Irish Interdisciplinary Journal of Science & Research (IIJSR)
Volume 10, Issue 4, Pages 24-43, Oct-Dec 2026

Green Economy as a Driver of Sustainable Development: A Comparative Philosophical and Ecological Analysis of Green Growth Policies, Natural Ecological Standards, Afforestation, Zero Waste Practices and Pollinator Protection in Turkey and Uzbekistan

Hakima Yusupovna Salomova*

Professor, Doctor of Philosophical Sciences (DSc), Department of Islamic History and Source Studies (Philosophy), Bukhara State University, 11 Muhammad Iqbol Street, Bukhara 200118, Uzbekistan.
*Corresponding Author Email: khakima.salomova@mail.ru**

DOI: Under Assignment

Copyright © 2026 Hakima Yusupovna Salomova. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Article Received: 18 August 2026 *Article Accepted: 24 October 2026* *Article Published: 27 October 2026*

ABSTRACT

This article examines the green economy as a key driver of sustainable development through a comparative analysis of the experiences of Turkey and Uzbekistan. The green economy is conceptualised as a system of economic management that improves human well-being and social equity while reducing environmental risks and ensuring the rational use of natural resources; its core principles are identified as low-carbon development, resource efficiency and social inclusiveness, and its relationship with the related concept of green growth is clarified. Using comparative logical analysis combined with dialectical and systemic approaches, the study examines national policies, environmental initiatives and their practical outcomes, including afforestation programmes, waste management, drone-assisted seeding and environmental education. International sustainable development rankings and national targets are used to assess the position of both countries. Turkey shows stronger institutional results in the digital monitoring of afforestation, waste separation and recycling, and the integration of environmental topics into education, whereas Uzbekistan demonstrates rapid progress through the Yashil Makon (Green Space) nationwide project and its emission-intensity reduction target, while waste sorting and the digital registration of planted saplings remain at an early stage. The study argues that natural ecological standards and the ecological value of environmental components, illustrated by forests, the balance of atmospheric gases and pollinating insects, must form the normative foundation of economic decision-making. The findings offer a conceptual basis for aligning green economy policy with the limits of the biosphere in transition economies.

Keywords: Green Economy; Green Growth; Sustainable Development; Natural Ecological Standards; Ecological Value; Environmental Education; Afforestation; Zero Waste; Honeybee Pollination; Biodiversity; Turkey; Uzbekistan.

1. Introduction

Concepts such as green growth, green space, green technologies, green belts, green energy, green transport, green economy, green chemistry, and environmentally friendly products are increasingly used in contemporary socio-economic discourse. Although the concepts of the green economy and green growth are closely related, they differ in their content and scope (Loiseau et al., 2016).

The green economy represents not only a model of economic growth but also a comprehensive socio-economic system based on new principles of economic organization and management.

A green economy is a system of economic management that aims to enhance human well-being and ensure social equity while simultaneously reducing environmental risks and preventing ecological scarcity (UNEP, 2011).

The green economy is grounded in three fundamental principles:

1. Low-carbon development: minimizing the volume of harmful emissions and the amount of carbon dioxide (CO_2) released into the atmosphere;
2. Resource efficiency: rational and efficient use of resources;
3. Social inclusiveness: ensuring that this system delivers benefits to all segments of the population.

Green growth refers to an approach to economic development in which national prosperity increases without causing environmental degradation or depleting natural resources (OECD, 2011). It advances principles such as

recycling waste; stabilizing the economy through the efficient use of solar and wind energy instead of relying on imported fuels; and reducing healthcare expenditures by improving public health through a cleaner environment, including clean air and safe water.

The term green economy was introduced into academic discourse in 1989 by British environmental economists D. Pearce, A. Markandya and E.B. Barbier in their report *Blueprint for a Green Economy* (Pearce et al., 1989) and is sometimes used alongside the concept of green growth. The concepts of the green economy and green growth are dialectically interrelated: both imply abandoning conventional technologies that lack an adequate environmental rationale and adopting a qualitatively new, economically and ecologically conscious attitude toward the environment, natural systems, and natural resources.

The green economy represents a methodological framework for economic development that promotes harmonious interaction between humanity and nature while simultaneously seeking to satisfy the needs of both in a balanced manner.

The Green Growth Index is a composite statistical indicator that measures the extent to which countries maintain a balance between economic development and environmental protection. In philosophical terms, it assesses not only the extent to which a country is becoming more prosperous, but also whether this prosperity is achieved without causing harm to nature, that is, without exceeding the natural ecological threshold limits of environmental components.

The Index is calculated by the Global Green Growth Institute (GGGI). It evaluates countries in terms of their efficient use of natural resources, the extent to which they utilize green economic opportunities, and their achievements in promoting social equity (GGGI, n.d.).

Although a growing body of research has examined green growth in Central Asia and waste and energy transitions in Turkey, comparative studies that connect the policy experience of these two countries with the philosophical and ecological concepts of natural ecological standards and the ecological value of environmental components remain scarce. The present article addresses this gap.

1.1. Study Objectives

The study pursues the following objectives:

1. To clarify the content of, and the dialectical relationship between, the concepts of the green economy and green growth.

2. To compare the positions of Turkey, Uzbekistan and neighbouring countries (Kazakhstan, Kyrgyzstan and Azerbaijan) in international sustainable development and green growth assessments.

3. To analyse and compare the afforestation, waste management and other greening policies implemented in Turkey and Uzbekistan.

4. To substantiate natural ecological standards as a normative basis for economic activity, with reference to biospheric indicators such as atmospheric carbon dioxide and oxygen.

5. To reveal the ecological value of environmental components and its relationship with economic value, using forests and honeybees as illustrative cases.

6. To assess the state of environmental education in the countries examined and to formulate recommendations for accelerating the transition to a green economy.

2. Literature Review

The conceptual foundations of this study are rooted in the sustainable development paradigm. The term "sustainable development" was popularized in 1987 by the World Commission on Environment and Development chaired by Gro Harlem Brundtland, which defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). The concept was subsequently endorsed at the United Nations Conference on Environment and Development (Rio de Janeiro, 1992). This definition implies that every individual has the right to live in a healthy and clean environment.

The notion of the green economy was first articulated by Pearce et al. (1989), who argued that environmental assets must be properly valued in economic decision-making. The United Nations Environment Programme (UNEP, 2011) later defined the green economy as one that results in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities, whereas the Organisation for Economic Co-operation and Development (OECD, 2011) framed green growth as fostering economic growth while ensuring that natural assets continue to provide the resources and environmental services on which well-being relies. Reviewing these and related concepts, Loiseau et al. (2016) showed that the green economy functions as an umbrella concept that encompasses green growth, the circular economy and the bioeconomy, while placing greater emphasis on social equity.

A second strand of literature documents the biophysical limits within which economic activity takes place. Richardson et al. (2023) concluded that six of the nine planetary boundaries have already been transgressed. According to the Global Carbon Project, fossil carbon dioxide emissions reached 36.8 billion tons in 2023 (Friedlingstein et al., 2025) and were projected to rise further to about 38.1 billion tons in 2025 (Friedlingstein et al., 2026). Ke et al. (2024) reported a sharp decline of the land carbon sink in 2023 associated with drought and wildfires, while Pan et al. (2024) found that the carbon uptake of the world's forests has been largely offset by emissions from tropical deforestation. Crowther et al. (2015) estimated that more than 15 billion trees are cut down each year, and the Food and Agriculture Organization of the United Nations (FAO, 2020) reported a net loss of 178 million hectares of forest between 1990 and 2020.

Research on pollinators provides a third strand. Klein et al. (2007) demonstrated that most of the leading global food crops benefit from animal pollination, and Potts et al. (2016) identified pesticides, land-use change and pathogens among the main drivers of pollinator decline. A meta-analysis by Siviter et al. (2021) further showed that combinations of agrochemicals act synergistically to increase bee mortality.

Regional studies have begun to examine the green transition in the countries considered here. Caporin et al. (2024) found that the green transition contributes more effectively to economic development in Central Asia than the blue

(water) or energy transitions. For Uzbekistan, Nuriddinova and Ahmad (2025) showed that carbon dioxide emissions continue to rise with income, and Bakhtiyorov (2026) characterized the country's green transition as broad and institutionally coordinated in comparison with Azerbaijan. In Turkey, Tan (2021) described the Zero Waste project as a national strategy for waste prevention and recovery. The national legal framework of Uzbekistan, notably Resolution No. PQ-436 (2022) and Decree No. UP-46 (2021), sets quantitative targets for the green economy and afforestation. Earlier works by the author (Salomova, 1996a, 1996b, 2023) introduced the distinction between the ecological and economic value of environmental components. However, the literature rarely combines these philosophical-ecological categories with a comparative analysis of national green economy policies, which is the focus of the present study.

3. Methodology

The methodology of this study is based on comparative logical analysis, which is used to identify the key factors contributing to the achievement of sustainable development. The study adopts a qualitative comparative case-study design covering Turkey and Uzbekistan, with Kazakhstan, Kyrgyzstan and Azerbaijan used as regional reference points.

Three groups of sources were analysed: (i) international assessments, namely the Sustainable Development Report 2025 (Sachs et al., 2025) and the Green Growth Index of the GGGI (GGGI, n.d.); (ii) national legal and policy documents, including Resolution of the President of the Republic of Uzbekistan No. PQ-436 of 2 December 2022, Decree No. UP-46 of 30 December 2021 on the Yashil Makon (Green Space) nationwide project, and official information on Turkey's Zero Waste project (Anadolu Agency, 2019, 2023); and (iii) scientific literature and case materials on biospheric indicators, forests and pollinators.

Dialectical and systemic methods of philosophical analysis were applied to interpret the relationship between economic and ecological value, and the law of the transformation of quantitative changes into qualitative changes was used as an interpretive principle for biospheric processes. Quantitative indicators are reported as presented in the cited sources; no new statistical modelling was performed.

4. Results and Discussion

4.1. Sustainable Development and Green Growth Indicators of the Selected Countries

The Global Green Growth Institute was established on June 16, 2010, at the initiative of Lee Myung-bak, the President of South Korea. Uzbekistan joined the Institute in 2019, followed by Kyrgyzstan in 2020 and Kazakhstan in 2022. Turkey became a member of the organization in 2022–2023.

The Institute supports member states in implementing green economy strategies by providing access to technologies and knowledge and by offering practical assistance for achieving low-carbon development and sustainable growth.

At present, Turkey and Uzbekistan demonstrate a serious commitment to environmental responsibility through large-scale national greening programmes; however, as shown in Table 1, their positions in the Sustainable Development Goals (SDG) Index differ considerably from those of Kyrgyzstan, Kazakhstan and Azerbaijan.

According to the Green Growth Index, Uzbekistan ranks 33rd among Asian countries. This result indicates that Uzbekistan demonstrates a moderate level of green development, while showing relatively strong performance in environmental indicators and green opportunities.

Table 1. Rank and Overall Score of Turkey, Kazakhstan, Kyrgyzstan, Azerbaijan and Uzbekistan in the Sustainable Development Goals (SDG) Index of The Sustainable Development Report 2025 (167 Countries Assessed; A Score of 100 Indicates Full Achievement of all SDGs)

No.	Country	Ranking Position	Index Score	Remarks
1	Turkey	73rd place	70.61	—
2	Kazakhstan	70th place	71.52	—
3	Kyrgyzstan	47th place	74.50	—
4	Azerbaijan	64th place	72.90	—
5	Uzbekistan	62nd place	73.10	Improved by 19 places compared with the previous edition

Source: *Compiled by the Author from Sachs Et Al. (2025).*

It should be noted that in the 2025 edition of the Sustainable Development Report Uzbekistan improved its position in the SDG Index by 19 places, reaching 62nd place (Sachs et al., 2025). This progress indicates the effectiveness of ongoing reforms aimed at the transition to a green economy.

Within the framework of the Green Economy Programme, Uzbekistan aims to reduce specific greenhouse gas emissions per unit of gross domestic product (GDP) by 35% from the 2010 level by 2030 (Resolution No. PQ-436, 2022). These targets suggest that the country's position in international rankings is likely to improve further in the coming years.

4.2. Comparative Analysis of Afforestation and Greening Policies in Turkey and Uzbekistan

The main directions of the environmental protection and greening policies implemented in the two countries are compared in Table 2.

Table 2. Comparative Overview of Environmental Protection and Greening (Afforestation) Policies in Turkey and Uzbekistan: State Policy Status, Forest Area Dynamics, Digital Monitoring of Saplings, Species Selection for Water-Scarce Areas, Public Participation Campaigns, Waste Management and Drone-Assisted Seeding.

Turkey	Uzbekistan
Environmental protection and greening (afforestation) have been elevated to the level of state policy.	Turkey's experience shows notable similarities with Uzbekistan's national Yashil Makon (Green Space) initiative (Decree No. UP-46, 2021).
Over the past 20 years, Turkey's forest area has expanded by about 2 million hectares, and forests now cover approximately 29.4% of the country's territory. In addition, smart irrigation systems have been introduced.	By 2025, new forests had been established over a total area of 150.7 thousand hectares, increasing the country's forest area to 4.7 million hectares. Over the past six years, forest cover has expanded by more than 1 million hectares.

Strength: The registration and monitoring of each planted sapling are digitalized.	The registration and monitoring of planted saplings are currently being prepared for digitalization.
Targeted species selection: In water-scarce areas, drought-tolerant or low-irrigation species such as juniper, pistachio, and almond are planted.	In water-scarce regions, water-saving cultivation technologies are applied, and salt-tolerant local species such as saxaul, elm, and oleaster are planted.
The nationwide "Breath for the Future" campaign involves broad public participation—from school pupils to civil servants. The idea that every individual should plant at least one tree in their own name is actively promoted.	Social initiatives such as "Every mahalla has its own garden" and "Every family has its own tree" are currently being implemented.
The Zero Waste (Sıfır Atık) initiative, launched under the leadership of the Turkish First Lady Emine Erdoğan, has enabled the recycling of millions of tons of paper and the preservation of hundreds of thousands of trees (Anadolu Agency, 2019). Recycling 69 kg of paper can prevent the felling of one mature tree. One ton of recycled paper requires 60% less energy and 50% less water than paper produced from virgin pulp.	Waste is not yet being sorted at the required scale.
In both Turkey and Uzbekistan, drones are used to distribute seeds in areas that are difficult to access.	This technology has been applied in the mountainous areas of Kashkadarya, Jizzakh, and Surkhandarya, as well as on the dried seabed of the Aral Sea. In Navoi Region, grasses and nectar-producing plants have been sown by drones over 350,000 hectares.

Source: *compiled by the author on the basis of national programme materials, Decree No. UP-46 (2021) and Anadolu Agency (2019).*

4.3. Principles and Components of Sustainable Development

The scientific management of nature and natural systems requires all people living on Earth to understand and comply with the laws of nature. In our view, sustainable development implies, first, maintaining a population level compatible with the carrying capacity of the biosphere; and second, the scientific management of the environment and natural systems, including the rational governance of each ecosystem, as well as the ability to identify and observe reasonable human needs that do not exceed natural limits. Achieving these objectives requires providing the younger generation with modern knowledge, promoting respect for the laws of nature, and ensuring the efficient use of natural resources.

The United Nations Sustainable Development Goals constitute a comprehensive roadmap for addressing the most pressing global challenges. A common guiding principle underlies all of these goals: maintaining global peace; preserving the biosphere and its vital ecological parameters; identifying and strictly observing the natural ecological limits of environmental components and factors; promoting a healthy ecological lifestyle for all people on the planet; and fostering the development of a green economy.

When such balanced development is considered within a common framework, it becomes evident that the overarching objective is to ensure a high quality of life for humanity. In other words, sustainable development encompasses the following dimensions (Ergashev et al., 2016):

- Environmental responsibility – maintaining the purity and quality of air and water; addressing the problem of waste through its reduction toward zero levels; and promoting environmental awareness and environmental legal responsibility.
- Rational use of natural resources – ensuring a high level of efficiency and conservation in the use of natural resources; organizing production in accordance with the principles of sustainable development; and managing product life cycles.
- A just society – ensuring employment opportunities; developing professional competence and expertise; and promoting business ethics.
- Social development – ensuring respect for human rights.
- Economic development – promoting innovation, economic expansion, and effective risk management.
- Environmental sustainability of the planet – safeguarding public health; monitoring climate change; and preserving biodiversity.

The harmonious interaction of these six dimensions constitutes the foundation of sustainable development. An analysis of the new approaches associated with these components, as well as the factors that ensure balance between the green economy and green growth, highlights several essential principles:

First, in the process of economic stabilization and development, it is necessary to consistently comply with natural and ecological standards.

Second, the ecological value of all environmental components must be taken into account.

Third, it is necessary to avoid the production of chemical compounds that do not participate in the natural cycles of the biosphere, in accordance with the principles of green chemistry.

Fourth, all new technologies should undergo thorough environmental assessment and ecological justification before being introduced into production.

4.4. Natural Ecological Standards and Anthropogenic Impact on the Biosphere

What environmental standards must be observed in economic activity? Each natural component and environmental factor is characterized by specific qualitative and quantitative parameters. These parameters constitute what are known as natural ecological standards (Butorina et al., 2003).

For example, for fish populations, the optimal level of water mineralization ranges from 6 to 8 g/L, or 6,000–8,000 mg of dissolved minerals per liter of water. Fish can thrive under such conditions because these values correspond to their natural ecological standards (Dajoz, 1975).

Honeybees do not forage on flowers whose nectar contains less than 4.25% sugar. This threshold represents one of the natural ecological limits governing bee behavior. Another important ecological constraint is the intolerance of honeybees to harmful odors and pollutants.

In objective reality, ecological standards are manifested through the laws of nature such as Liebig's Law of the Minimum, the Lindeman efficiency principle (the 10% rule), the 70% rule, Williams' Law of Return, and the law of the ecological niche, as well as through ecological balance and the regulatory limits of environmental factors, including biotic, abiotic, and anthropogenic factors.

In scientific literature, ecological standards are also expressed through such terms as "vital indicators of the biosphere" and "the limits of the biosphere's capacity" (Richardson et al., 2023). In addition, there exist specific regulatory norms governing the use of natural resources, including water-use limits and standards for the use of land and forest resources.

A comparison of the natural ecological standards of carbon dioxide and oxygen with their anthropogenically altered levels in the biosphere is presented in Table 3 and Table 4.

Table 3. Natural Ecological Standard and Anthropogenic Emissions of Carbon Dioxide (CO_2) in the Biosphere: Comparison of the Natural Background Flux with Anthropogenic Emissions from the 1960s to 2025 and Associated Changes in Climate and in the Global Carbon Sink.

Natural Ecological Standard of a Chemical Element or Compound in the Biosphere	**Anthropogenic Levels of the Same Element or Compound in the Biosphere**
Carbon dioxide (CO_2). Under natural background conditions, approximately 9 billion tons of CO_2 are released into the atmosphere annually.	In the 1960s, anthropogenic emissions amounted to approximately 9–10 billion tons per year. In the 1970s, emissions from industry, transport, and domestic activities increased to 14–15 billion tons annually, reaching approximately 20 billion tons by the middle of the decade. In 1975, emissions amounted to approximately 18 billion tons, and by 1990 they had reached about 22 billion tons. In 2023, fossil CO_2 emissions reached 36.8 billion tons (Friedlingstein et al., 2025), and they were projected at about 38.1 billion tons in 2025 (Friedlingstein et al., 2026).
	In 2024, the global mean near-surface air temperature was about 1.55 °C above the pre-industrial (1850–1900) level (WMO, 2025). The land carbon sink weakened sharply during the hot and dry years of 2023–2024 (Ke et al., 2024; Friedlingstein et al., 2026). The most significant reductions in carbon absorption have been observed in dry and hot forest regions, where forests are increasingly shifting from carbon sinks to carbon sources. Major contributing factors include deforestation, declining precipitation, and increasing heat waves and droughts.

Source: *Compiled by the Author; Recent Values from Friedlingstein et al. (2025, 2026), Ke et al. (2024) and WMO (2025).*

The annual amount of atmospheric **CO_2** emissions has increased by approximately **four times** compared with the natural background level. The **law of the transformation of quantitative changes into qualitative changes** is clearly manifested in these biospheric processes.

Calculations indicate that even a 1 °C increase in the average global air temperature can significantly affect atmospheric circulation patterns and soil moisture conditions.

Table 4. Natural Ecological Standard of Atmospheric Oxygen (O_2) and the Anthropogenic Factors Affecting it, Primarily Deforestation and the Long-Term Reduction of Global Forest Area.

Natural Ecological Standard of a Chemical Element or Compound in the Biosphere	**Anthropogenic Levels of the Same Element or Compound in the Biosphere**
Oxygen (O_2). Oxygen constitutes approximately 21% of the Earth's atmosphere.	Due to deforestation, the annual reduction in atmospheric oxygen is estimated at approximately 10–12 billion tons. If this trend continues, it will inevitably have negative consequences for the biosphere's vital indicators. According to United Nations data, ongoing deforestation is aggravated by the fact that only one tree is planted for every ten trees cut down, contributing to the gradual decline in oxygen levels. Historically, global forest areas amounted to approximately 7.2 billion hectares, whereas today they do not exceed about 4.06 billion hectares (FAO, 2020). Between 1990 and 2020 alone, the world lost a net 178 million hectares of forest (FAO, 2020), resulting in a substantial decline in atmospheric oxygen relative to its natural ecological standards.

Source: *Compiled by the Author; Forest Area Data from FAO (2020).*

A decrease of approximately 3% below the natural ecological standard of atmospheric oxygen has a negative impact on the biosphere's vital indicators.

Within natural systems, one ecological parameter may fall below its permissible range (for example, depletion of the ozone layer or a decline in atmospheric oxygen), while another may exceed its upper threshold (for example, rising atmospheric CO_2 concentration). In practice, both types of deviation adversely affect the biosphere's vital indicators.

4.5. Ecological Standards, Waste Management and Chemical Pollution

Anthropogenic factors likewise have regulatory limits—namely, restrictions and requirements established to prevent damage to nature. In the context of fisheries and marine resources, ecology emphasizes the need for coordinated harvesting standards and scientifically justified catch quotas. In general ecology, this approach is often described through the 70% rule, which refers to allowable harvest levels that do not harm the viability of a species' population. In other words, an ecological standard denotes a safe threshold that does not cause damage to environmental components, ecosystems, or human health.

For example, the permissible limit of technogenic (man-made) radiation exposure for the population is defined as not exceeding 0.001 sieverts (1 millisievert) per year (ICRP, 2007). Comparable regulatory measures include maximum permissible concentrations of harmful substances and limits on waste generation and disposal.

In this regard, Turkey provides a positive example, particularly through the implementation of the Zero Waste (Sıfır Atık) program, whose practical experience is regarded as instructive for other countries (Tan, 2021). Since June 2017, approximately 33.8 million tons of recyclable waste have been reintegrated into the economy. A

zero-waste management system was introduced in more than 164,000 buildings, and about 19 million people in Turkey participated in environmental education and zero-waste initiatives (Anadolu Agency, 2023). Another positive aspect of this program is its continuity and long-term implementation, as it aims to minimize waste generation and maximize recycling rates by 2030.

An ecological standard is a scientifically grounded system of qualitative and quantitative indicators established to preserve the natural state of the environment, ensure the rational use of natural resources in accordance with actual needs, and protect human health. It is widely recognized that one of the major factors causing damage to the environment and biodiversity is the anthropogenic factor, particularly the insufficient level of ecological knowledge and environmental awareness.

In June–July 2025, a large-scale loss of honeybee colonies was recorded in the Fergana Region of Uzbekistan, including the districts of Yazavan, Kuva, and Rishtan. Hundreds and even thousands of bee colonies perished. Typically, each colony consists of approximately 30,000 to 70,000 bees, which indicates the scale of the losses.

According to specialists and beekeeping farmers, the mass mortality of bees was caused by the use of harmful chemical pesticides—particularly neonicotinoids—applied in cotton fields, which poisoned the bees and led to large-scale die-offs. The loss of honeybees represents not only a significant economic loss for beekeepers but also negatively affects the pollination of cotton and other agricultural crops, as well as the productivity of wild plants and fruit trees (Tashkent Times, 2025). This interpretation is consistent with evidence that agrochemicals interact synergistically to increase bee mortality (Siviter et al., 2021). In fact, the primary responsibility lies with farmers who lack sufficient knowledge of proper pesticide application practices, have not adopted biological protection methods, and are unaware that honeybees serve as indicator organisms of environmental conditions.

Within the framework of economic activity, natural pollution accounts for approximately 3–10% of total pollution, whereas anthropogenic pollution constitutes about 90–97%. The economic and ecological damage caused by chemical pollution is clearly illustrated by the example discussed above.

4.6. Ecological Value of Environmental Components: Forests and Honeybees

The economic value of environmental components is largely created through human labor and economic activity, whereas their ecological value is formed through long-term natural processes. Ecological value is characterized by a range of ecological and bioenergetic indicators, including bioproductivity, biomass, population size, adaptability, stability, ecological valence, ecological efficiency, tolerance limits, optimal conditions, limiting thresholds, roles in ecological balance, and the capacity for self-renewal and regeneration, as well as other ecological and energy-related parameters.

For example, the formation of a 10-centimeter layer of fertile soil (humus horizon) requires approximately 2,000 to 7,000 years of natural processes and ecological interactions.

The essence of ecological value can be summarized as follows (Salomova, 1996a, 1996b, 2023):

- The ecological value of any environmental component generally exceeds its economic value and is directly proportional to it.

- The ecological value of an environmental component has biospheric significance; therefore, it cannot be replaced by another environmental component, regardless of its economic value.
- In other words, water cannot be replaced by air, air cannot be replaced by water, and one plant species cannot be substituted by another. Each environmental component possesses biospheric significance and plays an irreplaceable role within the natural system.
- For example, pond frogs and aquatic organisms can transform large quantities of plant biomass into valuable natural fertilizer. It is estimated that within a single season they are capable of converting up to 100 million tons of plant biomass into nutrient-rich organic matter. This process reflects the ecological value of such organisms. Because humanity has often failed to recognize ecological value, environmental losses frequently lead to significant economic damage.

The creator of ecological value is nature itself and its components, formed through thousands of years of evolutionary development, whereas the economic value of an environmental component is created by human activity.

Ecological value represents the natural qualitative characteristics, ecological functions, normative parameters, and biospheric significance of an environmental component.

The ecological value of one environmental component is directly proportional to the ecological value of other components. For example, deforestation in the biosphere leads to a decrease in atmospheric oxygen. Therefore, preserving forests also ensures the preservation of atmospheric oxygen—an essential abiotic component of the biosphere.

A single aircraft flight between Europe and America consumes approximately 50–100 tons of oxygen. The restoration of this amount of oxygen requires approximately 10,000 hectares of forest functioning for one day, yet forests continue to be destroyed at an alarming rate.

Ecological Value of Forests

- Forests provide essential habitats for humans and animals and cover approximately 31% of the Earth's land surface (FAO, 2020).
- The Amazon forests are often credited with producing approximately 20% of the world's oxygen; although much of this oxygen is consumed within the ecosystem itself, the Amazon remains one of the principal regulators of the global carbon and water cycles.
- Forests serve as ecological niches for more than 25% of medicinal plants.
- Forests protect water reservoirs and watersheds.
- Forests prevent soil erosion and help regulate climatic conditions.

Today, there is a growing need to implement digital technologies for the systematic monitoring and accounting of individual trees. According to Crowther et al. (2015), more than 15 billion trees are cut down worldwide each year, and the global number of trees has fallen by approximately 46% since the beginning of human civilization.

Broad-leaved tree species release approximately 5 kilograms of biologically active substances per hectare, which contribute to the neutralization of harmful microorganisms. Green spaces are capable of purifying up to 85% of polluted air, thereby playing an important role in maintaining environmental quality.

Although the economic value and ecological value of each environmental component differ in their essential characteristics, a dialectical relationship exists between them. This relationship is illustrated by honey production, compared across Turkey, Kyrgyzstan, Kazakhstan and Uzbekistan in Table 5.

Table 5. Comparative Characteristics of Honey Production in Turkey, Kyrgyzstan, Kazakhstan and Uzbekistan: Notable Honey Types, Their Botanical and Geographical Origin, Reported Market Values and Pollination-Related Productivity Indicators (TRY – Turkish Lira; USD – United States Dollar; Kg/Ha – Kilograms per Hectare).

Turkey	**Kyrgyzstan**	**Kazakhstan**	**Uzbekistan**
Honey obtained from caves at depths of around 1,800 meters in Turkey's Artvin province is reportedly priced at about 6,800 Turkish lira (TRY).	Kyrgyzstan's "White Mountain" honey, collected in the Tian Shan mountain landscapes, is also highly valued due to its limited production.	Honey from the mountain herbs of Kazakhstan's Burabay region is considered an ecologically clean product with a distinctive taste and aroma; it is valued because it is collected from the nectar of medicinal plants.	In Uzbekistan, the most common type is polyfloral honey, produced from plants such as sainfoin, camelthorn, thyme, basil, and black cumin (Nigella).
Honey collected from mountain caves has been reportedly valued at €10,000 per kg (i.e., more than USD 10,000), a record stated to have been recognized by the Guinness World Records.	—	—	Honey produced from cotton and acacia is regarded as high-quality monofloral honey. In the Bukhara region, honey was reportedly harvested nine times per season prior to World War II, whereas today it is harvested only twice per season.
Rare honey produced from rhododendron flowers (also known from Nepal) is considered highly valuable. Ilgaz honey was reportedly sold at an auction in 2025 for €11,118.	—	—	In Uzbekistan, up to 300 kg of honey per hectare can be obtained from cotton fields, about 30 kg/ha from pumpkin fields, and approximately 50 kg/ha from sunflower fields. Scientific evidence indicates that when cotton is pollinated by honeybees, yields increase by around 25%, the number of bolls rises by 12–13%, and the ripening period is shortened by 5–9 days. In addition, fiber and seed quality improve, seed germination increases, and the oil content of cottonseed rises.

Source: *Compiled by the author from open media reports and specialist literature.*

Manuka honey, produced from the nectar of the manuka shrub in New Zealand, is considered a highly valuable product, with a price of approximately USD 2,200 per kilogram. Honeybees collect nectar from manuka flowers for only about twelve days per year, which reflects the limited natural availability of nectar and the narrow ecological tolerance of bees with respect to this resource.

The ecological significance of this delicate insect has long been recognized in philosophical and literary thought. The renowned scholar and poet Jalal al-Din Rumi devoted the following verses to the honeybee. Written in Persian-Tajik, these lines express profound wisdom about the natural world (Rumi, 2008):

Khānahā sāzand az halvā-yi tar,

Ḥaqq bar ān ki 'ilm-rā bikshād dar.

Translation:

By divine wisdom and knowledge, the honeybee takes flight

And builds its dwelling filled with sweetness.

It is well known that rare and valuable types of honey are typically produced in unique ecological environments, including mountainous regions, islands, caves, and even at altitudes of up to 2,500 meters. These honeys are distinguished by their strong antibacterial and medicinal properties and are rich in minerals and antioxidants. The bees producing such honey are predominantly associated with monofloral nectar sources, meaning that nectar is collected primarily from a single plant species.

Ecological Value of Honeybees

1. **Pollination of plants.** During nectar collection, honeybees pollinate plants. Approximately 75% of the leading global food crop types benefit from animal pollination (Klein et al., 2007). The productivity of fruit trees such as apples, pears, and cherries, as well as vegetables and melon crops, declines significantly in the absence of honeybees.

2. **Indicator species.** Honeybees function as ecological indicator species, providing information about environmental quality through their physiological condition and behavior. Bees possess a highly developed sense of smell and are extremely sensitive to environmental changes. They can rapidly detect pesticides, climate variations, and air pollution and are capable of distinguishing odors with a sensitivity estimated to be up to 1,000 times greater than that of humans.

3. **Role in biodiversity conservation.** Honeybees play a crucial role in maintaining biodiversity by supporting the reproduction of wild plants, preventing the disappearance of plant species, and preserving ecosystem balance (Potts et al., 2016). The disappearance of honeybees would lead to cascading negative effects on other insects and animals.

4. **Health-related properties of bee products.** Bee products contribute significantly to human well-being. Honeybees consume only about 1% of the honey they produce, while the remaining 99% becomes available for

human use. Honey is known for its antimicrobial properties and is traditionally regarded as beneficial for the liver, blood circulation, and metabolic processes.

When a honeybee stings, a very small amount of venom, approximately 0.15 mg, enters the skin. The venom is gradually absorbed into the tissues and spreads through the lymphatic system. Some studies suggest that bee venom therapy may improve local blood circulation and may be used in complementary treatment of certain conditions such as rheumatic disorders and joint pain, although these effects require careful medical supervision.

After stinging, a honeybee usually dies because its stinger becomes detached from its body. Honeybees are therefore regarded as highly beneficial insects whose ecological and economic importance is considerable.

Honeybees represent one of the fundamental and irreplaceable pillars of ecosystem functioning.

1. **Guarantee of food security and preservation of biodiversity.** Honeybees play a crucial role in ensuring food security and maintaining biodiversity. The ecological significance of honeybees was recognized even in earlier intellectual traditions. The great scholar and poet Jalal al-Din Rumi expressed this idea in the following lines:

Bolarī etgan yumushni, yo'q shak,

Na arslon uddā aylar, na eshak.

Translation:

The task accomplished by the honeybee, without doubt,

Neither the lion nor the donkey can perform.

2. In modern scientific terms, the ecological functions performed by honeybees within the biosphere cannot be replaced by any other species, even by animals that are larger and physically stronger. This reflects the fundamental principle of biodiversity, according to which each species in the biosphere performs a specific and irreplaceable ecological function.

3. **The economic importance of pollination.** The pollination function of honeybees has a significantly higher ecological and economic value than honey production itself.

4. **Environmental regulation.** By facilitating plant reproduction, honeybees contribute to increased absorption of CO_2, support the preservation of forests and vegetation cover, and help reduce soil erosion.

In our view, preventing the global ecological crisis requires strict adherence to ecological standards in the use of natural resources and in all forms of anthropogenic activity. The preservation of the ecological value of natural resources, which constitute the material foundation of the green economy, and the organization of production processes on this basis represent key factors for achieving sustainable development. The traditional model of resource utilization has demonstrated its inefficiency through excessive resource consumption and declining production productivity. Contemporary ecological tensions and environmental crises have demonstrated the necessity of abandoning such models and adopting a new development paradigm—the green economy—which ensures material well-being without generating ecological risks, environmental scarcity, or social inequality.

Approximately 15 billion trees are cut down worldwide each year (Crowther et al., 2015), while no more than five billion trees are planted. As a result, the global number of trees decreases by roughly 10 billion annually, leading to a reduction in oxygen-producing sources and disruption of ecosystem functioning. Quantitative changes lead to qualitative transformations, a principle clearly manifested in current biospheric processes.

Another important factor is the long period required for newly planted trees to reach ecological maturity. A young tree requires many years to grow to a height of approximately 20 meters, after which it can fully perform its function as a natural green shield. Consequently, large-scale deforestation disrupts ecological balance, intensifies desertification and drought processes, increases average air temperatures, and contributes to the emergence of global water scarcity.

4.7. Environmental Education in the Countries Examined

A comparative analysis of environmental education in Turkey, Kazakhstan, Kyrgyzstan, Azerbaijan, and Uzbekistan indicates that Turkey has achieved the most advanced results in this field. In Turkey, environmental topics have been systematically integrated into national educational curricula at all levels. University programs focusing on climate change and sustainable development are actively implemented. Environmental research and projects, particularly the Zero Waste (Sıfır Atık) initiative, have been successfully put into practice and have generated significant economic benefits. The widespread implementation of the Eco-Schools Programme in schools demonstrates Turkey's strong institutional and systematic approach in this area.

In Kazakhstan, a national strategy for the transition to a green economy has been adopted. Educational and research programs in sustainability and environmental studies have been actively developed, including those at Nazarbayev University.

In Kyrgyzstan, international projects related to mountain ecosystems and biodiversity are actively implemented, and local environmental initiatives are relatively well developed.

In Azerbaijan, however, the integration of environmental education into the education system is still limited and less systematic.

In Uzbekistan, environmental subjects are included in school and higher education curricula. Nationwide initiatives such as Yashil Makon (Green Space) and research programs related to the Aral Sea region are being implemented; however, the transition from policy initiatives to practical implementation requires further acceleration.

5. Conclusion and Future Recommendations

The comparative analysis leads to three main conclusions. First, the green economy and green growth are dialectically interrelated, but only the green economy explicitly combines low-carbon development and resource efficiency with social inclusiveness. Second, the effectiveness of national greening policies depends not only on the scale of planting but also on institutional mechanisms such as the digital monitoring of saplings, waste separation and broad public participation, in which Turkey's experience is instructive for Uzbekistan. Third, the cases of atmospheric carbon dioxide and oxygen, forests and honeybees show that the ecological value of an environmental

component cannot be reduced to its economic value: disregard for natural ecological standards ultimately results in economic losses, as the 2025 honeybee mortality in the Fergana Region illustrates. On this basis, the following recommendations are proposed.

(1) Development of systematic environmental education. A systematic model of environmental education has been established in the region. Among the five countries examined, Turkey occupies a leading position in this field, followed by Kyrgyzstan. The effectiveness of environmental education in all five countries could be further enhanced by incorporating more comprehensive scientific knowledge on the laws of nature, environmental components and ecosystems, natural ecological standards, the regulatory limits of abiotic, biotic, and anthropogenic factors, and the ecological value of environmental components. This approach would strengthen the development of practical and competency-based learning.

(2) Ecological standards as the foundation of the green economy. Compliance with natural ecological standards and recognition of the ecological value of environmental components constitute the foundation of the green economy. Each new environmental program should be implemented through the integrated application of legislative measures, modern environmental education, and economic mechanisms.

(3) Consideration of biospheric limits. Social and economic development must take into account the limits of the biosphere's capacity. Practical experience in the fields of sustainable development and environmental protection should be more widely disseminated among the general public.

(4) Dissemination of scientific knowledge. The dissemination of scientific knowledge concerning the vital indicators of the biosphere, including physical, chemical, geological, and biological parameters, is of considerable theoretical and practical importance for the development of environmental awareness and ecological culture in society.

(5) International cooperation. Cooperation among countries through the exchange of advanced environmental projects, knowledge, and practical experience represents an essential condition for preserving the stability and health of the biosphere.

5.1. Future Suggestions

1. Develop a quantitative composite indicator of natural ecological standards that can be integrated into the national green economy monitoring system of Uzbekistan.

2. Conduct field studies on pesticide use, pollinator health and cotton yields in the agricultural regions of Uzbekistan, including the Fergana Valley, to support a transition to biological plant protection methods.

3. Introduce digital registration and monitoring of planted saplings within the Yashil Makon nationwide project, drawing on Turkey's experience, and evaluate sapling survival rates over time.

4. Assess the economic and environmental effects of a nationwide waste separation system in Uzbekistan modelled on Turkey's Zero Waste project.

5. Extend the comparative analysis to all Central Asian countries and Azerbaijan using harmonized green growth and sustainable development indicators over a longer time series.

6. Develop and pilot competency-based environmental education modules on the laws of nature, ecological standards and ecological value for schools and universities.

Declarations

Source of Funding

The author did not receive any grant or funding for this study.

Competing Interests Statement

The author declares that she has no competing financial, professional, or personal interests that might have influenced the work described in this manuscript.

Consent for publication

The author declares that she consented to the publication of this study.

Authors' contributions

The author is solely responsible for the conception of the study, the collection and analysis of materials, and the writing and revision of the manuscript.

Informed Consent

Not applicable.

Availability of data and material

All data analysed in this study are drawn from the publicly available sources cited in the article. Supporting material is available from the author upon reasonable request.

Institutional Review Board Statement

Not applicable.

Ethical Approval

Not applicable. The study did not involve experiments on human participants or animals.

Acknowledgement

Not applicable.

Declaration of Artificial Intelligence

During the revision of this manuscript, the author used Claude (Anthropic), an artificial intelligence assistant, to support language editing, restructuring of the manuscript according to the journal template and formatting of references. All content was subsequently reviewed, verified and approved by the author, who takes full responsibility for the content of the published article.

References

Anadolu Agency (2019). Zero waste project: Turkey's role in the waste cycle. 2 July 2019. https://www.aa.com.tr/en/economy/zero-waste-project-turkey-s-role-in-waste-cycle/15212621.

Anadolu Agency (2023). Over 164,000 buildings in Türkiye implement zero waste management since 2017. 30 March 2023. https://www.aa.com.tr/en/energy/turkey/over-164-000-buildings-in-turkiye-implement-zero-waste-management-since-2017/37827.

Bakhtiyorov, A. (2026). Green transition drivers and economic growth in Uzbekistan: A mixed-method analysis with comparative insights from Azerbaijan. Economics and Environment, 97(2): 1315. https://doi.org/10.34659/eis.2026.97.2.1315.

Butorina, M.V., Vorobyev, P.V., & Dmitrieva, A.P. (2003). Inzhenernaya ekologiya i ekologicheskiy menedzhment [Engineering Ecology and Environmental Management]. Logos, Moscow, 528 Pages.

Caporin, M., Kuziboev, B., Ibadullaev, E., Khodjaniyazov, E., Marty, P., & Saidmamatov, O. (2024). The contribution of green, blue, and energy sources to economic development in Central Asia. Economies, 12(9): 251. https://doi.org/10.3390/economies12090251.

Crowther, T.W., Glick, H.B., Covey, K.R., et al. (2015). Mapping tree density at a global scale. Nature, 525(7568): 201–205. https://doi.org/10.1038/nature14967.

Dajoz, R. (1975). Osnovy ekologii [Fundamentals of Ecology]. Russian translation, Progress, Moscow.

Decree of the President of the Republic of Uzbekistan No. UP-46 (2021). On measures to speed up work on afforestation and further effective organization of tree protection in the country. 30 December 2021. National Database of Legislation of the Republic of Uzbekistan, Tashkent.

Ergashev, A., Rudenko, S., Davletov, S., et al. (2016). Barqaror taraqqiyot va tabiatshunoslik asoslari [Foundations of sustainable development and natural science]. Tashkent, 296 Pages.

FAO (2020). Global forest resources assessment 2020: Main report. Food and Agriculture Organization of the United Nations, Rome. https://doi.org/10.4060/ca9825en.

Friedlingstein, P., O'Sullivan, M., Jones, M.W., Andrew, R.M., Hauck, J., et al. (2025). Global Carbon Budget 2024. Earth System Science Data, 17: 965–1039. https://doi.org/10.5194/essd-17-965-2025.

Friedlingstein, P., O'Sullivan, M., Jones, M.W., Andrew, R.M., Bakker, D.C.E., et al. (2026). Global Carbon Budget 2025. Earth System Science Data, 18, 3211–3288. https://doi.org/10.5194/essd-18-3211-2026.

GGGI (n.d.). Green Growth Index: Scores and ranks. Global Green Growth Institute, Seoul. Accessed 3 November 2026. https://greengrowthindex.gggi.org/scores-and-ranks-for-green-growth-index/.

ICRP (2007). The 2007 recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Annals of the ICRP, 37(2–4): 1–332. https://doi.org/10.1016/j.icrp.2007.10.003.

Ke, P., Ciais, P., Sitch, S., et al. (2024). Low latency carbon budget analysis reveals a large decline of the land carbon sink in 2023. National Science Review, 11(12): nwae367. https://doi.org/10.1093/nsr/nwae367.

Klein, A.M., Vaissière, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B: Biological Sciences, 274(1608): 303–313. https://doi.org/10.1098/rspb.2006.3721.

Loiseau, E., Saikku, L., Antikainen, R., Droste, N., Hansjürgens, B., Pitkänen, K., Leskinen, P., Kuikman, P., & Thomsen, M. (2016). Green economy and related concepts: An overview. Journal of Cleaner Production, 139, 361–371. https://doi.org/10.1016/j.jclepro.2016.08.024.

Nuriddinova, M., & Ahmad, M. (2025). Economic growth with environmental hurdles in Uzbekistan: Testing the EKC hypothesis. Frontiers in Environmental Science, 13: 1589766. https://doi.org/10.3389/fenvs.2025.1589766.

OECD (2011). Towards green growth. OECD Green Growth Studies, OECD Publishing, Paris. https://doi.org/10.1787/9789264111318-en.

Pan, Y., Birdsey, R.A., Phillips, O.L., et al. (2024). The enduring world forest carbon sink. Nature, 631: 563–569. https://doi.org/10.1038/s41586-024-07602-x.

Pearce, D., Markandya, A., & Barbier, E.B. (1989). Blueprint for a green economy. Earthscan Publications, London.

Potts, S.G., Imperatriz-Fonseca, V., Ngo, H.T., et al. (2016). Safeguarding pollinators and their values to human well-being. Nature, 540(7632): 220–229. https://doi.org/10.1038/nature20588.

Resolution of the President of the Republic of Uzbekistan No. PQ-436 (2022). On measures to increase the effectiveness of reforms aimed at the transition of the Republic of Uzbekistan to a "green" economy until 2030. 2 December 2022. https://lex.uz/docs/6303233.

Richardson, K., Steffen, W., Lucht, W., et al. (2023). Earth beyond six of nine planetary boundaries. Science Advances, 9(37): eadh2458. https://doi.org/10.1126/sciadv.adh2458.

Rumi, J. (2008). Hikmatlar [Wisdom sayings]. Sharq, Tashkent, Page 151.

Sachs, J.D., Lafortune, G., Fuller, G., & Iablonovski, G. (2025). Financing sustainable development to 2030 and mid-century: Sustainable Development Report 2025. SDSN, Paris & Dublin University Press, Dublin. https://doi.org/10.25546/111909.

Salomova, H.Yu. (1996a). Ekologik qiymat ustunmi yoki iqtisodiy qiymat? [Is ecological value or economic value more important?]. Iqtisod va hayot, 5: 40–41.

Salomova, H.Yu. (1996b). Ekologiya, proizvodstvo, chelovek [Ecology, production, and man]. Ekonomika i statistika, 5: 30–32.

Salomova, H.Yu. (2023). Ekologiya va yashil iqtisodiyot [Ecology and green economy]. Durdona, Bukhara, Pages 102–104.

Siviter, H., Bailes, E.J., Martin, C.D., Oliver, T.R., Koricheva, J., Leadbeater, E., & Brown, M.J.F. (2021). Agrochemicals interact synergistically to increase bee mortality. Nature, 596(7872): 389–392. https://doi.org/10.1038/s41586-021-03787-7.

Tan, B. (2021). Zero waste strategies and Turkey's Zero Waste Project. Environmental Research & Technology, 4(1): 97–101. https://doi.org/10.35208/ert.843106.

Tashkent Times (2025). Why are bees pollinating cotton fields in Uzbekistan dying en masse? https://tashkenttimes.uz/national/15780-why-are-bees-pollinating-cotton-fields-in-uzbekistan-dying-en-masse.

UNEP (2011). Towards a green economy: Pathways to sustainable development and poverty eradication. United Nations Environment Programme, Nairobi.

WCED (1987). Our common future. World Commission on Environment and Development, Oxford University Press, Oxford.

WMO (2025). State of the global climate 2024 (WMO-No. 1368). World Meteorological Organization, Geneva.