

A comparative study of environmental protection efforts in the European Union and India

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Abstract

Climate change and global warming, driven by decades of neglect and pollution, increasingly threaten life on Earth. Rising temperatures, species extinction, and frequent wildfires highlight the problem's severity. To prevent irreversible damage, individuals, institutions, and governments promote recycling, energy-efficient technologies, environmental laws, and other sustainable environmental projects. These efforts aim to mitigate climate change and preserve resources for future generations. However, significant differences exist between the environmental conservation practices of the EU and India, comparable mainly by size but different culturally and economically. These differences influence their approaches to sustainable development and environmental protection. Further analysis using the DEA method could offer valuable insights into the effectiveness of their strategies.

Keywords: environment, sustainable development, practices and policies, DEA

1. Introduction

Environmental conservation is a key issue today due to the visible impacts of climate change and resource overuse. Pollution and biodiversity loss cause serious economic and health consequences, demanding action from governments, businesses, and individuals. Sustainable management offers numerous benefits like resource efficiency, green jobs, and lower health costs.

This paper examines the role of governments, businesses, and individuals in environmental conservation through legal frameworks, responsible behavior, and energy-efficient practices, with a focus on comparing examples from the European Union and India. Although India and the European Union are very different regions, it is possible to assess their eco-efficiency by Data envelopment analysis (DEA).

2. Environmental Conservation and Sustainability Strategies

The environment is defined as the entirety of all living and non-living components that interact with each other, including air, soil, water, energy, material resources, and cultural heritage (Zakon o zaštiti okoliša, NN 80/2013). Its protection represents a key prerequisite for maintaining the balance of ecosystems and the functionality of biological systems, especially in the context of intense human-induced pressure, global urbanization, and climate change (Kolbert, 2014; Martin, 2022).

Climate change, accelerated by greenhouse gas emissions and changes in land use, leads to systemic disturbances of ecosystems, including soil degradation, loss of biodiversity, and alterations in hydrological cycles (Rahmati, 2024). The effects of such changes manifest in the disruption of the stability of ecological networks and the reduction of ecosystem resilience to natural and human-induced stressors. At the global level, the loss of key habitats, including forests, coral reefs, and wetlands, threatens the functional connectivity of ecosystems and reduces the ability of natural systems to recycle nutrients and regulate climate (Vuong, Jones, Nguyen, 2025).

Industrial and production systems represent primary sources of human-caused environmental burden. Energy production based on fossil fuels, intensive agriculture and livestock farming, as well as textile production and *fast* fashion, generate

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significant greenhouse gas emissions, water pollution, and soil degradation. Sustainable strategies, including the transition to renewable energy sources, the application of circular economic models, and ecologically certified agricultural practices, have been identified as crucial for mitigating human impact on the environment and reducing the negative ecological consequences of industrial activities (Kolbert, 2014; Henninger, Alevizou, Oates, 2016)

Monitoring and modeling of ecological systems using advanced technologies, such as artificial intelligence, enables precise mapping of biodiversity and the prediction of ecological changes, thereby improving the capacity for timely interventions and adaptive policies (Rahmati, 2024). Education and the application of sustainable strategies in education and daily social behavior contribute to the formation of collective ecological awareness and the reduction of pressure on natural resources (Leopold, 1949). Although written in 1949, Leopold's *A Sand County Almanac* provides foundational ecological principles that remain relevant for contemporary sustainability and environmental management.

A comprehensive approach to environmental conservation requires coordination between political decisions, corporate strategies, and social norms. The implementation of ecological policies, the promotion of research and the development of sustainable technologies, and the support of social initiatives are key factors for ensuring long-term ecological stability. Such an approach allows the maintenance of ecosystem functionality, ensures resource regeneration, and achieves a balance between economic development and the conservation of natural systems (Martin, 2022; Vuong, Jones, Nguyen, 2025).

3. Key challenges and driving factors of environmental protection efforts in the EU and India

Countries implement various laws and systems to protect the environment and sanction violators, aiming to safeguard nature and improve citizens' lives. This paper analyzes the differences in environmental practices between the European Union and India, along with the institutional tools used to mitigate climate change and its effects.

The introduction provides key geographical and demographic data: the EU covers 4.23 million km² with 448.4 million inhabitants (106 inhabitants/km²), while India covers 3.28 million km² (77.5% of the EU's area) and has 1.4 billion inhabitants (three times more), with a density of 419 inhabitants/km² (four times higher than the EU).

3.1. Drivers and Risks of Environmental Conservation in the EU

Key environmental factors, including legislation, infrastructure, and awareness, are analyzed for each region, along with risks related to air, water, and soil pollution.

3.1.1. Legislative factor

The EU and its citizens are known for high environmental standards. Governments set targets for a clean, green, and sustainable EU through numerous policies, directives, laws, and programs to combat climate change, improve health, preserve biodiversity, and promote sustainable growth. Key initiatives include:

- *The European Green Deal (EGD)* aims for climate neutrality and net-zero emissions by 2050 (Dupont and Torney, 2021), alongside the *Effort Sharing Regulation (ESR)* to reduce emissions in sectors like agriculture and transport by 2030 (European Commission, 2025a).
- *The Water Framework Directive (WFD)* seeks to reduce pollution and ensure sufficient water for humans and animals, updating priority substances every 6 years (European Commission, 2025b).
- *The Renewable Energy Directive (RED)* promotes a greater share of renewable energy, reducing EU dependence on external suppliers and enabling affordable domestic energy (European Commission, 2025c).

These are just a few of the many EU policies and directives focused on protecting air, water, and soil.

3.1.2. Infrastructure factor

The EU's infrastructure significantly impacts environmental protection and conservation, covering transport, technology, energy, telecommunications, utilities, and other sectors.

- *Green infrastructure* includes natural and semi-natural areas that improve air and water quality, protect biodiversity, and help climate change adaptation. The EU views it as essential for sustainable development.
- *Transport infrastructure* positively impacts the environment by investing in sustainable transport like public transit, cycle paths, and electric vehicles. Projects such as *Shift2Rail* and *Cycle Cities* are enhancing rail and cycling infrastructure in cities like Amsterdam, Copenhagen, Strasbourg, Berlin, Barcelona and others (Stouhi, 2023). These efforts aim to protect the environment and achieve climate neutrality.
- *Energy infrastructure* reduces negative environmental impact by lowering CO₂ emissions and fossil fuel dependence. The EU provides subsidies of up to 60% (sometimes 80%) for renewable energy systems, such as solar panels (E.ON

Hrvatska, n.d.). Some cities use offshore wind farms, which are more efficient but costlier to install than onshore ones (Kolarić, 2024).

- *Smart and sustainable construction* involves energy-efficient buildings made from recycled and processed materials, often with green roofs that support pollinators like bees (Razvojna agencija IGRA d.o.o., n.d.). The *Energy Performance of Buildings Directive (EPBD)* sets energy efficiency standards for buildings in EU member states, with the obligation for member states to optimize energy efficiency requirements every 5 years (European Union, 2024).

Through sustainable infrastructure, the EU aims to achieve climate neutrality and improve quality of life.

3.1.3. Factor of rising environmental awareness

In addition to sustainable infrastructure, raising awareness about environmental protection is essential for preserving natural resources, biodiversity, and ecosystems, reducing pollution, and ensuring sustainable development. Environmental awareness is best developed from an early age through education. The EU has introduced various strategies and programs for both children and adults. Environmental subjects like biology and geography are taught at all education levels, and universities offer specialized programs in sustainability and environmental policies. Many schools, with EU subsidies, have created gardens for practical teaching in ecology, biology, and agriculture. Students engage in workshops and activities like recycling, cleaning rivers and beaches, planting trees, and more. Digital tools, such as educational games and videos, help students understand environmental issues. In addition to student programs, professional teacher training on ecological challenges through EU initiatives like Erasmus+, Eco-school, Horizon Europe, LIFE program, and others, is also crucial (EuroSchool, 2023).

3.1.4. Environmental risks and threats

Despite efforts, the EU still faces environmental pollution that harms human health and ecosystems:

- The greatest risk is air pollution, responsible for around 4.2 million deaths worldwide each year, including 300,000 in the EU (WHO). Besides mortality, it causes respiratory diseases, weakened immunity, and other health issues. City dwellers are particularly exposed to air pollution from traffic, industry, etc. To reduce harmful emissions, the EU, in cooperation with the WHO and member states, adopts guidelines for emission control, ecological integration in energy and transport sectors, and fuel quality improvement (Council of Europe, Parliamentary Assembly, 2019).
- The EU implements measures to combat water pollution, crucial for all life and sustainable development. European rivers, lakes, and groundwater are increasingly threatened by pollution, climate change, and overexploitation. Fresh and saltwater, essential for agriculture, industry, tourism, and other sectors, face rising pollution levels, posing serious environmental and health risks. To protect water resources, the EU introduced the Water Framework Directive, requiring member states to monitor and report pollutants (European Environment Agency, 2025).
- Soil is a vital part of natural capital, providing food, water purification, and habitats for many species. It supplies 90% of food, fibres, fuel, and raw materials. However, up to 2.8 million sites in Europe may be contaminated. Unsustainable farming, pesticide use, and artificial fertilizers harm soil, plants, animals, and humans, while intensive agriculture leads to deforestation, CO₂ emissions, and soil erosion. Contamination is worsened by municipal and industrial waste, oil spills, and toxic substance leaks. Urbanization also contributes to soil degradation by covering it with asphalt and concrete, hindering its natural functions such as food production, climate regulation, water storage, pollutant filtration and biodiversity preservation (European Environment Agency, 2024).

Due to rising air, water, and soil pollution, the EU has launched various initiatives, passed laws, and introduced policies to mitigate the negative effects of pollution and climate change.

3.2. Drivers and risks of environmental conservation in the India

The following outlines the key factors and potential risks that either help preserve or contribute to the pollution of India's environment. These include legislative measures, infrastructure development, public awareness, as well as threats to air, water, and soil quality across different regions of the country.

3.2.1. Legislative factor

India, like the EU, has adopted numerous laws for environmental protection and biodiversity conservation, enforced by the Ministry of Environment, Forests and Climate Change, the State Pollution Control Board, and the Central Pollution Control Board. Key laws include:

- The Environment Protection Act (1986), introduced after the Bhopal disaster, focuses on pollution prevention, imposes strict penalties, and requires industries to report emissions.
- The Water Act (1974), aims to prevent pollution and improve water quality, requiring permits for wastewater discharge and inspections, with strict penalties for violations.

- The Air Act (1981), controls air pollution by setting air quality standards, regulating emissions, and promoting clean and energy-efficient technologies.

Since 2016, India has been aligning its environmental laws with those of developed economies like the EU, particularly in waste management, with more industries adopting the *polluter pays* principle. Companies are obliged to report on Corporate Social Responsibility (CSR), have a CSR committee, and invest at least 2% of their average net profit in related initiatives. To address the lack of a unified regulatory framework, India is preparing a new comprehensive environmental law to replace existing laws and eliminate contradictions and overlaps between them (Paudyal, 2022).

3.2.2. Infrastructure factor

At COP26 (United Nations Climate Change Conference), India committed to achieving net-zero greenhouse gas emissions by 2070, requiring the development of sustainable infrastructure. This is expected to create jobs, improve living standards, boost economic competitiveness, and attract foreign investment. To support this, India launched programs such as the National Infrastructure Pipeline (NIP), the National Monetization Pipeline (NMP), and the National Logistics Policy (NLP), targeting sectors like roads, ports, railways, energy, and urban infrastructure, with major investments in transport, telecommunications, and energy.

In 2019, India launched the *100 Resilient Cities* initiative to promote low-carbon development, energy efficiency, and climate-resilient infrastructure in cities like Pune, Chennai, Jaipur, and Surat. The program supports sustainable water management, better air quality, waste management, and flood adaptation by implementing early warning systems, green infrastructure (green roofs, urban parks), and sustainable transport (public transport, cycle paths).

These projects strengthen climate resilience, reduce pollution, protect the environment, and improve health and quality of life (India Sanitation Coalition, n.d.). The Government of India has also launched additional initiatives for sustainable infrastructure and environmental protection:

- The FAME program (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) promotes the production and use of electric and hybrid vehicles. The first phase (2015–2019) provided financial incentives for vehicles and charging infrastructure, while the second phase (2019–2024) focuses on integrating them into public transport. The program boosted electric vehicle use, expanded charging networks, and reduced urban air pollution (Deshpande, 2022).
- The PLI (Production Linked Incentive) program actively supports domestic production of high-efficiency solar panels, reducing reliance on imported renewable energy. These panels supply clean, affordable energy, create jobs, and boost economic growth. They are durable, low-maintenance, and suitable for various buildings and facilities. The government also subsidizes solar panel installation, covering 30–70% of total installation costs (Ministry of New and Renewable Energy, Government of India, 2025).

3.2.3. Factor of rising environmental awareness

Education is key to raising environmental awareness in India. Due to growing concerns about climate change and degradation, the Government of India, like the EU, is integrating environmental topics into school curricula at all levels. Still, the National Curriculum Framework emphasizes the need for even stronger integration. The Ministry of Environment, Forests and Climate Change has also launched several programs to promote environmental education:

- The *National Green Corps (NGC)* program establishes school environmental clubs and organizes workshops, seminars, and activities such as tree planting, recycling, and water conservation.
- The *National Environmental Awareness Campaign (NEAC)* raises awareness about environmental protection and sustainable practices through workshops, seminars, and networks of environmental volunteers across India.
- The *National Environmental Awareness Campaign (NEAC)* raises awareness about environmental protection and promotes sustainable lifestyle practices through workshops, seminars, and networks of environmental volunteers across India.

Environmental awareness is also significantly promoted and supported by non-governmental organizations like the Centre for Science and Environment (CSE), the World-Wide Fund for Nature (WWF-India), and the Centre for Environmental Education (CEE):

- *CSE*, founded in 1980 in New Delhi, focuses on sustainable development and environmental issues, offering training, courses, workshops, and educational materials for all age groups.
- *WWF-India*, established in 1969, focuses on actively preserving natural habitats, biodiversity, and ecosystems. It organizes educational programs for students, teachers, and the public and supports government agencies on environmental matters.
- *CEE*, founded in 1984, promotes environmental education and sustainable development through camps, workshops, and conservation projects, and helps develop curricula on environmental issues.

Through the efforts of government bodies and NGOs, young generations can be educated from an early age about environmental protection and sustainable living, contributing to the preservation of India's environment and public health (Centre for Environment Education (CEE), n.d.).

3.2.4. Environmental risks and threats

The previously described efforts aim to reduce the harmful effects of pollution on the environment and human health, particularly air, water, and soil pollution.

India faces some of the world's worst air pollution levels, with PM_{2.5} concentrations up to 16 times higher than WHO limits. The main causes are economic development - in cities, industry and traffic dominate, while in rural areas, heating with organic materials and crop residue burning prevail. Air pollution in India causes nearly 2 million deaths annually, with rising numbers leading to more illnesses, lower productivity, and GDP decline (Mangrulkar, Pawade, Bhorkar, 2024). Beyond health, air pollution also impacts education and daily life, often paralyzing cities, closing schools and public spaces, while many urban residents are advised to wear protective masks (Clean Air Fund, n.d.).

Water pollution is also a major issue in India. Many industries discharge wastewater directly into nearby water bodies, and only about 60% of urban wastewater is treated. Groundwater, the main drinking water source for 85% of the rural population, is increasingly contaminated with heavy metals and pesticides, threatening public health and agriculture. The Ganges River, despite its sacred status, is among the world's most polluted. Although the government runs many projects and initiatives, the problem remains unresolved (Rana & Thakur, 2024).

According to the National Bureau of Soil Survey and Land Use Planning, over 135 million hectares, or 30% of India's soil, is degraded, mainly due to intensive farming, excessive pesticide and fertilizer use, mining, overgrazing, and deforestation. Despite many legislative measures, soil pollution remains a major challenge. Greater institutional efforts, environmental awareness, and promotion of sustainable solutions are crucial for conserving resources and improving quality of life (Menon, 2023).

Even though India's environmental situation is more complex, both the European Union and India face long-term environmental challenges. Institutional measures help address these issues, while awareness and education promote sustainability, curb climate change, and preserve resources for future generations.

4. Data envelopment analysis

Data envelopment analysis can be shortly explained as a mathematical technique (linear programming method) that compares units that use inputs (resources) to produce outputs (outcomes). The result of such a comparison is not only an assessment of the efficiency of the individual units, but also possible changes for inefficient units in order to achieve efficiency.

4.1. DEA Method: procedures and principles

The DEA analysis consists of the following steps:

- Definition of the units whose efficiency is to be evaluated;
- Selection of inputs and outputs, which can be in different units of measurement;
- Selection of a suitable DEA analysis model (CCR, BCC, SBM, Super efficiency, Categorical, ...);
- Selection of the orientation of the model to be used;
- Explanation of the results obtained;
- Recommendations for changes to make inefficient units more efficient.

Due to the advantages of the DEA method, manifested in the ability to consider multiple inputs and outputs, and the unnecessary knowledge of the functional relationship between inputs and outputs, DEA is a widely used method in a variety of fields such as healthcare, industry, trade, insurance, banking, energy sector, manufacturing, etc.

4.2. DEA applications in eco-efficiency estimating

The areas of application of DEA analysis for assessing eco-efficiency can be divided into the following areas:

- Industry – how efficient and environmentally friendly are factories;
- Agriculture – assessment in terms of production and emissions of gases, and water pollution;
- Cities and regions according to resource consumption and pollutant emissions;
- Transport – assessment of means of transport in terms of fuel consumption and pollutant emissions;
- Building construction – consuming a high volume of natural resources and generating solid waste.

Regarding the use of DEA analysis in the assessment of eco-efficiency, the selection of inputs and outputs reflects the relevant indicators: eco-efficiency inputs are the resources used: energy, water, raw materials, labor, capital, and the outputs are the desired outcomes such as profit, production, services, but also undesired outcomes such as wastewater, CO₂ emissions, SO₄, unsorted waste and so on. In the remainder of the article, only some of the most recent applications of DEA analysis in these areas are presented.

Lo Storto (2024) estimated eco-efficiency of municipal solid waste services (MSW) in 258 municipalities in the Apulia region, Italy (2012-2016). Model included the operating cost per quantity of waste (as input) and the per capita quantities of sorted and unsorted waste (as the desirable and undesirable outputs). The results show that the average MSW service decreased from 0.63 to 0.55 which means that there is possibility of improvement of about 45%.

Lei et al. (2023) assessed the eco-efficiency of recycling transformation in 21 industrial parks in Jiangsu Province, China. The results indicated that eco-efficiency varies among different parks: parks in regions with modest economies tend to focus on environment-technology-oriented transformations, while parks in more developed regions rely more on external factors, such as the regulatory framework.

Abdella et al. (2021) developed and integrated application of mathematical and operational procedures, called *Weighted Penalized Maximum Likelihood Estimation (W-PMLE)*, for analysing the eco-efficiency of U.S. food consumption. They highlighted challenges in carrying out an eco-efficiency analysis to account for multiple environmental impact categories with different units of measurement. Results showed that CO₂ emissions, metallic mineral consumption, and water use were the most critical factors affecting eco-efficiency of U.S. food consumption.

Albertini et al. (2021) investigated inefficiency during building construction with regard to environmental aspects, such as waste generation, water and energy consumption. They combined DEA with Tobit model and find that the building construction standards had a negative impact on environmental performance.

Belucio et al. (2021) propose DEA model to assess climate change, acidification, non-renewable primary energy and net present value for building retrofits in Southern European climates.

Zhang et al. (2021) employed three-stage DEA model to measure green efficiency in the fundamental sectors in 30 provinces in China (2010 - 2015). The results showed that green efficiency varied spatially and that policy opportunities for enhancing it mainly lie in region-specific policy and regulations.

Guimaraes et al. (2014) applied the DEA model as a support tool to evaluate the performance of Brazilian container terminals based on eco-efficiency performance. They determined four ports as eco-efficient and assessed how much each non-efficient terminal must improve to achieve eco-efficiency.

It can be concluded that DEA is a suitable method for assessing eco-efficiency in different areas, whose results and suggested changes can serve decision-makers as a valuable tool for optimal decisions, policies, and strategies.

5. Conclusion

Sustainable development and biodiversity conservation require the commitment of the entire society, from individuals and businesses to governments. Governments must create effective environmental policies, businesses must adopt sustainable practices, and individuals must be aware of their own impact. Only through joint action can we ensure a healthy environment for future generations. Although both the European Union and India invest considerable efforts in environmental protection, they start from different positions: the EU has long applied strict standards and technologies, while India continues balancing rapid urbanization and industrialization with environmental protection, leading to differing practices and priorities. Assessing these efforts through the DEA method could offer valuable insights into the effectiveness of their approaches. Recent applications of DEA analysis in the assessment of eco-efficiency show a trend towards the integration of sustainability and sector-specific aspects. This approach enables a deeper understanding of how organizations, sectors and countries can improve their eco-efficiency by taking into account economic, environmental and social aspects.

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