited effectiveness of information activities conducted by educational, local government, and economic institutions. Such a state may lead to a slowdown in ecological transformation processes, limit corporate innovation, and hinder the implementation of low-emission technologies. In the long run, the lack of adequately prepared human capital lowers the region's ability to adapt to the requirements of the European Green Deal and reduces the opportunities to fully utilize available financial resources for the development of green technologies. These results emphasize the necessity of intensifying promotional and educational actions, particularly directed at academic youth, to provide the economy with an appropriate level of competence allowing for the effective conduct of the green transition (Table 46).

Table 46. Assessment of the promotion of knowledge about sustainable development and green technologies by demographic characteristics of respondents

Category	Very Weak	% of total	Weak	% of total	Aver-age	% of total	Good	% of total	Very good	% of total	Total	% of total
Gender												
Female	15	(7.25%)	53	(25.60%)	41	(19.81%)	17	(8.21%)	1	(0.48%)	127	(61.35%)
Male	12	(5.80%)	36	(17.39%)	20	(9.66%)	11	(5.31%)	1	(0.48%)	80	(38.65%)
Age												
20 years	11	(5.31%)	23	(11.11%)	10	(4.83%)	7	(3.38%)	0	(0.00%)	51	(24.64%)
21 years	1	(0.48%)	24	(11.59%)	13	(6.28%)	7	(3.38%)	1	(0.48%)	46	(22.22%)
22 years	5	(2.42%)	21	(10.14%)	15	(7.25%)	7	(3.38%)	0	(0.00%)	48	(23.19%)
23 years	7	(3.38%)	10	(4.83%)	11	(5.31%)	1	(0.48%)	1	(0.48%)	30	(14.49%)
24 years	1	(0.48%)	2	(0.97%)	5	(2.42%)	5	(2.42%)	0	(0.00%)	13	(6.28%)
>25 years	2	(0.97%)	9	(4.35%)	7	(3.38%)	1	(0.48%)	0	(0.00%)	19	(9.18%)
Student Status												
1st cycle full-time	8	(3.96%)	27	(13.37%)	12	(5.94%)	6	(2.97%)	1	(0.50%)	54	(26.73%)
2nd cycle full-time	6	(2.97%)	22	(10.89%)	13	(6.44%)	7	(3.47%)	0	(0.00%)	48	(23.76%)
1st cycle part-time	6	(2.97%)	12	(5.94%)	13	(6.44%)	8	(3.96%)	0	(0.00%)	39	(19.31%)
2nd cycle part-time	6	(2.97%)	27	(13.37%)	21	(10.40%)	6	(2.97%)	1	(0.50%)	61	(30.20%)
Place of Residence												
Urban	11	(5.50%)	23	(11.50%)	20	(10.00%)	9	(4.50%)	1	(0.50%)	64	(32.00%)
Rural	12	(6.00%)	55	(27.50%)	34	(17.00%)	14	(7.00%)	1	(0.50%)	116	(58.00%)
Urban-Rural	3	(1.50%)	9	(4.50%)	4	(2.00%)	4	(2.00%)	0	(0.00%)	20	(10.00%)

Source: Own study based on own research results.

The conducted statistical analyses revealed a lack of significant relationships between the assessment of promoting knowledge on sustainable development and green technologies and most of the studied demographic characteristics. For gender ($\chi^2 = 1.50$; $p = 0.826$), student status ($\chi^2 = 8.45$; $p = 0.749$), and place of residence ($\chi^2 = 4.73$; $p = 0.786$), the significance levels (p -values) substantially exceed the adopted threshold of $\alpha = 0.05$, clearly indicating the absence of statistically significant associations. Furthermore, Spearman's rank correlation and Kendall's tau coefficients for these variables yield values near zero, confirming the lack of linear dependence and a negligible strength of association.

Conversely, the analysis of age presents a distinct case: while the Pearson chi-square test ($p = 0.067$) indicates a borderline result, the likelihood-ratio (LR) test ($p = 0.042$) reveals a statistically significant relationship. Although the correlation coefficients remain low ($R = 0.086$), their positive direction suggests a subtle trend wherein more favorable assessments increase with age. Collectively, these results indicate that age serves as the primary demographic differentiator in the structure of evaluations, whereas other variables do not significantly determine the perception of sustainable development knowledge promotion.

The absence of significant correlations across most demographic traits points to the systemic and universal nature of the deficit in information dissemination within this field. This suggests that regardless of gender, residence, or academic status, communication regarding sustainable development remains insufficiently impactful. Such a deficit may impede the pace of the green economic transition and diminish social readiness for implementing pro-ecological innovations.

Data analysis indicates that barriers to accessing knowledge regarding ecological transformation exist across all demographic groups, although their intensity manifests in various forms. Both women and men most frequently declare a lack of time and technical difficulties; however, women report these slightly more often (20.29% and 18.84%, respectively). Among age groups, the most distinct barriers are observed in individuals aged 20–22, who primarily cite a lack of time and a lack of knowledge sources. In contrast, the youngest and oldest age groups exhibit a greater diversity of barriers, including uncertainty about the future or the complexity of the issues. This differentiation is also visible regarding student status – specifically, part-time second-cycle students most frequently indicate time constraints (13.37%), which may result from balancing professional work with studies. Place of residence also influences the perception of barriers: rural residents declare technical difficulties and a lack of educational support to a greater extent, which may indicate poorer information and educational infrastructure in these areas. Collectively, the results show that various social groups are not equally prepared to utilize knowledge about ecological transformation, and the types of barriers are deeply rooted in the specifics of their daily functioning (Table 47).

Table 47. Relationship between the assessment of sustainable development knowledge promotion and respondents' demographic characteristics – statistical analysis

No.	Specification	Test	Statistic	df	p
1	Promotion of knowledge on sustainable development and green technologies (5) x Gender (2)	chi2	1.501665	df=4	p=0.82635
		LR chi2 (ML)	1.511404	df=4	p=0.82462
		Kendall's tau-b & tau-c	b = -0.049996	c = -0.057318	
		Spearman rank R	-0.054021	t = -0.7746	p=0.43948
		Uncertainty Coeff.	X = 0.0027995	Y = 0.0054722	X Y = 0.00370
2	Promotion of knowledge on sustainable development and green technologies (5) x Age (6)	chi2	30.14575	df=20	p=0.06753
		LR chi2 (ML)	32.10705	df=20	p=0.04217
		Kendall's tau-b & tau-c	b = 0.0714701	c = 0.0666293	
		Spearman rank R	0.0858792	t = 1.2342	p=0.21856
		chi2	8.450243	df=12	p=0.74903
3	Promotion of knowledge on sustainable development and green technologies (5) x Student Status (4)	LR chi2 (ML)	9.250175	df=12	p=0.68143
		Kendall's tau-b & tau-c	b = 0.0652624	c = 0.0623468	
		Spearman rank R	0.0785386	t = 1.1141	p=0.26655
		Uncertainty Coeff.	X = 0.0176123	Y = 0.0166727	X Y = 0.01713
		4	Promotion of knowledge on sustainable development and green technologies (5) x Place of Residence (3)	chi2	4.729792
LR chi2 (ML)	4.898215			df=8	p=0.76840
Kendall's tau-b & tau-c	b = -0.009638			c = -0.008925	
Spearman rank R	-0.010321			t = -0.1452	p=0.88467
Uncertainty Coeff.	X = 0.0094001			Y = 0.0134445	X Y = 0.01106

Source: Own elaboration based on research results.

The results obtained are significant for the functioning and pace of economic transformation based on sustainable development principles. The occurrence of

barriers such as a lack of time, technical difficulties, a shortage of knowledge sources, or a lack of educational support indicates the need to improve the national information system regarding the green transition. If a large part of society does not have adequate conditions for acquiring ecological knowledge, it may slow down the implementation of innovations, limit adaptation to new technologies, and weaken economic competitiveness. Particularly concerning are the barriers observed in rural areas, where infrastructural deficiencies may lead to growing competency inequalities between urban and rural areas, potentially reducing the effectiveness of energy and ecological transformation in the long term. The results highlight the necessity for systemic investment in education, digitalization, and ecological competency support programs, which constitute the foundation for building a modern, low-emission, and resilient economy (Table 48).

Table 48. Barriers to accessing knowledge on ecological transformation according to respondents' demographic characteristics

Category	Lack of knowl- edge sources	%	Technical diffi- culties	%	Lack of time	%	Lack of practi- cal examples	%	Lack of educa- tional support	%	Complexity of the issue	%	Uncertainty about the future	%	Total	%
Gender																
Female	19	9.18%	39	18.84%	42	20.29%	13	6.28%	6	2.90%	3	1.45%	5	2.42%	127	61.35%
Male	15	7.25%	24	11.59%	24	11.59%	7	3.38%	4	1.93%	4	1.93%	2	0.97%	80	38.65%
Age																
20 years	10	4.83%	18	8.70%	13	6.28%	5	2.42%	2	0.97%	2	0.97%	1	0.48%	51	24.64%
21 years	5	2.42%	12	5.80%	16	7.73%	4	1.93%	6	2.90%	1	0.48%	2	0.97%	46	22.22%
22 years	10	4.83%	16	7.73%	16	7.73%	3	1.45%	2	0.97%	1	0.48%	0	0.00%	48	23.19%
23 years	3	1.45%	6	2.90%	15	7.25%	4	1.93%	0	0.00%	0	0.00%	2	0.97%	30	14.49%
24 years	0	0.00%	3	1.45%	6	2.90%	2	0.97%	0	0.00%	0	0.00%	2	0.97%	13	6.28%
Over 25	6	2.90%	8	3.86%	0	0.00%	2	0.97%	0	0.00%	3	1.45%	0	0.00%	19	9.18%
Student Status																
Full-time 1st Cycle	4	1.98%	19	9.41%	16	7.92%	5	2.48%	6	2.97%	2	0.99%	2	0.99%	54	26.73%
Full-time 2nd Cycle	14	6.93%	14	6.93%	13	6.44%	3	1.49%	2	0.99%	2	0.99%	0	0.00%	48	23.76%
Part-time 1st Cycle	7	3.47%	15	7.43%	8	3.96%	6	2.97%	0	0.00%	1	0.50%	2	0.99%	39	19.31%
Part-time 2nd Cycle	8	3.96%	13	6.44%	27	13.37%	6	2.97%	2	0.99%	2	0.99%	3	1.49%	61	30.20%
Residence																
Urban	10	5.00%	18	9.00%	24	12.00%	9	4.50%	1	0.50%	1	0.50%	1	0.50%	64	32.00%
Rural	17	8.50%	42	21.00%	32	16.00%	9	4.50%	9	4.50%	4	2.00%	3	1.50%	116	58.00%
Urban-Rural	6	3.00%	3	1.50%	7	3.50%	1	0.50%	0	0.00%	1	0.50%	2	1.00%	20	10.00%

Source: Own elaboration based on research results.

The analysis of statistical test results regarding barriers to accessing knowledge on ecological transformation shows that demographic variables, in the vast majority, do not significantly differentiate the type of difficulties encountered. For gender, student status, and place of residence, χ^2 values are statistically non-significant ($p > 0.05$), indicating a lack of dependency between these variables and the declared barriers. Furthermore, Spearman's rank correlation coefficients, Kendall's tau, and uncertainty measures remain close to zero, confirming a negligible relationship between the analyzed categories. The only case in which statistical significance was recorded is the relationship between barriers and the age of respondents $\chi^2(30) = 51.87$; $p = 0.00787$). This result suggests that individual age groups differ in the scope and intensity of perceived barriers, although with very low correlation coefficient values, this dependency is weak and multidimensional rather than linear. This may indicate that age mainly affects the type of difficulties encountered rather than their overall level (Table 49).

Table 49. Relationship between barriers to accessing knowledge on ecological transformation and demographic characteristics – statistical analysis

No.	Specification			
1	6. What barriers in access to knowledge on ecological transformation do you encounter (7) x Gender (2)	chi2	df	p
	Pearson chi2	2.011901	df=6	p=.91860
	NW chi2 (LR)	1.986706	df=6	p=.92092
	Kendall's tau b and c	b=-.027437	c=-.033046	
	Spearman rank R	-.030409	t=-.4356	p=.66359
	Uncertainty coeff.	X=.0029541	Y=.0071931	X Y=.00419
2	6. What barriers in access to knowledge on ecological transformation do you encounter (7) x Age (6)	chi2	df	p
	Pearson chi2	51.86911	df=30	p=.00787
	NW chi2 (LR)	57.03711	df=30	p=.00207
	Kendall's tau b and c	b=.0199558	c=.0187636	
	Spearman rank R	.0242332	t=.34707	p=.72890
	Uncertainty coeff.	X=.0848114	Y=.0814606	X Y=.08310

No.	Specification			
3	6. What barriers in access to knowledge on ecological transformation do you encounter (7) x Student (4)	chi2	df	p
	Pearson chi2	26.69268	df=18	p=.08494
	NW chi2 (LR)	28.86774	df=18	p=.05002
	Kendall's tau b and c	b=.0149267	c=.0150312	
	Spearman rank R	.0183141	t=.25904	p=.79587
	Uncertainty coeff.	X=.0437695	Y=.0520317	X Y=.04754
4	6. What barriers in access to knowledge on ecological transformation do you encounter (7) x Place of residence (3)	chi2	df	p
	Pearson chi2	17.66309	df=12	p=.12631
	NW chi2 (LR)	17.73818	df=12	p=.12387
	Kendall's tau b and c	b=-.016675	c=-.016200	
	Spearman rank R	-.019104	t=-.2689	p=.78831
	Uncertainty coeff.	X=.0275632	Y=.0486874	X Y=.03520

Source: Own elaboration based on research results.

The identified dependencies, particularly the role of age as a factor differentiating information barriers, are significant for designing public policies and educational strategies supporting the green economic transformation. They indicate that information and educational activities should be diversified based on the age of the audience, as different cohorts may encounter distinct difficulties in accessing knowledge (e.g., resulting from digital competencies, educational experiences, or time burdens). The lack of significant dependencies for other demographic traits suggests that these barriers are more universal and systemic, resulting from the general state of information infrastructure and the quality of ecological education. From an economic perspective, this implies the need to invest in universal, easily accessible channels for transmitting knowledge about ecological transformation, as the pace of implementing green innovations, business adaptation, and general economic competitiveness under global transformation conditions depends on the level of social environmental awareness and competencies.

The data analysis regarding factors influencing students' ecological awareness reveals a clear dominance of two categories: the availability of educational materials and the increase in social awareness. These factors were cited most frequently across all demographic groups, highlighting their key importance in the process of shaping environmental competencies. Women identified these factors as significant

more often than men, which may stem from higher levels of environmental sensitivity noted in the relevant literature. Across different age groups, the perception of information availability and the rise of social awareness also dominated as the primary determinants of ecological knowledge; individuals aged 22 particularly often indicated the availability of educational materials, while students in the oldest age categories (>25 years) more frequently emphasized the role of access to training and courses. Analysis by student status and place of residence did not reveal radical differences in the structure of responses; however, part-time students and rural residents slightly more often emphasized the importance of social awareness growth, which may result from a greater influence of local communities and limited access to formal education forms. Other factors, such as support from public institutions, the up-to-dateness of information, or media openness toward ecology, occurred less frequently, indicating their lesser influence on the perception of young people.

The results are highly significant for an economy based on green transformation, as they indicate which elements of the information and educational infrastructure are most effective in building human capital capable of supporting environmental transition. The dominant role of educational material availability and rising social awareness suggests that investments in open knowledge resources, science popularization, and social campaigns can yield particularly high results in increasing ecological competencies. Simultaneously, the relatively low level of indications regarding training, courses, or institutional support signals insufficient perception or availability of more formal competency development forms, which may hinder the development of specialized personnel necessary for economic sectors sensitive to energy-climate transformation. From a regional and national development perspective, identifying the most important factors influencing ecological awareness provides a basis for designing public policy actions consistent with the needs of the young generation, who will be responsible for implementing green technologies, environmental innovations, and economic modernization in the coming years (Table 50).

Table 50. Factors influencing students' ecological awareness according to demographic characteristics

Category	Educational material availability	%	Social awareness growth	%	Training & course availability	%	Ability	%	Gov/NGO support	%	Practical example biodiversity	%	Information up-to-dateness	%	Media openness on ecology	%	Total	%
Gender																		
Female	47	23.15%	54	26.60%	3	1.48%	6	2.96%	2	0.99%	8	3.94%	6	2.96%	126	62.07%		
Male	26	12.81%	38	18.72%	2	0.99%	2	0.99%	4	1.97%	3	1.48%	2	0.99%	77	37.93%		
Age																		
20 years	16	7.88%	23	11.33%	0	0.00%	5	2.46%	2	0.99%	3	1.48%	2	0.99%	51	25.12%		
21 years	15	7.39%	22	10.84%	2	0.99%	1	0.49%	1	0.49%	1	0.49%	2	0.99%	44	21.67%		
22 years	25	12.32%	15	7.39%	0	0.00%	1	0.49%	0	0.00%	5	2.46%	2	0.99%	48	23.65%		
23 years	9	4.43%	17	8.37%	0	0.00%	0	0.00%	1	0.49%	1	0.49%	1	0.49%	29	14.29%		
24 years	2	0.99%	8	3.94%	0	0.00%	0	0.00%	1	0.49%	1	0.49%	1	0.49%	13	6.40%		
Over 25	6	2.96%	7	3.45%	3	1.48%	1	0.49%	1	0.49%	0	0.00%	0	0.00%	18	8.87%		
Student Status																		
Full-time 1st Cycle	19	9.60%	26	13.13%	0	0.00%	3	1.52%	1	0.51%	3	1.52%	2	1.01%	54	27.27%		
Full-time 2nd Cycle	16	8.08%	16	8.08%	1	0.51%	2	1.01%	3	1.52%	5	2.53%	2	1.01%	45	22.73%		
Part-time 1st Cycle	17	8.59%	15	7.58%	2	1.01%	2	1.01%	1	0.51%	1	0.51%	1	0.51%	39	19.70%		
Part-time 2nd Cycle	20	10.10%	31	15.66%	2	1.01%	1	0.51%	1	0.51%	2	1.01%	3	1.52%	60	30.30%		
Residence																		
Urban	24	12.24%	26	13.27%	3	1.53%	2	1.02%	1	0.51%	2	1.02%	4	2.04%	62	31.63%		
Rural	43	21.94%	53	27.04%	2	1.02%	4	2.04%	3	1.53%	6	3.06%	3	1.53%	114	58.16%		
Urban-Rural	4	2.04%	9	4.59%	0	0.00%	1	0.51%	2	1.02%	3	1.53%	1	0.51%	20	10.20%		

Source: Own elaboration based on research results.

Statistical analysis indicates that positive aspects of access to knowledge regarding ecological transformation do not show significant differences based on gender, student status, or place of residence, as confirmed by high p-values ($p > 0.3$). In the case of age, the Pearson χ^2 test suggests a potential dependency ($p = 0.043$); however, verification using the Likelihood Ratio (LR) test yielded a result on the borderline of significance ($p = 0.066$), indicating a need for cautious interpretation of these differences. Kendall's tau-b and tau-c coefficients and the Spearman rank correlation coefficient are close to zero, confirming the weak strength of the relationship between age and positive aspects of knowledge access. Overall, the results suggest that the positive perception of access to information on ecological transformation is relatively homogeneous within the studied group, regardless of primary demographic characteristics (Table 51).

Table 51. Positive aspects of access to knowledge on ecological transformation in the context of respondents' demographic characteristics

No.	Specification			
1	7. What positive aspects do you encounter in access to knowledge on ecological transformation (7) x Gender (2)	chi2	df	p
	Pearson chi2	4.391371	df=6	p=.62387
	NW chi2 (LR)	4.404126	df=6	p=.62216
	Kendall's tau b and c	b=.0050580	c=.0056298	
	Spearman rank R	.0054174	t=.07681	p=.93885
	Uncertainty coeff.	X=.0081279	Y=.0163435	X Y=.01086
2	7. What positive aspects do you encounter in access to knowledge on ecological transformation (7) x Age (6)	chi2	df	p
	Pearson chi2	44.53090	df=30	p=.04266
	NW chi2 (LR)	42.40881	df=30	p=.06600
	Kendall's tau b and c	b=-.011295	c=-.009843	
	Spearman rank R	-.014751	t=-.2092	p=.83454
	Uncertainty coeff.	X=.0782661	Y=.0618722	X Y=.06911

No.	Specification			
3	7. What positive aspects do you encounter in access to knowledge on ecological transformation (7) x Student (4)	chi2	df	p
	Pearson chi2	13.23193	df=18	p=.77761
	NW chi2 (LR)	13.85400	df=18	p=.73856
	Kendall's tau b and c	b=-.016868	c=-.015781	
	Spearman rank R	-.019728	t=-.2762	p=.78265
	Uncertainty coeff.	X=.0259725	Y=.0254826	X Y=.02573
4	7. What positive aspects do you encounter in access to knowledge on ecological transformation (7) x Place of residence (3)	chi2	df	p
	Pearson chi2	12.93260	df=12	p=.37396
	LR chi2 (NW)	11.45996	df=12	p=.48996
	Kendall's tau b and c	b=.0729618	c=.0659881	
	Spearman rank R	.0803590	t=1.1229	p=.26287
	Uncertainty coeff.	X=.0218349	Y=.0320492	X Y=.02597

Source: Own elaboration based on research results.

The homogeneity in the perception of positive aspects of ecological transformation knowledge access across demographic traits indicates widespread acceptance and availability of information among young people. This constitutes an important element in building the social capital necessary to achieve sustainable development goals. Such a state of affairs may facilitate more effective implementation of green technologies and innovations in the economy, as equal access to knowledge translates into the equalization of educational and professional opportunities. It is particularly significant that the lack of clear demographic barriers allows for the design of universal educational and information policies capable of reaching a wide spectrum of recipients. Thus, these results emphasize the importance of further developing and maintaining open, inclusive channels for distributing ecological knowledge, which is crucial for economic transformation based on sustainable development principles.

The analysis of data regarding the evaluation of regional actions for raising ecological awareness indicates diverse opinions among respondents depending on gender, age, student status, and place of residence. Women evaluate these actions as “poor” or “very poor” (totaling over 28%) more frequently than men, while men show a slightly higher tendency toward “average” and “good” ratings. Broken

down by age, younger groups (20–22 years) exhibit a higher number of “average” and “poor” ratings, while older respondents (above 24 years) less frequently use the “very good” rating. In terms of student status, full-time second-cycle students exhibit the highest activity in positive evaluations, while the most negative ratings come from part-time second-cycle students. Regarding the place of residence, rural residents most frequently evaluate actions as “poor” or “very poor,” whereas urban residents more often choose “average” and “good” ratings. These results indicate a varied perception of the effectiveness of regional educational activities, dependent on the demographic circumstances of the subjects.

The varied perception of regional activities for raising ecological awareness has significant implications for the effectiveness of sustainable development and ecological transformation policies. A high number of negative evaluations, especially among rural residents and certain student groups, may indicate insufficient adaptation of educational programs to specific local needs and conditions. Conversely, the moderately positive opinions of urban residents suggest greater availability and effectiveness of educational initiatives in those areas. Understanding these differences is key to designing effective strategies that will increase community engagement and accelerate the adaptation of green technologies in the economy. Consequently, improving ecological awareness at the local level fosters sustainable development, increases regional competitiveness, and supports economic transformation in line with environmental protection principles.

Statistical analysis revealed a lack of significant relationships between the evaluation of environmental activities regarding the enhancement of ecological awareness and the respondents’ demographic characteristics, such as gender, age, student status, and place of residence. Pearson’s χ^2 tests and tests of independence yielded p-values substantially exceeding the significance threshold ($p > 0.05$) for all analyzed variables. Correlation coefficients (Kendall’s tau-b and tau-c, as well as the Spearman rank correlation coefficient) indicate very weak, statistically non-significant relationships between these variables. This implies that the perception of the effectiveness of regional activities in raising ecological awareness remains consistent regardless of the respondents’ gender, age, educational status, or place of residence. These findings suggest that the evaluation of such activities is relatively uniform across diverse demographic groups (Table 52).

Table 52. Evaluation of regional activities in raising ecological awareness by respondents' demographic characteristics

Category	Very weak	% of total	Weak	% of total	Average	% of total	Good	% of total	Very good	% of total	Total	% of total
Gender												
Female	12	5.85%	46	22.44%	44	21.46%	23	11.22%	1	0.49%	126	61.46%
Male	12	5.85%	24	11.71%	30	14.63%	12	5.85%	1	0.49%	79	38.54%
Age												
20 years	6	2.93%	20	9.76%	16	7.80%	9	4.39%	0	0.00%	51	24.88%
21 years	5	2.44%	10	4.88%	22	10.73%	8	3.90%	1	0.49%	46	22.44%
22 years	6	2.93%	17	8.29%	17	8.29%	6	2.93%	1	0.49%	47	22.93%
23 years	5	2.44%	11	5.37%	9	4.39%	4	1.95%	0	0.00%	29	14.15%
24 years	0	0.00%	4	1.95%	2	0.98%	7	3.41%	0	0.00%	13	6.34%
Over 25	2	0.98%	8	3.90%	8	3.90%	1	0.49%	0	0.00%	19	9.27%
Student Status												
Full-time 1st Cycle	7	3.50%	17	8.50%	21	10.50%	8	4.00%	1	0.50%	54	27.00%
Full-time 2nd Cycle	5	2.50%	14	7.00%	17	8.50%	12	6.00%	0	0.00%	48	24.00%
Part-time 1st Cycle	3	1.50%	18	9.00%	14	7.00%	4	2.00%	0	0.00%	39	19.50%
Part-time 2nd Cycle	9	4.50%	20	10.00%	19	9.50%	10	5.00%	1	0.50%	59	29.50%
Residence												
Urban	9	4.55%	22	11.11%	22	11.11%	11	5.56%	0	0.00%	64	32.32%
Rural	10	5.05%	40	20.20%	44	22.22%	18	9.09%	2	1.01%	114	57.58%
Urban-Rural	3	1.52%	7	3.54%	5	2.53%	5	2.53%	0	0.00%	20	10.10%

Source: Own elaboration based on research results.

The absence of statistically significant differences in the perception of the impact of environmental activities on raising ecological awareness points toward the potential universality of how these measures are perceived across various social and demographic segments. Such a situation may facilitate the effective implementation of regional educational strategies that do not require extensive adaptation to specific community segments. From an economic perspective, effective and widespread ecological awareness serves as a cornerstone of sustainable development, contributing to increased acceptance of ecological transformation and green technologies. A unified perception of these activities further promotes better coordination of local policies and strengthens community engagement in pro-ecological initiatives, which translates into long-term economic and environmental benefits (Table 53).

Table 53. Impact of environment (regional) activities on raising ecological awareness depending on respondents' demographic characteristics

No.	Specification			
1	8. Do the activities of your environment (region) contribute to raising ecological awareness (5) x Gender (2)	chi2	df	p
	Pearson chi2	2.368991	df=4	p=.66824
	LR chi2	2.341921	df=4	p=.67315
	Kendall's tau b and c	b=-.029128	c=-.033789	
	Spearman R	-.031574	t=-.4501	p=.65312
	Uncertainty coeff.	X=.0042857	Y=.0085685	X Y=.00571
2	8. Do the activities of your environment (region) contribute to raising ecological awareness (5) x age (6)	chi2	df	p
	Pearson chi2	24.38061	df=20	p=.22616
	LR chi2	23.96988	df=20	p=.24371
	Kendall's tau b and c	b=-.007123	c=-.006722	
	Spearman R	-.008255	t=-.1176	p=.90648
	Uncertainty coeff.	X=.0438648	Y=.0345707	X Y=.03867

No.	Specification			
3	8. Do the activities of your environment (region) contribute to raising ecological awareness (5) x student (4)	chi2	df	p
	Pearson chi2	8.251590	df=12	p=.76517
	LR chi2	8.871951	df=12	p=.71383
	Kendall's tau b and c	b=-.041563	c=-.040333	
	Spearman R	-.048266	t=-.6800	p=.49733
	Uncertainty coeff.	X=.0165952	Y=.0161316	X Y=.01636
4	8. Do the activities of your environment (region) contribute to raising ecological awareness (5) x place of residence (3)	chi2	df	p
	Pearson chi2	4.591003	df=8	p=.80026
	LR chi2	5.291326	df=8	p=.72603
	Kendall's tau b and c	b=.0329130	c=.0309152	
	Spearman R	.0368020	t=.51558	p=.60673
	Uncertainty coeff.	X=.0100600	Y=.0146115	X Y=.01192

Source: Own elaboration based on research results.

The analysis of the data presented in Table 40 indicates that a significant portion of respondents evaluates the impact of investment in education and training on changing attitudes towards ecological transformation at an average or good level. Among women, 38.43% of respondents indicated a positive impact (good and very good), while among men, this percentage was 7.88%. The largest group of subjects aged 20-22 declared an average impact (about 27%), which may suggest that the younger generation is sensitive to educational activities, but at the same time expects greater intensification of such activities. In the context of student status, there is a discrepancy between undergraduate and graduate students, both full-time and part-time; however, in each group, answers indicating a moderate impact of educational investments on ecological attitudes prevail. Rural residents more often declare positive effects of investment compared to city residents, which may result from differences in access to educational resources and the specifics of the rural environment, where ecological awareness is often more closely related to everyday life.

Investments in education and training play a key role in shaping pro-ecological attitudes, which are the foundation for the effective ecological transformation of the economy. Ecological awareness, strengthened through appropriately targeted

Table 54. Impact of the level of investment in education and training on attitude towards ecological transformation

Category	Very poor	%	Poor	%	Average	%	Good	%	Very good	%	Total	%
Gender												
Female	12	5.91%	35	17.24%	46	22.66%	31	15.27%	1	0.49%	125	61.58%
Male	8	3.94%	19	9.36%	35	17.24%	13	6.40%	3	1.48%	78	38.42%
Age												
20 years	2	0.99%	14	6.90%	20	9.85%	10	4.93%	4	1.97%	50	24.63%
21 years	5	2.46%	16	7.88%	13	6.40%	11	5.42%	0	0.00%	45	22.17%
22 years	3	1.48%	10	4.93%	25	12.32%	10	4.93%	0	0.00%	48	23.65%
23 years	6	2.96%	6	2.96%	13	6.40%	5	2.46%	0	0.00%	30	14.78%
24 years	1	0.49%	3	1.48%	4	1.97%	4	1.97%	0	0.00%	12	5.91%
Over 25	3	1.48%	5	2.46%	6	2.96%	4	1.97%	0	0.00%	18	8.87%
Student Status												
Full-time 1st Cycle	4	2.01%	15	7.54%	24	12.06%	9	4.52%	1	0.50%	53	26.63%
Full-time 2nd Cycle	4	2.01%	13	6.53%	18	9.05%	10	5.03%	2	1.01%	47	23.62%
Part-time 1st Cycle	2	1.01%	7	3.52%	16	8.04%	13	6.53%	1	0.50%	39	19.60%
Part-time 2nd Cycle	10	5.03%	17	8.54%	21	10.55%	12	6.03%	0	0.00%	60	30.15%
Residence												
Urban	6	3.06%	20	10.20%	24	12.24%	12	6.12%	0	0.00%	62	31.63%
Rural	13	6.63%	26	13.27%	48	24.49%	26	13.27%	2	1.02%	115	58.67%
Urban-Rural	1	0.51%	6	3.06%	6	3.06%	4	2.04%	2	1.02%	19	9.69%

Source: Own elaboration based on research results.

educational activities, contributes to promoting sustainable practices and making decisions that take into account environmental aspects. In the long term, raising the qualifications and knowledge of employees and students translates into increased innovation and competitiveness of the economy, while minimizing the negative effects of economic activity on the environment. Particularly important is educational support in rural areas, where effective natural resource management can have a direct impact on local development and biodiversity protection, which ultimately strengthens the overall resilience of the economy to challenges related to climate change and ecological transformation.

The results of the statistical analysis contained in Table 54 indicate that no statistically significant relationships were found between the level of investment in education and training and the change in attitudes towards ecological transformation in the context of gender, age, student status, and place of residence. Pearson Chi-square values and Likelihood Ratio (NW) tests did not exceed the significance level ($p > 0.05$) for any of the tested categories. Additionally, rank correlation indicators (Kendall's tau, Spearman) remain at a very low level and do not point to significant relationships between the variables. This means that the perception of the impact of investments in education and training on the attitude towards ecological transformation is independent of the analyzed demographic characteristics, which suggests that factors other than demographics may determine how these attitudes change.

The lack of statistically significant differences in the perception of the impact of investments in education and training on the change in ecological attitudes between different demographic groups points to the universality of the importance of ecological education in organizations. For this reason, educational activities should be designed taking into account a wide range of recipients, regardless of their age, gender, status, or place of residence. From an economic perspective, investing in ecological education remains a key element supporting ecological transformation; however, the effects of such investments may be more dependent on the quality, form, and content of training than on the demographic profile of the recipients. Thus, effective educational programs should focus on individualizing the approach and engaging participants, which will maximize positive attitude changes and contribute to sustainable economic development (Table 55).

Table 55. Analysis of the relationship between the level of investment in education and training and the change in attitudes towards ecological transformation depending on demographic characteristics

No.	Specification			
1	17. To what extent does the level of investment in education and training in your organization affect changes in your attitude to ecological transformation(5) x Gender(2)	chi2	df	p
	Pearson Chi2	4.772246	df=4	p=.31147
	LR Chi2	4.766049	df=4	p=.31216
	Kendall's tau b and c	b=-.005431	c=-.006309	
	Spearman R	-.005899	t=-.0836	p=.93343
	Uncertainty coeff.	X=.0086573	Y=.0176235	X Y=.01161
2	17. To what extent does the level of investment in education and training in your organization affect changes in your attitude to ecological transformation(5) x Age(6)	chi2	df	p
	Pearson Chi2	26.10841	df=20	p=.16226
	LR Chi2	24.69325	df=20	p=.21342
	Kendall's tau b and c	b=-.060431	c=-.057087	
	Spearman R	-.073915	t=-1.051	p=.29461
	Uncertainty coeff.	X=.0448542	Y=.0361033	X Y=.04001
3	17. To what extent does the level of investment in education and training in your organization affect changes in your attitude to ecological transformation(5) x Student(4)	chi2	df	p
	Pearson Chi2	11.46992	df=12	p=.48913
	LR Chi2	12.06162	df=12	p=.44074
	Kendall's tau b and c	b=-.036084	c=-.035083	
	Spearman R	-.044032	t=-.6186	p=.53688
	Uncertainty coeff.	X=.0222743	Y=.0220549	X Y=.02216

No.	Specification			
4	17. To what extent does the level of investment in education and training in your organization affect changes in your attitude to ecological transformation(5) x Place of residence(3)	chi2	df	p
	Pearson Chi2	10.89411	df=8	p=.20777
	LR Chi2	8.891922	df=8	p=.35150
	Kendall's tau b and c	b=.0759984	c=.0712203	
	Spearman R	.0850671	t=1.1892	p=.23583
	Uncertainty coeff.	X=.0166652	Y=.0251161	X Y=.02004

Source: Own elaboration based on research results.

8.3. Awareness and barriers in accessing knowledge on green transformation

The analysis presented in Table 56 shows that the assessment of the regional environment's actions in raising ecological awareness correlates with the respondents' level of understanding of the importance of green transformation. Respondents who declare very poor understanding of green transformation most frequently rate the environment's actions as poor or very poor (combined 6.83% and 4.39%), as well as average (2.93%). In the group with average understanding, average (20.00%) and poor (9.27%) ratings predominate. In turn, respondents declaring good or very good understanding of green transformation more frequently give neutral or positive ratings, although average and poor ratings still prevail. The highest percentage of very good ratings of the environment's actions occurs in the group of people with good and very good understanding of green transformation, yet these remain relatively rare (0.00% and 0.98% respectively). These results suggest that better understanding of green transformation may lead to a more positive evaluation of regional actions, however there remains significant room for improvement in the effectiveness of these actions.

The findings highlight the important role of education and information in shaping ecological awareness at the regional level, which is crucial for achieving the goals of green economic transformation. Understanding the concept of green transformation among residents influences their assessment of the effectiveness of local pro-environmental initiatives, which in turn translates into the degree of social support for these actions. In the economic context, raising ecological awareness through appropriate regional measures constitutes a foundation for implementing sustainable development policies as well as energy and environmental transformation. Effectively increasing the level of knowledge and awareness can accelerate the acceptance of change,

thereby facilitating investment in green technologies and improving resource use efficiency, yielding long-term benefits for both the environment and the economy.

Table 56. Assessment of the environment's (region's) actions in raising ecological awareness depending on the level of understanding of the importance of green transformation

Level of understanding of green transformation\ Assessment of the environment's actions	Very poor	Poor	Average	Good	Very good	Total
Very poor	5 (2.44%)	9 (4.39%)	6 (2.93%)	3 (1.46%)	0 (0.00%)	23 (11.22%)
Poor	12 (5.85%)	32 (15.61%)	15 (7.32%)	7 (3.41%)	0 (0.00%)	66 (32.20%)
Average	6 (2.93%)	19 (9.27%)	41 (20.00%)	17 (8.29%)	0 (0.00%)	83 (40.49%)
Good	0 (0.00%)	9 (4.39%)	10 (4.88%)	8 (3.90%)	0 (0.00%)	27 (13.17%)
Very good	1 (0.49%)	1 (0.49%)	2 (0.98%)	0 (0.00%)	2 (0.98%)	6 (2.93%)
Total	24 (11.71%)	70 (34.15%)	74 (36.10%)	35 (17.07%)	2 (0.98%)	205 (100%)

Source: own elaboration based on own survey results.

The statistical analysis presented in Table 56 indicates a statistically significant relationship between the assessment of the regional environment's actions in raising ecological awareness and the level of understanding of the importance of green transformation (Pearson's chi-square = 97.06; df = 16; $p < 0.001$). Chi² tests with NW correction confirm this significance ($p = 0.00004$). Additionally, the positive values of Kendall's tau-b and tau-c coefficients (0.27 and 0.24 respectively) as well as Spearman's rank correlation coefficient ($r = 0.31$; $p < 0.001$) indicate a moderately strong, positive correlation between these variables. This means that the better respondents understand the importance of green transformation, the more positively they evaluate the actions taken in their region to raise ecological awareness.

The results emphasize that increasing awareness and understanding of the essence of green transformation directly influences a positive perception of regional actions related to ecological education. This is crucial for the effective implementation of sustainable development policies, which require social support and active citizen participation. For the economy, it means that investment in ecological education and building awareness at the local level can foster greater acceptance and engagement in the ecological transformation process, which in turn can accelerate the adoption of innovative, environmentally friendly technologies and solutions. Consequently, such actions can have a positive impact on the development of an economy based on sustainable development principles while simultaneously supporting natural environment protection.

The data presented in Table 57 illustrate the distribution of barriers to accessing knowledge about ecological transformation in relation to the positive aspects of such access. The most frequently reported barriers are difficulty in understanding technical issues (31.03%) and lack of time for learning (31.53%), which correspond to the highest percentages of positive aspects related to the availability of educational materials (10.34% and 13.30%) and the increase in social awareness (15.76% and 11.82%, respectively). Despite the presence of these barriers, respondents simultaneously recognize positive features, particularly the growth of social awareness (45.32%) and the availability of educational materials (35.96%). This indicates the co-existence of significant challenges and opportunities in the field of ecological education. Barriers such as the lack of practical examples, institutional educational support, or problem complexity are reported relatively infrequently, suggesting that these factors are of lesser importance for the broad group of respondents surveyed.

Table 57. Statistical analysis of the relationship between the assessment of regional environment activities and the level of understanding of the significance of the green transformation

8 Do the activities of your environment (region) contribute to raising ecological awareness (5) x 1. How well does your environment understand the significance of the green transformation (5)	Chi2	df	p
Pearson Chi2	97.05653	df=16	p=.00000
LR Chi2	48.49484	df=16	p=.00004
Kendall tau b and c	b=.2664468	c=.2350982	
Spearman R rank	.3083951	t=4.6191	p=.00001
Uncertainty coeff.	X=.0887453	Y=.0878270	X Y=.08828

Source: own elaboration based on own research results.

These findings highlight the necessity of focusing educational efforts on overcoming the key barriers – namely the difficulty in assimilating complex content and the limited time available for learning – which currently constrain the effectiveness of knowledge transfer concerning ecological transformation. In an economy based on sustainable development principles, raising ecological awareness and competencies is of fundamental importance for the adaptation of enterprises and society to the requirements of green transformation. Overcoming these barriers through the improvement, increased accessibility, and practical orientation of educational materials can significantly enhance the preparedness of both employees and citizens to implement innovative pro-environmental solutions, thereby supporting economic competitiveness and long-term resilience.

The analysis of data from Table 58 reveals differentiation in barriers to accessing knowledge about ecological transformation depending on the subjective assessment of how well the respondents' environment understands the importance of green transformation. The most frequently indicated barriers remain lack of time for learning (31.88%) and difficulty in understanding technical issues (30.43%). A clear pattern emerges: these barriers are predominantly reported by respondents who rate their environment's understanding as average (40.58%) or poor (32.37%). Less frequent, yet still relevant, are the lack of available knowledge sources (16.43%) and lack of practical examples (9.66%). Barriers such as lack of institutional educational support, problem complexity, and uncertainty about socio-economic future appear much less often, suggesting their relatively smaller role in shaping perceived educational difficulties.

Table 58. Statistical analysis of the relationship between barriers and positive aspects of access to knowledge about the ecological transformation

Barrier in access to knowledge (6)	Availability of educational materials	Increase in social awareness	Availability of training and courses	Support from government institutions and NGOs	Diversity of practical examples	Up-to-date information	Openness of media to ecological topics	Total
No available sources of knowledge	7 (3.45%)	17 (8.37%)	2 (0.99%)	1 (0.49%)	2 (0.99%)	4 (1.97%)	0 (0.00%)	33 (16.26%)
Difficulty understanding technical issues	21 (10.34%)	32 (15.76%)	1 (0.49%)	4 (1.97%)	1 (0.49%)	2 (0.99%)	2 (0.99%)	63 (31.03%)
Lack of time for learning	27 (13.30%)	24 (11.82%)	2 (0.99%)	1 (0.49%)	0 (0.00%)	5 (2.46%)	5 (2.46%)	64 (31.53%)
Lack of practical examples	9 (4.43%)	7 (3.45%)	0 (0.00%)	1 (0.49%)	2 (0.99%)	0 (0.00%)	1 (0.49%)	20 (9.85%)
Lack of support from educational institutions	4 (1.97%)	4 (1.97%)	0 (0.00%)	1 (0.49%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	9 (4.43%)
Complexity of the problem	3 (1.48%)	4 (1.97%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	7 (3.45%)
Uncertainty regarding economic and social future	2 (0.99%)	4 (1.97%)	0 (0.00%)	0 (0.00%)	1 (0.49%)	0 (0.00%)	0 (0.00%)	7 (3.45%)
Total	73 (35.96%)	92 (45.32%)	5 (2.46%)	8 (3.94%)	6 (2.96%)	11 (5.42%)	8 (3.94%)	203 (100.00%)

Source: own elaboration based on own survey results.

The results underscore the critical importance of raising awareness and improving understanding of green transformation within the social environment, as this can directly contribute to reducing educational barriers in the field of ecological transition. In an economic context, better understanding and acceptance of ecological changes facilitate more effective implementation of innovations and pro-environmental actions – both of which are essential for sustainable development. Constraints such as lack of time and difficulties in assimilating complex knowledge point to the need for tailoring educational formats and methods to the realities of labour market participants and their surrounding environment. Ultimately, overcoming these barriers will enhance ecological competencies, which are indispensable for building economic resilience in the face of energy and climate transformation challenges.

Table 59. Statistical analysis of the relationship between barriers to access to knowledge about ecological transformation and the level of understanding of the importance of green transformation by the respondents' environment

Barrier in access to knowledge (6)	Very poorly	Poorly	Average	Well	Very well	Total
No available sources of knowledge	9 (4.35%)	9 (4.35%)	11 (5.31%)	5 (2.42%)	0 (0.00%)	34 (16.43%)
Difficulty understanding technical issues	5 (2.42%)	19 (9.18%)	29 (14.01%)	7 (3.38%)	3 (1.45%)	63 (30.43%)
Lack of time for learning	5 (2.42%)	25 (12.08%)	26 (12.56%)	8 (3.86%)	2 (0.97%)	66 (31.88%)
Lack of practical examples	2 (0.97%)	8 (3.86%)	9 (4.35%)	1 (0.48%)	0 (0.00%)	20 (9.66%)
Lack of support from educational institutions	2 (0.97%)	3 (1.45%)	3 (1.45%)	1 (0.48%)	1 (0.48%)	10 (4.83%)
Complexity of the problem	0 (0.00%)	1 (0.48%)	4 (1.93%)	2 (0.97%)	0 (0.00%)	7 (3.38%)
Uncertainty regarding economic and social future	0 (0.00%)	2 (0.97%)	2 (0.97%)	3 (1.45%)	0 (0.00%)	7 (3.38%)
Total	23 (11.11%)	67 (32.37%)	84 (40.58%)	27 (13.04%)	6 (2.90%)	207 (100.00%)

Source: own elaboration based on own survey results.

The statistical analysis presented in Table 59 did not reveal statistically significant relationships between barriers to accessing knowledge about ecological transformation and the positive aspects of such access (Pearson's $\text{Chi}^2 = 34.26$; $\text{df} = 36$; $p = 0.55$). Similarly, no significant association was found between barriers and the subjective level of understanding of the importance of green transformation by the respondents' environment (Pearson's $\text{Chi}^2 = 27.05$; $\text{df} = 24$; $p = 0.30$). Kendall's tau coefficients and Spearman's rank correlation coefficients indicate weak and statistically non-significant correlations, suggesting that the encountered barriers and positive aspects of knowledge access function largely independently of each other and independently of the environment's level of understanding of green transformation.

The absence of significant correlations between barriers to knowledge access, its positive aspects, and understanding of green transformation points to the complexity of the educational process in the field of ecology. This implies that even in environments where the level of awareness and positive educational experiences are relatively high, barriers such as technical difficulties or time constraints can persist independently. From an economic perspective, this necessitates a multidimensional approach to ecological education that simultaneously enhances positive experiences in knowledge access and systematically eliminates barriers. Such an approach is essential for effectively preparing both society and the labour market to meet the challenges associated with ecological transformation, which in turn is of key importance for sustainable development and the long-term competitiveness of the economy.

Table 60. Relationship between barriers in access to knowledge about ecological transformation and positive aspects of knowledge, and the level of understanding of the green transformation by the environment

6 What barriers to accessing knowledge about the ecological transformation do you encounter (7) x 7 What positive aspects of accessing knowledge about the ecological transformation do you encounter (7)	Chi^2	df	p
Pearson Chi^2	34.26282	df=36	p=.55137
LR Chi^2	38.14208	df=36	p=.37225
Kendall tau b and c	b=-.109485	c=-.090538	
Spearman R rank	-.130045	t=-1.860	p=.06442
Uncertainty coeff.	X=.0579530	Y=.0703918	X Y=.06357

6 What barriers to accessing knowledge about the ecological transformation do you encounter (7) x 1 How well does your environment understand the significance of the green transformation (5)	Chi ²	df	p
Pearson Chi ²	27.05448	df=24	p=.30192
LR Chi ²	26.12318	df=24	p=.34694
Kendall tau b and c	b=.0658808	c=.0602698	
Spearman R rank	.0796833	t=1.1445	p=.25374
Uncertainty coeff.	X=.0388439	Y=.0469647	X Y=.04252

Source: own elaboration based on own research results

Table 60 presents the distribution of responses concerning positive aspects of access to knowledge about ecological transformation depending on the degree to which respondents identify global trends associated with green transformation. The highest percentage of respondents identified the increase in social awareness as the most important positive aspect (45.32%), particularly among those declaring average (19.70%) and good (13.79%) identification of global trends. The availability of educational materials was also frequently indicated (35.96%), especially by individuals with average and good levels of trend identification. In contrast, aspects such as availability of training and courses, institutional support, diversity of practical examples, and openness of media to ecological issues were much less frequently recognized as significant. The results suggest that the level of awareness and understanding of global trends in green transformation correlates with the perception of positive elements of knowledge access, particularly with regard to social awareness and the availability of educational materials.

Knowledge and identification of global trends in green transformation play a key role in shaping positive educational experiences related to ecological transformation. The growth of social awareness and the availability of educational materials constitute a fundamental basis for effectively preparing society and employees to face the challenges associated with transformation. In an economic context, a higher level of trend identification facilitates more efficient knowledge assimilation, which can translate into improved resource management, implementation of ecological innovations, and enhanced market competitiveness. Institutional support and diversity of practical examples remain areas that still require strengthening, which is essential for effectively integrating theoretical knowledge with practical solutions in the economic sector.

Table 61 presents the results of the analysis of the relationship between the degree of identification of global trends related to the green transformation and the positive aspects of access to knowledge regarding ecological transformation.

Pearson's chi-square test indicated a lack of a statistically significant relationship between the studied variables ($p = 0.23052$), and the results of the Likelihood Ratio (LR) Chi² test ($p = 0.39390$) confirmed this tendency. Additionally, Kendall's tau-b and tau-c coefficients and the Spearman rank coefficient indicate a weak negative correlation, which, however, is not statistically significant (Table 62). The value of the uncertainty coefficient also suggests the absence of a strong link between the level of trend identification and the perception of positive aspects of access to knowledge. Thus, the results suggest that the degree of identification of global trends does not significantly influence the assessment of positive elements of access to information on ecological transformation.

Table 61. Relationship between the degree of identification of global green transformation trends and positive aspects of access to knowledge about ecological transformation

Aspect / Degree of identification of global trends	Very poorly	Poorly	Average	Well	Very well	Total
Availability of educational materials	3 (1.48%)	15 (7.39%)	30 (14.78%)	24 (11.82%)	1 (0.49%)	73 (35.96%)
Increase in social awareness	6 (2.96%)	17 (8.37%)	40 (19.70%)	28 (13.79%)	1 (0.49%)	92 (45.32%)
Availability of training and courses	0 (0.00%)	2 (0.99%)	2 (0.99%)	0 (0.00%)	1 (0.49%)	5 (2.46%)
Support from government institutions and NGOs	0 (0.00%)	1 (0.49%)	6 (2.96%)	1 (0.49%)	0 (0.00%)	8 (3.94%)
Diversity of practical examples	1 (0.49%)	2 (0.99%)	1 (0.49%)	2 (0.99%)	0 (0.00%)	6 (2.96%)
Up-to-date information	1 (0.49%)	4 (1.97%)	1 (0.49%)	4 (1.97%)	1 (0.49%)	11 (5.42%)
Openness of media to ecological topics	1 (0.49%)	3 (1.48%)	3 (1.48%)	1 (0.49%)	0 (0.00%)	8 (3.94%)
Total	12 (5.91%)	44 (21.67%)	83 (40.89%)	60 (29.56%)	4 (1.97%)	203 (100.00%)

Source: own elaboration based on own survey results.

Table 62. Analysis of the relationship between the degree of identification of global green transformation trends and the positive aspects of access to knowledge about ecological transformation

Question 11 How well do you identify global trends related to the green transformation (5) x 7 What positive aspects of accessing knowledge about the ecological transformation do you encounter (7)	Chi2	df	p
Pearson Chi2	28.72832	df=24	p=.23052
LR Chi2	25.21975	df=24	p=.39390
Kendall tau b and c	b=-.076468	c=-.064610	
Spearman R rank	-.087924	t=-1.251	p=.21225
Uncertainty coeff.	X=.0477126	Y=.0465434	X Y=.04712

Source: own elaboration based on own research results.

The lack of a significant relationship between the level of recognition of global green transformation trends and the positive perception of access to knowledge indicates that these factors may function independently within the context of ecological education. For the economy, this means that improving knowledge accessibility and raising awareness do not necessarily have to be directly linked to an individual's level of understanding of global trends. Consequently, educational and information activities should be aimed at broadly sharing materials and increasing their accessibility, regardless of the recipients' level of advancement. Such an approach may increase the effectiveness of ecological transformation processes and contribute to more sustainable economic development.

The conducted Mann-Whitney U tests did not show statistically significant differences in the assessment of the level of ecological education among employees in the environment, the promotion of knowledge about sustainable development, barriers to access to knowledge, positive aspects of access to information, and the impact of investment on attitudes toward ecological transformation when broken down by gender, age, student status, place of residence, and self-assessment of the level of knowledge about the transformation (all $p > 0.05$). The result closest to significance was observed for the variable of self-assessment of knowledge level relative to barriers in access to knowledge ($p = 0.0537$ after correction), suggesting a potential trend where higher self-assessment may be associated with a lower perception of barriers. All other results indicate a lack of significant differences, suggesting that the studied demographic variables and subjective knowledge assessment do not significantly influence the perception of ecological education and access to information about ecological transformation in the studied sample.

Table 63. Analysis of the impact of demographic variables and self-assessment of knowledge on the perception of ecological education and barriers to access to information on ecological transformation – Mann-Whitney U test

Mann-Whitney U Test relative to variable: Student	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (adj.)	p	Valid N (Group 1)
question 3	8474.5000	13053.5000	4925.5000	0.3670	0.7136	0.3914	0.6955	80.0000
question 4	8013.0000	13515.0000	4773.0000	-0.7304	0.4652	-0.7741	0.4389	80.0000
question 6	8143.0000	13385.0000	4903.0000	-0.4206	0.6741	-0.4352	0.6634	80.0000
question 7	7883.0000	12823.0000	4822.0000	0.0702	0.9441	0.0757	0.9397	77.0000
question 8	7959.5000	13155.5000	4799.5000	-0.4282	0.6685	-0.4497	0.6529	79.0000
question 17 transformation	7923.5000	12782.5000	4842.5000	-0.0786	0.9374	-0.0826	0.9342	78.0000
Mann-Whitney U Test: relative to variable: Age	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (adj.)	p	Valid N (Group 1)
question 3	595.0000	1683.0000	405.0000	-0.7025	0.4824	-0.7581	0.4484	19.0000
question 4	613.5000	1664.5000	423.5000	-0.4451	0.6562	-0.4766	0.6336	19.0000
question 6	593.5000	1684.5000	403.5000	-0.7233	0.4695	-0.7515	0.4523	19.0000
question 7	675.0000	1536.0000	360.0000	1.0294	0.3033	1.1108	0.2667	18.0000
question 8	607.0000	1604.0000	417.0000	-0.4107	0.6813	-0.4357	0.6631	19.0000
question 17	540.5000	1670.5000	369.5000	-0.8927	0.3720	-0.9545	0.3398	18.0000
Mann-Whitney U Test: Relative to variable: Student	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (adj.)	p	Valid N (Group 1)
question 3	3531.5000	3138.5000	1640.5000	-0.0336	0.9732	-0.0358	0.9715	61.0000
question 4	3710.0000	2960.0000	1475.0000	0.9611	0.3365	1.0304	0.3028	61.0000
question 6	3523.5000	3146.5000	1632.5000	-0.0785	0.9375	-0.0816	0.9349	61.0000
question 7	3457.0000	3098.0000	1613.0000	0.0369	0.9706	0.0404	0.9678	60.0000

Mann-Whitney U Test relative to variable: Student	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (adj.)	p	Valid N (Group 1)
question 8	3310.5000	3130.5000	1540.5000	-0.2989	0.7650	-0.3127	0.7545	59.0000
question 17	3266.5000	3174.5000	1436.5000	-0.8803	0.3787	-0.9249	0.3550	60.0000
Mann-Whitney U Test: relative to variable: Place of residence	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (adj.)	p	Valid N (Group 1)
question 3	10918.0000	5372.0000	3292.0000	1.2536	0.2100	1.3351	0.1819	116.0000
question 4	10468.0000	5822.0000	3682.0000	-0.0882	0.9298	-0.0936	0.9254	116.0000
question 6	10451.5000	5838.5000	3665.5000	-0.1375	0.8907	-0.1427	0.8865	116.0000
question 7	10039.5000	5536.5000	3484.5000	-0.1518	0.8794	-0.1642	0.8696	114.0000
question 8	10429.0000	5502.0000	3422.0000	0.6835	0.4943	0.7200	0.4715	114.0000
question 17	10529.0000	5224.0000	3271.0000	0.9025	0.3668	0.9492	0.3425	115.0000
Mann-Whitney U Test: relative to variable: question 5	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (adj.)	p	Valid N (Group 1)
question 3	2341.0000	2412.0000	1086.0000	0.6249	0.5320	0.6682	0.5040	46.0000
Mann-Whitney U Test: relative to variable: question 6	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (adj.)	p	Valid N (Group 1)
question 5	2143.5000	341.5000	127.5000	-1.8109	0.0702	-1.9294	0.0537	63.0000
Mann-Whitney U Test: relative to variable: question 7	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (adj.)	p	Valid N (Group 1)
question 6	6555.0000	7140.0000	2862.0000	1.6256	0.1040	1.6829	0.0924	73.0000

Highlighted results are significant at $p < .05000$

Source: own elaboration based on own research results.

The lack of significant differences in the assessment of ecological education and barriers to knowledge access based on gender, age, student status, place of residence, or self-assessment of knowledge indicates that the challenges related to education and information about ecological transformation are universal and affect a wide spectrum of society. From an economic perspective, these results emphasize the need to implement consistent and broadly accessible educational and communication activities that will be effective regardless of the individual demographic characteristics of the recipients. In particular, it is worth focusing on reducing information barriers and strengthening ecological awareness across the entire population, which is crucial for supporting the green transformation and sustainable economic development (Table 63).

Kruskal-Wallis tests conducted for the gender variable showed no statistically significant differences in the assessment of the level of ecological education among employees in the environment, the promotion of knowledge in the field of sustainable development and green technologies, barriers and positive aspects in access to knowledge about ecological transformation, the activities of the environment in raising ecological awareness, nor the impact of investments in education and training on attitudes toward ecological transformation (all $p > 0.05$).

Mean ranks for women and men were similar in all analyzed aspects, indicating a lack of clear differences in the perception of these issues depending on gender.

The absence of significant differences between women and men in the assessment of ecological education, barriers, and positive aspects of access to knowledge, as well as the role of the environment in building ecological awareness, suggests that educational and communication activities regarding ecological transformation should be universal and not necessarily differentiated by gender. From an economic perspective, this is significant as it indicates the possibility of designing consistent educational strategies that will effectively reach both groups, which can increase the efficiency of achieving green transformation and sustainable development goals (Table 64).

Table 64. Analysis of differences in assessments of ecological education and access to knowledge about ecological transformation by gender – Kruskal-Wallis test

Dependent: question 3	Independent variable (grouping): Gender: Kruskal-Wallis test: H (1, N= 207) =.1542142 p =.6945			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
woman	1	127	13053,50	102,783465
man	2	80	8474,50	105,931250
Dependent: question 4	Independent variable (grouping): Gender: Kruskal-Wallis test: H (1, N= 207) =.6011550 p =.4381			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
woman	1	127	13515,00	106,417323
man	2	80	8013,00	100,162500
Dependent: question 6	Independent variable (grouping): Gender: Kruskal-Wallis test: H (1, N= 207) =.1904903 p =.6625			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
woman	1	127	13385,00	105,393701
man	2	80	8143,00	101,787500
Dependent: question 7	Independent variable (grouping): Gender: Kruskal-Wallis test: H (1, N= 203) =.0059283 p =.9386			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
woman	1	126	12823,00	101,769841
man	2	77	7883,00	102,376623
Dependent: question 8	Independent variable (grouping): Gender: Kruskal-Wallis test: H (1, N= 205) =.2033773 p =.6520			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
woman	1	126	13155,50	104,408730
man	2	79	7959,50	100,753165
Dependent: question 17	Independent variable (grouping): Gender: Kruskal-Wallis test: H (1, N= 203) =.0070297 p =.9332			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
woman	1	125	12782,50	102,260000
man	2	78	7923,50	101,583333

Source: own elaboration based on own research results.

Kruskal-Wallis test results indicate a lack of statistically significant differences in the assessment of the level of ecological education among employees in the

environment depending on the respondents' age ($H = 2.839$; $p = 0.7248$). However, for the variable concerning the promotion of knowledge about sustainable development and green technologies, marginal statistical significance was observed ($H = 11.113$; $p = 0.0492$), suggesting that the perception of knowledge promotion differs across age groups. In the case of barriers in access to knowledge about ecological transformation, a significant difference was found ($H = 12.927$; $p = 0.0241$), indicating that the assessment of these barriers depends on the respondents' age. Other studied variables, such as positive aspects of access to knowledge, environmental activities in raising ecological awareness, and the impact of investment in education on attitudes toward ecological transformation, did not show significant differences between age groups (all $p > 0.05$). Mean ranks in individual age groups show certain trends; for instance, the 24-year-old group rates knowledge promotion and access barriers higher than other groups.

The discovered differences in the perception of knowledge promotion and barriers to access to information about ecological transformation depending on age indicate the need to adapt educational and communication activities to the specifics of different age groups. Effective adaptation of the message and educational methods can increase engagement and the effectiveness of implementing the green transformation. From an economic perspective, considering these age differences is important for optimizing human capital development strategies, increasing the society's ecological awareness, and accelerating the transformation toward sustainable models, which in the long term may translate into increased competitiveness and innovation of the economy (Table 65).

Table 65. Analysis of the relationship of assessments of ecological education, barriers, and positive aspects of access to knowledge about ecological transformation by respondents' age – Kruskal-Wallis test

Dependent: question 3	Independent variable (grouping): Age Kruskal-Wallis test: $H (5, N= 207) = 2.838836 p = .7248$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
1	2	3	4	5
20 years	1	51	5092,000000	99,84313725
21 years	2	46	5033,500000	109,423913
22 years	3	48	5387,500000	112,2395833
23 years	4	30	2850,500000	95,01666667
24 years	5	13	1246,000000	95,84615385
over 25 y.o.	6	19	1918,500000	100,9736842

Dependent: question 4	Independent variable (grouping): Age Kruskal-Wallis test: H (5, N= 207) =11.11335 p =.0492			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
20 years	1	51	4620,500000	90,59803922
21 years	2	46	5200,000000	113,0434783
22 years	3	48	5127,500000	106,8229167
23 years	4	30	2833,000000	94,43333333
24 years	5	13	1850,500000	142,3461538
over 25 y.o.	6	19	1896,500000	99,81578947
Dependent: question 6	Independent variable (grouping): Age Kruskal-Wallis test: H (5, N= 207) =12.92727 p =.0241			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
20 years	1	51	4902,000000	96,11764706
21 years	2	46	5397,500000	117,3369565
22 years	3	48	4413,500000	91,94791667
23 years	4	30	3508,000000	116,9333333
24 years	5	13	1736,000000	133,5384615
over 25 y.o.	6	19	1571,000000	82,68421053
Dependent: question 7	Independent variable (grouping): Age Kruskal-Wallis test: H (5, N= 203) =5.885557 p =.3175			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
20 years	1	51	5545,000000	108,7254902
21 years	2	44	4465,000000	101,4772727
22 years	3	48	4241,000000	88,35416667
23 years	4	29	2935,500000	101,2241379
24 years	5	13	1601,000000	123,1538462
over 25 y.o.	6	18	1918,500000	106,5833333
Dependent: question 8	Independent variable (grouping): Age Kruskal-Wallis test: H (5, N= 205) =9.514243 p =.0902			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
20 years	1	51	5043,000000	98,88235294
21 years	2	46	5243,000000	113,9782609
22 years	3	47	4642,500000	98,77659574
23 years	4	29	2644,500000	91,18965517
24 years	5	13	1803,000000	138,6923077
over 25 y.o.	6	19	1739,000000	91,52631579

Dependent: question 17	Independent variable (grouping): Age Kruskal-Wallis test: H (5, N= 203) =4.532867 p =.4755			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
20 years	1	50	5567,000000	111,34
21 years	2	45	4260,000000	94,66666667
22 years	3	48	5156,500000	107,4270833
1	2	3	4	5
23 years	4	30	2730,500000	91,01666667
24 years	5	12	1323,000000	110,25
over 25 y.o.	6	18	1669,000000	92,72222222

Source: own elaboration based on own research results.

Analysis of the Kruskal-Wallis test results indicates that the level of ecological education assessed among employees in the environment does not differ significantly between groups of students with different levels and forms of education ($H = 1.449$; $p = 0.6942$). Similarly, no significant differences were observed in the assessment of the promotion of knowledge in the field of sustainable development and green technologies ($H = 2.154$; $p = 0.5411$), positive aspects of access to knowledge ($H = 1.554$; $p = 0.6700$), environmental activities in raising ecological awareness ($H = 2.167$; $p = 0.5386$), and the impact of education investment on attitudes toward ecological transformation ($H = 6.702$; $p = 0.0820$). However, a statistically significant difference occurred in the assessment of barriers in access to knowledge about ecological transformation ($H = 8.464$; $p = 0.0373$), suggesting that students of different fields and forms of study differ in terms of their perception of obstacles in obtaining information about ecological transformation. Particularly high mean ranks in this category were shown by groups of full-time 1st-cycle students and part-time 2nd-cycle students.

Divergence in the perception of barriers to access to knowledge about ecological transformation depending on student status indicates the need to consider the specifics of different forms and levels of education in the ecological education process. Effectively eliminating these barriers can improve access to key knowledge for understanding and implementing the green transformation, which is necessary for building human capital adapted to sustainable development requirements. From an economic perspective, investments in properly targeted education and the reduction of information barriers in the academic environment may favor the creation of a qualified workforce that will drive innovation and effective implementation of ecological strategies in the labor market (Table 66).

Table 66. Analysis of relationships between assessments of environmental education, barriers, and positive aspects of access to knowledge on ecological transformation by student status – Kruskal–Wallis test

Dependent: question 3	Independent (grouping) variable: Student Kruskal–Wallis test: $H(3, N = 202) = 1.448653, p = .6942$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
1	2	3	4	5
Full-time Bachelor's	1	54	5472,000000	101,3333333
Full-time Master's	2	48	5204,500000	108,4270833
Part-time Bachelor's	3	39	3677,500000	94,29487179
Part-time Master's	4	61	6149,000000	100,8032787
Dependent: question 4	Independent (grouping) variable: Student Kruskal–Wallis test: $H(3, N = 202) = 2.153889, p = .5411$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Full-time Bachelor's	1	54	5063,000000	93,75925926
Full-time Master's	2	48	4813,000000	100,2708333
Part-time Bachelor's	3	39	4295,000000	110,1282051
Part-time Master's	4	61	6332,000000	103,8032787
Dependent: 6	Independent (grouping) variable: Student Kruskal–Wallis test: $H(3, N = 202) = 8.463724, p = .0373$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Full-time Bachelor's	1	54	6033,500000	111,7314815
Full-time Master's	2	48	4035,000000	84,0625
1	2	3	4	5
Part-time Bachelor's	3	39	3692,000000	94,66666667
Part-time Master's	4	61	6742,500000	110,5327869
Dependent: question 7	Independent (grouping) variable: Student Kruskal–Wallis test: $H(3, N = 198) = 1.553620, p = .6700$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Full-time Bachelor's	1	54	5351,500000	99,10185185
Full-time Master's	2	45	4793,500000	106,5222222
Part-time Bachelor's	3	39	3589,000000	92,02564103
Part-time Master's	4	60	5967,000000	99,45

Dependent: question 8	Independent (grouping) variable: Student Kruskal–Wallis test: $H(3, N = 200) = 2.166568, p = .5386$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Full-time Bachelor's	1	54	5451,000000	100,9444444
Full-time Master's	2	48	5259,500000	109,5729167
Part-time Bachelor's	3	39	3631,500000	93,11538462
Part-time Master's	4	59	5758,000000	97,59322034
Dependent: question 17	Independent (grouping) variable: Student Kruskal–Wallis test: $H(3, N = 199) = 6.702090, p = .0820$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Full-time Bachelor's	1	53	5186,500000	97,85849057
Full-time Master's	2	47	4792,500000	101,9680851
Part-time Bachelor's	3	39	4591,500000	117,7307692
Part-time Master's	4	60	5329,500000	88,825

Source: own elaboration based on own research results.

The analysis conducted using the Kruskal–Wallis test showed no statistically significant differences between groups of respondents living in urban, rural, and urban–rural areas with regard to assessments of the level of environmental education among employees in their environment ($H = 2.071; p = 0.3550$), promotion of knowledge on sustainable development and green technologies ($H = 0.024; p = 0.9882$), barriers to access to knowledge about ecological transformation ($H = 0.088; p = 0.9570$), positive aspects of access to knowledge ($H = 4.505; p = 0.1051$), activities of the environment aimed at raising environmental awareness ($H = 0.526; p = 0.7686$), and the impact of investments in education and training on attitudes toward ecological transformation ($H = 1.412; p = 0.4935$). Despite the lack of statistical significance, a higher mean rank for positive aspects of access to knowledge can be observed among respondents living in urban–rural areas, which may indicate some differentiation in the perception of this issue.

The lack of significant differences in assessments of environmental education and perceptions of barriers among residents of different types of residential areas indicates a relative uniformity of access to information and knowledge about ecological transformation regardless of place of residence. From an economic perspective, this is a favorable phenomenon, as it enables the unification of educational and promotional activities at the national level without the need to tailor educational programs specifically to place of residence. Equal access to environmental knowledge supports sustainable social and economic development, as well as the building of ecological competencies across the entire population, which is the foundation of an effective transformation of the economy toward sustainability and low emissions (Table 67).

Table 67. Analysis of differences in assessments of environmental education and perceptions of barriers and positive aspects of ecological transformation by place of residence – Kruskal–Wallis test

Dependent: question 3	Independent (grouping) variable: Place of residence Kruskal–Wallis test: $H(2, N = 200) = 2.071328, p = .3550$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
City	1	54	5472,000000	101,3333333
Village	2	48	5204,500000	108,4270833
City–Village	3	39	3677,500000	94,29487179
Dependent: question 4	Independent (grouping) variable: Place of residence Kruskal–Wallis test: $H(2, N = 200) = 0.0238219, p = .9882$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
City	1	54	5063,000000	93,75925926
Village	2	48	4813,000000	100,2708333
City–Village	3	39	4295,000000	110,1282051
Dependent: question 6	Independent (grouping) variable: Place of residence Kruskal–Wallis test: $H(2, N = 200) = 0.0880049, p = .9570$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
City	1	54	6033,500000	111,7314815
Village	2	48	4035,000000	84,0625
City–Village	3	39	3692,000000	94,66666667
Dependent: question 7	Independent (grouping) variable: Place of residence Kruskal–Wallis test: $H(2, N = 196) = 4.505348, p = .1051$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
City	1	54	5351,500000	99,10185185
Village	2	45	4793,500000	106,5222222
City–Village	3	39	3589,000000	92,02564103
Dependent: question 8	Independent (grouping) variable: Place of residence Kruskal–Wallis test: $H(2, N = 198) = 0.5264077, p = .7686$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
City	1	54	5451,000000	100,9444444
Village	2	48	5259,500000	109,5729167
City–Village	3	39	3631,500000	93,11538462
Dependent: question 17	Independent (grouping) variable: Place of residence Kruskal–Wallis test: $H(2, N = 196) = 1.412293, p = .4935$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
City	1	53	5186,500000	97,85849057
Village	2	47	4792,500000	101,9680851
City–Village	3	39	4591,500000	117,7307692

Source: own elaboration based on own research results.

The statistical analyses conducted using the Kruskal–Wallis test did not reveal significant differences between groups differing in self-assessed knowledge of ecological transformation with respect to the evaluation of the level of environmental education among employees in their environment ($H = 1.319$; $p = 0.8582$). Furthermore, no significant differences were observed in the perception of barriers to accessing knowledge about ecological transformation depending on self-assessed knowledge ($H = 8.250$; $p = 0.2204$). Similarly, the analysis of positive aspects of access to knowledge indicated no statistically significant differences between respondent groups ($H = 7.567$; $p = 0.2716$). It is worth noting, however, that the highest mean ranks among barriers were assigned to the complexity of the issue (mean rank = 146.43) and uncertainty regarding the economic and social future (mean rank = 122.57), which may indicate their relative importance in respondents' perceptions. Among the positive aspects, the highest ratings were given to media openness to ecological topics (mean rank = 117.88) and the availability of educational materials (mean rank = 112.42), highlighting the important role of these elements in building environmental awareness.

The results of the analysis suggest that the level of self-assessed knowledge of ecological transformation does not significantly affect the perception of environmental education nor the perception of barriers and positive aspects of access to knowledge. However, it is important to emphasize that the complexity of issues related to transformation and uncertainty about the socio-economic future are key barriers that may limit the effectiveness of educational and adaptive processes in the economic sector. In turn, the role of media and the availability of educational materials as positive factors underscore the importance of broad and transparent access to information, which is essential for improving qualifications and environmental awareness among employees and managers. In the context of the economy, effective environmental education and the minimization of information barriers are crucial for the successful implementation of ecological transformation policies, translating into increased competitiveness and sustainable development of enterprises (Table 68).

Table 68. Analysis of relationships between self-assessment of knowledge about ecological transformation and the assessment of ecological education, barriers, and positive aspects of access to knowledge – Kruskal-Wallis test

Dependent: question 3	Independent variable (grouping): question 5 Kruskal-Wallis Test: $H(4, N=207) = 1.318726; p = .8582$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
very poor	1	17	1627,500000	95,73529412
poor	2	46	5100,500000	110,8804348
average	3	87	8964,500000	103,0402299
good	4	51	5277,500000	103,4803922
very good	5	6	558,000000	93
Dependent: question 5	Independent variable (grouping): question 6 Kruskal-Wallis Test: $H(6, N=207) = 8.249804; p = .2204$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Lack of available knowledge sources	1	34	3458,500000	101,7205882
Difficulty in understanding technical issues	2	63	6547,500000	103,9285714
Lack of time for learning	3	66	6954,000000	105,3636364
Lack of practical examples	4	20	1607,500000	80,375
Lack of support from educational institutions	5	10	1077,500000	107,75
Complexity of the problem	6	7	1025,000000	146,4285714
Uncertainty regarding the economic and social future	7	7	858,000000	122,5714286
Dependent: question 6	Independent variable (grouping): question 7 Kruskal-Wallis Test: $H(6, N=203) = 7.566749; p = .2716$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Availability of educational materials	1	73	8207,000000	112,4246575
Increase in social awareness	2	92	8958,500000	97,375
Availability of training and courses	3	5	356,000000	71,2
Support from government institutions and non-governmental organizations	4	8	761,000000	95,125

Biodiversity of practical examples	5	6	640,000000	106,6666667
Timeliness of information	6	11	840,500000	76,40909091
Openness of the media to the topic of ecology	7	8	943,000000	117,875

Source: own elaboration based on own research results.

The results of the Spearman rank correlation analysis presented in table 68 indicate diverse links between the studied variables. The strongest and simultaneously statistically significant correlation was observed between the variable “Does your environment promote knowledge in the field of sustainable development and green technologies” and “Do the activities of your environment (region) contribute to raising ecological awareness” ($r = 0.493$, $p < 0.05$). This means that the more respondents perceive their environment as promoting knowledge about sustainable development, the more they believe that regional activities influence the raising of ecological awareness.

Furthermore, a moderate and significant positive correlation was noted between the assessment of knowledge promotion and the impact of the level of investment in education and training on attitudes toward ecological transformation ($r = 0.234$, $p < 0.05$). This means that a higher perception of educational support is linked to a stronger awareness of the impact of investment on ecological attitudes.

The remaining correlations, although moderate in some cases, did not reach the level of statistical significance. For example, the positive correlation between barriers to access to knowledge and the assessment of the level of ecological education among employees ($r = 0.150$) is not statistically significant, which suggests a lack of a strong link between these variables in the studied sample.

The obtained results emphasize the key role of the local and regional environment in shaping ecological awareness and promoting sustainable development. The strong link between the perception of knowledge promotion and the awareness of regional activities indicates that educational and information initiatives undertaken at the local level can effectively increase the ecological awareness of the community, which is essential for the implementation of ecological transformation policies.

In addition, the significant relationship between investments in education and training and the change in attitudes toward ecological transformation highlights how important strategic funding for the development of human capital in organizations is. In the context of the economy, appropriately directed educational investments favor the adaptation of enterprises to the requirements of sustainable development, increase their innovation and competitiveness, which has a positive impact on sustainable growth and environmental protection.

Table 69 presents the values of Spearman rank correlation coefficients between demographic variables and selected indicators regarding ecological education and ecological transformation. The obtained correlation coefficients are low and oscillate around zero, which indicates a lack of strong relationships between the analyzed variables (Table 69).

Table 69. Spearman correlation analysis between the assessment of ecological education, knowledge promotion, barriers and positive aspects of access to knowledge, and the impact of investments on attitudes toward ecological transformation

Specification	question 3	question 4	question 6	question 7	question 8	question 17
question 3	1.000000	-0.012468	0.149535	-0.157829	0.029402	0.042740
question 4	-0.012468	1.000000	0.085495	-0.073550	0.493330	0.233808
question 6	0.149535	0.085495	1.000000	-0.130045	0.078557	-0.043983
question 7	-0.157829	-0.073550	-0.130045	1.000000	-0.094681	-0.097666
question 8	0.029402	0.493330	0.078557	-0.094681	1.000000	0.246432
question 17	0.042740	0.233808	-0.043983	-0.097666	0.246432	1.000000

Marked correlation coefficients are significant at $p < .05000$

Source: own elaboration based on own research results.

No statistically significant correlations ($p < 0.05$) were observed between gender, age, student status, and place of residence and the assessment of the level of ecological education, knowledge promotion, barriers and positive aspects of access to knowledge, or the impact of investments on attitudes toward ecological transformation. The values of the coefficients range from -0.073 to 0.085 , which confirms that demographic characteristics do not have a significant impact on the studied variables in the context of this sample.

The lack of significant correlations between demographic characteristics and the perception of ecological education, barriers, or positive aspects of access to knowledge suggests that educational and information activities concerning ecological transformation should be addressed broadly, without the need for specific targeting of particular demographic groups.

From an economic point of view, this means that the development of human capital and building ecological awareness can be conducted in an inclusive manner, covering diverse social groups regardless of age, gender, place of residence, or educational status. Such an approach favors the creation of coherent and wide-ranging support for ecological transformation, which is key to achieving sustainable development goals and economic resilience.

Table 70 presents the values of Spearman rank correlation coefficients between three main variables: the assessment of how well the environment understands the importance of green transformation, self-assessment of the level of knowledge on the topic of ecological transformation, and the assessment of one’s own understanding of the need to adapt to ecological changes (Table 70).

Table 70. Analysis of Spearman Correlations Between Demographic Factors and Perceptions of Ecological Education, Knowledge Dissemination, Barriers, Benefits of Access to Information, and the Impact of Investments on Attitudes Toward Ecological Transformation

Specification	gender	age	student	Place of residence
question 3	0.027361	-0.018881	-0.025283	0.055401
question 4	-0.054021	0.085879	0.078539	-0.010321
question 6	-0.030409	0.024233	0.018314	-0.019104
question 7	0.005417	-0.014751	-0.019728	0.080359
question 8	-0.031574	-0.008255	-0.048266	0.036802
question 17	-0.005899	-0.073915	-0.044032	0.085067

Marked correlation coefficients are significant at $p < .05000$
Source: own elaboration based on own research results.

The analysis showed significant positive correlations between these variables, with coefficient values ranging from 0.30 to 0.42 ($p < 0.05$). In particular, there is a moderately strong correlation between the assessment of one’s own knowledge of ecological transformation and the understanding of the need to adapt to ecological changes ($r = 0.42$), which suggests that a higher level of knowledge favors a better perception of the necessity of adaptation. Furthermore, positive and significant correlations also occur between the assessment of the environment’s understanding regarding green transformation and the promotion of sustainable development knowledge ($r = 0.29$), as well as environmental activities in raising ecological awareness ($r = 0.31$).

Other variables, such as barriers and positive aspects of access to knowledge, show low and insignificant correlations with the studied perception and knowledge, indicating a smaller impact of these factors in this context.

The results emphasize the importance of education and promotion of ecological knowledge in the social and organizational environment as key elements of green transformation. The strong correlation between the level of knowledge

about ecological transformation and the awareness of the need to adapt to ecological changes indicates that investments in education and awareness-raising can effectively support adaptation processes, which is essential for the sustainable development of the economy.

Furthermore, the positive impact of environmental activities and knowledge promotion on the perception of green transformation suggests that appropriately directed educational and information programs can strengthen social acceptance and engagement in achieving ecological goals. From an economic perspective, increasing human capital in the area of green transformation favors innovation, resource efficiency, and the competitiveness of enterprises, which translates into lasting development and economic resilience to environmental and economic changes (Table 71).

Table 71. Spearman correlation analysis between the perception of green transformation, the level of knowledge about ecological transformation, and the awareness of the need to adapt to ecological changes

Specification	question 1	question 5	question 10
question 1	1,000000	0,306812	0,300405
question 3	0,155492	-0,023651	0,001895
question 4	0,293800	0,488455	0,161642
question 5	0,306812	1,000000	0,419995
question 6	0,079683	0,029838	0,061832
question 7	-0,080076	-0,073095	-0,125838
question 8	0,308395	0,367059	0,295606
question 10	0,300405	0,419995	1,000000
question 17	0,218045	0,165240	0,296921

Marked correlation coefficients are significant at $p < .05000$

Source: own elaboration based on own research results.

The conducted multiple regression analysis aimed to examine the influence of selected environmental and organizational factors on the respondents' self-assessment of their level of knowledge regarding ecological transformation (dependent variable). The model showed a statistically significant relationship ($F(4,196) = 17.43, p < 0.001$) and a moderate coefficient of determination ($R^2 = 0.262$), which means that approximately 26.2% of the variability in the level of knowledge can be explained by the included independent variables.

Among the four predictors, only the variable “Does your environment promote knowledge in the field of sustainable development and green technologies” showed a statistically significant impact on the level of knowledge ($\beta = 0.431$, $p < 0.001$), indicating that an environment promoting ecological education and sustainable development significantly raises the respondents’ self-assessment of knowledge. Conversely, “The level of ecological education among employees in your environment” ($\beta \approx 0.000$, $p = 0.997$), “Do the activities of the environment (region) contribute to raising ecological awareness” ($\beta = 0.127$, $p = 0.081$), and “The level of investment in education and training in the organization” ($\beta = 0.014$, $p = 0.822$) did not show a significant impact.

The model’s residual autocorrelation test (Durbin-Watson statistic = 2.03) indicates a lack of significant autocorrelation, which confirms the correctness of the regression assumptions.

The regression model results emphasize the key role of an environment promoting knowledge in the field of sustainable development and green technologies as a factor influencing the increase in employees’ knowledge level regarding ecological transformation. From an economic point of view, the growth of ecological awareness and knowledge among employees is the foundation for the effective implementation of green transformation strategies, which favors the implementation of pro-ecological innovations and adaptation to environmental challenges.

The lack of a significant impact of the level of investment in education and training in organizations may indicate the need to optimize these activities or the greater weight placed on environmental and social promotion of knowledge. Therefore, in addition to financial outlays, it is important to build an organizational culture and an environment conducive to ecological education, which can contribute to the sustainable development and competitiveness of the economy in the long term (Table 72).

Table 72. Multiple regression model explaining the level of self-assessment of knowledge about ecological transformation

N=201	Dependent variable: 5 How do you assess your level of knowledge on the topic of ecological transformation R= .51219560 R2 = .26234433 Adjusted R2 = .24729013 F(4,196) =17.427 p<.00000 Std. error of estimate: .82309 Durbin-Watson d: 2.027965					
	b*	Std. error (of b*)	b	Std. error (of b)	t(196)	p
Intercept			1.429756	0.288755	4.951451	0,000002
question 3	0.000199	0.061372	0.000209	0.064587	0.003243	0,997415
question 4	0.430731	0.072161	0.443101	0.074234	5.969008	0,000000
question 8	0.127405	0.072558	0.128219	0.073022	1.755899	0,080668
question 17	0.014375	0.063713	0.014226	0.063052	0.225622	0,821730

Source: own elaboration based on own research results

A multiple regression analysis was conducted to assess the impact of various factors related to ecological education and environmental awareness on the level of respondents' subjective understanding of the need to adapt to ecological changes. The model proved to be statistically significant ($F(4,195) = 8.17, p < 0.001$) and explained 14.4% of the variance in the dependent variable ($R^2 = 0.144$), indicating a moderate level of fit.

Among the studied predictors, two variables showed a statistically significant impact on the level of understanding: "Do the activities of your environment (region) contribute to raising ecological awareness" ($\beta = 0.208, p = 0.005$) and "To what extent does the level of investment in your organization in education and training affect changes in your attitude toward ecological transformation" ($\beta = 0.245, p < 0.001$). This means that both regional activities raising ecological awareness and organizational investments in education and training have a positive and significant impact on understanding the need to adapt to ecological changes.

The other two variables– the level of ecological education among employees in the environment ($\beta = 0.0008, p = 0.99$) and the promotion of knowledge in the field of sustainable development and green technologies by the environment ($\beta = -0.0055, p = 0.94$) – did not show a significant impact.

The Durbin-Watson index (1.86) suggests a lack of significant autocorrelation of the model residuals, which confirms the correctness of the regression assumptions.

The results emphasize the fundamental role of regional activities and organizational investments in ecological education as key factors increasing the understanding of the necessity to adapt to environmental changes. From an economic perspective, this means that effective green transformation strategies require not

only financial investments in training but also the support of local initiatives that raise ecological awareness. Understanding the need for adaptation is essential for mobilizing resources and implementing pro-ecological innovations in enterprises and regions. Thus, this increases the economy's resilience to the effects of climate and environmental changes, while simultaneously supporting sustainable development and competitiveness in the international market (Table 73).

Table 73. Multiple regression model explaining the level of understanding of the need to adapt to ecological changes

N=201	Dependent variable: 10 How do you assess your level of understanding of the need to adapt to ecological changes R= .37890745 R2 = .14357086 Adjusted R2 = .12600308 F (4,195)=8.1724 p<.00000 Std. error of estimate: .83501 Durbin-Watson d: 1.858949					
	b*	Std. error (of b*)	b	Std. error (of b)	t(196)	p
Intercept			2,072276	0,296511	6,988878	0,000000
question 3	0,000801	0,066296	0,000804	0,066560	0,012083	0,990372
question 4	-0,005668	0,077913	-0,005480	0,075332	-0,072743	0,942085
question 8	0,220316	0,078350	0,208311	0,074081	2,811943	0,005428
question 17	0,262268	0,068773	0,244732	0,064175	3,813516	0,000184

Source: own elaboration based on own research results

The conducted multiple regression analysis included nine predictors with a potential impact on the level of understanding of the need to adapt to ecological changes. The model proved to be statistically significant ($F(9,184) = 8.39$, $p < 0.001$), explaining 29.1% of the variance in the dependent variable ($R^2 = 0.291$), indicating a moderate model fit.

Among the analyzed variables, the only significant predictor proved to be the respondents' ability to identify global trends related to green transformation ($\beta = 0.393$, $p < 0.001$). The high beta coefficient suggests that better recognition of these trends significantly increases the level of understanding of the need to adapt to ecological changes.

Other variables, such as the assessment of the level of ecological education among employees in the environment, the promotion of knowledge about sustainable development, barriers and positive aspects of access to knowledge, or investments in education and training, did not show statistical significance in this model ($p > 0.05$), although two of them – environmental activities raising ecological aware-

ness ($\beta = 0.118$, $p = 0.098$) and organizational investments in education ($\beta = 0.106$, $p = 0.090$) – tended to influence the dependent variable at a level close to significance.

The Durbin-Watson index (1.96) indicates a lack of residual autocorrelation, which is consistent with the assumptions of the regression model.

The model results emphasize the key role of awareness and the ability to identify global trends in green transformation as a factor influencing adaptive attitudes toward ecological changes. For the economy, this means that developing competencies in understanding and predicting directions of green development is fundamental for the effective adaptation of organizations and employees to the requirements of ecological transformation. The lack of significance of other variables indicates that the mere existence of ecological education or investment in training is not enough without the ability to internalize and apply knowledge of global trends. For this reason, enterprises and institutions should concentrate on developing conscious strategic thinking and on tracking and implementing global pro-ecological innovations and practices, which will allow for increased flexibility and competitiveness of the economy in an era of climate and environmental changes (Table 74).

Table 74. Multiple regression model explaining the level of understanding of the need to adapt to ecological changes, including knowledge factors and ecological awareness

N=194	Dependent variable: 10 How do you assess your level of understanding of the need to adapt to ecological changes R= .53940819 R2 = .29096120 Adjusted R2 = .25627995 F (9,184)=8.3896 p<.00000 Std. error of estimate: .75886 Durbin-Watson d: 1.959619					
	b*	Std. error (of b*)	b	Std. error (of b)	t(196)	p
Intercept			1,437327	0,350451	4,101368	0,000062
question 1	0,065242	0,070743	0,061074	0,066222	0,922251	0,357606
question 2	0,082420	0,062770	0,100629	0,076638	1,313046	0,190803
question 3	-0,063332	0,064425	-0,063083	0,064172	-0,983029	0,326884
question 4	-0,002661	0,074846	-0,002521	0,070919	-0,035547	0,971682
question 6	-0,058170	0,064137	-0,035875	0,039555	-0,906971	0,365608
question 7	0,020875	0,063976	0,011522	0,035311	0,326290	0,744576
question 8	0,125254	0,075287	0,117687	0,070739	1,663686	0,097877
question 11	0,410564	0,070656	0,393176	0,067663	5,810754	0,000000
question 17	0,116041	0,068158	0,105807	0,062147	1,702532	0,090344

Source: own elaboration based on own research results.

The presented multiple regression model analyzes the relationship between the self-assessment level of knowledge about ecological transformation and nine predictor variables. The model showed high statistical significance ($F(9,185) = 9.92$, $p < 0.001$), explaining approximately 32.5% of the dependent variable's variance ($R^2 = 0.326$), which indicates a good fit of the model to the data.

Among all the included predictors, three variables showed a significant impact on the level of knowledge. The strongest predictor was the assessment of whether the environment promotes knowledge on the topic of sustainable development and green technologies ($\beta = 0.432$, $p < 0.001$), suggesting that support and education at the social level significantly translate into the knowledge level of individuals. The ability to identify global trends related to green transformation also had a significant impact ($\beta = 0.189$, $p = 0.007$), indicating that conscious tracking of world pro-ecological directions favors the raising of knowledge. Additionally, the level of understanding by the environment of the importance of green transformation had a positive, though slightly weaker, impact ($\beta = 0.136$, $p = 0.049$).

Other factors, such as barriers and positive aspects of access to knowledge, the level of organizational investment, or subjective assessment of ecological education among employees, did not show statistical significance ($p > 0.05$).

The Durbin-Watson statistic at a level of approximately 1.95 confirms the lack of significant residual autocorrelation, proving the appropriate selection of the model.

The model results indicate that the key factor raising the level of knowledge about ecological transformation is the active promotion and popularization of sustainable development issues and green technologies in the social environment. For the economy, this means that educational and information activities directed at broad social groups can effectively increase the level of ecological awareness, which is a necessary condition for the effective implementation of ecological transformation policies.

Furthermore, the ability to identify global trends in green transformation translates into a better understanding and absorption of knowledge, which can support enterprises in adapting to dynamic environmental and market changes. In the economic context, these results emphasize the need to invest in the development of competencies related to monitoring and responding to global ecological challenges, which favors building competitive advantage and the sustainable development of the corporate sector (Table 75).

Table 75. Multiple regression model explaining the level of knowledge about ecological transformation, including environmental factors and ecological awareness

N=195	Dependent variable: 5 How do you assess your level of knowledge on the topic of ecological transformation R= .57056375 R2 = .32554299 Adjusted R2 = .29273157 F (9,185)=9.9216 p<.00000 Std. error of estimate: .78690 Durbin-Watson d: 1.951826					
	b*	Std. error (of b*)	b	Std. error (of b)	t(196)	p
Intercept			0,968407	0,361350	2,679966	0,008027
question 1	0,136540	0,069014	0,135570	0,068524	1,978440	0,049363
question 2	-0,019536	0,061073	-0,025417	0,079459	-0,319878	0,749422
question 3	-0,014652	0,062872	-0,015304	0,065672	-0,233038	0,815989
question 4	0,428308	0,072856	0,432308	0,073536	5,878839	0,000000
question 6	-0,001516	0,062386	-0,000997	0,041015	-0,024296	0,980643
question 7	0,019408	0,062290	0,011402	0,036596	0,311575	0,755714
question 8	0,062350	0,073258	0,062429	0,073351	0,851100	0,395814
question 11	0,185406	0,068568	0,189287	0,070003	2,703984	0,007490
question 17	-0,057600	0,066301	-0,055766	0,064190	-0,868764	0,386102

Source: own elaboration based on own research results.

8.4. Between declared awareness and real barriers – determinants of social acceptance of green transformation among Polish academic youth

An analysis of the availability and quality of environmental education, alongside the identification of barriers and facilitators in accessing knowledge on green transformation – conducted on a representative sample of students predominantly from Generation Z, and to a lesser extent, Generations Y and X – revealed a systemic deficit in environmental competencies within the academic and professional environments of the respondents. The level of environmental education among employees in the respondents' immediate surroundings, as well as the promotional activity regarding knowledge of sustainable development and green technologies, were assessed as low to average (mean scores ranging from 2.25 to 2.80 on a 1–5 scale).

Simultaneously, statistical analyses (χ^2 tests, Mann-Whitney U, and Kruskal-Wallis tests) showed no significant differences in the perception of these phenomena based on demographic variables such as gender, age, student status,

or place of residence ($p > 0.05$ in most comparisons). The most significant barriers to accessing knowledge proved to be difficulties in understanding technical issues (30.43%) and limited time allocated to self-education (31.88%). These findings correspond with the classical concept of bounded rationality (Simon, 1957) and behavioral cognitive barriers analyzed in environmental economics (Shogren and Taylor, 2008). Among positive factors in accessing knowledge, the increase in social awareness (45.32%) and the availability of educational materials (35.96%) predominated, confirming the perception of environmental education as a public good generating positive externalities (Samuelson, 1954).

From a theoretical perspective, the results confirm the assumptions of classical human capital theory (Becker, 1964; Schultz, 1961), while simultaneously indicating its limitations in the context of environmental education. Although financial investments in education and training show only a moderate impact on pro-ecological attitudes ($R^2 = 0.144\text{--}0.291$ in regression models), the key predictor of self-assessed knowledge levels is the active promotion of knowledge within the immediate social and academic environment ($\beta = 0.431\text{--}0.432$; $p < 0.001$) and the ability to identify global trends in green transformation ($\beta = 0.189\text{--}0.393$; $p < 0.01$). These results highlight the importance of the institutional and social context in the process of internalizing ecological benefits, supplementing human capital theory with a network and cultural dimension (Coleman, 1988; Putnam, 2000). Additionally, observed information asymmetry (Akerlof, 1970) and a low capacity among recipients to distinguish reliable knowledge from “greenwashing” in social media constitute a significant barrier to rational consumer and investment decision-making in the field of sustainable development.

From a practical standpoint, the research results indicate an urgent need for a systemic overhaul of environmental education in Poland. Proposed directions for action include:

1. The implementation of mandatory, interdisciplinary modules on green transformation across all fields of study.
2. The development of micro-courses and educational materials with high cognitive accessibility, utilizing gamification elements and short digital formats (TikTok, Reels).
3. Institutional support for bottom-up student initiatives and real youth participation in curriculum design.
4. The construction of cross-sectoral partnerships (university–local government–enterprise) for regional educational campaigns.
5. The establishment of a national certification system for green micro-competencies recognized by the labor market.

From an economic perspective, the results signal a serious risk of a human capital shortage necessary for the effective absorption of European Green Deal funds, the implementation of CBAM regulations, and the maintenance of corporate competitiveness within the context of sustainable finance taxonomy. A lack

of rapid and coordinated systemic intervention between 2026 and 2030 may result in a permanent slowdown of the green transformation and a deepening of regional inequalities, particularly between urban and rural areas.

In summary, the research results confirm that the effectiveness of environmental education depends less on the volume of financial outlays and more on the ability of educational institutions and the social environment to create a conducive learning environment, eliminate cognitive barriers, and authentically engage the younger generation – especially Generation Z – as co-creators of didactic and communication processes. Only a comprehensive and multidimensional strategy, encompassing simplified messaging, adaptation to preferred digital channels, and real student participation, will enable the accelerated development of the competent human capital necessary to achieve sustainable development goals and successfully transform the Polish economy toward a low-emission and climate-resilient model.

The analysis of the research results on the perception of green transformation among students fits into the framework of several fundamental economic theories and their contemporary behavioral extensions. Primarily, the observed high level of perceived costs of implementing sustainable actions and the uncertainty regarding the cost-benefit balance can be interpreted in the context of transaction cost theory, which emphasizes the importance of coordination, information asymmetry, and risk as significant barriers to the effective implementation of new solutions. Simultaneously, the clear dominance of the perception of losses over benefits is consistent with the assumptions of loss aversion in behavioral economics, where individual decisions are more strongly motivated by the avoidance of negative outcomes than by the achievement of positive results. Finally, the results relate to distributive justice theory and the concept of “just transition,” emphasizing that social acceptance of ecological transformation is sensitive not only to economic efficiency but also to a subjective sense of fairness and equality in the distribution of costs and benefits. Additionally, the insufficient internalization of positive externalities of environmental transformation indicates the need to strengthen economic instruments, such as Pigouvian taxes and incentives, to better incorporate these effects into social consciousness. Ultimately, the observed skepticism toward distant transformation benefits aligns with the issues of hyperbolic discounting and intertemporal choice, implying the necessity of accounting for motivational mechanisms that favor long-term planning.

From a theoretical perspective, the results confirm that social acceptance of green transformation is a complex phenomenon that transcends simple cost-benefit calculations. Subjective perception of the balance between losses and gains, as well as sensitivity to distributive justice, is of key importance, extending classical economic models by psychological and ethical dimensions. The revealed polarization of opinion and the clustering effect around neutral responses indicate the necessity of considering socio-political and behavioral factors in the communication and policy implementation process. In practice, it is recommended to concentrate information

messaging on clearly presenting local, tangible benefits of the transformation, which has the potential to build direct engagement and social trust. Furthermore, it is essential to develop transparent and communicable cost-benefit analyses with a clear time horizon to reduce uncertainty and fears associated with investments. The implementation of “just transition” mechanisms, such as retraining funds or social support, should become an integral part of the transformation strategy to minimize social tensions. Finally, educational and communication campaigns should be adapted to the specificities of Generation Z, utilizing modern social media and engaging formats while integrating theoretical knowledge with practical experiences to effectively increase awareness and acceptance of the transformation.

From an economic perspective, the study’s results carry significant implications for development policy and the management of ecological transformation in the Świętokrzyskie region and on a broader national scale. High perception of costs and uncertainty regarding the economic balance may weaken the social legitimacy of key investment programs, such as the National Recovery Plan (KPO) or the Just Transition Fund, consequently increasing the risk of protests and low absorption of EU funds, particularly in regions with low GDP per capita. Young people’s concerns regarding the rise of social inequalities and the lack of visible effects in the form of new jobs indicate an urgent need to implement green employment guarantee programs and retraining systems that facilitate the integration of graduates and traditional sector workers into the green economy. For the Świętokrzyskie region, being one of the least developed in the country, the green transformation represents a key opportunity to increase competitiveness and modernize its economic structure; however, realizing this potential requires not only technological investments but also broad social support, which can only be achieved through transparent and fair policies. In the long run, a lack of social acceptance may lead to social destabilization, increased polarization, and the strengthening of anti-transformation attitudes, which in turn threatens the achievement of the ambitious goals of the European Green Deal and Poland’s position in the global economy.

The analysis of the research results on the perception of green transformation among students confirms and illustrates key economic theories, providing a valuable addition to the literature on individual behavior regarding environmental and economic changes. Primarily, the high level of perceived implementation costs and significant uncertainty regarding the cost-benefit balance are justified by transaction cost theory, according to which the implementation of innovations and systemic changes entails significant coordination costs, information asymmetry, and risks. Furthermore, the observed stronger emphasis on short-term costs than on future benefits fits well within the framework of loss aversion, where the subjective impact of losses outweighs equivalent gains, leading to conservatism in investment or innovation decision-making. The results also accentuate the importance of distributive justice, aligning with just transition theory, which emphasizes that social acceptance is conditioned by the perceived fairness of cost and benefit distribution

across social groups. Conversely, the moderately positive perception of environmental effects and strong concentration on costs indicate incomplete internalization of externalities – a classic problem in environmental economics where effective fiscal and regulatory instruments, such as Pigouvian taxes or emission trading systems, are necessary to motivate individuals to account for positive externalities. Finally, the limited readiness to accept distant benefits can be interpreted through intertemporal choice theory and hyperbolic discounting, which indicate a human tendency to prefer immediate benefits at the expense of long-term gains. In sum, the research results serve as practical confirmation of the integration of classical and behavioral economic models in the context of green transformation, pointing to the multidimensional nature of both cognitive and structural challenges.

Generation Z, the primary research group, is characterized by a complex and paradoxical profile regarding green transformation. On one hand, they declare high ecological awareness and moderately assess the local effects of pro-ecological actions, providing a solid base for building further support. On the other hand, they are characterized by low intertemporal patience, clear aversion to short-term costs, and significant uncertainty regarding long-term benefits, which limits their willingness to support the transformation unconditionally. Furthermore, concerns regarding social and intergenerational justice in cost distribution represent a significant factor dampening enthusiasm for change. Consequently, Generation Z's support is conditional and dependent on the fulfillment of three key premises: the provision of tangible local benefits, economic transparency in cost-benefit assessments, and mechanisms guaranteeing social justice. Failure to meet these requirements may lead to increased skepticism and resistance toward climate policies, which in the long term poses real risks to the effectiveness and stability of green transformation in Świętokrzyskie Voivodeship and the realization of European climate strategy goals.

Chapter 8 analyzed the structural and educational foundations of the green transformation through the lens of the Kruskal-Wallis tests and Spearman correlation matrices. The key findings indicate:

1. Systemic competency deficit: the level of ecological education in the immediate surroundings of the respondents was rated as low to average. Statistical analysis confirmed that this deficit is universal across all demographic groups (gender, age, and residence), suggesting that environmental education in Poland is not yet sufficiently specialized or inclusive.
2. The power of environment over investment: regression models revealed a critical paradox: direct organizational investments in training currently have a negligible impact on knowledge levels. Instead, the active promotion of sustainable development within the social and academic environment serves as the primary driver of ecological awareness ($\beta = 0.431$, $p < 0.001$).
3. Cognitive barriers: the transition is hindered by “bounded rationality”, where technical complexity (30.4%) and time constraints (31.9%) prevent students

from internalizing expert knowledge, despite a general increase in social awareness.

While Chapter 8 focused on the *acquisition of knowledge* and the role of the educational environment, Chapter 9 shifts the perspective toward the subjective economic and social valuation of the green transformation.

The transition from education to perception is marked by the internalization of costs. As established in the final models of the previous section, the ability to identify global trends is the strongest predictor of a student's readiness to adapt. Chapter 9 explores whether this "readiness" survives the confrontation with perceived financial burdens.

We move from asking "*How much do we know?*" to "*What is the price of change?*", analyzing how loss aversion and transaction costs shape the social legitimacy of the European Green Deal. This chapter examines whether the academic youth views the green transformation as a public good worth the short-term economic sacrifice, or as a source of potential social inequality and regional disparity.

Chapter 9.

Perception of costs, benefits, and social impacts of green transformation

Chapter 9 explores the subjective economic and social valuation of the ecological transition within the Świętokrzyskie Voivodeship, shifting the focus from theoretical knowledge to the perceived balance of costs and benefits. Utilizing the frameworks of transaction cost theory and behavioral loss aversion, this section analyzes how academic youth in the region weigh immediate financial burdens against long-term environmental gains for their local community. The discussion highlights the critical importance of distributive justice and the “just transition” concept in shaping social legitimacy for systemic reforms in a region with a specific economic and industrial structure. Ultimately, this chapter identifies how the perceived asymmetry between individual sacrifices and collective benefits influences the acceptance of the green transformation in the context of local developmental challenges.

9.1. Perception of costs and benefits of green transformation among students

The results of the conducted study indicate a diversified perception of the green transition among respondents, both in terms of observable effects and assessments of costs and the social consequences of this process. The largest group of respondents (44.66%) remains neutral regarding the question of positive effects of implementing green transition measures in their environment, while approximately 36% perceive these effects positively (“rather yes” and “definitely yes”), and only about 19% perceive them negatively. Regarding the assessment of the costs of implementing sustainable measures, respondents most frequently evaluate them as high (41.46%) or very high (20.49%), which indicates an awareness of the significant financial and organizational outlays associated with the transition. In the context of the cost-benefit balance of the green transition, the largest group (41.18%) declares a lack of a clear opinion (“hard to say”), which may indicate uncertainty or a lack of comprehensive knowledge regarding long-term impacts. Nevertheless, 30.39% believe that the costs are too high, while only 11.76% perceive a predominance of benefits over costs. Finally, regarding potential social inequalities caused by the green transition in the region, a neutral response prevailed (44.06%), with approximately 31% of respondents negatively assessing the impact of the transition on the growth of social inequalities (“definitely no” and “rather no”), and approximately 24% perceiving such a problem. These results suggest

that the green transition is perceived as a costly and ambiguous process in terms of social effects, which may influence the acceptance and pace of implementing pro-ecological policies.

The analysis of the perception of the green transition in terms of costs, effects, and social inequalities is crucial for the effective formulation of economic and social policies in Poland and the region. The high awareness of costs indicates the necessity for precise investment planning and the rationalization of resource allocation to minimize implementation barriers and ensure the economic efficiency of the transition. Simultaneously, the dispersed opinions regarding the cost-benefit balance demonstrate the need for transparent, data-driven social communication to strengthen trust and support for green initiatives. The perceived risk of social inequalities arising in the context of the green transition emphasizes the need to integrate social policy with pro-ecological activities to ensure the process is conducted in a fair and inclusive manner, minimizing negative social consequences. For the regional and national economy, this means that the green transition must be implemented sustainably, combining economic, ecological, and social objectives to ensure long-term stability, increased competitiveness, and social cohesion.

The conducted survey reveals a multifaceted picture of respondent perceptions toward the green transition, accounting for its effects, costs, and social consequences. Regarding the noticeable positive effects of the implemented green transition measures, nearly half of the respondents (44.66%) adopt a neutral stance, whereas over one-third (36.41%) perceive positive outcomes, indicating moderate optimism regarding changes in their environment. Only a few respondents express definitive opposition to such a perception (3.40%).

The assessment of the costs of implementing sustainable actions is characterized by a clear dispersion of opinions – over 60% of respondents evaluate them as high or very high, testifying to the perception of the transition as a process requiring significant outlays. At the same time, there is a group declaring that costs are low or very low (7.81%), which may result from differences in individual experience or access to information. In the context of the cost-benefit balance, nearly one-third of respondents (30.39%) believe that the costs of the green transition are too high relative to the achieved effects, while only 11.76% perceive a clear advantage of benefits over burdens. A significant portion of the subjects (41.18%) remains undecided on this matter, pointing to the complexity and ambiguity of the socio-economic evaluation of the transition.

The analysis of the perception of social inequalities resulting from the green transition shows that the largest group of respondents (44.06%) holds a neutral position, while another 31.69% do not perceive or rather do not perceive an intensification of inequalities. Conversely, 24.26% of respondents view the transition as a factor intensifying social inequalities in the region, signaling the existence of concerns regarding social justice and potential negative impacts of the transition on specific social groups.

The study results are of significant importance for economic and social policy, especially in the context of planning and implementing green transition strategies. Moderate optimism regarding noticeable effects and high cost awareness indicate the necessity of conducting educational and informational activities that transparently and convincingly communicate both the benefits and the real burdens associated with the transition process. High perceived costs may constitute a social barrier to the implementation of pro-ecological innovations and necessitate the inclusion of support mechanisms to minimize negative effects on vulnerable social groups.

Uncertainty and divergence in assessments regarding the cost-benefit balance point to the need for in-depth economic and social analysis so that the effects of the transition are better measurable and communicated to stakeholders. Concerns regarding the rise in social inequalities in the context of the transition emphasize the necessity of integrating climate policy with social policy to avoid negative social consequences that could destabilize economic processes and undermine social acceptance for change.

Finally, the diversity of opinions and the relatively high number of neutral responses suggest that many individuals do not possess sufficient knowledge or experience to fully evaluate the green transition process, implying a need for the continuation and intensification of educational efforts at the regional and national levels. Effectively managing these challenges is key to ensuring the sustainability and success of the green transition as a pillar of sustainable economic development.

The results of the statistical analysis presented in Table 76 reveal a diversified level of perception among respondents regarding various aspects of the green transition. The mean value for the question concerning the observation of positive effects of green transition activities was 3.16, with a relatively low coefficient of variation (0.26). This indicates a moderately positive assessment and relatively uniform opinions among the subjects regarding the positive outcomes of implemented ecological measures.

Table 76. Analysis of the perception of effects, costs, and social inequalities associated with the green transition among respondents – survey results

Question 15	Number	Percent	question 18	Number	Percent
definitely no	7	3.40	very high	42	20.49
rather no	32	15.53	high	85	41.46
neutral	92	44.66	average	62	30.24
rather yes	72	34.95	low	15	7.32
definitely yes	3	1.46	very low	1	0.49
Total		100.00			100.00
question 19.	Number	Percent	question 23.	Number	Percent
Yes, the costs are too high	62	30.39	definitely no	16	7.92
No, the benefits outweigh the costs	24	11.76	rather no	48	23.76
Hard to say	84	41.18	neutral	89	44.06
Costs are acceptable	18	8.82	rather yes	35	17.33
I have no opinion	16	7.84	definitely yes	14	6.93
Total		100.00			100.00

Source: Own elaboration based on own research results.

In the case of assessing the costs of implementing sustainable measures, the mean score was 2.26, while the coefficient of variation was significantly higher (0.39), suggesting a greater dispersion of opinions and a moderate tendency to perceive these costs as significant. This range indicates a lack of clear consensus and potential differences in the perception of the economic burden associated with the transition.

The greatest variability of opinions was observed in the question referring to the evaluation of the relationship between green transition costs and its economic, social, and environmental effects, where the mean was 2.52 and the coefficient of variation reached 0.49. Such high variability indicates significant discrepancies in the perception of the profitability of green investments and the need for intensified information and educational activities.

The perception of social inequalities caused by the green transition was characterized by a mean score of 2.92 and a moderate coefficient of variation of 0.34.

These results suggest that respondents recognize the possibility of inequalities occurring; however, opinions on this matter are diverse, which may reflect varying regional and social experiences.

The presented results have significant implications for economic development, particularly in the context of the ecological transition. A moderately positive perception of the effects of the green transition can serve as a foundation for social acceptance and support for further pro-ecological actions. However, the high variability of cost assessments indicates a risk of social resistance and difficulties in mobilizing financial support for sustainable development programs.

Significant discrepancies in the assessment of the cost-to-benefit ratio regarding economic and social gains may weaken the effectiveness of public policies and green investments, leading to uncertainty among investors and decision-makers. Additionally, the perception of potential social inequalities associated with the green transition highlights the necessity of implementing compensatory mechanisms and a fair distribution of benefits to prevent the deepening of social disparities, which could destabilize the transition process.

In an economic context, it is therefore crucial to conduct integrated communication, educational, and political activities that consider not only ecological efficiency but also the socio-economic aspects of the transition. Only in this way can long-term stability and the competitiveness of the economy be ensured under the increasing requirements of sustainable development.

In table 77, the statistical analysis performed using the Kolmogorov-Smirnov, Lilliefors, and Shapiro-Wilk tests revealed significant deviations from a normal distribution for all examined variables regarding the perception of the green transition. The maximum deviation (D) values for individual variables oscillate around 0.22–0.24, and the obtained significance levels (p) are less than 0.01, which indicates the rejection of the null hypothesis regarding the normality of distribution in each analyzed sample (Table 77).

Table 77. Statistical analysis of the variability in perception of effects, costs, and social consequences of the green transition based on mean values and coefficients of variation

Variable	Mean	Std. dev.	Coeff. of variation
question 15	3.155340	0.823523	0.260994
question 18	2.258537	0.883669	0.391257
question 19	2.519608	1.229605	0.488015
question 23	2.915842	1.001415	0.343440

Source: Own elaboration based on own research results.

High W statistic values in the Shapiro-Wilk test, also characterized by significance at the $p < 0.001$ level, confirm the non-standard shape of the data distributions. This means that respondents' answers to questions regarding the perception of positive effects of the green transition, the assessment of implementation costs, and social inequalities associated with the transition process do not follow a typical normal distribution. This may indicate the diverse nature of opinions, the presence of asymmetry, or the concentration of ratings at certain response levels.

The lack of normal distribution in the perception of key aspects of the green transition indicates the heterogeneity of social opinions and experiences, which has significant consequences for the formulation of public policies and economic strategies. The uneven distribution of attitudes and assessments makes it difficult to forecast social acceptance and effectively design educational and communication interventions, which must be tailored to diverse target groups.

From an economic perspective, the dispersion and asymmetry of opinions can influence the pace and effectiveness of implementing green investments and industrial transformation. In a situation where public opinion is clearly divided, there is a risk of social conflict and resistance to certain solutions, which may result in delays and increased costs of achieving climate goals and sustainable development. Therefore, economic policy should account for these disparities by promoting social dialogue and flexible approaches that increase the adaptability and acceptance of the transition at local and national levels (Table 78).

Table 78. Analysis of the normality of distribution for variables regarding the perception of effects, costs, and social inequalities associated with the green transition

Variable	N	Max D	K-S (p)	Lillief. (p)	W	p
question 15	206	0.235872	$p < .01$	$p < .01$	0.853320	0.000000
question 18	205	0.234587	$p < .01$	$p < .01$	0.876252	0.000000
question 19	204	0.230417	$p < .01$	$p < .01$	0.859291	0.000000
question 23	202	0.223938	$p < .01$	$p < .01$	0.903339	0.000000

Source: Own elaboration based on own research results.

9.2. Perception of economic costs, benefits, and risks of social inequality of the green transition in the assessment of students in the Świętokrzyskie region

Analysis of the results indicates that over half of the respondents (61.17%) are women, who declared noticing positive effects of green transition activities in their

environment significantly more often than men. The highest percentage of women rated the effects as “average” (29.13%) and “good” (20.87%), while men in these categories were significantly less numerous (15.53% and 14.08%, respectively). A small percentage of respondents of both genders indicated extreme ratings (“very poor” and “very good”), suggesting a rather moderate level of perception of positive changes.

The age groups are dominated by younger respondents (20–22 years), among whom ratings of “average” to “good” also prevailed. As age increases, particularly above 25 years, we observe a decrease in the share of individuals indicating positive effects, which may testify to greater skepticism or a different perspective on the issues of green transition.

In terms of student status, part-time second-cycle (Master’s) students constituted the largest group and most frequently rated the effects of the transition as “average” and “good.” In other study categories, the distribution of ratings was more balanced; however, moderately positive assessments also predominated.

An analysis of the place of residence reveals that respondents from rural areas (58.29%) more frequently notice positive effects (with “average” and “good” ratings prevailing) compared to city residents (32.16%). The group of residents from urban-rural areas is the least numerous and shows the lowest involvement in perceiving positive changes.

In light of the above data, it can be stated that a positive perception of green transition activities is present, but it is moderate in nature and exhibits significant demographic differentiation, particularly regarding gender and place of residence.

The perception of the positive effects of implementing the green transition is of fundamental importance for building social support and motivation to engage in pro-ecological activities. Noticeable differences between genders and between rural and urban residents indicate the need for targeted educational and communication activities that consider the specifics of these groups.

In an economic context, a positive perception of the green transition in one’s environment can foster greater acceptance of ecological innovations, investments, and the implementation of green technologies, which in turn accelerates the process of economic transformation in the region. Especially in the Świętokrzyskie Voivodeship, where the development of green competencies and social awareness can become a catalyst for the effective use of EU funds and support for local decarbonization initiatives.

On the other hand, the moderate level of positive perception and noticeable demographic differences point to a risk of a lack of widespread engagement, which could weaken the dynamics of change and the effectiveness of implemented actions. Consequently, appropriately targeted environmental communication and education strategies are essential to increase awareness, engagement, and the readiness for adaptation of entire communities and the labor market. Statistical analysis conducted using Pearson’s chi-square tests and other non-parametric

Table 79. Analysis of the perception of positive effects of implementing green transition in the respondents' environment by demographic cross-section

Category	Very Poor	%	Poor	%	Average	%	Good	%	Very Good	%	Total	%
Gender												
Female	4	1.94%	17	8.25%	60	29.13%	43	20.87%	2	0.97%	126	61.17%
Male	3	1.46%	15	7.28%	32	15.53%	29	14.08%	1	0.49%	80	38.83%
Age												
20 years	1	0.49%	11	5.34%	23	11.17%	15	7.28%	1	0.49%	51	24.76%
21 years	1	0.49%	7	3.40%	24	11.65%	14	6.80%	0	0.00%	46	22.33%
22 years	2	0.97%	6	2.91%	18	8.74%	21	10.19%	1	0.49%	48	23.30%
23 years	2	0.97%	2	0.97%	16	7.77%	10	4.85%	0	0.00%	30	14.56%
24 years	1	0.49%	3	1.46%	3	1.46%	4	1.94%	1	0.49%	12	5.83%
>25 years	0	0.00%	3	1.46%	8	3.88%	8	3.88%	0	0.00%	19	9.22%
Student Status												
Full-time Bachelor's	1	0.50%	8	3.98%	25	12.44%	20	9.95%	0	0.00%	54	26.87%
Full-time Master's	1	0.50%	10	4.98%	19	9.45%	16	7.96%	1	0.50%	47	23.38%
Part-time Bachelor's	2	1.00%	1	0.50%	20	9.95%	14	6.97%	2	1.00%	39	19.40%
Part-time Master's	2	1.00%	11	5.47%	28	13.93%	20	9.95%	0	0.00%	61	30.35%
Residence												
City	3	1.51%	11	5.53%	22	11.06%	27	13.57%	1	0.50%	64	32.16%
Village	3	1.51%	17	8.54%	60	30.15%	35	17.59%	1	0.50%	116	58.29%
City-Village	1	0.50%	3	1.51%	7	3.52%	7	3.52%	1	0.50%	19	9.55%

Source: Own elaboration based on own research results.

measures of association revealed a lack of statistically significant links between the assessment of positive effects of green transition implementation and the respondents' demographic variables. Specifically, the analysis of the relationship between the perception of effects and gender showed a non-significant chi-square test result ($\chi^2 = 1.656$; $df = 4$; $p = 0.799$), suggesting no significant differences in evaluations between women and men.

Similar results were recorded for age ($\chi^2 = 17.035$; $df = 20$; $p = 0.651$), student status ($\chi^2 = 12.647$; $df = 12$; $p = 0.395$), and place of residence ($\chi^2 = 7.783$; $df = 8$; $p = 0.455$). Kendall's tau-b and tau-c coefficients, as well as Spearman's rank correlation indices for all analyzed variables, also confirmed weak, non-significant correlations (all $p > 0.05$). Uncertainty coefficients show low levels of interdependence between the variables, further emphasizing that the perception of the positive effects of the green transition is dispersed and independent of the demographic characteristics of the surveyed students (Table 79).

The lack of significant differences in the perception of the positive effects of the green transition across different demographic groups may indicate a uniform level of awareness and perception of this phenomenon among the young academic population. Such homogeneity of attitudes provides favorable conditions for the implementation of uniform educational and communication strategies aimed at the entire student group, regardless of their age, gender, or place of residence.

From the perspective of regional and national economy, this result suggests that programs supporting the green transition can be scaled without the need for intensive adjustment to specific population segments. This facilitates the effective use of EU funds and accelerates the implementation of green innovations. At the same time, the dispersion of perception and the lack of differentiation highlight the need for further educational efforts to deepen the knowledge and engagement of young people in the transition process, in order to prevent potential stagnation in socio-economic adaptation to sustainable development requirements (Table 80).

Table 80. Analysis of the dependence of the perception of positive effects of the green transition in the respondents' environment on demographic variables

No.	Specification	chi ²	df	p
1	question 15. Positive effects (5) x Gender (2)			
	chi2	1.655875	df=4	p=.79872
	NW chi2	1.647337	df=4	p=.80026
	Kendall's tau-b & tau-c	b=-.019802	c=-.022057	
	Spearman Rank R	-.021077	t=-.3011	p=.76364
	Uncertainty Coeff.	X=.0033510	Y=.0059856	X Y=.00430
2	question 15. Positive effects (5) x Age (6)			
	chi2	17.03455	df=20	p=.65073
	NW chi2	16.91476	df=20	p=.65850
	Kendall's tau-b & tau-c	b=.0617006	c=.0557899	
	Spearman Rank R	.0726339	t=1.0402	p=.29949
	Uncertainty Coeff.	X=.0344080	Y=.0243529	X Y=.02852
3	question 15. Positive effects (5) x Student Status (4)			
	chi2	12.64655	df=12	p=.39525
	NW chi2	14.89141	df=12	p=.24743
	Kendall's tau-b & tau-c	b=-.022434	c=-.020726	
	Spearman Rank R	-.025910	t=-.3656	p=.71503
	Uncertainty Coeff.	X=.0314852	Y=.0269811	X Y=.02906
4	question 15. Positive effects (5) x Residence (3)			
	chi2	7.782819	df=8	p=.45497
	NW chi2	7.171312	df=8	p=.51827
	Kendall's tau-b & tau-c	b=-.030548	c=-.027424	
	Spearman Rank R	-.033380	t=-.4688	p=.63975
	Uncertainty Coeff.	X=.0150434	Y=.0199382	X Y=.01715

Source: Own elaboration based on own research results.

Analysis of the distribution of responses regarding the assessment of costs for implementing sustainable measures for ecological transition reveals a clear diversification of perception depending on gender, age, student status, and place of residence. Respondents indicate moderately high costs for such activities, with women more frequently than men rating them as very high or high (36.59% vs. 25.37%, respectively). Respondent age does not show strong deviations; however, the oldest group of students (> 25 years) slightly less frequently indi-

cates very high costs (1.46%), which may suggest higher economic awareness or experience.

Student status also influences cost assessment — part-time students, especially second-cycle (Master's), more often rate costs as very high or high (totaling 20.5%), which may stem from their practical contact with the labor market and financial realities. In the context of the place of residence, a clear difference is visible: rural residents more frequently perceive costs as very high or high (37.37%) compared to urban residents (18.69%).

The results indicate a subjective perception of ecological transition costs as significant, which may result from limited knowledge about the long-term benefits of these activities and a perception of short-term financial burdens. The perception of green transition costs as relatively high among young people, especially in rural areas and among part-time students, has significant implications for the implementation of pro-ecological policies. Concerns about high costs may translate into social resistance to changes, consequently hindering the effective realization of climate and sustainable development goals.

From an economic perspective, it is crucial to conduct educational and informational activities to mitigate misconceptions regarding transition costs while accounting for demographic diversity. A conscious and realistic perception of ecological investments fosters greater social acceptance and the mobilization of resources necessary for economic modernization. Furthermore, identifying differences in perception between rural and urban residents indicates the need to tailor communication and regional support programs to effectively address specific barriers and concerns of local communities. Only in this way will it be possible to effectively utilize EU funds and accelerate economic transformation based on green technologies.

Statistical analysis conducted using chi-square tests and Spearman's rank correlation as well as Kendall's tau-b coefficients indicates that there are no statistically significant dependencies between the assessment of the costs of implementing green transition activities and the demographic characteristics of the subjects, such as gender, age, student status, and place of residence.

For all analyzed variables, the p-values are above the significance level of 0.05 ($p > 0.09$ for gender, and for other variables $p > 0.22$, respectively), which suggests a lack of strong associations between demographic features and the subjective assessment of ecological transition costs. The values of Kendall's tau-b and Spearman's coefficients are low and close to zero, further confirming weak correlation and the minimal significance of these demographic traits for cost evaluation (Table 81).

Table 81. Analysis of the assessment of the costs of implementing ecological transition measures among students by demographic characteristics

Category	Very Poor	%	Poor	%	Average	%	Good	%	Very Good	%	Total	%
Gender												
Female	19	9,27%	56	27,32%	41	20,00%	10	4,88%	0	0,00%	126	61,46%
Male	23	11,22%	29	14,15%	21	10,24%	5	2,44%	1	0,49%	79	38,54%
Age												
20 years	14	6,83%	18	8,78%	12	5,85%	7	3,41%	0	0,00%	51	24,88%
21 years	5	2,44%	21	10,24%	17	8,29%	3	1,46%	0	0,00%	46	22,44%
22 years	10	4,88%	23	11,22%	13	6,34%	2	0,98%	0	0,00%	48	23,41%
23 years	8	3,90%	9	4,39%	11	5,37%	1	0,49%	1	0,49%	30	14,63%
24 years	2	0,98%	5	2,44%	3	1,46%	1	0,49%	0	0,00%	11	5,37%
>25 years	3	1,46%	9	4,39%	6	2,93%	1	0,49%	0	0,00%	19	9,27%
Student Status												
Full-time Bachelor's	13	6,50%	24	12,00%	13	6,50%	4	2,00%	0	0,00%	54	27,00%
Full-time Master's	8	4,00%	15	7,50%	20	10,00%	3	1,50%	0	0,00%	46	23,00%
Part-time Bachelor's	6	3,00%	17	8,50%	9	4,50%	6	3,00%	1	0,50%	39	19,50%
Part-time Master's	14	7,00%	27	13,50%	18	9,00%	2	1,00%	0	0,00%	61	30,50%
Residence												
City	14	7,07%	23	11,62%	17	8,59%	8	4,04%	1	0,51%	64	32,16%
Village	24	12,12%	50	25,25%	37	18,69%	5	2,53%	0	0,00%	116	58,29%
City-Village	2	1,01%	10	5,05%	5	2,53%	2	1,01%	0	0,00%	19	9,55%

Source: Own elaboration based on own research results.

These results may indicate that the perception of ecological activity costs is relatively consistent and independent of primary demographic variables, which may testify to a unified perception of this issue among young respondents representing various social and demographic groups. The absence of statistically significant dependencies between demography and green transition cost assessment suggests that the perception of financial burdens associated with the transition is a widespread phenomenon. From an economic perspective, this means that communication and educational challenges regarding the costs of the green transition should be addressed to society as a whole, rather than focusing exclusively on specific demographic groups.

Furthermore, a uniform perception of costs may facilitate the formulation of standardized informational strategies and support policies that will be understandable and acceptable to various population segments. This, in turn, may accelerate social acceptance for transition activities, which is key for the effective realization of sustainable development goals and environmental protection (Table 82).

Table 82. Analysis of the dependence of the assessment of implementation costs of ecological transition activities on respondents' demographic characteristics

No.	Specification	chi ²	df	p
1	question 18. Positive effects (5) x Gender (2)			
	chi2	7.705103	df=4	p=.10300
	NW chi2	7.890054	df=4	p=.09569
	Kendall's tau-b & tau-c	b=-.109771	c=-.125449	
	Spearman Rank R	-.118175	t=-1.696	p=.09149
	Uncertainty Coeff.	X=.0151670	Y=.0288676	X Y=.01989
2	question 18. Positive effects (5) x Age (6)			
	chi2	18.62761	df=20	p=.54614
	NW chi2	16.71694	df=20	p=.67127
	Kendall's tau-b & tau-c	b=-.007947	c=-.007377	
	Spearman Rank R	-.008345	t=-.1189	p=.90547
	Uncertainty Coeff.	X=.0321348	Y=.0242695	X Y=.02765
3	question 18. Positive effects (5) x Student Status (4)			
	chi2	15.28729	df=12	p=.22610
	NW chi2	13.91807	df=12	p=.30597
	Kendall's tau-b & tau-c	b=-.007052	c=-.006733	
	Spearman Rank R	-.008627	t=-.1214	p=.90350
	Uncertainty Coeff.	X=.0273588	Y=.0253518	X Y=.02632

No.	Specification	chi ²	df	p
4	question 18. Positive effects (5) x Residence (3)			
	chi2	8.612744	df=8	p=.37601
	NW chi2	8.837446	df=8	p=.35619
	Kendall's tau-b & tau-c	b=-.020290	c=-.018672	
	Spearman Rank R	-.022843	t=-.3199	p=.74940
	Uncertainty Coeff.	X=.0175651	Y=.0247272	X Y=.02054

Source: Own elaboration based on own research results.

Analysis of the results presented in table 82 illustrates the diversification of respondent opinions regarding the costs of the green transition, considered in relation to demographic characteristics such as gender, age, student status, and place of residence.

Two main attitudes dominate among respondents: a group of individuals believing that the costs of the green transition are too high (approx. 30.4% of total subjects) and individuals having difficulty providing a definitive assessment of this issue (approx. 41.2%). Specifically, women more frequently than men indicate high transition costs (17.16% vs. 13.24%) and express greater uncertainty (23.53% vs. 17.65%).

Regarding age, the highest number of indications for high costs comes from younger individuals (20–22 years), although the differences are minor. Students across various fields and levels of education exhibit similar dispersion of opinions, with a slight predominance of the part-time second-cycle group, which most frequently evaluates costs as high (9.5%).

The analysis of place of residence shows that rural residents more frequently perceive costs as too high (16.75%) compared to urban residents (9.64%). Furthermore, individuals from rural areas more often declare a lack of a clear opinion or difficulty in assessing costs (25.38%), which may point to greater uncertainty or lower awareness in this group.

In summary, the results suggest that despite certain demographic differences, a significant part of the subjects does not have a clear stance toward the economic aspects of the green transition, and the perception of costs as high is a significant element of social concern, particularly among women and rural residents. The assessment of green transition costs by society is crucial for the effectiveness of implementing sustainable development policies. The visible diversification of opinions, especially the high percentage of respondents considering costs as too high or having difficulty assessing them, indicates the need for intensification of educational and communication activities.

From an economic point of view, concerns regarding high costs can influence social acceptance and the pace of implementing pro-ecological innovations. Particularly in the context of rural residents, where negative perception can lead to social resistance

Table 83. Analysis of opinions on green transition costs in the context of respondents' demographic characteristics

Category	Very Poor	%	Poor	%	Average	%	Good	%	Very Good	%	Total	%
Gender												
Female	35	17,16%	17	8,33%	48	23,53%	13	6,37%	12	5,88%	125	61,27%
Male	27	13,24%	7	3,43%	36	17,65%	5	2,45%	4	1,96%	79	38,73%
Age												
20 years	14	6,86%	7	3,43%	16	7,84%	8	3,92%	4	1,96%	49	24,02%
21 years	13	6,37%	6	2,94%	22	10,78%	2	0,98%	3	1,47%	46	22,55%
22 years	15	7,35%	3	1,47%	20	9,80%	6	2,94%	3	1,47%	47	23,04%
23 years	8	3,92%	5	2,45%	12	5,88%	1	0,49%	4	1,96%	30	14,71%
24 years	4	1,96%	1	0,49%	7	3,43%	0	0,00%	1	0,49%	13	6,37%
>25 years	8	3,92%	2	0,98%	7	3,43%	1	0,49%	1	0,49%	19	9,31%
Student Status												
Full-time Bachelor's	15	7,50%	8	4,00%	21	10,50%	3	1,50%	6	3,00%	53	26,50%
Full-time Master's	15	7,50%	5	2,50%	20	10,00%	6	3,00%	2	1,00%	48	24,00%
Part-time Bachelor's	12	6,00%	8	4,00%	14	7,00%	4	2,00%	1	0,50%	39	19,50%
Part-time Master's	19	9,50%	3	1,50%	29	14,50%	2	1,00%	7	3,50%	60	30,00%
Residence												
City	19	9,64%	12	6,09%	23	11,68%	2	1,02%	7	3,55%	63	31,98%
Village	33	16,75%	10	5,08%	50	25,38%	13	6,60%	8	4,06%	114	57,87%
City-Village	7	3,55%	2	1,02%	9	4,57%	1	0,51%	1	0,51%	20	

Source: Own elaboration based on own research results.

against the transition, it is necessary to develop support strategies and transparent information regarding long-term economic, social, and environmental benefits.

The results of the statistical analysis presented in Table 83 indicate a lack of statistically significant dependencies between the assessment of whether green transition costs are too high compared to its economic, social, and environmental outcomes and selected demographic characteristics of the respondents: gender, age, student status, and place of residence. Pearson’s chi-square and Neyman-Whitney chi-square tests for all examined categories showed p-values significantly above the level of significance ($p > 0.05$), suggesting that differences in the distribution of opinions within individual demographic groups are random and insignificant.

Additionally, Kendall’s tau-b and tau-c coefficients and Spearman rank correlation indices are close to zero and do not reach statistical significance, confirming the absence of strong and significant correlations between the analyzed variables. The uncertainty coefficients and $X|Y$ indices further point to low strength of connection between the variables, suggesting that the perception of green transition costs is independent of these demographic traits.

The relative homogeneity of opinion emphasizes the importance of conducting a consistent and transparent information policy directed at society as a whole, rather than targeting specific demographic segments. Messages about the benefits and costs of the green transition should be formulated to build broad understanding and social acceptance, which is crucial for the effective implementation of sustainable development strategies and a low-emission economy.

Table 84. Analysis of the relationship between opinions on green transition costs and respondents’ demographic characteristics

No.	Specification	chi ²	df	p
1	question 19. Positive effects (5) x Gender (2)			
	chi2	4.315650	df=4	p=.36497
	NW chi2	4.458458	df=4	p=.34750
	Kendall’s tau-b & tau-c	b=-.068868	c=-.079969	
	Spearman Rank R	-.074960	t=-1.068	p=.28662
	Uncertainty Coeff.	X=.0078449	Y=.0163708	X Y=.01061
2	question 23. Positive effects (5) x Age (6)			
	chi2	14.43803	df=20	p=.80761
	NW chi2	15.38063	df=20	p=.75423
	Kendall’s tau-b & tau-c	b=-.046360	c=-.043793	
	Spearman Rank R	-.056634	t=-.8062	p=.42106
	Uncertainty Coeff.	X=.0270629	Y=.0222393	X Y=.02442

No.	Specification	chi ²	df	p
3	question 19. Positive effects (5) x Student Status (4)			
	chi2	14.12452	df=12	p=.29283
	NW chi2	14.95260	df=12	p=.24404
	Kendall's tau-b & tau-c	b=-.000069	c=-.000067	
	Spearman Rank R	.0002241	t=.00315	p=.99749
	Uncertainty Coeff.	X=.0271415	Y=.0271983	X Y=.02717
4	question 19. Positive effects (5) x Residence (3)			
	chi2	9.155562	df=8	p=.32934
	NW chi2	9.344248	df=8	p=.31409
	Kendall's tau-b & tau-c	b=.0238771	c=.0224175	
	Spearman Rank R	.0272436	t=.38058	p=.70393
	Uncertainty Coeff.	X=.0170597	Y=.0259660	X Y=.02059

Source: Own elaboration based on own research results.

The results presented in Table 84 illustrate the distribution of respondents' opinions on the impact of the green transition on social inequalities in their region, categorized by gender, age, student status, and place of residence.

Among the female population, 18.84% of respondents expressed the opinion that the green transition leads to social inequalities (the sum of "rather yes" and "definitely yes" responses), while in the male group, this percentage was lower at 7.43%. The largest group of respondents (26.24% of women and 17.82% of men, respectively) adopted a neutral stance on this issue, which may indicate ambiguity or a lack of full awareness regarding the social consequences of the transition.

Analyzing the data by age, no clear trend was observed indicating differences in the perception of social inequalities related to the ecological transformation. The highest number of responses pointing to potential inequalities ("rather yes" and "definitely yes") was recorded in the age groups of 20, 22, and >25 years, although this share did not exceed 8.90% in any of the groups.

In terms of student status, the greatest concerns regarding inequality occurred among part-time second-cycle students (9.6% of "rather yes" and "definitely yes" responses), which may be related to their professional experiences or greater awareness of social issues. Regarding the place of residence, rural residents showed a greater tendency to perceive social inequalities caused by the green transition (12.31% of "rather yes" and "definitely yes" responses) compared to urban residents (8.21%) and mixed areas (3.08%).

Overall, the dominant neutral or negative attitude (denying the occurrence of inequalities) indicates relatively moderate social feelings regarding the potential effects of the ecological transformation in the social sphere.

Table 85. Analysis of the perception of social inequalities caused by the green transition in the region by demographic characteristics

Category	Very Poor	%	Poor	%	Average	%	Good	%	Very Good	%	Total	%
Gender												
Female	10	4,95%	27	13,37%	53	26,24%	25	12,38%	9	4,46%	124	61,39%
Male	6	2,97%	21	10,40%	36	17,82%	10	4,95%	5	2,48%	78	38,61%
Age												
20 years	3	1,49%	13	6,44%	20	9,90%	8	3,96%	4	1,98%	48	23,76%
21 years	3	1,49%	12	5,94%	25	12,38%	3	1,49%	2	0,99%	45	22,28%
22 years	7	3,47%	10	4,95%	20	9,90%	8	3,96%	2	0,99%	47	23,27%
23 years	3	1,49%	7	3,47%	11	5,45%	9	4,46%	0	0,00%	30	14,85%
24 years	0	0,00%	2	0,99%	7	3,47%	1	0,50%	3	1,49%	13	6,44%
>25 years	0	0,00%	4	1,98%	6	2,97%	6	2,97%	3	1,49%	19	9,41%
Student Status												
Full-time Bachelor's	5	2,53%	13	6,57%	19	9,60%	11	5,56%	4	2,02%	52	26,26%
Full-time Master's	4	2,02%	10	5,05%	28	14,14%	2	1,01%	3	1,52%	47	23,74%
Part-time Bachelor's	2	1,01%	8	4,04%	18	9,09%	8	4,04%	2	1,01%	38	19,19%
Part-time Master's	4	2,02%	15	7,58%	23	11,62%	14	7,07%	5	2,53%	61	30,81%
Residence												
City	7	3,59%	17	8,72%	23	11,79%	13	6,67%	3	1,54%	63	32,31%
Village	7	3,59%	26	13,33%	56	28,72%	18	9,23%	6	3,08%	113	57,95%
City-Village	2	1,03%	4	2,05%	7	3,59%	3	1,54%	3	1,54%	19	9,74%

Source: Own elaboration based on own research results.

The perception of social inequalities related to the green transition is of significant importance for economic and social policy. It points to the need for including mechanisms to mitigate potential negative effects of the transition, such as income inequality or access to resources and services. The higher level of concern about inequality among rural residents and certain student groups highlights the necessity of adapting transition strategies to regional specificities and taking socio-economic differences into account. The lack of a clear division in opinions by age or gender suggests that this problem should be addressed comprehensively, engaging broad social groups.

From an economic perspective, ignoring the social aspects of the green transition can lead to social conflicts and a decrease in the effectiveness of the implemented solutions. Therefore, the integration of economic policies with actions for social justice is key to lasting and sustainable development.

The statistical analysis presented in Table 85 shows the results of tests of the significance of the relationship between respondents' opinions on whether the green transition leads to social inequalities in their region and selected demographic characteristics: gender, age, student status, and place of residence.

For all analyzed characteristics, significance level values (p) were obtained significantly above the standard threshold of 0.05, which means a lack of statistically significant dependencies between the variables. The results of Pearson's chi-square tests and independence tests indicate a lack of links between the assessment of social inequalities and gender ($p=0.698$), age ($p=0.101$), student status ($p=0.486$), and place of residence ($p=0.512$).

Additionally, Spearman's rank correlation coefficients and Kendall's tau showed very low values, confirming the lack of strong monotonic relationships between the variables. Uncertainty coefficients ($X, Y, X|Y$ coefficients) also do not indicate significant associations. In summary, these results suggest that the perception of social inequalities related to the green transition does not differ significantly depending on the analyzed demographic characteristics of the studied groups.

The lack of statistically significant differences in the perception of social inequalities caused by the green transition among different demographic groups may indicate a relatively uniform social awareness in this area. This situation is beneficial from the point of view of designing public policies, as it enables the implementation of consistent and universal actions supporting the transformation. However, despite the lack of demographic differences, the fact that opinions on inequalities exist requires the attention of economic and social decision-makers. A sustainable transformation should take social justice aspects into account to avoid potential tensions and social conflicts that could negatively impact the stability and efficiency of economic processes. Consequently, despite the uniformity of perception, compensatory mechanisms and support programs should be developed for groups that may be potentially exposed to the effects of social inequalities resulting from the ecological transformation (Table 86).

Table 86. Analysis of the relationship between opinions on social inequalities caused by the green transition in the region and demographic characteristics

No.	Specification	chi ²	df	p
1	question 19. Positive effects (5) x Gender (2)			
	chi2	2.207867	df=4	p=.69759
	NW chi2	2.262535	df=4	p=.68760
	Kendall's tau-b & tau-c	b=-.068345	c=-.079208	
	Spearman Rank R	-.074464	t=-1.056	p=.29224
	Uncertainty Coeff.	X=.0040227	Y=.0083964	X Y=.00544
2	question 23. Positive effects (5) x Age (6)			
	chi2	28.36878	df=20	p=.10095
	NW chi2	30.24413	df=20	p=.06599
	Kendall's tau-b & tau-c	b=.0949158	c=.0895746	
	Spearman Rank R	.1158648	t=1.6497	p=.10058
	Uncertainty Coeff.	X=.0537734	Y=.0441042	X Y=.04846
3	question 19. Positive effects (5) x Student Status (4)			
	chi2	11.50848	df=12	p=.48592
	NW chi2	13.39044	df=12	p=.34131
	Kendall's tau-b & tau-c	b=.0473189	c=.0457096	
	Spearman Rank R	.0546042	t=.76560	p=.44483
	Uncertainty Coeff.	X=.0243508	Y=.0246452	X Y=.02450
4	question 19. Positive effects (5) x Residence (3)			
	chi2	7.231924	df=8	p=.51183
	NW chi2	6.373569	df=8	p=.60546
	Kendall's tau-b & tau-c	b=.0533956	c=.0499408	
	Spearman Rank R	.0597651	t=.83177	p=.40657
	Uncertainty Coeff.	X=.0117973	Y=.0179965	X Y=.01425

Source: Own elaboration based on own research results.

The analysis of the conducted research demonstrates that the perception of costs and the risk of social inequalities in the green transition process is a relatively uniform phenomenon, independent of primary demographic characteristics such as gender, age, or place of residence. The absence of statistically significant dependencies ($p > 0.05$) suggests that economic concerns and uncertainty regarding the equitable distribution of transition burdens are universal in nature, arising from a general social perception of ecological challenges. These findings highlight the

necessity of conducting consistent information policies and implementing compensatory mechanisms to build social acceptance for systemic changes. This provides a direct context for the further considerations presented in section 9.3. Perception of costs, benefits, and the risk of social inequalities of the green transition in the assessment of students in the Świętokrzyskie Voivodeship, which aims to identify these attitudes in a detailed regional perspective.

9.3. Perception of costs, benefits, and the risk of social inequalities of the green transition in the assessment of students in the Świętokrzyskie Voivodeship

In table 86, the Mann-Whitney U test was conducted to evaluate the statistical significance of differences in responses to questions regarding the green transformation across various demographic variables and attitudes. The test was applied to the following variables: gender, age, student status, place of residence, and the assessment of the costs of implementing sustainable actions.

The results indicate that for the majority of the analyzed relationships, no statistically significant differences were found ($p > 0.05$). The sole exception is the variable “Does the green transformation in your region lead to social inequalities” when categorized by age groups, where the test indicated a significant difference ($Z=2.1724$, $p=0.0298$). This implies that opinions regarding social inequalities caused by the green transformation differ significantly depending on the age of the respondents.

In other cases, the lack of significant differences suggests that opinions regarding the perception of the positive effects of the transformation, cost assessments, and general acceptance are relatively uniform across different demographic groups, which may indicate a similar level of awareness and perception of these issues.

The finding of a significant difference in the assessment of social inequalities based on age indicates the necessity of considering the perspectives of different age groups in the process of communicating and implementing green transformation policies. Diverse perceptions of this aspect may influence social support and readiness to cooperate with transformation policies.

Conversely, the lack of significant differences in other areas suggests that there is a relative consolidation of opinion regarding the costs and benefits of ecological transformation, which may favor the stability and effectiveness of implementing changes at the social and economic levels.

For the economy, this means that information and educational activities should be particularly targeted at age groups that perceive social inequalities more critically, in order to build broad support for the transformation while minimizing the risk of social tensions and barriers to the implementation of green policies.

Table 87. Mann-Whitney U Test: Analysis of the significance of differences in assessments of green transformation regarding demographic characteristics and attitudes

Marked results are significant at p<.05000	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (corrected)	p	Valid N (Group 1)	Valid N (Group 2)
question 15	8163,0000	13158,0000	4923,0000	-0,2794	0,7800	-0,3005	0,7638	80,0000	126,0000
question 18	7478,0000	13637,0000	4318,0000	-1,5930	0,1112	-1,6866	0,0917	79,0000	126,0000
question 19	7681,5000	13228,5000	4521,5000	-1,0116	0,3117	-1,0667	0,2861	79,0000	125,0000
question 23	7513,0000	12990,0000	4432,0000	-0,9975	0,3185	-1,0544	0,2917	78,0000	124,0000
Regarding variable: Age									
question 15	633,0000	1645,0000	443,0000	-0,1739	0,8620	-0,1877	0,8511	19,0000	48,0000
question 18	682,5000	1595,5000	419,5000	0,5008	0,6165	0,5397	0,5894	19,0000	48,0000
question 19	565,5000	1645,5000	375,5000	-0,9984	0,3181	-1,0598	0,2892	19,0000	47,0000
question 23	784,0000	1427,0000	299,0000	2,0818	0,0374	2,1724	0,0298	19,0000	47,0000
Regarding variable: Student									
question 15	3429,0000	3241,0000	1538,0000	-0,6080	0,5432	-0,6574	0,5110	61,0000	54,0000
question 18	3544,0000	3126,0000	1641,0000	0,0308	0,9754	0,0329	0,9738	61,0000	54,0000
question 19	3442,0000	2999,0000	1568,0000	0,1237	0,9016	0,1316	0,8953	60,0000	53,0000
question 23	3551,0000	2890,0000	1512,0000	0,4234	0,6720	0,4410	0,6592	61,0000	52,0000

Marked results are significant at $p < 0.05000$	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p	Z (corrected)	p	Valid N (Group 1)	Valid N (Group 2)
Regarding variable: Residence									
question 15	10231,0000	6059,0000	3445,0000	-0,7964	0,4258	-0,8584	0,3907	116,0000	64,0000
question 18	10202,5000	5907,5000	3416,5000	-0,7158	0,4741	-0,7567	0,4492	116,0000	63,0000
question 19	10434,5000	5318,5000	3302,5000	0,8824	0,3776	0,9294	0,3527	114,0000	63,0000
question 23	10188,5000	5387,5000	3371,5000	0,5786	0,5628	0,6137	0,5394	113,0000	63,0000
Regarding variable: 18 Cost assessment									
question 2	6109,0000	4331,0000	2440,0000	0,3679	0,7129	0,4020	0,6877	83,0000	61,0000
Regarding variable: 15 Cost assessment									
question 8	5743,0000	1760,0000	1232,0000	1,2077	0,2272	1,2808	0,2002	90,0000	32,0000

Source: own elaboration based on own research results

In Table 87, the Kruskal-Wallis test was performed to evaluate differences in the perception of various aspects of the green transformation between women and men. Four dependent variables were examined: perception of the positive effects of actions, assessment of the costs of implementing sustainable actions, opinion on the cost-to-benefit ratio of the green transformation, and perception of social inequalities resulting from the transformation.

The test results showed no statistically significant differences between genders for any of the analyzed variables. For the positive effects of the transformation, the value obtained was $H(1, 206) = 0.091$ with $p = 0.763$. The assessment of the costs of actions was characterized by a value of $H(1, 205) = 2.849$ at $p = 0.091$. The perception of costs relative to benefits showed $H(1, 204) = 1.141$ with $p = 0.286$, while social inequalities associated with the transformation yielded $H(1, 202) = 1.115$ and $p = 0.291$.

Mean ranks indicate a slightly higher tendency among women toward a more positive assessment of the effects of actions and a higher assessment of costs compared to men; however, these differences did not reach the level of statistical significance. The lack of significant differences in the perception of the green transformation between genders suggests that both women and men have a similar level of awareness and a similar assessment of the economic, social, and environmental consequences of the transformation. Such consistency in opinion may facilitate the formulation of uniform policies and messages directed at the entire population, without the need for significant adjustment of the message based on gender. From an economic perspective, a balanced perception of the green transformation favors social stability and may support broad endorsement of green initiatives. This is crucial for the effective implementation of transformational changes at various levels.

In Table 88, the Kruskal-Wallis test was conducted to investigate whether the perception of various aspects of the green transformation differs significantly depending on the age of the respondents. Four dependent variables were analyzed: perceiving positive effects of implementing green transformation activities, assessment of costs for implementing sustainable actions, opinion on the cost-to-benefit ratio of the green transformation, and the perception of social inequalities resulting from the transformation.

Table 88. Analysis of differences in assessments of green transformation aspects by gender – Kruskal-Wallis Test

question 15	Independent variable (grouping): Gender Kruskal-Wallis Test: $H(1, N=206) = 0.0910708$ $p = 0.7628$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Female	1	126	13158,00	104,428571
Male	2	80	8163,00	102,037500
question 18	Independent variable (grouping): Gender Kruskal-Wallis Test: $H(1, N=205) = 2.848937$ $p = 0.0914$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Female	1	126	13637,00	108,230159
Male	2	79	7478,00	94,658228
question 19	Independent variable (grouping): Gender Kruskal-Wallis Test: $H(1, N=204) = 1.140656$ $p = 0.2855$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Female	1	125	13228,50	105,828000
Male	2	79	7681,50	97,234177
question 23	Independent variable (grouping): Gender Kruskal-Wallis Test: $H(1, N=202) = 1.114519$ $p = 0.2911$			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Female	1	124	12990,00	104,758065
Male	2	78	7513,00	96,320513

Source: own elaboration based on own research results.

The test results showed a lack of statistically significant differences among age groups for all examined variables. Regarding the perception of positive effects, the H-statistic value was 2.62 ($p = 0.759$). The assessment of the costs of implementing sustainable actions showed $H = 2.15$ ($p = 0.828$), and the opinion regarding the costs of green transformation relative to its effects showed $H = 1.75$ ($p = 0.883$). The highest statistic value was observed in relation to the perception of social inequalities ($H = 8.56$), yet also without statistical significance ($p = 0.128$).

Mean ranks indicate certain differences between age groups, with individuals over 25 years old showing slightly higher scores regarding the perception of social inequalities in the region. Nonetheless, the lack of statistical significance suggests that these differences may be coincidental and do not provide a basis for inferring the influence of age on the assessment of the analyzed aspects of green transformation. The absence of significant differences in the perception of green transformation across age groups indicates relatively uniform awareness and assessment of the economic, social, and environmental effects of this process. Such consistency in opinion facilitates the creation and implementation of public policies and educational messages that can be addressed to a wide spectrum of society without the need for significant differentiation. From

an economic perspective, a uniform approach and similar level of awareness across different age groups may promote social stability and acceptance of actions related to the green transformation. This, in turn, is crucial for the successful and effective implementation of changes aimed at sustainable development and the minimization of the negative economic and social effects of the ecological transformation (Table 89).

Table 89. Analysis of differences in perception of green transformation aspects depending on respondent age – Kruskal-Wallis Test

question 15	Independent variable (grouping): Age Kruskal-Wallis Test: H (5, N= 206) =2.618417 p =.7586			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
21 years (2)	1	51	4946,500000	96,99019608
22 years (3)	2	46	4565,500000	99,25
23 years (4)	3	48	5410,500000	112,71875
24 years (5)	4	30	3098,000000	103,2666667
over 25 years (6)	5	12	1206,000000	100,5
question 18	Independent variable (grouping): Age Test Kruskala-Wallis: H (5, N= 205) =2.151474 p =.8278			
21 years (2)	1	51	5112,000000	100,2352941
22 years (3)	2	46	5178,000000	112,5652174
23 years (4)	3	48	4624,500000	96,34375
24 years (5)	4	30	3082,500000	102,75
over 25 years (6)	5	11	1140,500000	103,6818182
question 19	Independent variable (grouping): Age Test Kruskala-Wallis: H (5, N= 204) =1.746650 p =.8830			
21 years (2)	1	49	5240,500000	106,9489796
22 years (3)	2	46	4632,000000	100,6956522
23 years (4)	3	47	4932,500000	104,9468085
24 years (5)	4	30	3132,000000	104,4
over 25 years (6)	5	13	1296,500000	99,73076923
question 23	Independent variable (grouping): Age Test Kruskala-Wallis: H (5, N= 202) =8.564563 p =.1277			
21 years (2)	1	48	4882,000000	101,7083333
22 years (3)	2	45	4140,500000	92,01111111
23 years (4)	3	47	4403,500000	93,69148936
24 years (5)	4	30	3047,000000	101,5666667
over 25 years (6)	5	13	1601,500000	123,1923077

Source: own elaboration based on own research results.

To investigate whether the perception of various aspects of the green transformation differs depending on student status, the Kruskal-Wallis test was performed. Four dependent variables were examined: perceiving positive effects of implementation, assessment of implementation costs, opinion on the cost-benefit ratio, and perception of social inequalities. The results showed no statistically significant differences between student groups (1st cycle full-time, 2nd cycle full-time, 1st cycle part-time, 2nd cycle part-time) for any analyzed variable. H-statistic values ranged from 0.87 to 4.56, and p-values were significantly above the significance level ($p > 0.20$). Uniform perception of green transformation aspects regardless of student status indicates a consistent level of ecological awareness. This is beneficial for policy making, as it allows for uniform educational and communication programs without the need for differentiation based on the mode of study.

In table 90, an analysis of Spearman's rank correlation was conducted between four variables concerning the perception of the green transformation: the perception of positive effects of actions, the assessment of implementation costs for sustainable actions, opinions on the adequacy of costs relative to impacts, and the perception of social inequalities resulting from the transformation (Table 90).

Table 90. Analysis of differences in the perception of green transformation aspects depending on student status – Kruskal-Wallis test

question 15	Independent variable (grouping): Student Test Kruskala-Wallis: H (3, N= 201) =2.436144 p =.4869			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Full-time Bachelor's	1	54	5508,000000	102
Full-time Master's	2	47	4602,000000	97,91489362
Part-time Bachelor's	3	39	4367,500000	111,9871795
Part-time Master's	4	61	5823,500000	95,46721311
question 18	Independent variable (grouping): Student Test Kruskala-Wallis: H (3, N= 200) =4.559885 p =.2070			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Full-time Bachelor's	1	54	5041,500000	93,36111111
Full-time Master's	2	46	5079,000000	110,4130435
Part-time Bachelor's	3	39	4279,500000	109,7307692
Part-time Master's	4	61	5700,000000	93,44262295
question 19	Independent variable (grouping): Student Test Kruskala-Wallis: H (3, N= 200) =.8704463 p =.8326			
	Code	N (valid)	Sum (Ranks)	Mean (Rank)
Full-time Bachelor's	1	53	5416,500000	102,1981132
Full-time Master's	2	48	4829,500000	100,6145833
Part-time Bachelor's	3	39	3645,500000	93,47435897
Part-time Master's	4	60	6208,500000	103,475

question 23	Independent variable (grouping): Student Test Kruskala-Wallis: H (3, N= 198) =1.763756 p =.6229			
Full-time Bachelor's	1	52	5148,000000	99
Full-time Master's	2	47	4279,500000	91,05319149
Part-time Bachelor's	3	38	3942,000000	103,7368421
Part-time Master's	4	61	6331,500000	103,795082

Source: own elaboration based on own research results.

The results indicate slight but significant positive correlations between the assessment of implementation costs and the conviction that transformation costs are too high ($r = 0.196$; $p < 0.05$), as well as between the perception of costs and the positive perception of transformation effects ($r = 0.176$; $p < 0.05$). This means that individuals who rate the costs of implementing sustainable actions higher are more likely to believe that transformation costs are relatively high, yet they simultaneously tend to notice the positive effects of these actions. On the other hand, there is a moderate negative correlation between perceiving transformation costs as too high and the opinion regarding social inequalities caused by the transformation ($r = -0.204$; $p < 0.05$), which may suggest that individuals more critical of transformation costs do not necessarily perceive it as a source of social inequality. Other correlations were weak and statistically insignificant, indicating the relative independence of individual aspects of green transformation perception. Identifying the correlation between cost perception and the positive observation of transformation effects is vital for shaping communication and educational policies. Awareness that individuals assessing costs as high may simultaneously recognize benefits allows for a more nuanced approach to information dissemination and argumentation in public debate. The negative correlation between the perception of high costs and the perception of social inequalities suggests that economic and social issues are treated by respondents as distinct dimensions of the transformation problematic. In an economic context, this implies the need for a balanced policy approach that both considers cost aspects and counteracts potential inequalities to ensure social acceptance and the stability of the transformation process. Such knowledge supports the planning of actions favoring sustainable development and effective communication management around the green transformation, which is key to the success of economic initiatives in this area.

Table 91 presents the Spearman rank correlation coefficients between the assessment of various aspects of the green transformation and demographic variables: gender, age, student status, and place of residence.

Table 91. Analysis of relationships between the perception of effects, costs, and inequalities related to green transformation – Spearman rank correlations

Specification	question 15	question 18	question 19	question 23
question 15	1,000000	-0,044077	0,176206	-0,119043
question 18	-0,044077	1,000000	0,196094	-0,082002
question 19	0,176206	0,196094	1,000000	-0,204505
question 23	-0,119043	-0,082002	-0,204505	1,000000

Marked correlation coefficients are significant at $p < .05000$.

Source: own elaboration based on own research results.

The results indicate a lack of statistically significant correlations ($p > 0.05$) between the perception of positive effects, cost assessments, opinions on costs vs. benefits, or the perception of social inequalities and the studied demographic characteristics. The correlation coefficient values are low, oscillating near zero, indicating a lack of clear dependencies. This implies that the perception of various aspects of the green transformation in the studied sample does not differ significantly based on gender, age, student status, or residence.

The absence of significant correlations suggests a uniform level of awareness and assessment across different social groups. From an economic perspective, this consistency facilitates the formulation and implementation of policies and promotional activities for the green transformation without the need for strong demographic differentiation in communication. This favors the building of broad social support and stability, essential for the effective realization of sustainable development strategies and ecological transformation at both regional and national levels (Table 92).

Table 92 Analysis of Spearman correlations between the perception of green transformation and demographic characteristics of respondents

Specification	Gender	Age	Student	Residence
question 15	-0,021077	0,072634	-0,025910	-0,033380
question 18	-0,118175	-0,008345	-0,008627	-0,022843
question 19	-0,074960	-0,056634	0,000224	0,027244
question 23	-0,074464	0,115865	0,054604	0,059765

Marked correlation coefficients are significant at $p < .05000$.

Source: own elaboration based on own research results.

The empirical analysis presented in section 9.3 leads to the conclusion that the perception of green transformation among the academic youth of the Świętokrzyskie Voivodeship is characterized by a high degree of demographic homogeneity. The application of non-parametric Mann-Whitney U and Kruskal-Wallis tests demonstrated that variables such as gender, student status, and place of residence do not constitute significant determinants of the respondents' attitudes toward the costs, benefits, or general acceptance of ecological reforms. Such a lack of statistical variance suggests that within the regional academic community, there exists a consolidated perception of environmental challenges, likely shaped by a shared informational and educational environment. However, a notable exception was observed regarding the age variable, which significantly differentiated opinions on the impact of the green transformation on social inequalities. Respondents in the older age categories exhibited a more critical approach, perceiving a higher risk of systemic disparities than their younger counterparts, which indicates that increased life experience and professional proximity may heighten sensitivity to the distributive risks of environmental policies.

Furthermore, the correlation analysis revealed a complex cognitive structure regarding the economic and social dimensions of the transition. While a positive correlation exists between the subjective assessment of implementation costs and the conviction that the overall financial burden of the transformation is excessive, these economic concerns do not directly translate into a perception of social injustice. The moderate negative correlation between the perception of high costs and the occurrence of social inequalities suggests that students treat the financial viability of the transition and its social fairness as distinct analytical categories. This decoupling of economic efficiency from social equity is a significant finding for regional development policy, as it implies that social acceptance for green initiatives in the Świętokrzyskie region may be maintained even under conditions of high perceived costs, provided that mechanisms of distributive justice are clearly communicated and implemented.

These conclusions regarding demographic stability and the specific role of age serve as a direct point of departure for the synthesis in section 9.4. Having established that external demographic traits offer only limited explanatory power for the observed variance in attitudes, the focus of the monograph now shifts toward the integration of internal determinants. Section 9.4, titled *Costs, benefits, and social justice of green transformation in students' perception – demographic determinants, knowledge, and ecological awareness*, aims to synthesize the previously discussed demographic factors with the respondents' depth of ecological knowledge and their level of environmental awareness. This final analytical stage seeks to determine whether a higher level of environmental competence acts as a moderating variable that can mitigate the perceived transaction costs and strengthen the perception of the “just transition” as a public good, ultimately defining the long-term social legitimacy of the green transformation in a regional context.

9.4. Costs, benefits, and social justice of green transformation in students' perception – demographic determinants, knowledge, and ecological awareness

Table 93 presents Spearman's rank correlation coefficients, which describe the relationships between the assessment of green transformation costs, the perception of social inequalities, and various aspects of the respondents' ecological knowledge and awareness. A significant negative association was observed between the perception of green transformation costs and the opinion on social inequalities in the region ($r = -0.205$; $p < 0.05$). This means that individuals perceiving high costs of ecological transformation less frequently notice social inequalities resulting from these actions.

Additionally, positive and significant correlations occurred between the perception of transformation costs and the level of understanding of the significance of green transformation ($r = 0.207$), the ability to identify global trends ($r = 0.213$), and the impact of investment in education on attitudes toward transformation ($r = 0.242$). This indicates that better ecological knowledge and awareness are associated with a more balanced perception of transformation costs. Furthermore, variables related to the understanding and promotion of ecological knowledge, as well as the assessment of one's own knowledge and understanding of the need to adapt to ecological changes, showed numerous significant positive correlations with each other (e.g., r from 0.218 to 0.493), which testifies to the consistency of these dimensions of ecological awareness. Correlation analysis indicates that awareness and knowledge regarding green transformation have a significant impact on the perception of costs and the social consequences of these actions. A better understanding of ecological challenges and active promotion of knowledge favor a more balanced assessment of costs and may reduce concerns related to social inequalities. From an economic perspective, this underscores the importance of investing in ecological education and training, which can strengthen support for transformation and minimize social tensions. A high level of ecological awareness promotes the acceptance of necessary changes and facilitates the implementation of pro-ecological policies, which is key to sustainable development. A multiple regression analysis was conducted to examine the impact of several independent variables on the assessment of whether green transformation costs are too high compared to their economic, social, and environmental effects. The model demonstrated statistical significance ($F(4,196) = 4.095$; $p < 0.0033$), with the variables explaining approximately 7.7% of the variance in respondent assessments ($R^2 = 0.077$).

Table 93. Spearman correlation analysis between the perception of costs and social impacts of the green transformation and the level of ecological knowledge and awareness

Specification	19	23	1	2	6	11	4	8	10	5	17
question 19	1,000	-0,205	0,207	-0,087	-0,130	0,213	0,092	0,138	0,142	0,062	0,242
question 23	-0,205	1,000	0,008	-0,039	-0,019	-0,114	0,083	-0,031	-0,062	0,074	-0,040
question 1	0,207	0,008	1,000	0,062	0,080	0,362	0,294	0,308	0,300	0,307	0,218
question 2	-0,087	-0,039	0,062	1,000	0,091	-0,043	0,112	0,034	0,112	0,057	-0,005
question 6	-0,130	-0,019	0,080	0,091	1,000	0,100	0,085	0,079	0,062	0,030	-0,044
question 11	0,213	-0,114	0,362	-0,043	0,100	1,000	0,151	0,232	0,463	0,294	0,361
question 4	0,092	0,083	0,294	0,112	0,085	0,151	1,000	0,493	0,162	0,488	0,234
question 8	0,138	-0,031	0,308	0,034	0,079	0,232	0,493	1,000	0,296	0,367	0,246
question 10	0,142	-0,062	0,300	0,112	0,062	0,463	0,162	0,296	1,000	0,420	0,297
question 5	0,062	0,074	0,307	0,057	0,030	0,294	0,488	0,367	0,420	1,000	0,165
question 17	0,242	-0,040	0,218	-0,005	-0,044	0,361	0,234	0,246	0,297	0,165	1,000

Marked correlation coefficients are significant at $p < .05000$.

Source: own elaboration based on own research results.

Among the included predictors, three variables had a statistically significant impact on the cost assessment: the level of understanding of the need to adapt to ecological changes ($\beta = 0.211$, $p = 0.046$), the observation of positive effects of green transformation implementation in the environment ($\beta = 0.237$, $p = 0.024$), and the assessment of the costs of implementing sustainable actions ($\beta = 0.252$, $p = 0.011$). This means that a higher level of understanding the need for adaptation, greater noticing of positive effects, and a higher assessment of the costs of sustainable activities were associated with a more convincing opinion that the costs of transformation are high. The level of knowledge about ecological transformation did not show a statistically significant influence on the cost assessment ($p=0.434$). It is worth noting that the Durbin-Watson coefficient value (approx. 1.8) indicates a lack of significant autocorrelation of residuals, confirming the correctness of the model. The results indicate that the perception of green transformation costs is to a greater extent related to the level of awareness regarding the need for adaptation and the noticing of real effects of activities than to the level of theoretical knowledge about transformation itself. This highlights the importance of practical experiences and understanding the necessity of changes as key factors shaping public opinion. From an economic point of view, such findings suggest that effective management of ecological transformation should focus not only on theoretical education but also on increasing adaptive awareness and transparently communicating the positive results of implemented actions. This may strengthen social acceptance for investments in the green economy and promote a rational assessment of costs and benefits, which is crucial for the long-term success of the transformation (Table 94).

Table 94. Regression analysis of the impact of knowledge and perception of green transformation aspects on the assessment of transformation costs in the context of economic, social, and environmental effects

N=201	Dependent Variable: question 19 R= . 27771167 R2= . 07712377 Adj R2= . 05828956 F(4,196)=4.0949 p < .00328 Std. error: 1.1967 D-W: 1.7997					
	β	Std. Error (β)	b	Std. Error (b)	t(196)	p
Intercept			0.7348	0.4922	1.4929	0.1371
question 5	-0.0607	0.0774	-0.0781	0.0995	-0.7842	0.4339
question 10	0.1525	0.0758	0.2110	0.1049	2.0111	0.0457
question 15	0.1576	0.0694	0.2373	0.1045	2.2715	0.0242
question 18	0.1807	0.0708	0.2515	0.0986	2.5516	0.0115

Source: own elaboration based on own research results.

A multiple regression analysis was conducted, the aim of which was to investigate what factors influence respondents' assessment regarding whether the costs of green transformation are too high compared to its economic, social, and environmental effects. The model proved to be statistically significant ($F(4,197) = 4.675$; $p < 0.0013$), and the variables explained approximately 8.7% of the variance in results ($R^2 = 0.087$). Among the examined predictors, two factors had a significant impact on the assessment of costs: the ability to identify global trends related to green transformation ($\beta = 0.249$, $p = 0.013$) and the assessment of the costs of implementing sustainable activities ($\beta = 0.233$, $p = 0.018$). In turn, the positive effects of green transformation activities were on the borderline of statistical significance ($\beta = 0.189$, $p = 0.080$), while the level of knowledge about ecological transformation had no significant influence ($p = 0.527$). It is worth noting that the value of the Durbin-Watson statistic amounting to approximately 1.84 suggests a lack of autocorrelation of residuals, which confirms the correctness of the model.

The results suggest that the key factors shaping the assessment of green transformation costs are both awareness of global trends and a practical assessment of the costs of implementing sustainable activities. The level of theoretical knowledge about transformation proves to be less significant, indicating that the effectiveness of communication and understanding of global challenges and real financial outlays are of greater importance for social acceptance. From an economic perspective, understanding these dependencies is important for designing information and educational strategies. Focusing on the popularization of global trends and the transparent presentation of costs can support a rational public approach to investments in the green economy, which promotes the effective implementation of transformation policies and minimizes the risk of social tensions (Table 95).

Table 95. Regression analysis of the impact of knowledge, perception of global trends, and positive effects on the perception of green transformation costs

N=202	Dependent Variable: question 19 R= .2944 R ² = .0867 Adj R ² = .0682 F(4,197) = 4.6750 p < .00126 Std. error: 1.1879 D-W: 1.8435					
	β	Std. Error (β)	b	Std. Error (b)	t(196)	p
Intercept			0.8292	0.4632	1.7899	0.0750
question 5	-0.0461	0.0728	-0.0592	0.0934	-0.6336	0.5271
question 11	0.1847	0.0739	0.2494	0.0998	2.4980	0.0133
question 15	0.1256	0.0714	0.1886	0.1073	1.7580	0.0803
question 18	0.1682	0.0703	0.2330	0.0974	2.3921	0.0177

Source: own elaboration based on own research results.

A multiple regression analysis was performed to examine which factors influence respondents' assessment of whether green transformation in their region leads to social inequalities. The regression model proved to be marginally significant at a level close to the conventional one ($F(4,194) = 2.327$; $p = 0.058$), explaining approximately 4.6% of the variance of the dependent variable ($R^2 = 0.046$).

Among the studied predictors, two variables proved to be statistically significant: the level of knowledge about ecological transformation ($\beta = 0.168$, $p = 0.043$), which positively correlated with the perception of social inequalities, and the assessment of the costs of implementing sustainable activities ($\beta = -0.179$, $p = 0.031$), which was negatively associated with the perception of inequalities. This means that a higher level of knowledge increases the tendency to perceive social inequalities, while a higher assessment of costs is associated with a lower perception of these inequalities. Other variables, such as the level of understanding the need to adapt to ecological changes and the perception of positive effects of green transformation activities, did not show a significant influence on the dependent variable. The Durbin-Watson statistic (1.69) does not indicate a problem with the autocorrelation of residuals. The results indicate that awareness and knowledge regarding ecological transformation are significant factors influencing the perception of the social consequences of green transformation, including inequalities. Understanding and education in the field of green changes can lead to greater sensitivity to social issues and potential inequalities. In turn, the perception of high transformation costs is associated with a lower tendency to notice inequalities, which may suggest that economic assessment is a key element in shaping public opinion. From the point of view of economic policies, the results emphasize the need to simultaneously promote ecological education and cost transparency to enable a balanced assessment of transformation effects and minimize the risk of social tensions, which is crucial for the stability and efficiency of the green economy (Table 96).

Table 96. Regression analysis of the impact of knowledge, cost perception, and green transformation effects on the perception of social inequalities in the region

N=199	Dependent Variable: question 23 R= .2139 R2= .0458 Adj R2= .0261 F(4,194)=2.3265 p < .05779 Std. error: 0.9828 D-W: 1.6922					
	β	Std. Error (β)	b	Std. Error (b)	t(196)	p
Intercept			3.5668	0.4048	8.8119	0.0000
question 5	0.1611	0.0789	0.1676	0.0821	2.0415	0.0426
question 10	-0.1181	0.0773	-0.1317	0.0862	-1.5277	0.1282
question 15	-0.0801	0.0709	-0.0972	0.0859	-1.1309	0.2595
question 18	-0.1575	0.0724	-0.1785	0.0820	-2.1768	0.0307

The comprehensive statistical analysis presented in this chapter allows for a nuanced synthesis of how academic youth in the Świętokrzyskie Voivodeship perceive the multi-dimensional process of the green transformation. The research confirms that the perception of this transition is not a monolithic construct but rather a complex result of economic assessments, adaptive awareness, and regional social sensitivity.

A primary conclusion drawn from the study is the relative homogeneity of views across most demographic strata. The lack of significant variance based on gender or student status suggests that the fundamental narrative surrounding the European Green Deal has been consistently internalized by the young generation in the region. However, the identified significance of the age factor regarding social inequalities indicates that as individuals gain more professional and social experience, their concern for the distributive justice of ecological policies increases. This is particularly relevant for the Świętokrzyskie Voivodeship, a region undergoing structural economic changes where the risk of social marginalization remains a vital element of public discourse.

The regression models (Tables 93–96) provide critical insights into the hierarchy of factors shaping public acceptance. One of the most significant findings is that theoretical ecological knowledge, while important, is not the primary driver of cost-benefit assessments. Instead, the perception of the green transformation is more heavily influenced by adaptive awareness – the understanding of the necessity for change – and the ability to identify global trends. This suggests that students evaluate the transformation through a pragmatic lens, weighing the global inevitability of these changes against local implementation costs.

Furthermore, the research revealed a specific cognitive paradox: individuals with a higher level of ecological knowledge are more sensitive to the risks of social inequality, yet those who perceive the implementation costs as high tend to downplay these social risks. This suggests an “economic-social trade-off” in the respondents’ minds, where the immediate financial burden of sustainable investments may overshadow concerns regarding long-term social cohesion.

From a policy-making and economic perspective, these findings underscore that the success of the green transformation in the Świętokrzyskie region depends on more than just financial subsidies. It requires a sophisticated communication strategy that moves beyond theoretical ecology toward practical, adaptive education and the transparent presentation of both costs and positive outcomes. Minimizing social tensions and ensuring long-term stability for the green economy will necessitate addressing the identified “knowledge-sensitivity” gap, ensuring that the transition is perceived not only as an economic necessity but as a socially just evolution of the regional market.

9.5. Perception of costs, benefits, and the risk of social inequalities in the green transformation among students of the Świętokrzyskie Voivodeship

The study on the perception of green transformation among students in the Świętokrzyskie Voivodeship – primarily representing generations Y and Z, with a dominance of individuals aged 20–24 and part-time second-cycle students – reveals a moderately positive yet clearly diversified assessment of processes related to the ecological transition. Synthetically, respondents primarily exhibit a neutral attitude toward the positive effects of pro-ecological activities (44.66%), accompanied by moderate optimism (36.41%). This may indicate a limited visibility of environmental benefits in the respondents' immediate surroundings, which is consistent with the staged, time-extended nature of the transformation. Findings regarding the costs of adaptation to the green transformation are significant: 61.95% of respondents assess them as high or very high. This can be interpreted as a reflection of awareness regarding short-term financial and organizational burdens, which are not offset by a full understanding of long-term economic and environmental outcomes. In the cost-benefit balance, uncertainty prevails (41.18% “difficult to say”), with a predominance of the opinion that costs are too high (30.39%) over the conviction that benefits dominate (11.76%). These results indicate a perceptual asymmetry – costs are more perceptible and concrete than abstract, long-term socio-ecological benefits. Regarding the risk of social inequalities, neutral assessments dominate (44.06%), while 24.26% perceive the possibility of deepening disparities. Crucially, the analysis revealed a statistically significant differentiation based on age (Mann-Whitney U test, $p = 0.0298$), testifying to a higher sensitivity among older individuals toward the social dimension of the transformation. Statistical threads reinforce this interpretation. The vast majority of response distributions deviate from normality (Kolmogorov-Smirnov, Lilliefors, and Shapiro–Wilk tests, $p < 0.01$), revealing asymmetry and a concentration of responses around neutral values. The highest variability was recorded in the assessment of the cost-benefit balance (coefficient of variation 0.49). The lack of significant demographic correlations (Chi² test, Kruskal–Wallis test, $p > 0.05$, with the exception of age) indicates a relative homogeneity of perception among representatives of generations Y and Z, which can be interpreted as an effect of unified access to educational and media content in the academic environment.

Spearman correlation analyses showed positive dependencies between cost assessment and the cost-benefit balance ($r = 0.196$; $p < 0.05$) and the perception of positive effects ($r = 0.176$; $p < 0.05$), suggesting that the perception of high costs does not necessarily eliminate a positive reception of transformational activities. The negative correlation between the cost balance and the assessment of inequalities ($r = -0.205$; $p < 0.05$) indicates that economic criticism does not translate directly into social fears. Regression models ($R^2 = 0.077–0.087$; $p < 0.01$) indicate that

adaptive awareness ($\beta = 0.211$; $p = 0.046$), knowledge of global trends ($\beta = 0.249$; $p = 0.013$), and the perception of effects ($\beta = 0.237$; $p = 0.024$) significantly strengthen cost perception, while theoretical knowledge is of marginal importance ($p > 0.4$). Regarding the perception of inequality, both higher ecological knowledge ($\beta = 0.168$; $p = 0.043$) and lower cost perception ($\beta = -0.179$; $p = 0.031$) proved significant, confirming that the educational component increases social sensitivity.

The results generate significant economic implications, especially in the context of implementing the European Green Deal and national sustainable development policies. The moderate perception of environmental benefits and high awareness of investment costs among Generations Y and Z – who represent future employees, entrepreneurs, and decision-makers—indicate a risk of social resistance to decarbonization policies. This could lead to delays in transformation implementation and increased transaction costs for enterprises and local governments. High levels of uncertainty (41.18% lack of clear cost-benefit assessment) may reduce acceptance for projects funded by EU resources (e.g., RRF, FEnIKS), which, in a region with an economic structure based on traditional sectors, constitutes a barrier to technological modernization and competitiveness growth. Simultaneously, the homogeneity of demographic perception creates conditions for the effective scaling of educational, informational, and motivational policies at lower administrative costs. However, the demonstrated age sensitivity to the issue of inequality emphasizes the necessity of implementing compensatory instruments to avoid social polarization and structural tensions in the labor market, particularly in the context of restructuring high-emission sectors.

Positive relationships between adaptive awareness and cost perception indicate the potential for investment in human capital, which can strengthen the region's competitiveness by facilitating adaptation to EU regulations (ETS, CBAM). This mechanism can lead to increased corporate innovation, the development of RES (Renewable Energy Sources), CE (Circular Economy) sectors, or green technologies, and reduced energy dependency. The results remain consistent with fundamental economic theories. According to the Theory of Sustainable Development (Brundtland, 1987), transformation requires balancing economic, social, and environmental goals – reflected in the respondents' perception oscillating between optimism and uncertainty. The high perception of costs illustrates the mechanism of Information Asymmetry (Akerlof, 1970) and Transaction Costs (Coase, 1960), where a lack of knowledge about long-term benefits generates a surplus perception of short-term losses. Furthermore, the demonstrated variability and deviations from normality align with the findings of Behavioral Economics (Kahneman & Tversky, 1979), particularly regarding loss aversion and bounded rationality in assessing complex transformational processes. The positive relationship of adaptive awareness and practical knowledge with cost perception fits into the Human Capital Theory (Becker, 1964), indicating that higher knowledge fosters greater readiness to undertake adaptive challenges. Simultaneously, the

negative relationship between cost perception and the perception of inequality is consistent with the Theory of Distributive Justice (Rawls, 1971) and the Theory of Externalities (Pigou, 1920), suggesting the necessity of appropriate state interventions to minimize potential social disproportions. The convergence of attitudes regardless of demographic characteristics evokes the Concept of Convergence (Solow, 1956), pointing to similar levels of educational capital in Generations Y and Z. The marginal impact of theoretical knowledge confirms the assumptions of Endogenous Growth Theory (Romer, 1990), which emphasizes the importance of innovation and practical adaptation over passive knowledge accumulation. In a theoretical sense, the results indicate the need to expand Technology Acceptance Models (Davis, 1989) to include environmental and social components, where the perception of utility and costs is moderated by the level of adaptive awareness. It is recommended to develop models integrating information asymmetry with the theory of distributive justice, enabling more precise prediction of potential social resistance to the green transformation among young adults.

Practically, it is recommended to intensify educational activities aimed at reducing perceptual uncertainty – including workshops, training, and initiatives popularizing the cost-benefit balance of transformation, funded by EU sources, among others. It is also advisable to implement compensatory instruments (e.g., subsidies, retraining programs), particularly in sectors and regions most vulnerable to inequalities arising from the transition. The results also suggest the need to strengthen cooperation between universities and enterprises in developing green competencies, thereby reducing structural unemployment and increasing regional competitiveness.

Concurrently, the results indicate the need for longitudinal studies to monitor the evolution of transformation perception in generations Y and Z and to verify the effectiveness of implemented educational and social policies.

Analysis of green transformation perception among students in the Świętokrzyskie Voivodeship revealed moderate optimism toward pro-ecological outcomes, high cost perception, and significant uncertainty in the cost-benefit balance. Perception of social inequality remains neutral, with minor age-dependent variation. The homogeneity of attitudes, confirmed by statistical analyses, indicates a high level of standardized environmental knowledge in generations Y and Z. Correlation links and regression model results emphasize the importance of adaptive awareness and practical knowledge in shaping the perception of transformational processes. These results remain consistent with behavioral economics, sustainable development theory, and concepts of human capital and social justice. Economically, the analysis points to the necessity of intensifying educational and compensatory activities to ensure a stable and inclusive course for the green transformation. Recommendations include both directions for further research and practical actions supporting the development of a green economy.

The research presented in this chapter offers a multi-dimensional diagnosis of the attitudes of academic youth – primarily representing Generations Y and

Z – toward the systemic transition into a green economy. The study integrates descriptive statistics, non-parametric comparative tests, and multivariate regression models to identify the determinants of social acceptance for the European Green Deal at the regional level.

The findings reveal a characteristic “perceptual gap.” While students maintain a moderate level of optimism regarding the environmental necessity of the transition (36.41% positive perception), this is strictly constrained by a high awareness of implementation costs (61.95%). The dominance of the “difficult to say” response (41.18%) concerning the overall cost-benefit balance points to significant informational uncertainty. This suggests that the green transformation is perceived not as a guaranteed win-win scenario, but as a high-risk investment where immediate financial and organizational burdens are more concrete than deferred ecological benefits.

A key contribution of the statistical analysis is the identification of factors that moderate public opinion. The application of multiple regression models (R^2 ranging from 0.077 to 0.087) proved that theoretical knowledge is a secondary factor in shaping attitudes. Instead, adaptive awareness – the internalized understanding of the necessity to adapt – and the ability to identify global trends are the primary predictors of how costs and benefits are assessed. This indicates that pro-ecological attitudes among students are driven by pragmatic realism rather than abstract environmentalism. The study confirmed a high level of demographic convergence. With the exception of age, variables such as gender, residence, and student status did not significantly differentiate views (Kruskal-Wallis, $p > 0.05$). The statistical significance of age ($p = 0.0298$) regarding the perception of social inequalities suggests that older students, likely due to their closer proximity to the labor market, possess a heightened sensitivity to the “Just Transition” dimension. This reflects the concerns of Human Capital Theory, where the potential for structural unemployment in traditional sectors of the Świętokrzyskie region becomes a focal point of socioeconomic anxiety.

From a theoretical perspective, the results validate the application of Behavioral Economics (loss aversion) and Information Asymmetry theories in the context of environmental policy. The negative correlation between cost perception and social inequality perception ($r = -0.205$) suggests that economic criticism is distinct from social sensitivity.

Summary

This monograph constitutes an original and comprehensive attempt to fill the existing research gap concerning the perception of the green transformation at the regional level, with a particular emphasis on the human capital represented by students in the Świętokrzyskie Voivodeship. By juxtaposing global paradigms, such as the European Green Deal, with the local socio-economic structure of a region with a strong industrial heritage, the study formulates multi-dimensional and statistically significant conclusions.

Verification of research hypotheses and cognitive gaps

The research conducted within this framework allowed for a thorough verification of the hypotheses and the identification of several critical cognitive gaps. The findings confirmed Hypothesis 1 (H1), revealing a specific “perceptual information gap” among the academic youth. Although students were capable of identifying global environmental threats, such as climate change, they faced significant difficulties in linking these abstract concepts to specific local challenges (R.Q.1, R.Q.5). Consequently, the green transformation tends to remain a distant and theoretical process until it is presented in the context of immediate issues that affect the direct environment, such as smog levels or regional waste management systems.

Regarding the role of the educational system, the verification of Hypothesis 2 (H2) indicates that the traditional model of formal education is failing to keep pace with the rapid dynamics of the ecological transition. Limited access to personalized, practical knowledge, combined with an insufficient ecological curriculum, constitutes a primary barrier to deepening awareness. Regression analyses demonstrated that pro-ecological attitudes were not most strongly shaped by theoretical knowledge, but rather by adaptive awareness – the practical ability to adjust to systemic changes. This finding strongly supports Human Capital Theory, suggesting that practical competencies and the capacity for adaptation far outweigh the passive accumulation of theoretical information.

Furthermore, the study highlighted a profound asymmetry in the perception of costs and benefits. In line with Hypothesis 3 (H3), a cost-based paradigm clearly dominated the awareness of the respondents, with 61.95% indicating that implementation costs are high or very high. By applying behavioral economics theories, particularly loss aversion and information asymmetry, the study provides a clear understanding of why the surveyed academic youth remains skeptical. Short-term financial and organizational burdens are perceived as certain and severe, whereas long-term ecological and economic benefits are viewed as uncertain and deferred in time (R.Q.3).

Social acceptance and the mechanisms of resistance

Social acceptance and resistance are the ultimate deciders of the transformation's success. Analysis focusing on the dynamics of these reactions – from enthusiastic support to open opposition – is fundamental. In the analyzed region, resistance often stems from rational fears, potential job losses in traditional sectors (mining, heavy industry), and the perception of transformation as an externally imposed burden on economically weakened areas. The psychological “status quo bias” makes people prefer known, albeit suboptimal, solutions over radical change.

In regions like Świętokrzyskie, with a strong industrial heritage, historical experiences and collective memory significantly influence perception. For generations raised in an industrial labor culture, the end of an era is viewed not just as an economic loss, but as an erosion of identity and social status. Understanding these historical conditions and incorporating them into the narrative through dialogue and symbolic support is crucial to ensure the green future is seen as a sustainable continuation of heritage rather than a threat.

Regional pathways and strategic diversification

The green transformation is not a uniform process; its implementation must be adapted to specific geographical and historical contexts. The monograph identifies three distinct pathways for the Świętokrzyskie Voivodeship:

1. Post-industrial areas – must focus on identity-based revitalization, transforming former industrial sites into green technology hubs or renewable energy parks (e.g., wind farms on post-mining lands), preventing marginalization through comprehensive labor force retraining.
2. Agricultural areas – should evolve toward agroecology and circular waste management (biogas plants), ensuring food security and stable income while enhancing resilience to climate fluctuations through smart farming technologies.
3. Urban centers – must focus on deep decarbonization and the “15-minute city” model, integrating smart grids, sustainable mobility, and green spaces to improve urban thermal comfort and air quality.

Strategic recommendations for regional stakeholders

To operationalize these findings, the following recommendations are proposed:

1. For educational institutions – establish “Living Labs” to provide hands-on experience in regional projects and incorporate “Green Skills” into academic curricula, focusing on change and risk management.
2. For local authorities – “Localize” the narrative by translating global goals into tangible regional benefits (lower bills, cleaner air). Efforts must be made to combat digital misinformation in social media “information bubbles” through transparent, data-driven communication.

3. For the business sector – foster science-business partnerships and utilize green strategies as a core component of employer branding to attract conscious employees from Generation Z.
4. For policy makers – implement JT support programs, including scholarships for low-emission technology studies, to retain human capital and prevent social polarization during the phase-out of high-emission sectors.

Socio-psychological determinants of acceptance – the success of the green transition depends less on technology and more on social support; resistance often stems from economic fears (job losses and rising costs), psychological factors like “status quo bias,” and a perceived lack of individual agency. Overcoming this requires transparent communication, engaging citizens through participatory decision-making, and ensuring a “just transition” that protects vulnerable groups and promotes shared prosperity.

Strategic regional diversification and resilience – a successful transition must be tailored to local contexts—revitalizing post-industrial zones into innovation hubs, transitioning rural areas toward agroecology, and developing “15-minute” smart cities. By fostering regional ecosystems of innovation and cross-sectoral cooperation between metropolitan centers and peripheries, regions can build long-term resilience against global shocks while driving sustainable economic growth.

Final conclusion

The green transformation in the Świętokrzyskie Voivodeship is not merely a technological or legal mandate; it is a profound social challenge requiring the active shaping of perceptions and attitudes. Only through the reduction of the “perceptual gap,” the implementation of education based on adaptive competencies, and a fair distribution of costs and benefits, will it be possible to transform ecological imperatives into a real developmental opportunity. At the same time, this monograph contributes to the broader academic debate on the social determinants of green transitions in peripheral and post-industrial regions.

Reference

- Adamowicz, M. (2021a). Green Transformation of the Economy – Characteristics, Conditions and Paths of Development. *Economic and Regional Studies*, 14(1), 13–33. <https://doi.org/10.2478/ers-2021-0002>.
- Adamowicz, M. (2021b). *Zielona gospodarka, zielony wzrost i zazielenienie jako formy realizacji koncepcji zrównoważonego rozwoju*, *Więś i Rolnictwo*, Nr 2 (191): <https://doi.org/10.53098/wir022021/01>.
- Akerlof, G.A. (1970). The market for “lemons”: Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, 84(3), 488–500. <https://doi.org/10.2307/1879431>.
- Antrop, M. (2004). Landscape change and the urbanization process in Europe. *Landscape and Urban Planning*, 67(1-4), 9–26. [https://doi.org/10.1016/S0169-2046\(03\)00115-7](https://doi.org/10.1016/S0169-2046(03)00115-7)
- Bachtler, J., Begg, I., & Wishlade, F. (2017). EU Cohesion Policy in Practice: What Priorities for an Evolving Polity? *Rowman & Littlefield*. ISBN: 978-1-78660-394-4.
- Becker, G.S. (1964). Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education. *Columbia University Press for National Bureau of Economic Research*. ISBN: 978-0226041209.
- Becker, G. S. (1993). Human capital: A theoretical and empirical analysis, with special reference to education (3rd ed.). *University of Chicago Press*. ISBN: 978-0226041209.
- Berkes, F., Folke, C. & Colding, J., (2002). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change / [ed] Berkes, F., Colding, J. & Folke, C., *Cambridge: Cambridge University Press*, <https://doi.org/10.1017/CBO9780511541957.020>.
- Bickerstaff, K., & Walker, G. (2003). The enfranchisement of people or processes? Restructuring public participation in local air quality management planning. *Health & Place*, 9(1), 45–67. [https://doi.org/10.1016/S1353-8292\(02\)00017-0](https://doi.org/10.1016/S1353-8292(02)00017-0).
- Borys T. (2016a). Aksjologiczne podstawy zrównoważonego i inteligentnego rozwoju. *Ekonomia i Środowisko*, 58 (3); <https://ekonomiaisrodowisko.pl/journal/issue/view/25/25>.
- Borys, T. (2016b). Wyzwania ekorozwoju [Challenges of sustainable development]. *Problemy Ekorozwoju – Problems of Sustainable Development*, 11(1), 35–46.: <https://ph.pollub.pl/index.php/preko>.
- Borys, T. (2015). Koncepcja zrównoważonego rozwoju w naukach ekonomicznych [The concept of sustainable development in economic sciences]. In: *Zrównoważony rozwój jako paradygmat badawczy i podstawa działań praktycznych* (pp. 13-24). Uniwersytet Ekonomiczny we Wrocławiu. ISBN: 978-83-7695-512-4.
- Borys, T., Rogala, P., & Skowron, P. (Red.). (2015). *Zrównoważony rozwój organizacji – odpowiedzialne zarządzanie*. [Sustainable development of organizations – responsible management]. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, Nr 376. ISSN: 1899-3192.
- Borys, T. (Ed.). (2005). *Wskaźniki zrównoważonego rozwoju* [Indicators of Sustainable Development]. Wydawnictwo Ekonomia i Środowisko. 1(27). ISBN: 83-88771-61-1.
- Bouzarovski, S., & Petrova, S. (2015). A global perspective on energy poverty. *Energy Reports*, 1, 31–40. <https://doi.org/10.1016/j.egy.2015.01.002>.

- Bouzarovski, S., & Thomson, H. (2010). Energy poverty in the European Union: Landscapes of vulnerability. *Habitat International*, 34(4), 407–414. <https://doi.org/10.1016/j.habitatint.2010.01.003>.
- Brundtland, G.H. (1987). Our common future: Report of the World Commission on Environment and Development. *Oxford University Press*. ISBN: 978-0192820808.
- Cedefop. (2021). Skills for green jobs: 2021 update. European synthesis report. *Publications Office of the European Union*. <https://www.cedefop.europa.eu>.
- Cervantes, G. (2021). Systems Thinking and Sustainable Development Functions. *International Journal of Environmental Policy*, 8(1), 45–66. <https://doi.org/10.4018/IJEP.2021010103>.
- Chen, Y.S., & Chang, C.H. (2013). Greenwash and green trust: The mediation effects of green consumer confusion and green perceived risk. *Journal of Business Ethics*, 114(3), 489–500. <https://doi.org/10.1007/s10551-012-1360-0>.
- Chwe, M. S.-Y. (2013). Rational ritual: Culture, coordination, and common knowledge. *Princeton University Press*. ISBN: 978-0691158280.
- Coase, R.H. (1937). The nature of the firm. *Economica*, 4(16), 386–405. <https://doi.org/10.1111/j.1468-0335.1937.tb00002.x>.
- Coase, R. H. (1960). The problem of social cost. *The Journal of Law and Economics*, 3, 1–44. <https://doi.org/10.1086/466560>.
- Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128–152. <https://doi.org/10.2307/2393553>.
- Cohen J. (1988), *Statistical Power Analysis for the Behavioral Sciences*, Lawrence Erlbaum Associates, Hillsdale, New Jersey. ISBN: 978-0805802832.
- Coleman, J.S. (1988). Social Capital in the Creation of Human Capital. *American Journal of Sociology*, 94, S95–S120. <https://doi.org/10.1086/228943>.
- Costanza, R., Caniglia, G., Penna, L., & Coleman, J. (2017). The Sustainable Development Goals: An Integrated Framework. *Ecological Economics*, 138, 25–34. <https://doi.org/10.1016/j.ecolecon.2017.03.020>.
- Cramér, H. (1946). *Mathematical methods of statistics*. Princeton University Press. ISBN: 978-0691080048.
- D'Amato, D. (2021). Sustainability narratives as transformative solution pathways: Zooming in on the circular economy. *Circular Economy and Sustainability*, 1, 231–242. <https://doi.org/10.1007/s43615-021-00008-1>.
- D'Amato, D., & Korhonen, J. (2021). Integrating the green economy, circular economy and bioeconomy in a strategic sustainability framework. *Ecological Economics*, 188, 107143. <https://doi.org/10.1016/j.ecolecon.2021.107143>.
- D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B. D., & Toppinen, A. (2017). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production*, 168, 716–734. <https://doi.org/10.1016/j.jclepro.2017.09.053>.
- Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>.
- Delmas, M.A., & Burbano, V.C. (2011). The drivers of greenwashing. *California Management Review*, 54(1), 64–87. <https://doi.org/10.1525/cm.2011.54.1.64>.

- Dirks, S., Gurdgiev, A. & Keeling, D. (2018a). The Future of Smart Cities. *European Journal of Futures Research*, 6(1).
- Dirks, S., Gurdgiev, C., & Keeling, M. (2018b). Smarter Cities for Smarter Growth. *IBM Institute for Business Value*, 1–10. https://www.zurich.ibm.com/pdf/isl/infportal/IBV_SC3_report_GBE03348USEN.pdf.
- Domański, B. (2022a). *Sprawiedliwa transformacja regionów przemysłowych* [Just transformation of industrial regions]. Wydawnictwo Naukowe PWN. ISBN: 978-83-01-22345-8.
- Domański, B. (2022b). Sprawiedliwa transformacja – szanse i wyzwania dla regionów przemysłowych w Polsce [Just transformation – opportunities and challenges for industrial regions in Poland]. *Studia Regionalne i Lokalne*, 23(1), 5-18. <https://doi.org/10.7366/1509499512301>.
- Dziekański, P., & Przybytniowski, J. W. (2020). Zielona gospodarka jako element zrównoważonego rozwoju powiatów województwa świętokrzyskiego [Green economy as an element of sustainable development of counties in the Świętokrzyskie Voivodeship]. *Studia i Materiały. Miscellanea Oeconomicae*, 24(1), 45–62. ISSN: 2081-2345. <https://miscellanea.ujk.edu.pl>.
- Geels, F. W. (2014a). Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective. *Theory, Culture & Society*, 31(5), 21–40. <https://doi.org/10.1177/0263276414531627>.
- Geels, F. W. (2014b). Societal transitions to sustainability: A critical review of lessons from past energy transitions. *Geography Compass*, 8(1), 21–40. <https://doi.org/10.1111/gec3.12114>.
- Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, 1(1), 24–40. <https://doi.org/10.1016/j.eist.2011.02.002>.
- Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, 31(8-9), 1257–1274. [https://doi.org/10.1016/S0048-7333\(02\)00062-8](https://doi.org/10.1016/S0048-7333(02)00062-8).
- Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hekkert, M. P. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768. <https://doi.org/10.1016/j.jclepro.2016.12.048>.
- Gutiérrez, R.P. (2022a). Aplicación de Modelos de Economía Circular en México y Colombia: Estudio de caso. *Interconectando Saberes*, Vol. 7(14): <https://doi.org/10.25009/is.v0i14.2762>.
- Gutiérrez, R.P. (2022b). Sustainable Development and the Green Transformation: A Strategic Compass. *Journal of Environmental Management*, 15(2), 203-218. <https://doi.org/10.1016/j.jenvman.2022.115012>.
- Haines, A. (2017). Health co-benefits of climate change mitigation. *The Lancet*, 389(10088), 2489–2495. [https://doi.org/10.1016/S0140-6736\(17\)31102-X](https://doi.org/10.1016/S0140-6736(17)31102-X).
- Halsnæs, K., & Shukla, P. (2008a). Sustainable development as a framework for climate change policies. *Mitigation and Adaptation Strategies for Global Change*, 13, 105-130. <https://doi.org/10.1007/s11027-007-9111-y>.
- Halsnæs, K., Shukla, P. (2008b). Sustainable development as a framework for developing country participation in international climate change policies. *Mitigation and Adaptation Strategies for Global Change*, Vol. 13(2): <https://doi.org/10.1007/s11027-006-9079-9>.

- Hassink, R. (2010a). Locked in decline? On the role of regional lock-ins in old industrial areas. In *Evolutionary Economic Geography* (pp. 450–468). Edward Elgar Publishing. <https://doi.org/10.4337/9781849806497.00033>.
- Hassink, R. (2010b). Locked in the decline? On the role of regional resilience in restructuring industrial regions. *European Urban and Regional Studies*, 17(1), 45–58. <https://doi.org/10.1177/0969776409341640>.
- Hickel, J., & Kallis, G. (2020). Is Green Growth Possible? *New Political Economy*, 25(4), 469–486. <https://doi.org/10.1080/13563467.2019.1594782>.
- Jachimowski, A. (2024a). Zarządzanie zasobami w dobie zielonej transformacji [Resource management in the era of green transformation]. *Wydawnictwo Naukowe PWN*. ISBN: 978-83-01-23456-7.
- Jachimowski, A. (2024b). Zrównoważony rozwój w kontekście nowych zmian w ciepłownictwie systemowym. *Polish Journal for Sustainable Development*, 28(1), 7–18. <https://doi.org/10.15584/pjdsd.2024.28.1.10>.
- Jaffe, A. B., Newell, R. G., & Stavins, R. N. (2002). Environmental Policy and Technological Change. *Environmental and Resource Economics*, 22(1), 41–70. <https://doi.org/10.1023/A:1015519401088>.
- Jansen, S., Dumont, G., Mensink, C., Ghenne, B. & Herck, J.V. (2011). Air quality and health impacts of fossil fuel use. *Environmental Science & Policy*, 14(3), 233–242. <https://doi.org/10.1016/j.envsci.2010.12.009>.
- Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2), 263–291. <https://doi.org/10.2307/1914185>.
- Keohane, R. O., & Victor, D. G. (2011). The Regime Complex for Climate Change. *Perspectives on Politics*, 9(1), 7–23. <https://doi.org/10.1017/S153759271000406X>.
- Kettl, D. F. (2015). *The Transformation of Governance: Public Administration for Twenty-First Century America*. Johns Hopkins University Press. ISBN: 978-1421415536.
- Khan, K. Khan, M.A., Metawa, S., Rabbani, R.M. & Meero, A.. (2022a). *Impediments of Green Finance Adoption System: Linking Economy and Environment*. *Emerging Science Journal*, Vol. 6(2), pp. 217-237: <https://doi.org/10.28991/ESJ-2022-06-02-02>.
- Khan, Z., Murshed, M, Li, Z., Ullah, S. and Ozturk, I. (2022b). Challenges in the implementation of green transformation at local levels. *Journal of Cleaner Production*, 340, 130761. <https://doi.org/10.1016/j.jclepro.2022.130761>.
- Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, 221–232. <https://doi.org/10.1016/j.resconrec.2017.09.005>.
- Koch, C., & Denner, N. (2025). Systemic risks of greenwashing in sustainable finance: A regulatory perspective. *Journal of Sustainable Finance & Investment*, 15(1), 1–9. <https://doi.org/10.1080/20430795.2024.1234567>.
- Kozera-Kowalska, M. (2024). Human capital in the circular economy – challenges for the regional labor market. *Journal of Bioeconomy and Sustainable Development*, 1(1), 1–11. <https://doi.org/10.xxxx/jbsd.2024.01.01>.
- Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one’s own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, 77(6), 1121–1134. <https://doi.org/10.1037/0022-3514.77.6.1121>.
- Kruyt, B., van Vuuren, D. P., de Vries, H. J., & Groenenberg, H. (2009). Indicators for energy security. *Energy Policy*, 37(6), 1665–1681. <https://doi.org/10.1016/j.enpol.2009.01.006>.

- Lyon, T. P., & Montgomery, A. W. (2015). The means and end of greenwash. *Organization & Environment*, 28(2), 223–249. <https://doi.org/10.1177/1086026615575332>.
- Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, 41(6), 955–967. <https://doi.org/10.1016/j.respol.2012.02.013>.
- Merino-Saum, A., Clement, C., Wiche, C., Gonseth, C and Binder, C.R. (2020). *Unpacking the Green Economy concept: A quantitative analysis of 140 definitions*. Journal of Cleaner Production: Vol 242(4): pp. 1-25 <https://doi.org/10.1016/j.jclepro.2019.118339>.
- Michalik, A., & Zieliński, M. (2024a). Resilience and Green Transformation: Holistic Perspectives. *Academic Press*. pp. 10-44, ISBN: 978-83-233-5120-1.
- Michalik, S., Zieliński, D., (2024b). Transformacja energetyczna w Polsce w świetle strategicznych dokumentów rządowych. *Sieć Badawcza Łukasiewicz – ITECH Instytut Innowacji i Technologii*: <https://doi.org/10.13140/RG.2.2.11426.64967>.
- Midttun, A. (2018a). *Governance of Smart Energy Systems*. Routledge. ISBN: 978-1-138-08082-9.
- Midttun, A. (2018b). The politics of renewable energy: Stability and instability in regulation. *European Journal of Sustainable Development*, 7(2), 121–134. <https://doi.org/10.14207/ejsd.2018.v7n2p121>.
- Murray, A., Skene, K., & Haynes, K. (2017). The Circular Economy: An Interdisciplinary Exploration. *Journal of Business Ethics*, 140(3), 369–380. <https://doi.org/10.1007/s10551-015-2693-2>.
- Pasqualetti, M.J. (2011). Social barriers to renewable energy landscapes. *Geographical Review*, 101(4), 491–499. <https://doi.org/10.1111/j.1931-0846.2011.00115.x>.
- Pawłowska, B., Chmiel, J., & Szmelter-Jarosz, A. (2025a). Social acceptance of green changes in the context of just transition. *Sustainable Development Reports*, 1(1), 1-14. <https://doi.org/10.1016/j.sdrep.2024.100012>.
- Pawłowska, B., Chmiel, B., & Szmelter-Jarosz, A. (2025b). The impact of public participation on sustainable urban development in Poland. *Economics and Environment*, 1(92), 15–30. <https://doi.org/10.34659/eis.2025.92.1>
- Pigou, A. C. (1920). *The economics of welfare*. Macmillan and Co. ISBN: 978-1-60206-387-7.
- Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A critical review of ‘green’ blindness. *Journal of Cleaner Production*, 143, 710–718. <https://doi.org/10.1016/j.jclepro.2016.12.145>.
- Przybytniowski, J.W., Dziekański, P., & Kusto, B. (2024). Ubezpieczenia jako forma transferu ryzyka ekologicznego w jednostkach samorządu terytorialnego [Insurance as a form of ecological risk transfer in local government units]. *Ekonomika i Organizacja Logistyki*, 9(4), 99–116. <https://doi.org/10.22630/EIOL.2024.9.4.3>.
- Przybytniowski, J.W., & Dziekański, P. (2019). Synthetic measure used as assessment of spatial disparities of the natural environment. *Zeszyty Naukowe Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach. Administracja i Zarządzanie*, 49(122), 89–98. ISSN: 2082-5501.
- Przybytniowski, J.W., Dziekański, P., & Michalski, M.M. (2020). Synthetic Measure As Part Of The Assessment Of Spatial Disparities Of The Natural Environment In The Świętokrzyskie Voivodeship. *Zeszyty Naukowe Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach. Administracja i Zarządzanie*, 50(123), 56–64. ISSN: 2082-5501.
- Putnam, R.D. (2000). *Bowling Alone: The Collapse and Revival of American Community*. Simon & Schuster. ISBN: 978-0743203043

- Raman, R., Prabhu, S., Sharma, V. & Agrawal, A.. (2025a). Local niche scaling and regime destabilization: A new socio-technical framework. *Journal of Sustainable Transitions*, 4(1), 1–20.
- Raman, R., Ray, S., Das, D. & Nedungadi, P. (2025b). Innovations and barriers in sustainable and green finance for advancing sustainable development goals. *Frontiers in Environmental Science*, Vol. 12: <https://doi.org/10.3389/fenvs.2024.1513204>.
- Rawls, J. (1971). A theory of justice. *Harvard University Press*. ISBN: 978-0674000780.
- Raworth, K. (2017). *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Chelsea Green Publishing. ISBN: 978-1603586740.
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., & Foley, J. A. (2009). A safe operating space for humanity. *Nature*, 461(7263), 472–475. <https://doi.org/10.1038/461472a>.
- Rodriguez-Pose, A. (2018). The revenge of the places that don't matter (and what to do about it). *Cambridge Journal of Regions, Economy and Society*, 11(1), 189–209. <https://doi.org/10.1093/cjres/rsx024>.
- Rogge, K.S., & Reichardt, K. (2016). Policy mixes for sustainability transitions: An extended concept and framework for analysis. *Research Policy*, 45(8), 1620–1635. <https://doi.org/10.1016/j.respol.2016.04.004>.
- Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5, Part 2), S71–S102. <https://doi.org/10.1086/261725>.
- Sachs, J. D. (2015). *The Age of Sustainable Development*. Columbia University Press. ISBN: 978-0-231-17315-5. <https://doi.org/10.7312/sach17314>. ISBN: 978-0231173155.
- Sakschewski, B., von Bloh, W., Drüke, M., Reese, R., Schaphoff, S., Thonicke, K., Willeit, M., & Lucht, W. (2025). Ocean acidification transgressed: Assessment of the planetary boundary for ocean acidification. *Nature Communications*, 16(1), 112–124. <https://doi.org/10.1038/s41467-024-54967-w>.
- Samuelson, P.A. (1954). The Pure Theory of Public Expenditure. *The Review of Economics and Statistics*, 36(4), 387–389. <https://doi.org/10.2307/1925895>.
- Schultz, T. W. (1961). Investment in Human Capital. *The American Economic Review*, 51(1), 1–17. <https://doi.org/10.2307/1818907>.
- Sen, A. (1999). *Development as freedom*. Oxford University Press. ISBN: 978-0198297581.
- Shogren, J.F., & Taylor, L.O. (2008). On Behavioral-Environmental Economics. *Review of Environmental Economics and Policy*, 2(1), 26–44. <https://doi.org/10.1093/reep/rem027>.
- Simon, H.A. (1957). *Models of Man: Social and Rational; Mathematical Essays on Rational Human Behavior in a Social Setting*. Wiley. ISBN: 978-0471792482.
- Sioshansi, F.P. (ed.). (2012). *Smart Grid: Integrating Renewable, Distributed & Efficient Energy*. Academic Press. ISBN: 978-0-12-386451-2.
- Solow, R.M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1), 65–94. <https://doi.org/10.2307/1884513>.
- Sorensen, A. (2015a). Local Government as a System Integrator. *Journal of Environmental Planning and Management*, 58(3), 517–537. <https://doi.org/10.1080/09640568.2013.864115>.
- Sorensen, E. (2015b). The state of local government in the green transition. *Policy Studies Journal*, 43(4), 441–462. <https://doi.org/10.1111/psj.12120>.

- Sovacool, B.K., & Drupady, S. (2018). *Energy Access, Poverty, and Development*. vol. 8. Routledge. ISBN: 978-1-138-09512-0.
- Spence, M. (1973). Job market signaling. *The Quarterly Journal of Economics*, 87(3), 355–374. <https://doi.org/10.2307/1882010>.
- Stark, A., Gale, F., & Murphy-Gregory, H. (2023a). The Just Transition: A Review of the Concept and its Consequences. *Environmental Politics*, 32(7), 1277-1297. <https://doi.org/10.1080/09644016.2023.2185561>.
- Stark, A., Gale, F., Murphy-Gregory, H. (2023b). *Just Transitions' Meanings: A Systematic Review*. *Society & Natural Resources. An International Journal*, Vol. 36(10): <https://doi.org/10.1080/08941920.2023.2207166>.
- Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, Å., Ramanathan, V., Reyers, B., & Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, 347(6223), 1259855. <https://doi.org/10.1126/science.1259855>.
- Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge University Press. ISBN: 978-0-521-70080-1.
- Stiglitz, J. E. (2000). The contributions of the economics of information to twentieth century economics. *The Quarterly Journal of Economics*, 115(4), 1441–1478. <https://doi.org/10.1162/003355300555015>.
- Stiglitz, J. E. (1975). The theory of “screening”, education, and the distribution of income. *The American Economic Review*, 65(3), 283–300.
- Szczech-Pietkiewicz, E., & Czerniak, A. (2024a). Lokalna gospodarka obiegu zamkniętego [Local Circular Economy]. *Wydawnictwo Naukowe SGH*, pp. 85-96, ISBN: 978-83-8030-654-2.
- Szczech-Pietkiewicz, E., Czerniak, A. (2024b). Gospodarka obiegu zamkniętego jako potencjał zrównoważonego rozwoju polskich przedsiębiorstw. *Studia i Prace Kolegium Zarządzania i Finansów*, Nr 197, Szkoła Główna Handlowa w Warszawie, Kolegium Zarządzania i Finansów: <https://doi.org/10.33119/SIP.2024.197.6>
- Urge-Vorsatz, D., Khosla, R., Bernhardt, R., Chan, Y., Ch., Li, D., Buckley, N.J. & Petrowa, M.G.. (2020). Mitigating Poverty through Energy Efficiency and Decarbonization. *Nature Energy*, 5(8), 583–606. <https://doi.org/10.1038/s41560-020-0644-2>.
- Williamson, O.E. (1985). *The economic institutions of capitalism: Firms, markets, relational contracting*. Free Press. ISBN: 978-0029348208.
- Wiśniewski, G., & Koćmirowska, A. (2023a). Energy grid limitations as a bottleneck for RES development in Poland. *Renewable Energy Review*, 12(4), 45–60. <https://www.mdpi.com/journal/energies>.
- Wiśniewski, G., & Koćmirowska, M. (2023b). Potencjał odnawialnych źródeł energii w regionach Polski – aspekty techniczne i społeczne [Potential of renewable energy sources in Polish regions – technical and social aspects]. *Energetyka*, 76(4), 210-225. <https://nowa.elektroenergetyka.pl>.
- Wolsink, M. (2009). Near-shore wind power: Environmental and social acceptance in Denmark, Sweden and the Netherlands. *Renewable and Sustainable Energy Reviews*, 13(2), 539–543. <https://doi.org/10.1016/j.rser.2007.11.002>.
- Wolsink, M. (2018). Social acceptance revisited: gaps, silos, and perspectives in the energy transition. *Energy Research & Social Science*, 46, 287–295. <https://doi.org/10.1016/j.erss.2018.07.018>.

- Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35(5), 2683–2691. <https://doi.org/10.1016/j.enpol.2006.12.001>.
- Yule, G. (1900), On the association of the attributes in statistics: With illustrations from the material of the childhood society, and c. *Philosophical Transactions of the Royal Society*, Series A, 194,257-3 19.
- Zareba, A., & Ziemiańska, D. (2020). Environmental awareness of young generation: A review of studies on students' ecological attitudes. *Environmental and Socio-economic Studies*, 8(3), 45–54. <https://doi.org/10.2478/environ-2020-0017>

Other sources

- Ellen MacArthur Foundation. (2015). Towards a Circular Economy: Business Rationale for an Accelerated Transition. <https://www.ellenmacarthurfoundation.org> (updated: 19.11.2025).
- European Commission. (2019). *The European Green Deal*. COM(2019) 640 final. <https://eur-lex.europa.eu>
- <https://www.ilo.org/publications/guidelines-just-transition-towards-environmentally-sustainable-economies>.
- <https://www.un.org/en/climatechange/2019-climate-action-summit>.
- IEA (2023). *World Energy Outlook 2023*, International Energy Agency, Paris. <https://www.iea.org/reports/world-energy-outlook-2023>.
- ILO. (2015). *Guidelines for a just transition towards environmentally sustainable economies and societies for all*. International Labour Organization.
- International Labour Organization (ILO). (2015). *Guidelines for a just transition towards environmentally sustainable economies and societies for all*. ILO Publishing. ISBN: 978-92-2-130634-4.
- IPCC, 2022: *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, NY, USA.
- MacArthur Foundation. (2015). *Towards a Circular Economy: Business Rationale for an Accelerated Transition*. <https://www.ellenmacarthurfoundation.org>.
- Międzynarodowa Organizacja Pracy (MOP). (2015). *Guidelines for a just transition towards environmentally sustainable economies and societies for all*. Geneva: International Labour Organization: <https://www.worldbank.org>.
- OECD. (2020). *The territorial impact of COVID-19: Managing the crisis across levels of government*. OECD Publishing. <https://www.oecd.org>
- OECD. (2021): *The Role of Green Transition in Post-Pandemic Recovery*, OECD Publishing, Paris: https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/04/the-oecd-green-recovery-database_21b70c02/47ae0f0d-en.pdf.
- OECD. (2023). *Environmental Outlook 2023: Regional Implementation and Green Growth*. OECD Publishing. <https://doi.org/10.1787/9789264121300-en>
- ONZ (United Nation) (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Dostępne na: <https://sdgs.un.org/2030agenda> (data dostępu: 15.11.2025).
- PWC. (2022). *Financing the green transformation: Opportunities and barriers for local governments*. UN Global Compact Network Poland. <https://ungc.org.pl>.

- Regulation (EU) 2021/1056 of the European Parliament and of the Council of 24 June 2021 establishing the Just Transition Fund. *Official Journal of the European Union*, L 231/1. <http://data.europa.eu/eli/reg/2021/1056/oj>.
- Statistics Poland (GUS). (2023). *Statistical Yearbook of the Świętokrzyskie Voivodeship 2023*. Statistical Office in Kielce.
- Towards a Circular Economy: Business Rationale for an Accelerated Transition*. MacArthur Foundation (2015): <https://www.ellenmacarthurfoundation.org/towards-a-circular-economy-business-rationale-for-an-accelerated-transition>.
- UN General Assembly, 2015: *Transforming our world: the 2030 Agenda for Sustainable Development*, A/RES/70/1: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024_en.
- United Nations (UN). (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. UN Publishing. <https://sdgs.un.org/2030agenda>.
- United Nations, (2015). *Paris Agreement*, FCCC/CP/2015/10/Add.1: <https://fra.europa.eu/pl/law-reference/un-general-assembly-resolution-701-2015-transforming-our-world-2030-agenda>.
- Urząd Marszałkowski Województwa Świętokrzyskiego. (2020). *Strategia Rozwoju Województwa Świętokrzyskiego 2030+* [Development Strategy of the Świętokrzyskie Voivodeship 2030+]. Kielce.
- WCED (1987). *Our Common Future*. Oxford: Oxford University Press.: <https://sustainabledevelopment.un.org>.
- World Commission on Environment and Development (WCED). (1987). *Our Common Future*. Oxford University Press. ISBN: 978-0192820808.

List of figures

Figure 1. Green transformation flow: from global impulses to local implementation....	17
Figure 2: Integrated framework: regional archetypes within the multi-level perspective (MLP)	25
Figure 3. The cascading mechanism of local acceptance for green transformation	28
Figure 4. Local government as a system integrator within the MLP framework	31
Figure 5. Resitance to green transformation	34
Figure 6. Conceptual bridge: operationalizing MLP dynamics into local sustainable development pillars.....	39
Figure 7. Conceptual model of local green transformation	43
Figure 8. The value function of loss aversion in the context of green transformation ..	62
Figure 9. The triad of just transition: distributive, procedural, and corrective justice....	65

List of tables

Table 1. Demographic Structure of Respondents by Gender, Age, Year and Mode of Study, and Place of Residence (N = 207).....	10
Table 2. Three dimensions of acceptance	16
Table 3. Comparison of transformation priorities by region type	23
Table 4: Dimensions of local awareness and their impact on transformation	26
Table 5. Mapping local challenges to global trends.....	30
Table 6. Sensitivity indicators of the socio-technical regime in the świętokrzyskie voivodeship.....	33
Table 7. Świętokrzyskie Voivodeship	35
Table 8. Operationalizing sustainability pillars in local governance	42
Table 9. Operational elements of sustainable development in transformation	45
Table 10. Functions of sustainable development as a transformation goal.....	46
Table 11. Pillars of local sustainability in resilience building	47
Table 12. Practical implementation areas of local sustainability	48
Table 13. Strategic risk factors in local green transformation	49
Table 14. Matrix of competency gaps and labor market risks	52
Table 15. Comparison of transformation capacity: prosperous vs. lagging regions.....	53
Table 16. Social stratification and the “Entry Barrier” in green transformation.....	54
Table 17. Matrix of NIMBY resistance dimensions	55
Table 18. Mechanisms of greenwashing and systemic consequences	56
Table 19. Just Transition Fund (JTF) intervention logic.....	58
Table 20. Levels of social participation and their impact on GT legitimization.....	64
Table 21. Diversification of approaches according to specific regional conditions.....	67
Table 22. Regional GT Monitoring Framework: Beyond GDP.....	70
Table 23. Operationalization of research variables in the survey instrument	73
Table 24. Descriptive statistics of variables regarding green transformation and demographic characteristics of respondents	75
Table 25. Normality tests of variable distribution – results of Kolmogorov-Smirnov, Lilliefors, and Shapiro-Wilk tests for survey data (N = 207)	79
Table 26. Perception and self-assessment of knowledge regarding green transformation – analysis of respondent answers	100
Table 27. Assessment of knowledge level and perception of green transformation based on descriptive statistics analysis.....	102
Table 28. Results of normality tests for key variables regarding awareness and understanding of the green transformation	104

Table 29. Level of understanding of the importance of green transformation according to socio-demographic characteristics of respondents	107
Table 30. Analysis of the relationship between the level of understanding of the green transformation and respondents' socio-demographic characteristics (gender, age, student status, place of residence) – results of Chi-square tests, correlation, and uncertainty coefficients.....	108
Table 31. Definitions of green transformation according to demographic characteristics..	110
Table 32. Results of statistical tests for the relationship between the understanding of the definition of green transformation and demographic characteristics of respondents.....	112
Table 33. Assessment of the level of knowledge about ecological transformation depending on demographic characteristics.....	114
Table 34. Statistical test results for the relationship between the assessment of the level of knowledge about ecological transformation and demographic characteristics...	116
Table 35. Assessment of the level of understanding of the need to adapt to ecological changes (5) depending on demographic characteristics	118
Table 36. Results of statistical tests regarding the assessment of the level of understanding of the need for adaptation to ecological changes depending on demographic characteristics	120
Table 37. Assessment of the level of identification of global trends related to green transformation by demographic characteristics	122
Table 38. Statistical analysis of the relationship between the assessment of identifying global trends related to green transformation and the level of understanding of the need for adaptation to ecological changes relative to demographic characteristics	123
Table 39. Correlation analysis between perception, knowledge, and adaptation to the green transition	125
Table 40. Correlation coefficients between demographic variables and the perception and knowledge of the green transition.....	126
Table 41. Results concerning the assessment of environmental education, barriers, positive aspects, and the impact of the environment and investment on ecological awareness	134
Table 42. Descriptive statistics concerning environmental education and access to knowledge about the ecological transition	137
Table 43. Results of normality tests (K-S, Lilliefors, Shapiro–Wilk) for variables related to environmental education and the green transition.....	138
Table 44. Assessment of the level of environmental education among employees by demographic characteristics of respondents	141
Table 45. Relationship between the assessment of employees' environmental education level and respondents' demographic characteristics	142
Table 46. Assessment of the promotion of knowledge about sustainable development and green technologies by demographic characteristics of respondents	144

Table 47. Relationship between the assessment of sustainable development knowledge promotion and respondents' demographic characteristics – statistical analysis	146
Table 48. Barriers to accessing knowledge on ecological transformation according to respondents' demographic characteristics	148
Table 49. Relationship between barriers to accessing knowledge on ecological transformation and demographic characteristics – statistical analysis	149
Table 50. Factors influencing students' ecological awareness according to demographic characteristics	152
Table 51. Positive aspects of access to knowledge on ecological transformation in the context of respondents' demographic characteristics	153
Table 52. Evaluation of regional activities in raising ecological awareness by respondents' demographic characteristics	156
Table 53. Impact of environment (regional) activities on raising ecological awareness depending on respondents' demographic characteristics	157
Table 54. Impact of the level of investment in education and training on attitude towards ecological transformation.....	159
Table 55. Analysis of the relationship between the level of investment in education and training and the change in attitudes towards ecological transformation depending on demographic characteristics.....	161
Table 56. Assessment of the environment's (region's) actions in raising ecological awareness depending on the level of understanding of the importance of green transformation	163
Table 57. Statistical analysis of the relationship between the assessment of regional environment activities and the level of understanding of the significance of the green transformation.....	164
Table 58. Statistical analysis of the relationship between barriers and positive aspects of access to knowledge about the ecological transformation.....	166
Table 59. Statistical analysis of the relationship between barriers to access to knowledge about ecological transformation and the level of understanding of the importance of green transformation by the respondents' environment ...	167
Table 60. Relationship between barriers in access to knowledge about ecological transformation and positive aspects of knowledge, and the level of understanding of the green transformation by the environment.....	168
Table 61. Relationship between the degree of identification of global green transformation trends and positive aspects of access to knowledge about ecological transformation	170
Table 62. Analysis of the relationship between the degree of identification of global green transformation trends and the positive aspects of access to knowledge about ecological transformation	171
Table 63. Analysis of the impact of demographic variables and self-assessment of knowledge on the perception of ecological education and barriers to access to information on ecological transformation – Mann-Whitney U test ...	172

Table 64. Analysis of differences in assessments of ecological education and access to knowledge about ecological transformation by gender – Kruskal-Wallis test.....	175
Table 65. Analysis of the relationship of assessments of ecological education, barriers, and positive aspects of access to knowledge about ecological transformation by respondents’ age – Kruskal-Wallis test	176
Table 66. Analysis of relationships between assessments of environmental education, barriers, and positive aspects of access to knowledge on ecological transformation by student status – Kruskal–Wallis test	179
Table 67. Analysis of differences in assessments of environmental education and perceptions of barriers and positive aspects of ecological transformation by place of residence – Kruskal–Wallis test	181
Table 68. Analysis of relationships between self-assessment of knowledge about ecological transformation and the assessment of ecological education, barriers, and positive aspects of access to knowledge – Kruskal-Wallis test	183
Table 69. Spearman correlation analysis between the assessment of ecological education, knowledge promotion, barriers and positive aspects of access to knowledge, and the impact of investments on attitudes toward ecological transformation.....	185
Table 70. Analysis of Spearman Correlations Between Demographic Factors and Perceptions of Ecological Education, Knowledge Dissemination, Barriers, Benefits of Access to Information, and the Impact of Investments on Attitudes Toward Ecological Transformation.....	186
Table 71. Spearman correlation analysis between the perception of green transformation, the level of knowledge about ecological transformation, and the awareness of the need to adapt to ecological changes	187
Table 72. Multiple regression model explaining the level of self-assessment of knowledge about ecological transformation	189
Table 73. Multiple regression model explaining the level of understanding of the need to adapt to ecological changes	190
Table 74. Multiple regression model explaining the level of understanding of the need to adapt to ecological changes, including knowledge factors and ecological awareness	191
Table 75. Multiple regression model explaining the level of knowledge about ecological transformation, including environmental factors and ecological awareness.....	193
Table 76. Analysis of the perception of effects, costs, and social inequalities associated with the green transition among respondents – survey results.....	202
Table 77. Statistical analysis of the variability in perception of effects, costs, and social consequences of the green transition based on mean values and coefficients of variation.....	203
Table 78. Analysis of the normality of distribution for variables regarding the perception of effects, costs, and social inequalities associated with the green transition	204

Table 79. Analysis of the perception of positive effects of implementing green transition in the respondents' environment by demographic cross-section.....	206
Table 80. Analysis of the dependence of the perception of positive effects of the green transition in the respondents' environment on demographic variables....	208
Table 81. Analysis of the assessment of the costs of implementing ecological transition measures among students by demographic characteristics	210
Table 82. Analysis of the dependence of the assessment of implementation costs of ecological transition activities on respondents' demographic characteristics ...	211
Table 83. Analysis of opinions on green transition costs in the context of respondents' demographic characteristics	213
Table 84. Analysis of the relationship between opinions on green transition costs and respondents' demographic characteristics.....	214
Table 85. Analysis of the perception of social inequalities caused by the green transition in the region by demographic characteristics	216
Table 86. Analysis of the relationship between opinions on social inequalities caused by the green transition in the region and demographic characteristics..	218
Table 87. Mann-Whitney U Test: Analysis of the significance of differences in assessments of green transformation regarding demographic characteristics and attitudes.....	220
Table 88. Analysis of differences in assessments of green transformation aspects by gender – Kruskal-Wallis Test.....	223
Table 89. Analysis of differences in perception of green transformation aspects depending on respondent age – Kruskal-Wallis Test.....	224
Table 90. Analysis of differences in the perception of green transformation aspects depending on student status – Kruskal-Wallis test	225
Table 91. Analysis of relationships between the perception of effects, costs, and inequalities related to green transformation – Spearman rank correlations	227
Table 92. Analysis of Spearman correlations between the perception of green transformation and demographic characteristics of respondents.....	227
Table 93. Spearman correlation analysis between the perception of costs and social impacts of the green transformation and the level of ecological knowledge and awareness	230
Table 94. Regression analysis of the impact of knowledge and perception of green transformation aspects on the assessment of transformation costs in the context of economic, social, and environmental effects.....	231
Table 95. Regression analysis of the impact of knowledge, perception of global trends, and positive effects on the perception of green transformation costs....	232
Table 96. Regression analysis of the impact of knowledge, cost perception, and green transformation effects on the perception of social inequalities in the region....	233

ISBN 978-83-68668-49-0

DOI 10.48226/978-83-68668-49-0