



UNIVERSITÀ  
DI PAVIA

DEPARTMENT OF ECONOMICS AND MANAGEMENT

Master's Program in International Business and Entrepreneurship

**Sustainable Development Management in Companies: Strategies,  
instruments, and impact on competitiveness**

**Supervisor:**

**Prof. Valentina Beretta**

**Student:**

**Nariman Suleymanov**

**Matr.n. 515809**

Academic Year 2022-2023

## Table of contents

<b>Abstract</b> .....	4
<b>Introduction</b> .....	5
<b>Chapter 1.</b> Theoretical and practical foundations of sustainable development and its role in modern business.....	8
<b>Chapter 2.</b> Strategic management of sustainable development in the enterprise.....	17
2.1. Sustainable development strategies for companies.....	17
2.2. Legislative and regulatory framework and the impact of sustainability policy on the company's development.....	24
2.3. Tools and methods for assessing the sustainability of companies.....	36
2.4. Risk management in the context of sustainable development.....	50
<b>Chapter 3.</b> Experience of implementing sustainable development strategies in practice, various companies.....	60
3.1. Implementation of sustainable development strategies in practice.....	61
3.2. Research on the impact of the implementation of sustainable development principles on the financial and non-financial performance of various companies .....	81
<b>Chapter 4.</b> Evaluation of sustainable development of companies based on the application of the fuzzy set method .....	93
4.1. Methodological approach to determining the level of sustainable development of companies based on the application of fuzzy logic tools.....	93
4.2. Conceptual comparative analysis of the fuzzy set method with others methods of assessing the sustainable development of companies.....	127

4.3. Practical use of the fuzzy set method for assessing the level of sustainable development. 133

**Conclusion**..... 135

**List of used sources**..... 140

## Abstract

The concept of sustainable development (SD) is becoming critically important for the operations of companies at all levels. It encompasses economic, environmental, and social aspects, which require companies to rethink traditional management approaches and implement integrated strategies aimed at long-term sustainability.

This paper examines the factors influencing the environmental, social, and economic conditions of enterprises. It begins with the history and definition of sustainable development and highlights its key aspects. The paper generalizes approaches to sustainable development management by integrating economic, managerial, and institutional aspects into a unified analytical framework. The evolution of the concept of sustainable development is systematized, and its applicability to modern corporate governance systems is explored. By developing management strategies that integrate SDGs, the paper makes both a theoretical contribution and provides practical recommendations for managers.

The paper substantiates the existence of a relationship between the level of a company's sustainable development and its key performance indicators, including competitiveness and strategic stability. It also develops a methodological approach based on fuzzy logic, which allows for a comprehensive assessment of both quantitative and qualitative sustainability indicators. This approach helps account for the uncertainty and incompleteness of information that companies face when making decisions, making it particularly useful in today's business environment, where complete and accurate data may be unavailable or difficult to interpret.

**Keywords:** Sustainability, corporate management, strategies, fuzzy set.

## INTRODUCTION

**Relevance of the research topic.** Global climate change, social and gender inequality, and environmental problems are part of the systemic economic crises and challenges that require a revision of the current management concept. Therefore, the concept of sustainable development (SD) is becoming critical for the activities of companies at all levels. It integrates economic, environmental, and social dimensions, requiring companies to review traditional management approaches and implement comprehensive strategies for long-term sustainability.

Sustainable development management in companies encompasses the development and implementation of strategies that minimize negative environmental impacts, promote social equality, and ensure economic efficiency. One of the key components is the integration of sustainable development principles into strategic planning and operational management, which allows companies to adapt to changing conditions.

The complexities and uncertainties associated with the external environment require managers to implement innovative solutions and a flexible approach to management. This includes the use of modern technologies, such as digitalization, as well as the transition to “green” technologies that help reduce resource consumption and emissions. Innovation also plays an important role in the development of new business models focused on sustainable development, such as circular-economy and social-entrepreneurship models (Brenner and Drdla 2023).

Stakeholder management is also becoming important in the context of sustainable development. Involving all participants in the process – employees, customers, suppliers, and local communities – allows not only to consider their interests, but also to form a positive corporate image. Thus,

successful sustainable development management requires open dialogue, cooperation, and a common vision among all stakeholders (Lyulyov Oleksii et al. 2023).

In conclusion, sustainable development and management in companies is a concept that requires a comprehensive approach and active interaction of all participants. Integrating sustainable development principles into management not only increases companies' competitiveness and adaptability but also creates positive social and environmental impacts, ensuring sustainable growth and development for future generations.

**The purpose of this** study is to develop and substantiate a comprehensive theoretical and methodological framework for managing the sustainable development of companies. This includes identifying strategic imperatives, developing tools for implementation and evaluation, and analysing the impact on increasing corporate competitiveness during strategic development.

To achieve this goal, the following research objectives are formulated and should be solved:

1. Systematize and analyze existing scientific and practical approaches to the implementation of sustainable development goals in companies, in various industries.
2. To develop and formulate a comprehensive practical mechanism for managing sustainable development at the corporate level.
3. Identify and substantiate the relationship between the level of sustainable development and key performance indicators of companies.
4. Apply a methodological approach based on fuzzy logic to assess the level of sustainable development of companies in conditions of uncertainty and multidimensionality.
5. Identify potential areas for practical application of the results of the assessment of sustainable development in corporate governance systems.

**The object of the study** is companies from various industries that are implementing or planning to implement sustainable development principles.

**The research examines** the theoretical, methodological, and practical foundations of sustainable development management in companies, as well as its impact on their competitive positions and strategic performance.

**Methodological basis of the research** includes general scientific methods of cognition, such as analysis, synthesis, systems approach, and comparative analysis. In addition, the study employs methods of fuzzy logic, which make it possible to assess complex, multidimensional, and weakly structured indicators of sustainable development and to reduce the limitations of traditional deterministic approaches under conditions of uncertainty. This research is based on content analysis of scientific publications and corporate sustainability reports, expert assessments, and statistical analysis.

## **Chapter 1. Theoretical and practical foundations of sustainable development and its role in modern business.**

Throughout human history, humanity has harnessed the expanding power of the human mind to construct its own ecological niche, often at the expense of the biosphere. Until recently, humankind has not been prepared to advance to a fundamentally new and higher stage of development made possible by this very progress. Nevertheless, human activity has brought the planet to a critical state. The situation has now reached a stage at which no single nation can resolve the problem independently, as it constitutes a global challenge affecting all of humanity.

Sustainable development was first defined in the World Commission on Environment and Development's 1987 Brundtland report 'Our common future' as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (*Brundtland Report. Our Common Future 1987*).

The relevance of this topic in modern world development is associated with the growth of the climate crisis, negative impact on the environment, depletion of natural resources, and disruption of the balance of the biosphere. All this leads to an exacerbation of social problems and limits opportunities for further development, and only the implementation of the concept of sustainable development can stop these degradation processes. A large number of scientists are showing interest in the concept of sustainable development. Among them, we can highlight V. Beretta (Beretta et al. 2023), J. Forrester (Forrester 1971), M. Mesarović (Mesarović M., Mako D., Takahara Y 1970), A. Pestel (A.(Aurelio Pestel 1977), E. Pestel (Mihajlo Mesarovic and Eduard Pestel 1974), B. Commoner (B. Commoner 1972), and others.

The concept of sustainable development emerged as a logical consequence of the active greening

of science and economics characteristic of the late 1960s and early 1970s. The aggravation of environmental pollution, overpopulation, and limited natural resources inherent in many countries raises questions about the prospects of development and the inevitability of a global crisis under the current consumption model. Overconsumption gave rise to the idea of correcting the inevitable global crisis of overproduction, overpopulation, and environmental disaster. In 1968, the so-called Club of Rome (a non-governmental organization created by a group of influential entrepreneurs, economists, famous scientists, and politicians), whose main goal was to develop methods to achieve global equilibrium, undertook one of the first attempts to scientifically understand the nature of the global crisis. At first, no successful result was achieved. In July 1970, J. Forrester, a professor at the Massachusetts Institute of Technology in Cambridge, was tasked with developing a model of sustainability. At the meeting of the Club of Rome in Bern, J. Forrester proposed 14 variables.

However, the model was criticized as primitive, crudely imitating the main processes of the world system. Later, in 1974, M. Mesarovich and E. Pestel developed the second global model of the Club of Rome, "Humanity at a crossroads" (Mihajlo Mesarovic and Eduard Pestel 1974). Instead of the theory of "zero growth", the theory of "organic growth" was proposed - the coordinated development of different parts of the global system, when one subsystem cannot change to the detriment of another, and progress in one of them is possible only under the condition of progressive processes in others. The theory of "organic growth" is determined by the interrelation of economic, environmental, and social crisis situations, which was later reflected in the triune approach to global sustainable development. Subsequently, the author expressed these ideas in «Beyond the Limits to Growth. Eduard Pestel» (Eduard Pestel 1989). Thus, the theory of "organic growth" became one of the foundations of the triune approach to sustainable development. The

greening of science, which was clearly evident in the early stages of the concept's evolution, gradually lost its exclusive role. Researchers recognized that both social and economic components are important in the process of forming sustainable development. The theory of "zero growth" was replaced by the theory of "organic growth", in which the socio-economic environment was no longer considered from the sole position of the destructive component of the environment. The consideration of sustainable development became broader: in addition to the problems of environmental sustainability, it included issues related to the standard of living and economic development. In 1983, at the initiative of the UN, the World Commission on Environment and Development (WCED) was established, chaired by the Prime Minister of Norway, Gro Harlem Brundtland. In April 1987, at the 42nd session of the General Assembly of the UN, a report from the Commission on Long-term Development of Humanity, called *Our Common Future*, (*Brundtland Report. Our Common Future 1987*), was presented.

As a result of the work of the "Club of Rome", an interpretation of sustainable development arose, which is often called the "triune concept of sustainable development" - the interdependence of three main eco-socio-economic aspects of sustainable development: environmental, social, and economic.

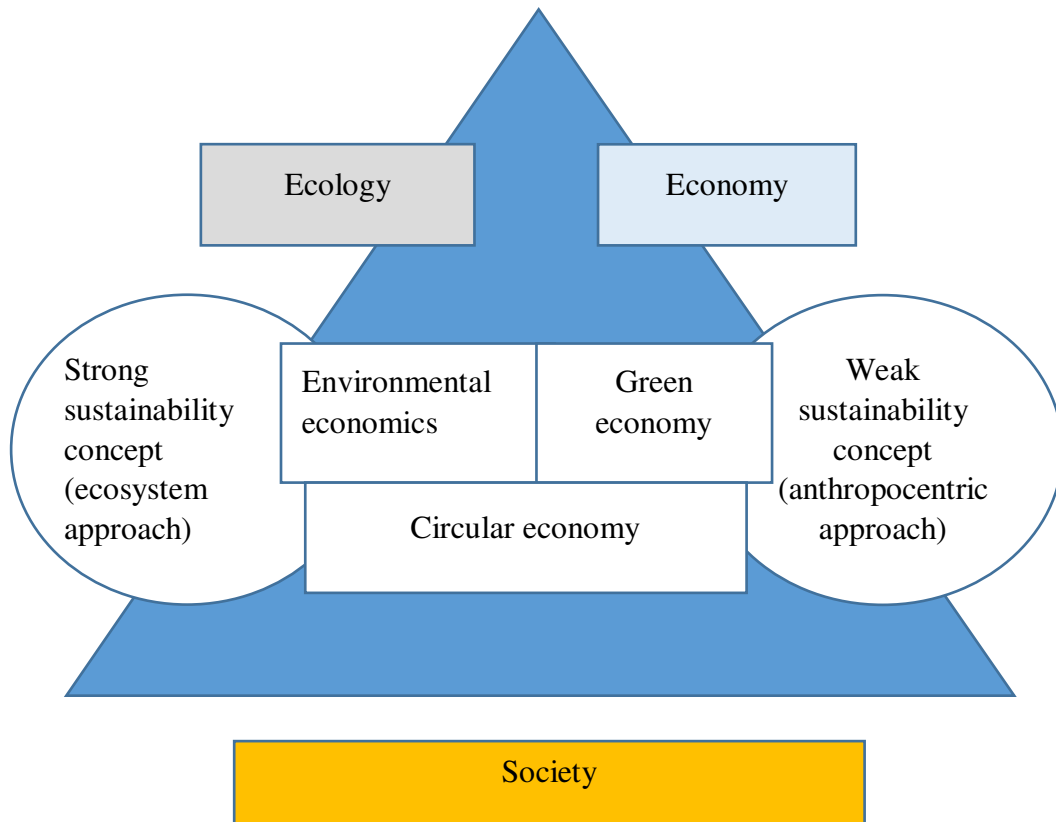


Figure 1. Triune concept of sustainable development, adopted by the Club of Rome (Tatyana Ponomarenko et al. 2020).

As stated above, the most widespread triune approach to sustainable development considers three aspects: environmental, social, and economic. Sustainable development becomes achievable only with the formation of sustainability of each of the three listed components. The environmental component of sustainable development should ensure the integrity, viability, and stability of the biosphere. Sustainable development from an environmental point of view is considered a process of harmonization of the interaction of humanity and the environment. A distinctive feature of the environmental component is the special scientific interest of researchers aimed at preserving the ability of systems to adapt to changes and independently recover. The social component of sustainable development focuses on humans, maintaining the stability of social and cultural systems, including fair sharing of benefits, the preservation of cultural capital and global

diversity, the development of non-dominant cultures, the achievement of social justice, and the encouragement of social pluralism. Most importantly, the goal of sustainable social development should be to raise the standard and quality of human life. The special role of sustainable social development is to create an equal society, eliminate poverty, reduce unemployment, expand productive employment, promote social integration, and free human participation in public, political, and economic life. The economic component of sustainable development implies the optimal use of limited economic resources. Sustainable economic development is based on a balanced economy based on the rational use of available resources, the use of environmentally friendly, energy-saving, and material-saving technologies, which include, among other things, the minimization and recycling of waste.

The principles of sustainable development were outlined in 1992 at the UN World Conference on Environment and Development in Rio de Janeiro. The result of this conference was the global community's recognition of the importance of sustainable development and its principles (*Report of the United Nations Conference on Environment and Development Rio de Janeiro 1992*).

This conference occupies a special place in the evolution of the concept of sustainable development, as it has set a challenge for society, the state and the business community with a task of socially responsible behavior. Also it introduced a new instrument - sustainable development strategy taking into account economic, social and environmental perspectives, based on a document called "Agenda 21" (Tomislav Klarin 2018).

In fact, at this stage, the ideology and direction of the concept were finally formulated, and the tasks and goals were set.

At the closing speech of the Summit, Maurice Strong, the Conference Secretary-General, called it a "historic moment for humanity". Although Agenda 21 had been weakened by compromise

and negotiation, he said, it was still the most comprehensive and, if implemented, effective program of action ever sanctioned by the international community ('The Earth Summit: Introduction' 1992).

He added, among other things, "The processes that generate an unprecedented level of well-being and power for the rich minority simultaneously lead to risks and imbalances that threaten both the rich and the poor equally". This model of development and the corresponding nature of production and consumption are not sustainable for the rich and cannot be replicated by the poor. Following this path could lead our civilization to collapse" (Koptuyug V.A 1992).

His words are very much in tune with the four laws of the American biologist and ecologist Barry Commoner, written in his two books on ecology, *The Violent Circle* (1974) and *The Technology of Profit* (1976) (Barry Draycott 2021):

The first law states, "Everything is connected to everything else." This law illustrates the vast number of connections between living beings in an ecosystem and the environment, the biosphere, society, and the components of many systems. Any impact, even a small one, has consequences, including negative ones.

The second law states: "Everything must go somewhere." It follows from the fundamental law of conservation of matter. Only those substances are synthesized in nature that can be destroyed naturally. According to the first principle, any pollution will return to man.

The third law formulated by an American biologist states: "Nature knows best." It is based on evolutionary theory. The organisms and combinations existing in the modern world are the result of a long process of evolution and natural selection.

Active transformations of the ecological environment (ecocide), biogeochemical processes (cenocide), as well as the extermination of plants and animals (genocide) by humans, can lead to

irreversible consequences, due to the world not being suitable for human existence.

The last law, derived by Commoner, is based on the law of rational use of natural resources and states: "Nothing is given for free" or "Everything has a price." This law combines the three previous ones. The biosphere, as a comprehensive ecosystem, is a single whole. Victory in one place is accompanied by defeat in another.

Since 1992, significant international conferences on sustainable development have taken place, such as the 25 June 1993 World Conference on Human Rights in Vienna ('Vienna Declaration and Program of Action' 1993).

There were other conferences, including these: International Conference on Population and Development (IC, PD) 05 - 13 September 1994, Cairo, Egypt ('Report of the International Conference on Population and Development Cairo' 1994).

World Summit for Social Development - 6-12 March 1995, Copenhagen, Denmark ('World Summit for Social Development' 1995).

Also, in April 1995, the "Berlin Mandate" ('Report of the Conference of the Parties on Its First Session, Held at Berlin' 1995) was adopted. This marked the beginning of the fight against carbon dioxide emissions into the atmosphere and culminated in the adoption of the Kyoto Protocol in 1997 ('Kyoto Protocol to the United Nations Framework Convention on Climate Change' 1998).

As a result, in January 1999, at the World Economic Forum in Davos, UN Secretary General Kofi Annan put forward the idea of the «Global Compact" Economic (*Report of the Secretary-General Proposes Global Compact on Human Rights, Labor, Environment, in Address to World Economic Forum in Davos* 1999). This idea, which 3,000 companies have adopted, created opportunities for the practical integration of sustainable development principles into business and led to the actual expansion of the concept of sustainable development to the micro level. The goal

of the Global Compact was to develop the principles of corporate social responsibility, integrate relations between business, the state, and society, and form a sustainable and open global economy. In fact, the Global Compact is a system of interactions between UN agencies and puts forward the principles of socially responsible business.

Following these conferences, the most successful basic document of the UN Division for Sustainable Development, the so-called "Johannesburg Plan" of 2002 ('Report of the World Summit on Sustainable Development' 2002), was written.

Finally, after a long time of work and conferences in September 2015, all 193 Member States of the United Nations adopted a plan for achieving a better future for all — laying out a path over the next 15 years to end extreme poverty, fight inequality and injustice, and protect our planet. At the heart of "Agenda 2030" are the 17 Sustainable Development Goals (SDGs), which clearly define the world we want - applying to all nations and leaving no one behind ('The SDGs Explained for Business' 2015).

Currently, to measure progress towards achieving Sustainable Development Goals (SDGs), 17 goals and 169 targets are used. Data helps to identify problems, formulate solutions, monitor implementation, and make necessary corrections. In the context of sustainable development and the Sustainable Development Goals (SDGs), terms such as targets, metrics, and indicators are being used.

The Sustainable Development Goals are a call to action for all countries, rich, poor, and middle-income. They aim to improve well-being and protect our planet. States recognize that poverty eradication efforts must go hand in hand with efforts to boost economic growth and to address a range of issues in education, health, social protection, and employment, as well as to combat climate change and protect the environment.

Today, scientists, leaders of countries and enterprises, using collective intelligence, are trying to solve interconnected three eco-socio-economic problems.

Because of the development of the doctrine of sustainable development and the UN's adoption of its goals and principles, it is gaining momentum among companies. The industrial civilization with access to resources and energy understands that its constant use has limitations and can eventually lose everything. The climate crisis, as experienced in real life, compels every person to consider the future. Today, all areas of human activity: the financial sector, the IT sector, the transport sector, and others, are moving towards meeting the requirements of sustainable development principles. By taking into consideration this moment, sustainable development management comes to the forefront. The most important thing is managing the company, its activities, in order to improve both the ecology and the social sphere in the company, and at the same time improve the economic indicators, since the first two indicators (ecology and social spheres) depend on the improvement of the company's economy. At least, if economic performance declines, the sustainability index in the report will deteriorate.

Nowadays, when global challenges such as climate change, loss of biodiversity, and social inequality are spreading throughout the world, companies are increasingly realizing the integration of sustainable development into corporate governance, creating integrated strategies, and integrating sustainability principles.

## **Chapter 2. Strategic management of sustainable development in the enterprise.**

Any company without a developed, clear strategy for sustainable development is not practicing strategic management, effective work, or good management, but rather a set of assets burdened with obligations. The organization must not only survive, but also strengthen its competitive position in the market, for which it is necessary to be engaged in a strategy for sustainable development at a high professional level. Strategic management is the development of a strategy, with the help of a set of formalized procedures, aimed not only to build a model of the company's future, but also to prepare the program for the transition from the current state to a sustainable state. Questions of study: Strategic management of sustainable development in the enterprise. The researchers, such as A Hrinko (Hrinko et al. 2022), M. Sartzetaki (M. Sartzetaki et al. 2025), A. Imashev (A. Imashev 2024), and others, studied it and showed that business development strategies help companies grow by focusing on vital areas of activity, including marketing, partnerships, and employee development. Effective strategic management can help new businesses navigate volatile early years, enabling them to become profitable and hold a strong position in their industry.

### **2.1. Sustainable development strategies for companies**

It is very important to clearly define the characteristics of the goal, principles, strategy, and implementation of sustainable development before management, so that the created management model works correctly. The difference between the goal, principles, strategy, and implementation of sustainable development is their hierarchical nature and sequence of actions:

**Sustainable Development Goal:** The desired outcome to be achieved. The goal is formulated in a measurable and specific way. It represents the desired future state. For example, "reduce greenhouse gas emissions by some % by 2030" or "provide access to clean water for the entire population of the Earth by 2050".

**Principles of sustainable development:** These fundamental, underlying ideas and guidelines define the overall approach to achieving sustainability. They are the ethical foundation on which all subsequent steps are built. Examples of principles are integration of environmental, social, and economic aspects; intergenerational justice (meeting the needs of the present without compromising those of future generations); respect for biodiversity; prevention of harm; and stakeholder participation. The principles provide direction toward sustainability but do not specify actions.

**Sustainable Development Strategy:** This is an action plan aimed at achieving the set goals. The strategy describes how to achieve the goal, what steps need to be taken, what resources to use, and what obstacles to overcome. The strategy may include various approaches, methods, and tools. For example, a strategy to reduce greenhouse gas emissions may include investments in renewable energy sources, increasing the energy efficiency of buildings and vehicles, introducing new technologies, and changing legislation. Strategy is a road map.

**Implementation of sustainable development** means the practical application of the strategy. These are specific actions, programs, projects, and activities undertaken to achieve the goals within the framework of the chosen plan. Implementation includes financing, organizing, monitoring, evaluating, and adjusting needed actions.

All four elements are closely interrelated. Principles underlie goals; strategy is developed to achieve goals, and implementation brings strategy to life. Without clearly defined principles,

goals, and strategy, implementation will be chaotic and ineffective. Moreover, without implementation, even the best strategy will remain just a plan in a computer.

The sustainability management strategy must be tailored to the specifics of each enterprise, taking into account its geographic location, industry, size, risks, and opportunities. There is no universal approach for all industries.

It is possible to identify several main strategic directions, created based on the goal, principles of sustainable development, and their adaptation to different types of enterprises.

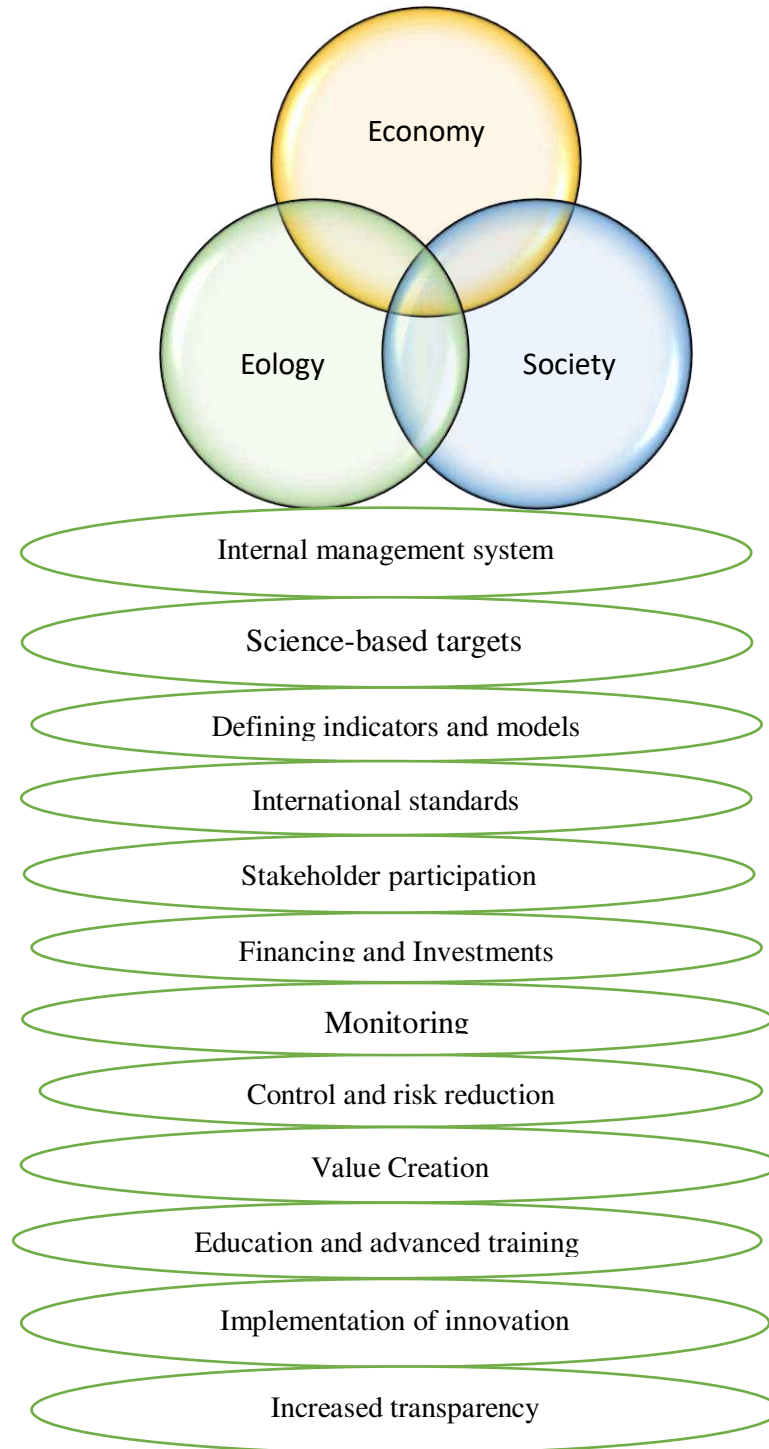


Figure 2. The main strategic plan of companies to achieve sustainable development goals (Source: developed by the author).

Table 1. The main strategic plan of companies is to achieve sustainable development goals and actions according to this plan.

No.	The main strategic plan	Action according to this plan (Source: developed by the author).
1	Internal management system	Determine the structure of the internal management system, its composition and set the task for it.
2	Science-based targets	Clarifying and defining the goal for the management team.
3	International standards	Implementing standards into the management system strategy.
4	Defining indicators and models	Scientifically determine all the indicators and models to determine ESG.
5	Stakeholder participation	Constantly take into account the opinions of stakeholders (investors, local communities, clients, employees) and involve them in the decision-making process.
6	Financing and Investments	The company's goal is to finance and attract investment in its activities, as well as invest in various scientific and technical projects of other companies.
7	Monitoring	Conduct monitoring of environmental parameters using various technologies.
8	Control and reduction of risks	Regularly identify, assess and manage risks, respond to challenges and opportunities related to sustainable development. Identify factors that may negatively affect the business.

9	Value Creation	Involve the development of new products and services, the introduction of innovative technologies, the improvement of brand reputation and the enhancement of customer loyalty in order to create economic, environmental and social value.
10	Education and advanced training	Organizing of training programs on sustainable development and focusing on professional growth.
11	Implementation of innovation	Search and implement new innovative technologies and methods.
12	Increased transparency	Reporting on sustainability performance should be transparent.

(Source: developed by the author).

Strategies must be adapted to different types of enterprises:

Table 2. Adaptation of strategies for different types of enterprises

Industry companies	Strategy	Examples
Metallurgy	Reducing of greenhouse gas emissions, improving of occupational safety, increasing energy efficiency, eliminating of coal, using of recycled materials, reducing of water and energy consumption, and reducing of waste.	Use of hydrogen technologies in metallurgy.
Oil and gas	Reducing of greenhouse gas emissions, switching to cleaner energy sources, increasing energy efficiency,	BP invests heavily in renewable energy and

	reducing of accidents and environmental damage during extraction and transportation, water resource management.	aims to be net zero by 2050.
Big Data	Improving of energy efficiency in data centers, using of electricity responsibly.	Google is investing in renewable energy to power its data centers.
Agrarian	Reducing of use of pesticides and fertilizers, rational use of water, increasing of biodiversity, reducing of gas emissions.	A farm that uses bio preparations instead of chemicals.
Logistics	Optimization of delivery routes to reduce fuel consumption, reduction of the amount of packaging materials, use of electric vehicles.	A company that uses electric vehicles to deliver goods in the city.

(Source: developed by the author).

No matter how we describe the strategy of companies in various industries, the research question will always arise about the effective use of economic, environmental, and financial rules offered by the legislative and regulatory environment in order to build a competent strategy. During strategy development, in addition to other factors, it is necessary to consider the legislative and regulatory environment.

## **2.2. Legislative and regulatory framework and the impact of sustainability policy on the company's development**

Sustainable development of companies determine by both external factors and internal initiatives, but also, mainly, by the legislative and regulatory environment, and state policy. The state plays a key role in forming incentives and restrictions that influence companies' decision-making process in the field of ESG.

International agreements, such as the Paris Agreement on climate change, play an important role in setting global standards for sustainable development. At the national level, legislation varies across countries and reflects their political priorities. Some countries implement strict requirements for ESG reporting, setting emission quotas, regulating waste management, ensuring workers' rights, etc. Other countries prefer incentive measures, such as tax breaks for companies investing in green technologies. Examples of legislation of different countries regulating various aspects of sustainable development are discussed below.

**Italy.** There is a long legal tradition in Italy linked with ESG issues, arising from the 1948 Constitution, which has a strong civic and human rights component. Particularly, the recent constitutional reform (Constitutional Law 1/2022) amended Articles 9 and 41 of the Italian Constitution, establishing on the Republic safeguards the environment, biodiversity and ecosystems “also in the interest of future generations”, and that private economic enterprise should be carried out in a manner that does not damage the environment or human health (Environmental, Social & Governance Law Italy 2025 2025).

In 2021, Italy adopted its National Action Plan on Business and Human Rights for 2021–2026, undertaking the implementation of the 17 Sustainable Development Goals (“SDGs”) and encouraging companies to realize the goal of decent work for all, as set out in SDG 8 (Decent

Work and Economic Growth) and to enhance the use of indicators of quality, sustainable development, equality, and gender.

In 2022, the Italian Government approved: 1. National Transition Plan (Piano per la Transizione Ecologica), which includes several policy actions aimed at fostering the transition of the industrial sector to net zero, in line with the objectives and actions of the European Green Deal; 2. National Strategy for Circular Economy (Strategia per l'Economia Circolare) setting out key policy actions and strategy related to a circular economy.

In addition, in 2023, a national biodiversity strategy for 2030 was adopted, providing key measures to achieve two strategic objectives: establish protected land and sea areas (and a smaller share of strictly protected ones); and restore maritime and terrestrial ecosystems.

In 2023, Italy adopted the National Plan on Adaptation to Climate Change (Piano Nazionale di Adattamento ai Cambiamenti Climatici, "PNACC") to establish a framework for the implementation of actions to adapt to the unavoidable impacts of climate change. Italy, located in the so-called "Mediterranean hot spot", is particularly vulnerable to climate change and related extreme weather events.

**United Kingdom.** Under the Paris Agreement, the UK set a target to reduce GHG emissions by 68% by 2030 compared to 1990 levels. In the second quarter of 2021, the UK announced an even more ambitious target reduce emissions by 78% compared to 1990 levels (Roger Harrabin 2021). By 2050, the UK plans to achieve net carbon neutrality under the Climate Change Act. The Clean Growth Strategy (Climate Policy Database 2017) has become the UK's founding document in the field of sustainable development, which builds on previously adopted laws, such as the Climate Change Act (2008) (Climate Change Act 2008), Pollution Control Act (1974) (183), Environmental Protection Act (Legislation.Gov.Uk 1990). In November 2020, the Green Industrial Revolution

Plan (HM Government 2020) was adopted, comprising 10 points that define the UK energy transition policy. In March 2021, the UK Industrial Decarbonization Strategy was adopted (HM Government 2021).

**France.** Climate policy in France is primarily determined by the pan-European approach and is adjusted in accordance with European legal regulation as it develops. The conclusion of the Paris Climate Agreement and its preliminary preparations gave additional impetus to the development of climate and environmental policy in France. In 2018, National Strategy for Low-Carbon Development of France was adopted (Ministeres Transition Ecologique Aménagement Du Territoire Transports Ville et Logement 2018). The National Low Carbon Energy Strategy (SNBC), adopted under the Energy Transition for Green Growth Act (LTECV), is France's roadmap to combat climate change. It sets out recommendations for the transition to a low-carbon, circular, and sustainable economy across all sectors. It sets out the trajectory reduction of greenhouse gas emissions by 2050 and sets short-term and medium-term targets: carbon budgets. Also very common are regulatory mechanisms for sustainable development, namely the system of trading quotas, pollution taxes, “green” investments, and bonds, which are relevant for all enterprises. Ideas of an English scientist Ronald H. Coase (C. Veljanovski 2013) on issues of property rights in institutional structure, economic functioning, and environmental protection have been developed by such economists as Elinor Ostrom, John Dalesey, and others. John Dales was among the first to propose pollution rights as a market mechanism. In his 1968 work “Pollution, Property & Prices: An Essay in Policy-making and Economics” (J. H. Dales 1968), John Dales established the basis for the modern emissions trading system based on Ronald H. Coase's theorem. Quota-based emissions are based on the following principle: the state sets targets for pollution control and determines the level of emission reduction required. The required reduction level is

calculated based on the existing level of emissions, based on which the number of permits to be issued is then calculated. Through specialized agencies, the state issues licenses/permits for the exercise of the right to pollute within established limits. The total number of permits must correspond to the level of emissions that the state considers necessary to achieve environmental protection goals. Firms that can operate with lower emissions than those mandated by the government receive additional incentives to promote environmentally friendly production. As a result, such a system limits companies in emissions and creates additional incentives for the development of new, environmentally friendly technologies.

The system of trading quotas, as well as the imposition of emissions taxes, constitutes state regulation based on market mechanisms. At the same time, the trading system for emission quotas is typically classified as an instrument with a long-term positive effect, in contrast to other instruments aimed at short-term outcomes, such as an emission tax. Thanks to the system of trading quotas, a limit is set on the emissions of carbon dioxide (or other gases) into the atmosphere, and for emissions exceeding this limit. Otherwise, the issuer must acquire the rights to exceed the limit ('What Is Emissions Trading?' 2011).

As of December 2022, 39 countries have introduced a carbon pricing system (World Bank Group 2025). One of the longest-term systems for trading quotas for environmental pollution is the European Union system – EU ETS (European Union Emissions Trading System). Power plants, as well as enterprises in energy-intensive industries, including oil refineries, steel and aluminum plants, are required to participate in this system.

By 2050, the EU plans to achieve net-zero emissions under the Green Deal. An emissions trading system will also facilitate this.

However, over its history, the EU emissions trading system has evolved and now constitutes an integral part of European policy on emissions reduction. The European emissions trading system covers about 40% of EU emissions, while the global equivalent is 18%.

Some countries, such as France, Sweden, Finland, Canada, etc., combine trading of quotas with the introduction of a carbon tax. Such a tax is mostly widespread in OECD countries and is designed to reduce energy consumption and CO<sub>2</sub> emissions. The revenues governments receive from carbon taxes can be used to invest in low-carbon and energy-efficient technology (P. Bertoldi 2022). Several studies (Alberini et al. (2011), (Patrick Criqui et al. 2019), (Aaron Finley et al. 2024), and others) confirm the reduction in emissions with the introduction of a carbon tax and the effectiveness of such an instrument. As of December 2022, 28 countries have introduced a carbon tax (World Economic Forum 2022).

Carbon tax programs support climate action under SDG 13, affordable and clean energy under SDG 7, and responsible consumption and production under SDG 12. Carbon taxes aim to reduce greenhouse gas emissions, improve energy efficiency, and encourage sustainable industrial practices by integrating environmental costs into economic activity.

Green investment in the most general sense can be defined as capital investments in projects aimed at implementing the Sustainable Development Goals. According to the UN definition, the category of "green" investments includes capital investments aimed at the (United Nation 2020):

- increasing the use of green technologies in various industries
- development of existing technologies in the field of resource efficiency.
- innovation and research in the field of increasing the efficiency of resource use and “clean” technologies.
- training and retraining of employees, considering the focus on the use of new technologies.

According to the UK Green Investment Bank, green investments are defined as investments that have a positive green impact, namely: (Gov.UK 2017):

- contribute to the reduction of greenhouse gases.
- increase the efficiency of natural resource use.
- contribute to environmental protection.
- contribute to the dissemination and strengthening of environmental sustainability.

Despite the lack of a single accepted definition of “green” investment, it generally refers to investment activities whose purpose is to maximize positive environmental and social impacts in the implementation of economic activities.

According to estimates by leading economists (IEA, Bloomberg Finance, World Economic Forum), to halve greenhouse gas emissions by 2050, the required volume of "green" investments is 1-2% of global GDP, or about \$ 1 trillion annually. And according to the IRENA (International Renewable Energy Agency) website “The level of Additional Investments needed to set the world on a more climate-friendly path above current plans and policies is USD 15 trillion by 2050, but one that decreased by over 40% compared to the previous analysis due in large part to rapidly falling renewable energy costs as well as opportunities to electrify transport and other enduses. Overall, total investment in the energy system would need to reach USD 110 trillion by 2050, or around 2% of average annual gross domestic product (GDP) over the period“ (IRENA (International Renewable Energy Agency) 2019). At the same time, most investments should be made in the dirtiest sectors, namely, transport, construction, etc. In 2021, the volume of green and social bond issuance amounted to \$0.5216 trillion. Currently, several international programs (e.g., the UN and the World Bank) are being implemented to promote green bonds, which are aimed at both combating climate change and adapting to its consequences. Bonds for sustainable development

are a mechanism for financing projects that have positive impacts on the environment, social development, and the climate.

One of the most common classifications of bonds aimed at sustainable development is the classification of the International Capital Markets Association (ICMA) (ICMA 2021), according to which the following types of bonds are distinguished:

- "green" bonds.
- social bonds (ICMA 2025).
- Sustainability bonds.
- Sustainability-linked bonds.

It is evident that “green” and social bonds can overlap in many ways, and often the project selected for financing under a particular bond cannot be clearly classified as either “green” or social. In such cases, the category of bonds in the field of sustainable development is used. (ICMA 2021), which combine features of both categories.

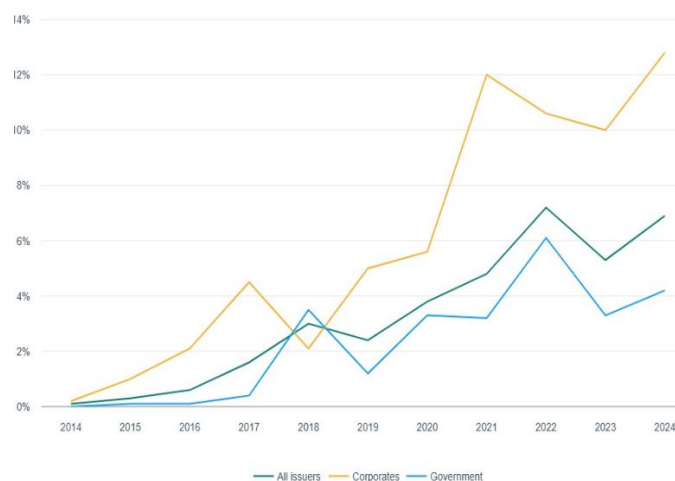


Figure 3. Green bonds as a percentage of total bonds issued by corporations, by governments, and by both corporations and governments in the EU-27, 2014-2024 (An Official Website of the European Union 2025b).

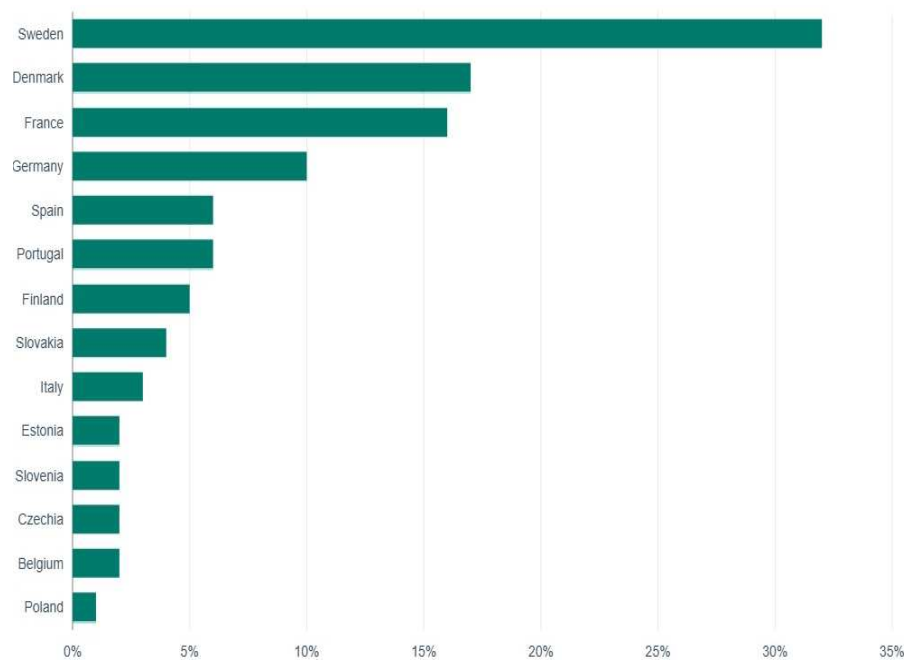


Figure 4. Shares of green bonds issued by corporations and by governments in 2023, by EU Member State

The European Green Deal (An Official Website of the European Union 2019) emphasizes the need to direct capital flows to green investments. One way to achieve this is by issuing green bonds, which, under the EU Sustainable Finance Framework (An Official Website of the European Union 2023), raise capital for projects that help achieve environmental and climate objectives. Additionally, the Competitiveness Compass (An Official Website of the European Union 2025a) emphasizes the need to better mobilize investments for a more competitive, innovative and decarbonised Europe.

Green bond issue increased significantly in the EU between 2014 and 2024, from 0.1% to 6.9% of total bonds issued. This indicates an increasing demand to finance sustainable investments, driven

in part by the European Green Deal and the need to fund the transition to a low-carbon, green economy (An Official Website of the European Union 2025b).

The European Investment Bank is currently one of the leaders in the green bond space. On 2 April 2025, the European Investment Bank (“EIB”) priced its first Climate Awareness Bond aligned with the European Green Bond Standard (“EuGBS-aligned CAB”), for €3 billion due 15 May 2037. The bond, the largest issued under this standard to date, pays an annual coupon of 3.125% and has an issue price of 99.627%, offering a spread of +50.7 basis points over the DBR of 2.500%, maturing on 15 February 2035. Since the beginning of 2025, the EIB has issued bonds worth around €35.8 billion, representing almost 60% of its €60 billion financing programmed for 2025.

Government and international organizations play a very important role in the implementation of sustainable development principles in enterprises. It is very important for the management team of the enterprise to study the provisions and recommendations of government and international organizations, and even to forecast changes in the legislative and regulatory environment and adapt to them. Companies should actively engage with government agencies, participate in public discussions, and, where possible, lobby state and international organizations to advance their interests in sustainable development. Effective government regulation should stimulate companies to sustainable development without hindering economic growth.

National and international legislation on sustainable development mainly concerns the following areas: economic, social, environmental, and managerial.

In addition, all businesses must embed the Ten Principles of the UN Global Compact into their strategies, policies, and procedures to build a culture of integrity and long-term success.

The Ten Principles of the United Nations Global Compact are derived from: the Universal Declaration of Human Rights, the International Labor Organization's Declaration on Fundamental Principles and Rights at Work, the Rio Declaration on Environment and Development, and the United Nations Convention Against Corruption (United Nations Global Compact 2011).

As we have said above, legislative acts of government and international organizations play an important and primary role in corporate governance in the context of sustainable development. However, political instability in the country and legislative changes can create significant uncertainty for companies planning long-term investments in sustainable development. Changes in tax legislation, the introduction of new regulations, or the cancellation of existing ones can lead to significant financial losses or the need to revise the strategy.

In the area of sustainability and ESG factors, two main types of policies influence strategy:

- 1) Global and public policy.

Global actors and scientists play a crucial role in shaping and promoting sustainable development strategies through the creation of global policies. By setting clear goals, encouraging innovation, and stimulating countries and companies to work on sustainable development, policies can guide society towards a more equitable future.

If we analyze the properties and impact of policy on sustainable development, then politicians establish rules, standards, laws, and decrees that promote the implementation of sustainable practices in various sectors, such as agriculture, industry, energy, transport, IT, etc. All established rules should avoid conflicting goals and promote synergy. The proposed economic, environmental, and social policies should influence sustainable development, economic development, create certain types of activities, protect natural resources and ecosystems, develop areas such as

education and health care, promote innovation and cooperation, stimulate cooperation between governments, businesses, and civil society organizations.

2) Internal policy of the company.

As a rule, policy is understood as a high-level document that sets out the principles and operational rules, general goals and objectives, management structure, and the main responsibilities of the parties responsible within the company. In other words, these are the guiding principles that help the company's specialists make appropriate decisions or act in a specific situation and thereby ensure uniformity of approaches and practices within (EcoStandard. Journal 2023).

To date, there is no universal methodology for developing a sustainable development policy for developing a sustainable development strategy for an enterprise, and each organization largely independently determines the concept, structure, and scope of the document.

Policy, as a framework and system-forming document, is largely formed based on general principles.

In most cases, the policy for developing a sustainable development strategy in enterprises sets the goals, principles, directions, and objectives of activities in the field of ESG and sustainable development, and also determines interaction with stakeholders. At the same time, many companies in their policies highlight such sections as risks, management system, reporting in the field of sustainable development, ESG, and financing.

If we compare policies and strategies for sustainable development, then the policy defines the rules, organizational structures, basic principles, deadlines, financing, and regulations that the company should follow to achieve the set goal, and the strategy builds a plan to achieve the set goal based on this policy.

The procedure for developing sustainable development policies should, where possible, include:

- 1) Analysis of global and national regulations, trends in the field of sustainable development and ESG.
- 2) Analysis of the regulatory environment.
- 3) Adoption and implementation of standards.
- 4) Analysis of the company's internal regulatory documents.
- 5) Adoption and implementation of standards and requirements (legal, environmental, social).
- 6) Drawing up a stakeholder map.
- 7) Conducting internal consultations with top management representatives, shareholders, and key employees of the company.
- 8) Conducting external consultations with other stakeholders.
- 9) Benchmark analysis of industry trends.
- 10) Integration of sustainable development principles into all functional areas of the company's activities, into all links of the production chain (comprehensive approach).

Both global and state policies, as well as the company's internal policies, shape the development of a sustainable development strategy, in turn influencing the company's activities and potential.

Table 3. Enterprises potential

<b>Potential</b>	<b>The nature of potential</b>
Financial	Own resources, investment resources, borrowed and attracted financial resources.
Industrial	Technical and technological, volume of production.
Personnel	Human and Social Capital
Business	Goodwill (an intangible asset that arises when a company is purchased and exceeds its net asset value) and reputational capital) (Royston Parkin 2024).
Market	Demand for products, company market share, market information resources.
Research and Development	Research works.
Labor	Organization and markets of production factors.

(Source: developed by the author).

It should be added that the potential of the enterprise in turn influences the development of the strategy for sustainable development of the enterprise, and in general, the sustainability of the enterprise. Therefore, it is necessary to view issues in a broader context so that the enterprise can strike a balance among remaining competitive, stimulating innovation, and preserving the environment.

### **2.3. Tools and methods for assessing the sustainability of companies.**

Methods are the tools and techniques used to collect, analyze, and evaluate data within the chosen methodology. They represent the computational steps that enable the methodological approach to be implemented in practice. They play an important role in choosing a strategy and in the following stages.

Methods answer the question: “What tools and methods will we use to collect, analyze, and evaluate data?”

Some examples of sustainability research methods:

- qualitative methods include document analysis, interviews, focus groups and observation.
- quantitative methods include modeling, statistical data analysis and experiments.
- The index method is used for the evaluation of complex indicators of sustainable development.
- Scenario planning means forecasting possible scenarios for the development of events.
- Life Cycle Analysis (LCA) is used for evaluation of the environmental impacts made by products and processes.
- Geographic information systems (GIS) are used for analyzing spatial data.
- Environmental impact assessment methods are used to assess potential environmental harm.

Analysis and evaluation of the sustainable development of an enterprise is a process of measuring, analyzing, and evaluation of the environmental, social, and economic impact of the company's activities. It is necessary to determine strong and weak sides, evaluate risks and opportunities, and control the progress, which is going to achieve the Sustainable Development Goals. Without objective analysis and evaluation, the effective management of sustainable development is not possible, and preparing a report to stakeholders (investors, customers, employees, society), and demonstrating the company's commitment to a sustainable future is a logical end of this process.

We would also like to add that the choice of methods for analyzing and assessing sustainable development depends on the industry, the specifics of the company, its activities, its goals, and its needs. For example, in Table 4, we will show what the main differences in assessing sustainable development between financial institutions and oil and gas companies are.

Table 4. Key differences in assessing sustainable development.

Aspect	Financial institutions	Oil and gas companies
Ecology	Financed emissions (Scope 3, Cat. 15), climate, and portfolio risks.	Direct emissions (Scope 1, 2), operational impacts, Scope 3 (product use).
Social	Financial inclusion, customer protection, sales ethics.	Occupational health and safety, local communities, just transition, security.
Management	Integration of ESG into risk management, responsible investing.	Energy transition strategy, lobbying transparency, operational risk management.
Main challenges	Client data collection, portfolio risk assessment methodology, ESG and profit balance.	Capital intensity of decarbonization, management of "stranded assets", public pressure
Role in the transition to sustainable development	Directing capital to sustainable projects and companies, managing systemic risks.	Direct impact reduction and business model transformation
Stakeholders	Investors, regulators (financial supervision), clients (depositors, borrowers).	Regulators, local communities, environmental NGOs, investors,

(Source: developed by the author).

The financial sector plays a major role in facilitating the energy transition of oil and gas companies. The requirements of investors, lenders, and financial institutions can compel companies to adopt more proactive sustainability measures and to integrate ESG considerations into the strategic decision-making process.

One well-known method for the evaluation of corporate sustainability is Life Cycle Costing (LCC), which was developed for the assessment of investment project costs. LCC has evolved to support comprehensive evaluation of environmental, social, and economic performance linked with a product or service's entire life cycle—from raw material extraction to disposal. The Life Cycle Sustainability Assessment (LCSA) builds on LCC, enabling organizations to quantify environmental impacts and social outcomes while also controlling economic indicators. LCSA frameworks often suggest international standards such as ISO 14040 and ISO 14044, which show the way to choosing impact categories, indicators, and characterization models.

The LCSA process starts from goal setting and scoping, continues with inventory analysis, impact assessment, and identification of significant sustainability issues. Results consist of conclusions, recommendations, and subsequent measures, which also include product improvements, strategic planning adjustments, stakeholder engagement policies, and corporate development strategies.

The mentioned example is the DESIRES framework (Azapagic, A., et al 2016), which integrates economic, environmental, and social sustainability through tools such as scenario analysis, life cycle cost evaluation, social sustainability evaluation, system optimization, and multi-attribute decision analysis. This framework has been successfully applied to the energy sector, demonstrating the practical value of combining life cycle analysis with strategic decision support for sustainable production and consumption.

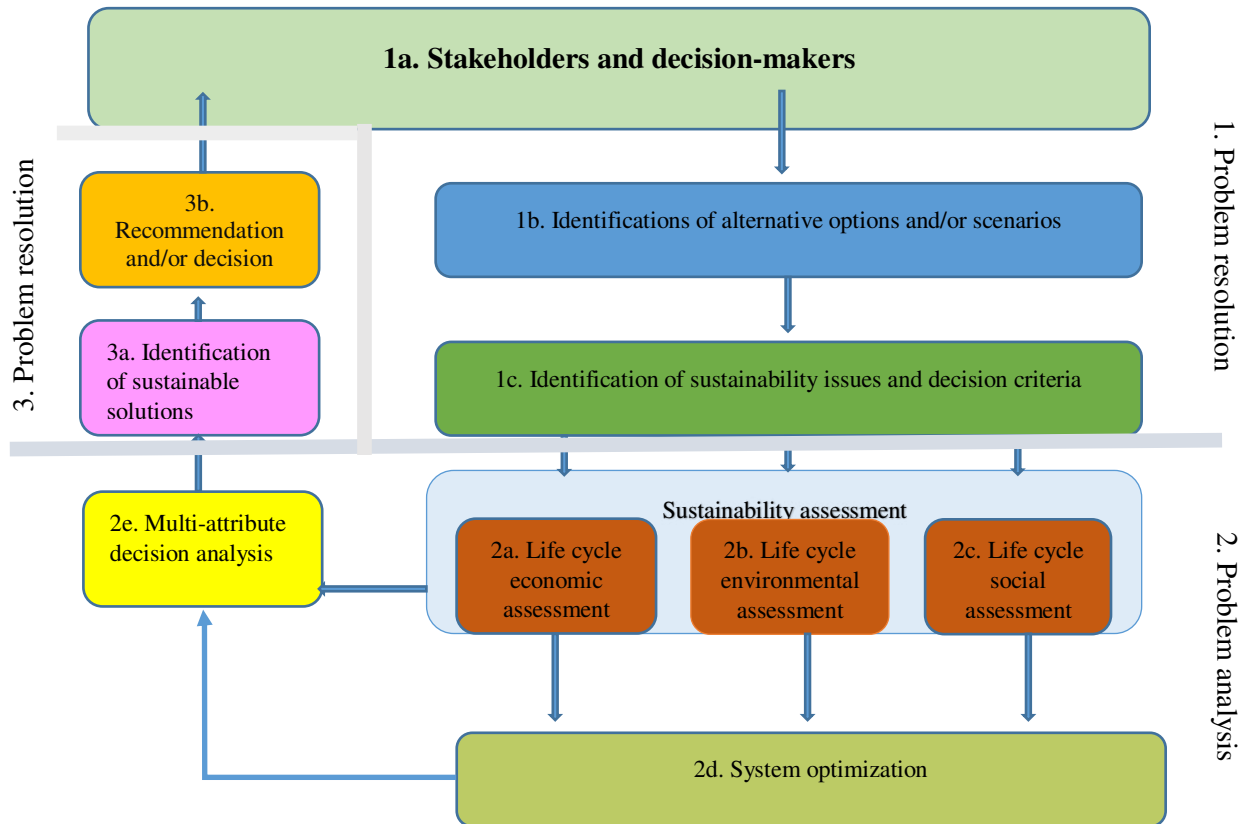


Figure 5. DESIRES: a decision–support framework for identifying sustainable production and consumption options. (Source: (Adisa Azapagic et al. 2016))

Stakeholders and decision makers define alternative options, issues related to environmental and social factors, as well as decision-making criteria. Next comes the process of assessment in terms of sustainable development principles: an assessment of the economic, environmental, and social aspects of the project life cycle is carried out. The LCC approach is used to assess the economic components, and the LCSA approach is used to assess the environmental ones. The Social Life Cycle Assessment (SLCA) is used to assess the social aspects according to the methodology proposed by UNEP (United Nations Environment Program) (UNEP 2009). SLCA follows the LCA approach, but instead of environmental impacts, it assesses various social aspects of the life cycle

of options of interest to stakeholders. Over 150 social impacts, both quantitative and qualitative, can be considered in SLCA. Examples of the former include the number of jobs created, the number of occupational injuries and health impacts. In contrast, qualitative indicators include issues such as child labor, corruption and cultural heritage.

Based on the assessment, the system is optimized through multi-criteria analysis. Subsequently, solutions in the field of sustainable development are developed, and recommendations are provided to stakeholders and decision-makers. The entire process includes three phases: structuring the problem, analyzing the problem, and developing a solution to eliminate the problem. Using such a structure, which includes all three phases, allows us to say that the information obtained during the study can be used within the framework of a much more comprehensive decision-making process.

To summarize, it is important to use reliable and transparent methods across industries to obtain an objective picture and make informed decisions in the field of sustainable development. Regular monitoring, analysis, evaluation, and learning from new methodologies are the key to successfully achieving long-term sustainability.

Indicators also play an important role in developing a sustainable development strategy.

Chapter 40 of Agenda 21 (Information for Decision-making) notes: “In order to provide a reliable basis for decision-making at all levels and to help facilitate the self-regulating sustainability of complex ecological and development systems, it is necessary to develop indicators of sustainable development.”

Indicators in sustainable development are quantitative or qualitative metrics that provide information about the state, trends, and changes in systems. Currently, two main directions in the field of developing indicators of sustainable development have found wide application:

1) Formation of a system of indicators, each of which reflects individual aspects of sustainable development. Within the framework of the general system, the following subsystems of indicators are distinguished: environmental, economic, social, and institutional.

2) Formation of an integral (aggregated) indicator, with the help of which it is possible to track the sustainability of development. Aggregation is carried out based on three groups of indicators: ecological-economic, ecological-socio-economic, and ecological.

Indicators and criteria of success are the main tools in any sustainable development strategy. They enable us to measure the progress and effectiveness of actions taken, determine whether the set goals have been achieved, and adjust the course if necessary. Without clear indicators and criteria of success, sustainable development remains only a good intention, devoid of measurable results.

When assessing sustainability in enterprises, at least four approaches can be distinguished:

- 1) Indicators that aggregate various indicators to obtain a single index. Most often, economic, social, and environmental indicators are combined. Indicator systems that combine individual indicators that reflect individual aspects or goals of sustainable development. Such systems may include economic, social, environmental, and management indicators in enterprises.
- 2) Special private indicators. Here, indicators of natural resource intensity, energy intensity, and pollution intensity (specific pollution) are widely used, reflecting the costs of natural resources and pollution (emissions, discharges, waste) per unit of final result.
- 3) Indicators obtained from sociological surveys reflect the attitude of stakeholders to individual sustainable development issues.

The first approach involves constructing an integral (aggregated) indicator, based on which one can judge the degree of sustainability of socio-economic development. Aggregation is usually carried out

based on three groups of indicators: economic, environmental, and social. This approach corresponds to the goals of constructing an environmental rating, since it allows one to obtain one indicator.

The second approach is based on the construction of a system of indicators, each of which reflects individual aspects of sustainable development. Most often, the following subsystems of indicators are distinguished within the general system:

- economic.
- related to the environment.
- social.
- managerial.

In the third approach, using private indicators, an important indicator is the natural capacity. Almost all systems of international organizations and individual countries widely present various modifications of this indicator. Reducing the natural capacity of the economy in dynamics is one of the effective implementations of sustainable development. As we know, environmental intensity in the context of sustainable development of the enterprise is an indicator reflecting the efficiency of natural resource use and the minimization of negative impact on the environment.

The fourth approach is the answers obtained from social research questions.

It should be noted that although indicators are classified as economic, environmental, and social, many specialized indicators can nevertheless reflect various aspects of sustainability. For example, the most important indicator of energy intensity, which reflecting the efficiency of energy resource use and reducing energy intensity, can be included in various groups of indicators: economic (its level reflects the level of efficiency of energy use in the economy); social (the amount and composition of emissions affect human health), environmental (connection with pollution levels,

greenhouse gas emissions). Taking this into account, individual indicators are interpreted as environmental-economic, environmental-social-economic, social-environmental, and so on.

Table 5. Indicators of sustainable development of enterprises.

Areas of Sustainable Development	Indicators
Economic	<ol style="list-style-type: none"> <li>1. Revenue from sustainable products/services: percentage of revenue generated from products or services that meet sustainable criteria.</li> <li>2. Resource efficiency: return per unit of energy or water consumed.</li> <li>3. Investment in sustainable innovation: Amount of funds spent on R&amp;D in sustainable technologies.</li> <li>4. Local procurement: Share of purchases from local suppliers.</li> <li>5. Taxes and economic contribution: Amount of taxes paid.</li> </ol>
Environmental	<ol style="list-style-type: none"> <li>1. Greenhouse gas emissions</li> <li>2. Energy consumption</li> <li>3. Water consumption</li> <li>4. Waste generation</li> <li>5. Impact on biodiversity</li> <li>8. Use of recycled or sustainable materials</li> </ol>
Social	<ol style="list-style-type: none"> <li>1. Equality and diversity: percentage of women/minorities in leadership positions, gender pay gap.</li> <li>2. Community development: the volume of investment in local communities, the number of jobs created the availability of social support programs.</li> </ol>

	<p>3. Working conditions: existence of collective agreements, number of industrial accidents, injury frequency rate, respect for human rights in the supply chain.</p> <p>4. Availability and quality of products/services: number of complaints, accessibility for people with limited mobility, level of customer satisfaction</p> <p>5. Staff training and development: staff turnover rate, number of training hours per employee.</p>
Governance	<p>1. Board composition: gender diversity on the board.</p> <p>2. Integration of ESG factors: presence of a sustainable development committee, presence of ESG goals in the top management remuneration system.</p> <p>3. Anti-corruption: number of cases of violation of ethical standards, trainings conducted on anti-corruption policy.</p> <p>4. Interaction with stakeholders: regular dialogue with interested parties, taking into account their opinions.</p> <p>5. Transparency of reporting: publication of non-financial reporting (according to GRI standards).</p>

(Source: developed by the author).

Above, we presented a list of indicators, mainly for industrial enterprises. Depending on the industry, the goals, objectives, and indicators differ. For example, to the indicators of sustainable development of agriculture, we can add such environmental indicators as,

Reducing emissions and waste can be realized by the implementation of technologies for reducing the negative impact on the environment.

Soil and water conditions needed for prevention of erosion.

Preservation of biodiversity entails the use of crop rotation methods and the preservation of natural landscapes.

Resource efficiency is about controlling the consumption of pesticides, fertilizers, energy, and water.

Agriculture is an industry that encompasses many aspects. Some people grow wheat; others keep cattle or raise fish.

When we discuss success criteria for sustainability, the strategic goals we aim to achieve are described. These goals are things that we can measure to know the level of the job. We determine these goals by examining indicators, and then we set specific targets for the organization to work toward. The main success criteria for a sustainability strategy are that it should be achievable yet challenging, and that we should have a clear target date for achieving them. Success criteria for a sustainability strategy are important because they help us stay on track and make sure we are doing what we set out to do.

In conclusion, intelligently selected indicators and criteria for success enable objective evaluation of the effectiveness of the enterprise's activities.

Additionally, with growing attention to climate change, social justice, and ethical business practices, sustainable standards and certifications have become an essential tool for companies

seeking responsible growth. They serve as a powerful mechanism for managing risk, building trust, demonstrating a commitment to sustainability, and gaining a competitive advantage.

**Sustainable Development Standards**— are sets of rules, requirements, criteria, or guidelines designed to ensure environmental, social, and economic sustainability in specific industries, processes, or products. They define “what” needs to be done to achieve sustainability. Many standards go beyond national and international regulations, helping companies remain compliant and avoid regulatory burdens.

**Sustainable Development Certifications**— is an independent third-party assessment process that verifies that an organization, product, or service meets certain sustainability standards. Certification is evidence that the stated sustainability principles are met and adds an element of trust and transparency.

Standards set the bar, and certification certifies that this bar has been reached. The application of sustainable standards and certification provides numerous benefits to companies and responds to numerous market and societal demands. The implementation of standards by companies leads to improved operational efficiency and cost reduction, as it leads to process optimization. Compliance with sustainable standards helps companies manage environmental and social risks, reduces the likelihood of fines, lawsuits from labor law violations, and environmental pollution. Compliance with sustainability standards has a positive effect on the company's image and its perception by customers and investors.

There are many standards and certifications covering different aspects of sustainable development and adapted to the specifics of different industries: ISO 14001 (Environmental Management System) (ISO 2015) , ISO 50001 (Energy Management System) (ISO 2018), GRI Standards (Global

Reporting Initiative), SA8000 (Social Responsibility), SASB (Sustainability Accounting Standards Board), etc.

After developing their internal sustainable development management, companies, considering the industry-specific characteristics of the company, its activities, goals, and resources, determine which standards are most suitable for them. Let us show, for example, some differences between the standards of a financial institution and an oil and gas company.

Table 6. Differences in standards in companies of different industries

Dominant standards of sustainable development	
Financial institution	Oil and gas enterprise
PCAF (Partnership for Carbon Accounting Financials), (Partnership for Carbon Accounting Financials 2025). This is a global initiative where financial institutions, as defined by the PCAF, come together to develop and implement a common approach to measuring and disclosing greenhouse gas emissions associated with their lending and investment operations.	GRI (Sector), (Global Reporting Initiative), (GRI, n.d.). These are standards developed for specific industries to help companies in those industries communicate more effectively and consistently about sustainability and their impact on the environment, society and the economy.
PRB/PRI (Principles for Responsible Banking and Principles for Responsible Investment), (UN. Environment Programme 2025) - international initiatives that promote the	IPIECA (International Petroleum Industry Environmental Conservation Association), (Ipieca 2025). The global oil and gas association for advancing environmental

<p>integration of ESG (environment, social responsibility and governance) factors into the financial sector to drive sustainable development</p>	<p>and social performance across the energy transition.</p>
<p>SASB (Sustainability Accounting Standards Board), (SASB 2025) - These are industry standards for companies to disclose information about sustainability. They help organizations provide investors with information about the risks and opportunities associated with sustainability.</p>	<p>SASB (Sustainability Accounting Standards Board) - These are industry standards for companies to disclose information about sustainability. They help organizations provide investors with information about the risks and opportunities associated with sustainability.</p>
<p>EU Taxonomy/SFDR (Apiday 2024). EU Taxonomy and SFDR are two interrelated sustainability standards introduced by the European Union. The EU Taxonomy defines which economic activities are considered environmentally sustainable, while the SFDR (Sustainable Finance Disclosure Regulation) obliges financial market participants to disclose information on how their products comply with the Taxonomy requirements.</p>	<p>The GHG Protocol (Greenhouse Gas Protocol) is a set of international standards and guidelines for measuring, managing and reporting greenhouse gas emissions. It provides a comprehensive framework that enables organizations, countries and cities to quantify, track and reduce greenhouse gas emissions.</p>

(Source: developed by the author).

Thus, the selected standards are implemented in the sustainable development management system. Perhaps after these procedures, it will be necessary to invest in new technologies so that the results of production activities correspond to the selected standard. Once the goals of sustainable development are achieved, the company applies to an accredited body to obtain a certificate in sustainable development.

The use of sustainable standards and certifications is an investment in a company's long-term success. The right choice and effective implementation of standards can lead to significant competitive advantages. They provide a necessary framework for action, stimulate innovation, increase accountability, and build trust in supply chains. Over time, the role of these tools will only increase, and new standards will emerge as companies, governments, and consumers become increasingly aware of the need to move towards a more sustainable future.

#### **2.4. Risk management in the context of sustainable development.**

Sustainable development is not just a desirable goal, but a comprehensive paradigm that inevitably brings enormous opportunities for those who actively integrate it into their activities. Understanding this is the key to developing a sustainable and successful strategy in the modern world.

In modern conditions, the implementation of risk management systems in organizations contributes to the achievement of strategic goals, increasing the value of the organization, ensuring the efficiency and effectiveness of the business, which is largely aimed at ensuring strategic sustainability in both the short and long term.

In this regard, the issues of building effective risk management that enables timely identification of emerging risks and prompt responses are relevant. In many organizations, the need to manage strategic sustainability is increasing, driven by the development of a risk management system that

aligns with the organization's stage of development and the maturity of its existing risk management system.

Risks in the context of sustainable development can be viewed in two ways: as risks associated with the transition to sustainability itself, and as more significant risks that arise when the principles of sustainable development are ignored.

When the principles of sustainable development are ignored or taken lightly, society, nature, and the enterprise itself suffer. Ignoring social risks: Failure to respect labor rights, low wages, poor working conditions, discrimination, and unfair distribution of benefits or the negative consequences of production may lead to strikes, boycotts, public protests, and the undermining of social stability. In environmental neglect, damage to the environment (air, water, and soil) will increase disease rates, reduce biodiversity, and decrease the sustainability of agricultural systems. And all this will lead to fines, lawsuits, and the loss of a "license to operate" from local communities. If economic and financial risks are ignored, when an enterprise does not take these risks into account, or does not take clear regulatory measures, it will lose profits, investors will turn away from it, it will pay large fines, its shares will depreciate, it will not be able to obtain green loans, etc. Companies that lack strategic flexibility, effective corporate governance, and technological breakthroughs will lose competitiveness.

The purpose of ESG risk identification is to identify obvious, non-obvious, open, and hidden risks that may affect the business in various future contexts or may generally create a shock. Risk identification and impact assessment enable the development of plans to mitigate them.

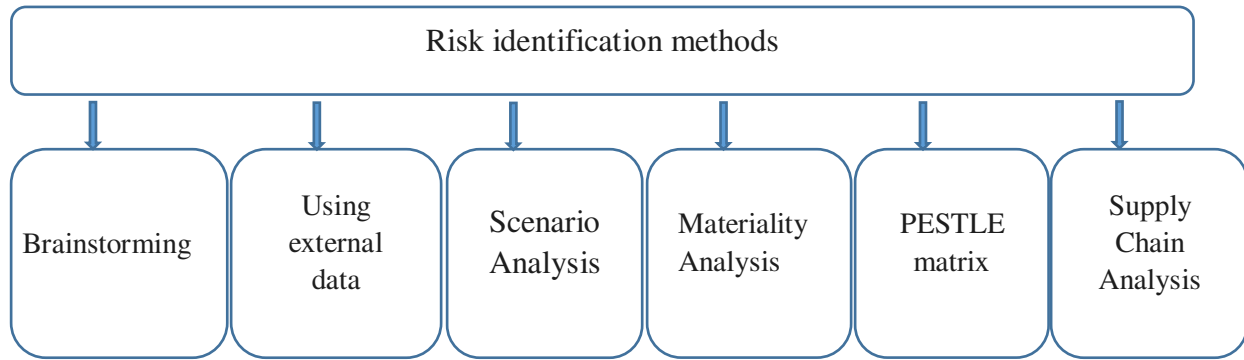


Figure 6. Risk identification methods (Source: developed by the author).

To begin identifying risks, it is first necessary to define the boundaries of the analysis. This includes the entire company, the production process, the products produced, the geographic region, and the specific supply chain.

The next step is to use the special methods indicated in Figure 6.

- brainstorming: collecting opinions of experts from different departments of the company, governing bodies.
- using external data: analysis of ESG rating reports, news articles, research publications, and market trend data.
- scenario analysis: development of different scenarios of the future and assessment of the probability of risks arising in each scenario.
- materiality analysis: identifying the most significant ESG factors for the company and its stakeholders.
- PESTLE matrix (or PESTEL): analysis of political, economic, social, technological, environmental, and legal factors that may affect the company.
- supply chain analysis: assessment of risks associated with suppliers, logistics, and distribution.

As an example, we will examine the PESTLE matrix and the scenario method for identifying risks.

PESTLE analysis examines how external factors affect a business.

By conducting a PESTLE analysis, HR professionals can anticipate potential regulatory changes and economic trends, enabling them to prepare and adapt their strategies accordingly. This foresight helps reduce risks and ensures that external changes do not take the organization by surprise. Based on the analysis, the opportunities and threats associated with each PESTLE factor are identified.

Scenario analysis is also highly effective for identifying, analyzing, and assessing risks (opportunities) and connections to an uncertain future. Depending on the level of development (ESG), it allows companies to prepare for any possible global development trajectory, influenced by macroeconomic, environmental, social, and political factors. Scenario analysis involves constructing a set of plausible but different future outcomes. These scenarios are defined as different forces of underlying factors (dynamic changes) that can arise and interact, leading to different outcomes. Instead of a single "most likely" forecast, several alternative futures are offered, with timeframes of 1, 5, 10, and 15 years. For example, a scenario for an oil and gas company. It's important to note that due to climate change, all countries are switching to renewable energy sources where possible; many governments are introducing strict laws to combat climate change. For example, suppose there is moderate regulatory pressure from existing global authorities and a sharp decline in the cost of new renewable energy technologies. In this case, risk management should consider a technological breakthrough scenario. However, in this situation, it is possible to rush in the wrong direction. Moreover, due to the low cost of the technology, other companies will also begin to implement it in renewable energy production, ultimately creating intense competition. All of this is related to ESG risks, but there is an opportunity to become a leader by implementing advanced solutions. After completing this stage, an analysis of the business implications is conducted and new risks and threats are identified. At this stage, a

description is given for each scenario, explaining how it may relate to operational activities (raw material availability, supply chain, production processes); financial performance (revenue, costs, profit, investments); the regulatory environment; reputation; and stakeholder relationships. In the next stage, specific ESG risks are calculated, which become more likely or significant in each scenario. The next step is to develop an investigation strategy and implement it: - Assess the sustainability of the current strategy: how effective is the company's current business strategy in each of the realized results. The impact method has many advantages. Most importantly, this method observes a variety of factors, including those that are difficult to predict.

Effective sustainability risk management is key to creating long-term value and ensuring the sustainable development of an enterprise. Regular identification, assessment, and management of risks enable companies to respond to sustainability challenges and opportunities and strengthen their market position.

Sustainable development is not just an “additional” responsibility, but a fundamental component of modern business. Ignoring its principles entails a cascade of increasing risks that can undermine a company’s reputation, financial well-being, and very existence. At the same time, actively integrating sustainable practices creates substantial opportunities for growth, innovation, greater efficiency, and long-term value creation. Companies that can turn risks into opportunities will become future leaders.

Once the priority ESG risks have been fully identified, the following processes should be carried out (A. McGrath et al. 2025):

- 1) Risk acceptance: Accepting a risk if the potential benefit outweighs the potential loss (C. Rae 2024).
- 2) Risk mitigation: Taking action to reduce the likelihood or impact of a risk.

- 3) Transfer of risk: Transfer of risk to a third party (e.g., insurance).
- 4) Risk aversion: Changing strategy or activities to avoid a risk.

This already applies to the development of a risk management strategy.

An effective sustainability risk management strategy (ESG risk) should be comprehensive, integrated into the overall business strategy, and cover all aspects of the company's activities. Its structure usually includes the following blocks:

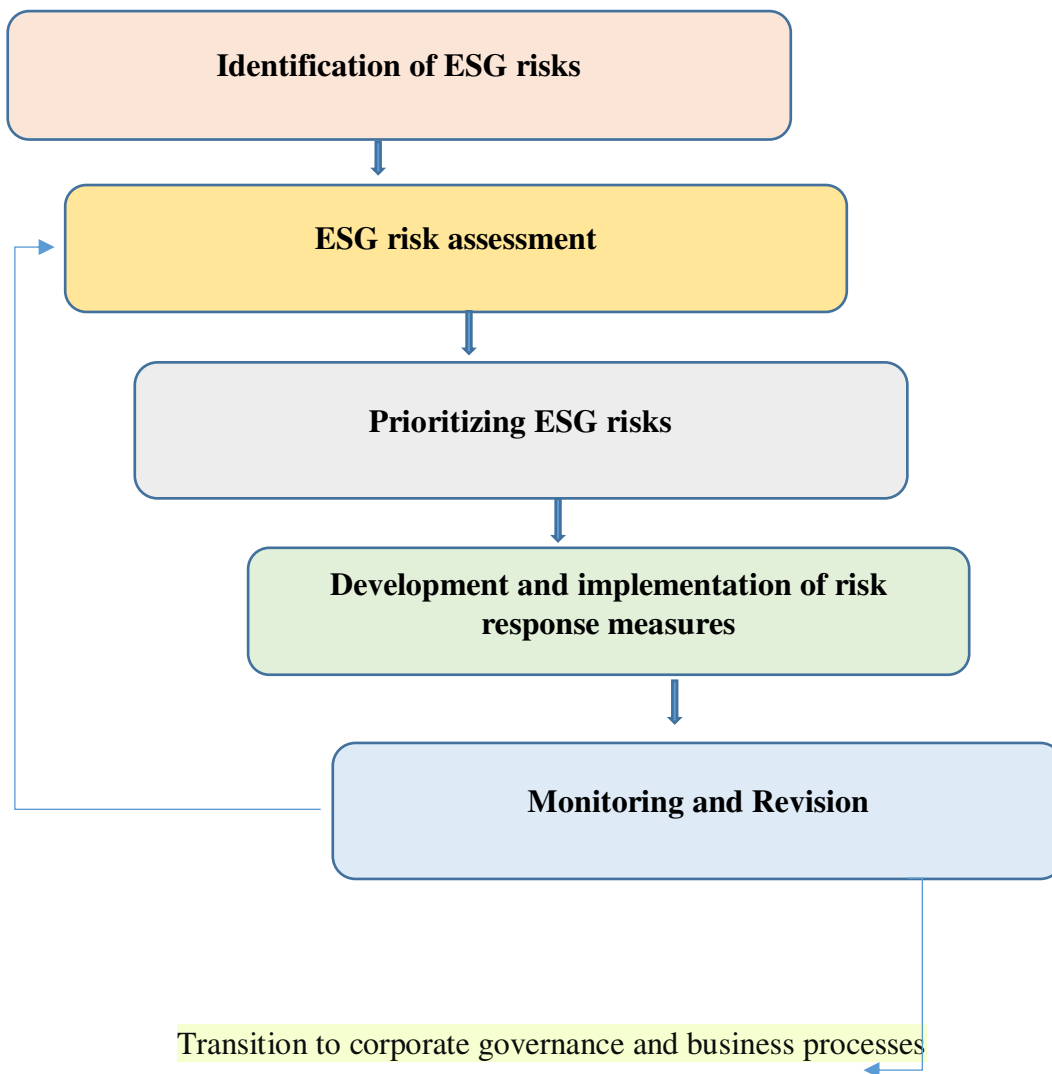


Figure 7. Sustainable Development Risk Management Strategy

(Source: developed by the author).

The Risk Identification block uses brainstorming, expert interviews, industry analysis, stakeholder analysis, historical data analysis, scenario analysis, and international standards analysis to identify risks.

The ESG Risk Assessment block uses:

- 1) Qualitative assessment. This includes determining the probability of an event occurring and its potential impact (e.g., on a scale of "low-medium-high"). Fuzzy set theory methods can be used.
- 2) Quantitative assessment. Statistical analysis, Monte Carlo simulation, financial modeling (DCF with ESG factors), scenario analysis, and stress testing are used.

The ESG Risk Assessment block identifies the risks that are most significant for the business and its stakeholders. At the same time, risks are visualized to determine the most critical ones using the Probability x Impact matrix.

ESG risk analysis uses a variety of mathematical and statistical methods because it covers complex, multi-factorial, and often uncertain phenomena. These methods help to quantify the probability of adverse events, their potential damage, and to develop risk mitigation strategies.

Table 7. Mathematical methods for the analysis of sustainable development risks

Sustainable Development Risk Management Methods	Name of methods
Risk management methods	SWOT analysis (Strengths, Weaknesses, Opportunities, Threats)
	FMEA (Failure Mode and Effects Analysis)

Data Analysis and Machine Learning Methods	Natural Language Processing (NLP)
Supply Chain Risk Analysis Methods	Critical Path Analysis
	Modeling network resilience
MCDM - Multi-Criteria Decision Making	Method ELECTRE (Elimination and Choice Expressing Reality)
	Method TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)
	AHP - Analytic Hierarchy Process
Quantitative assessment of ESG risks	Discounted Cash Flow (DCF) with ESG Factors (R. Moro Visconti 2021)
	Stress testing
	Rating models
	Scenario analysis (Tim Vipond 2025)
Methods for assessing the probability and consequences	Monte Carlo Simulation Methods (IBM 2025)
	Regression analysis
	Correlation analysis
	Time Series Analysis
	Bayesian methods (QuantStart 2022)

(Source: developed by the author).

- An IT company can use NLP to analyze customer and employee feedback, identifying key social risks or areas for improvement.

- A food manufacturer can use correlation analysis to analyze time series to predict water shortages.
- An oil and gas company might use Monte Carlo simulation to estimate potential financial losses from scenarios involving higher carbon prices.
- A financial institution might use the Analytic Hierarchy Process to rank various ESG initiatives based on multiple criteria.

The choice of specific mathematical methods depends on the nature of the industry specifics, the risk being analyzed, and the objectives of the analysis. Sometimes, a combination of different methods is used for a comprehensive analysis.

The "Prioritization" block ranks risks based on their potential impact on financial, reputational, operational, and other indicators. It uses risk visualization to determine the most critical ones using the "Probability x Impact" matrix. After assessing the risks, it is necessary to determine which ones require priority attention and which high-impact risks require immediate action.

The "Development and implementation of risk response measures" block represents a response strategy:

- 1) Avoidance: Avoidance of high-risk activities.
- 2) Mitigation: Implementation of measures to reduce the likelihood or impact of a risk (e.g., investments in energy efficiency, improvement of working conditions).
- 3) Transfer: Insurance, outsourcing, risk transfer to suppliers.
- 4) Acceptance: Conscious acceptance of a risk if its consequences are insignificant or the costs of mitigation are too high.

The "Monitoring and Analysis" unit analyzes the received data. If low efficiency is detected, the data is transferred to the "ESG Risk Assessment" unit for adjustment. The received data is simultaneously fed into corporate governance systems and business processes.

It should be added that ESG risks should be integrated into the overall sustainable development management system. It is always necessary to select appropriate mathematical models for analyzing ESG risks. Consider that often, combined approaches are used in the analysis. Preventive measures should be implemented rather than applied after incidents have occurred. The strategy should be regularly reviewed and adapted. After implementing measures, it is necessary to continue collecting and analyzing data using the same methods to evaluate the effectiveness of the steps taken and, if necessary, adjust the model and strategy.

One of the questions facing companies today is how to turn sustainability risks into opportunities. In fact, sustainability risks can create new opportunities. (Haque 2024), (Jones et al. 2022).

Given the above, we can conclude that sustainability risks are not merely threats but powerful drivers of transformation. Companies should not be afraid of change and transformation. Instead of fearing change, everyone should see it as an opportunity to create a more sustainable future and to build profitable, responsible businesses(Brauns 2015).

In conclusion, sustainable development and the right strategy are essential success factors for a modern company. Not only does it help build a positive image and reputation, but it also ensures long-term business sustainability and competitiveness in the marketplace.

### **Chapter 3. Experience in implementing sustainable development strategies in various companies**

As the United Nations leads the world's largest corporate sustainability initiative, the UN Global Compact is interested in carrying out such collaboration to develop a wide range of solutions to global challenges. The UN Global Compact calls on companies to align their shifts and operations with ten universal principles on human rights, labor, the environment, and anti-corruption, and to implement them step by step for achieving social goals and the SDGs (United Nations Global Compact 2017).

The analytical platform, InfluenceMap, that provides objective analysis about the impact of companies and financial institutions on the climate and biodiversity crises, declares, "Corporate climate policy collaboration is rapidly becoming a key focus for both investors and regulators. Nearly three-quarters of the world's largest companies now report that they are part of direct climate policy engagement. However, only a small part of them (15%) provides both complete and accurate information. Revealing information about indirect engagement, such as through industry associations, is even more limited. Around 90% of companies offer little or no meaningful information" (InfluenceMap 2025).

According to the Carbon Majors platform, run by the global non-profit think tank InfluenceMap, it estimates that in 2023 the emissions of the database-tracked 169 companies were 33.9 GtCO<sub>2</sub>e, up 0.7% from 2022. In the database, in 2023, of this report, 80.3% of global CO<sub>2</sub> emissions were from fossil fuels and cement, and just 36 companies were responsible for more than half of these global emissions (CarbonMajors 2025).

The database categorizes entities into three types: investor-owned companies, state-owned companies, and nation-states. Historically, investor-owned companies account for 31% of all emissions tracked by the database (440 GtCO<sub>2</sub>e), and Chevron, ExxonMobil, and BP are the three largest contributors. State-owned companies account for 33% of the database total (465 GtCO<sub>2</sub>e),

and three of them, Saudi Aramco, Gazprom, and the National Iranian Oil Company, are the largest contributors. Nation-states account for the remaining 36% (516 GtCO<sub>2</sub>e), of which China's coal production and the Former Soviet Union are the largest contributors (CarbonMajors 2025).

### 3.1. Implementation of sustainable development strategies in practice

Many scientists have researched the implementation of sustainable development strategies in practice across various regions and in large and small companies, and have made significant scientific contributions to this field. For example, articles such as (A. Ismail et al. 2022), (I. Düzel, 2025), (Sedovs et al. 2025), (Khanra et al. 2022) include ideas related to the strategy of sustainable development in companies.

The Oil & Gas Decarbonization Charter (OGDC) is an initiative presented on December 2, 2023, at the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28) in the UAE, which calls on oil and gas companies to reduce their carbon emissions and achieve net-zero emissions.

Table 8. GHG Emissions (Scope 1 + Scope 2) (million metric tons CO<sub>2</sub>e)

Oil and gas companies	2020	2021	2022	2023	2024
ExxonMobil	102	104	101	98	98
BP	46	35	32	32	34
SHELL	71	68	58	57	58
TotalEnergies	64	49	42	34	29
Saudi Aramco	67	68	66	67	68
Chevron	54	57	53	52	54

(Source: developed by the author based on the companies' reports on sustainable development)

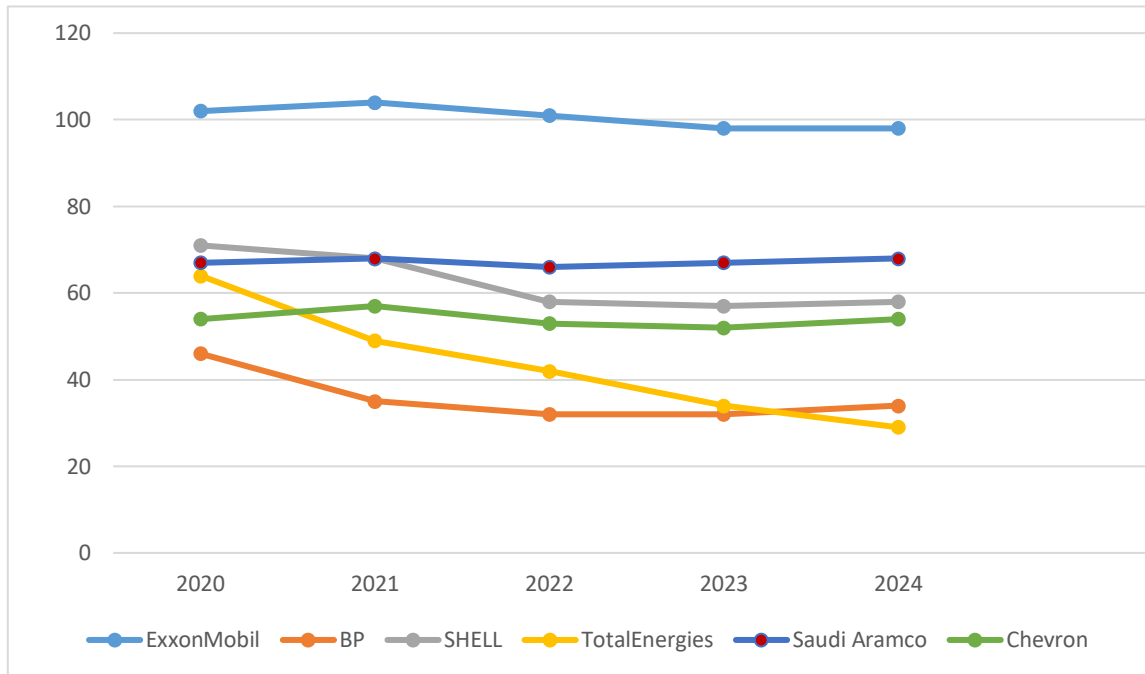


Figure 8. GHG Emissions (Scope 1 + Scope 2) (million metric tons CO<sub>2</sub>e) by the world's largest oil companies from 2020 to 2024

The world's largest oil and gas companies, such as BP, TotalEnergies, Saudi Aramco, ExxonMobil, and Shell, are under enormous pressure from society, investors, and regulators to develop and implement sustainable development strategies. For them, this means transitioning to a low-carbon economy and reducing greenhouse gas emissions while continuing to meet global energy needs.

Despite differences in the details of the strategies, general guidelines include:

1) Reduction of emissions from own activities (Scope 1 & 2): Improving energy efficiency, using renewable energy source facilities, reducing associated gas flaring, and introducing carbon capture technologies (CCUS).

2) Investments in low-carbon energy sources: Development of renewable energy sources (solar, wind), hydrogen production, bioenergy, and development of charging infrastructure for electric vehicles.

3) Product Emission Management (Scope 3): This is the most complex aspect, as it encompasses emissions from the combustion of oil products and from the sale of gas by end users. Strategies in this case include reducing the share of fossil fuels in the portfolio, promoting the use of biofuels, and developing CCUS for industrial users.

4) Transparency and accountability: Publication of sustainability reports, compliance with ESG (environmental, social, and governance) standards.

Let us look at each company, its goals, and strategies in line with the UNSDGs:

**ExxonMobil** (*ExxonMobil. Sustainability Report 2025*).

Table 9. ExxonMobil goals and strategy

Goals and strategy	Alignment with UN SDGs
Achieve net-zero greenhouse gas emissions: Net-Zero for own operations (Scope 1 and Scope 2) by 2050.	7, 13
Reduce Scope 1 and 2 emissions intensity by 25% by 2030 (relative to 2019 levels)	3, 7, 8, 9, 12, 13, 14, 15
Increase Clean Energy: Provide people with the clean energy they need to fuel economic growth.	7

Energy Transition: Financing Renewable Energy. Providing Affordable, Reliable and Safe Energy for People and Businesses	7, 13, 9, 12
Equity: Creating an inclusive workplace to unlock employee potential and achieve business goals. Creating jobs for both its employees and contractors and suppliers, being a major employer.	4, 8, 10, 16
Gender Equality: Increasing the Proportion of Women Managers to Avoid Gender Inequality	5, 10
Leadership in Personnel Safety: Motivate employees to comply with safety standards and replace equipment that does not meet safety standards with new ones.	3, 8
Public Safety and Security: Increased production of isopropyl alcohol for disinfectants, temporary conversion of some manufacturing facilities to produce disinfectants to meet increased demand. Promotion of the “Culture of Health” program in the workplace.	3, 16
Interaction with local communities: Implementation of a corporate social responsibility program aimed at supporting local communities in the regions.	11, 16
Ethical business conduct and the fight against corruption: Committed to transparency, ethics and anti-corruption.	16
Risk Management: Focus on managing operational, financial and reputational risks.	9, 12
Caring for land and biodiversity: Reducing potential impacts on ecosystems and maintaining their value for nature and people.	15
Water conservation: Protecting water resources through wise management and monitoring of water use, with an emphasis on freshwater quality and supply.	6, 14

Improving quality of air. Meet or exceed regulatory requirements and work on reducing of emissions of nitrogen oxides (NOx), sulfur oxides (SOx) and volatile organic compounds (VOCs).	7, 13
Minimization of production waste: Implementation of best practices in waste management and recycling.	12
Evaluating product benefits through life cycle assessment and extending the life cycle of plastics.	12
Carbon Capture, Use and Storage (CCUS): Investing in CCUS projects, considering them a key tool for reducing emissions in the oil and gas industry and other sectors.	7, 8, 9, 13

(Source: developed by the author based on the company's sustainability report)

These sustainability priorities have been developed based on an analysis of environmental and social impacts, business strategies, and internal and external stakeholder priorities. The company believes that these priorities are the most important for both the company and society. Exxon Mobil develops strategies, allocates resources, and implements plans to address risks and seize opportunities in each area, thereby diversifying its portfolio to become a multi-energy company. Exxon Mobil plans to invest up to \$30 billion to reduce emissions between 2025 and 2030.

It is important to note that we have assigned several goals to each strategic task. The fact is that the implementation of any strategic task under the SDGs is directly or indirectly interconnected with many goals. This is one of the fundamental principles of the SDGs: they constitute a single, indivisible system, not a list of independent targets. The SDGs call for inclusive development. This means that progress must be achieved for everyone, and no goal can be fully realized if others are ignored.

For example, the problems addressed by the SDGs (poverty, hunger, health, education, climate, equality, etc.) do not exist in isolation in the real world. They are part of a complex, interdependent system. It is impossible to solve one problem without considering its impact on others.

Understanding this interrelationship is critical to the effective implementation of the SDGs. It means that we cannot focus on just one or a few goals while ignoring the others. Solutions must be comprehensive and integrated, considering the potential impact on all aspects of sustainable development.

**TotalEnergies** (*More Energy. Less Emissions Sustainability & Climate 2024 Progress Report 2025*).

French company Total has changed its name to TotalEnergies to highlight its transformation into a "large-scale energy company."

The main goal of this company is to become a major player in energy production and supply.

Their priority areas of sustainable development:

Table 10. TotalEnergies goals and strategy

Goals and strategy	Alignment with UN SDGs
More energy, less emissions: Produce the energy the world needs today while reducing industrial emissions, including moving towards net-zero methane emissions by 2030.	3, 7, 8, 9, 12, 13, 14, 15

Achieving carbon neutrality by 2050 together with society (implementation of a multi-energy strategy): Production and expansion of renewable electricity capacity.	7, 13
Redefining oil production: focusing on low-cost, low-emission oil assets and reduction in sales of petroleum products: Leveraging low-carbon technology innovations	3, 7, 9, 12, 13,
LNG (Liquefied Natural Gas) Development: Views LNG as a bridge fuel, less carbon intensive than coal or oil.	9
Investments in biogas, hydrogen: Investments in these areas	9, 12
Investments in CCUS: Large-scale investments in carbon capture, use and storage projects.	7, 8, 9, 13
Improving energy efficiency: Reducing flaring to 0.1 million m3 per day from 2025	7,9,11,13
Creating Clean Energy: Development and solution of the TotalEnergies digital factory to improve energy performance, development of a digital solution in the field of energy consumption and greenhouse gas emissions assessment	7
Diversity and Inclusion: Committed to providing equal opportunities for all employees in terms of recruitment, training, promotion and compensation. Committed to creating an inclusive work environment where differences are valued and equal opportunities are provided to all employees, regardless of gender, background, etc.	8, 10, 16
Gender equality: The goal is to increase the proportion of women in leadership positions.	5, 10

Respect for human rights: Respect for human rights at all stages of its activities, including assessing human rights risks and developing measures to prevent them.	10, 16
Stakeholder dialogue and community support: Important attitude to dialogue with local communities, government bodies and public organizations to take into account their interests and minimize the negative impact of their operations. Participation in corporate social responsibility programs aimed at improving the quality of life in the regions of their presence. This includes support for education, healthcare, access to clean water, development of local economies.	4, 7, 13, 16, 17

(Source: developed by the author based on the company's sustainability report)

Despite diversification, the company continues to actively invest in gas projects, which has drawn criticism from environmentalists who consider gas a fossil fuel.

**BP (British Petroleum)** (*BP Sustainability Report 2024 2025*).

BP was among the first major companies to declare its ambition to "go beyond oil" in the early 2000s, although it faced challenges along the way.

Main objective: Transform from an international oil company into an integrated energy company focused on delivering energy solutions.

Table 11. BP goals and strategies

Goals and strategy	Alignment with UN SDGs
Net zero emissions by 2050(for all three-emission areas, including Scope 3).	7, 13
Significant reduction in oil and gas production: Plans to cut oil and gas production by about 40% by 2030 compared to 2019.	3, 7, 8, 9, 12, 13, 14, 15
Large-scale investments in low-carbon businesses: Active development of renewable energy sources (solar, wind), hydrogen, bioenergy, charging infrastructure for electric vehicles, CCUS technologies.	3, 7, 9, 8, 12, 13
Digitalization and optimization: Improving the efficiency of current operations.	1, 7, 9, 13
Energy transition: Promoting an energy transition strategy aimed at reducing the share of fossil fuels in its portfolio and increasing the share of renewable energy sources	3, 7, 9, 12
Job creation and economic contribution: Striving for economic growth by creating jobs, supporting local supply chains and investing in new projects, especially in renewable energy.	8,10, 16
Investment in training and developing its employees to meet the demands of the changing energy industry. This includes training in new technologies, project management and developing green skills.	4, 8, 9

Risk management and resilient adaptation to climate change: Committed to adapting the business model to a low-carbon future. Focusing on managing operational, financial, climate and reputational risks.	9, 12
Circular Economy: Applying the principles of the circular economy in your activities.	7, 9, 12, 13
Stakeholder Dialogue and Community Support: Aiming for dialogue with local communities, governments, and other stakeholders to ensure that their interests are taken into account and their concerns are addressed. Implementing responsibility (CSR) to support the local communities in which it operates. This may include investing in education (especially STEM), health care, access to clean water, and supporting local entrepreneurs and development projects.	4, 11, 16,
Human rights: Commitment to respecting human rights in all its operations and supply chains and to the elimination of forced labour and exploitation.	8,10,16
Diversity and Inclusion: Committed to creating a diverse and inclusive work environment where employees with different backgrounds, perspectives, and experiences are valued. Creating equal opportunities for all employees in terms of recruitment, training, promotion, and compensation.	8, 10, 16

(Source: developed by the author based on the company's sustainability report)

BP is committed to conducting business ethically and transparently, adhering to high standards of corporate governance and anti-corruption.

**Saudi Aramco** (*Aramco Sustainability Report 2024 2025*).

Saudi Aramco is the world's largest oil company, owned by Saudi Arabia. Its sustainability strategy has its own unique characteristics due to its status as a national oil giant.

Its main goal: to continue to be a reliable energy supplier to the world, while reducing our carbon footprint and investing in new energy solutions.

Table 12. Saudi Aramco's goals and strategy

Goals and strategy	Alignment with UN SDGs
Net zero Scope 1 and 2 emissions by 2050(i.e. operational emissions). An important distinction: Now, the company does not undertake obligations under Scope 3, i.e. emissions from the combustion of its products by end consumers.	7, 13
Improving operational efficiency: Reducing the intensity of emissions at our facilities, reducing flaring, using renewable sources for our own needs.	7, 9, 12, 13
Development of CCUS technologies: Large-scale investments in carbon capture, use and storage projects.	7, 8, 9, 13
Development of "blue" and "green" hydrogen: Saudi Arabia aims to become a major exporter of hydrogen.	7, 9,13
Maintaining oil and gas production capacity: The company emphasizes its role in ensuring global energy security, which means continuing to produce hydrocarbons.	9

Economic growth: Developing the ability of alternative energy sources to competitively meet future energy demand.	8
Energy Transition: To achieve a smooth transition to clean energy, extracting economic benefits from oil and gas. To mitigate the growth of emissions from increased oil and gas production and reduce them to 67 million tons by 2035. To develop and propose a concept of a circular carbon economy, the essence of which is the cyclicity and removal of carbon from the atmosphere.	7, 9, 11, 12, 13
Digitalization and drones: safety in production and CO2 control.	9
Gender equality: increasing the participation of women in the workforce.	5, 10
Good Health and Well-Being: Caring for the well-being of employees.	3
Caring for land and biodiversity: Reducing potential impacts on ecosystems and maintaining their value for nature and people.	14, 15
Water conservation: Protecting water resources through wise management and monitoring of water use, with an emphasis on freshwater quality and supply.	6, 14

(Source: developed by the author based on the company's sustainability report)

The main criticism is the lack of commitment to Scope 3, which calls into question its contribution to the overall decarbonization of the global economy. In 2024, Aramco enhanced its gas strategy to support the company's efforts to reduce emissions through innovative gas processing technologies:

- gas plant Shedgum: A new amine absorber control system was patented, which reduced CO2 emissions by 170 million tons of CO2 equivalent by reducing steam and fuel consumption.
- gasworks Haradh: Patented use of 14 wireless flow meters to improve accuracy and reduce emissions in a gas treatment area.

Saudi Aramco uses a range of unmanned automated vehicle (UAV) technologies for safety inspections. Fixed-wing UAVs provide routine monitoring of main pipelines, while drones inspect high-altitude cable trays, eliminating the need for scaffolding. Salamatic Eagle – AI-powered safety monitoring. Salamatic Eagle reduces rig and construction site injuries, safety hazards, and unsafe human behavior. Raqeeb is an AI-powered tool that helps identify safety violations and provides critical information. Using real-time data analytics to improve risk detection and compliance, Raqeeb also expands the safety database to highlight key risks and provide stakeholders with personalized support (Aramco 2025).

In 2024, Aramco strengthened its methane emissions management through the development of the Methane Detection and Minimization Program (MDMP). This initiative aims to reduce Aramco's upstream methane intensity in alignment with the OGCI near-zero methane emissions target.

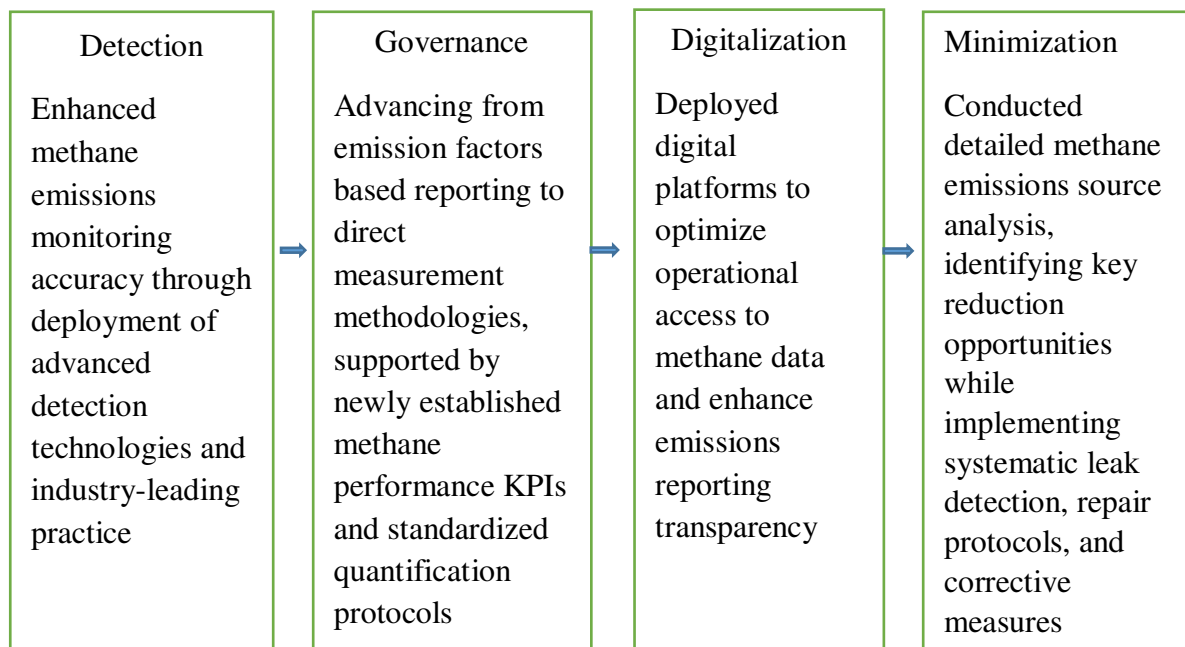


Figure 9. The MDMP framework is built upon four main pillars

**Shell (Annual Report and Accounts 2024)**

The British-Dutch energy giant is also actively transforming itself into a SDG, while remaining a giant producer and exporter of oil and gas.

Main objective: Powering the world by moving towards net zero emissions and being a socially responsible company.

Table 13. SHELL goals and strategy

Goals and strategy	Alignment with UN SDGs
Net zero emissions by 2050(for all three-emission areas, including Scope 3).	7, 13
"Powering Progress": A strategy aimed at decarbonising operations, investing in low-carbon energy sources and developing customer solutions.	7, 9, 13
Development of renewable energy sources: Investments in wind, solar energy, biofuels.	7, 9, 13
Hydrogen and Electric Vehicle Charging: Development of infrastructure and technology.	7, 9
CCUS technologies and nature-based solutions: Using forests, soils, etc. to capture carbon.	7, 8, 9, 12, 13
Gradual reduction of oil and gas production: Shell plans to gradually cut production, although it recently adjusted some of its targets, prompting criticism.	7

Circular Economy: The company's businesses develop local waste management plans. Explore ways to improve the application of circular economy principles by developing circularity strategies.	9, 12
Biodiversity Conservation: Have a positive impact on biodiversity; strive for zero waste and use water, other resources and materials efficiently.	6, 14 and 15
Water conservation: Implement water management principles in the company's facilities and develop local improvement plans. This includes a focus on sustainable freshwater management, including in water-stressed areas	6 and 15
Environmental Cooperation: Collaborate with global conservation partners, the International Union for Conservation of Nature (IUCN) and Earthwatch	9, 13 and 17
Life Improvement Approach: To improve people's lives through the company's products and activities, and by supporting an inclusive society.	3, 4,8, 10
Approach to Human Rights: Respect for human rights is embedded in Shell's General Business Principles and the Shell Code of Conduct. Shell is committed to upholding the human rights set out in the Universal Declaration of Human Rights and the International Labour Organization's Declaration on Fundamental Principles and Rights at Work.	8, 10, 16
Gender equality: increasing the participation of women in the workforce.	5, 10
Stakeholder Dialogue and Community Support: Aiming for dialogue with local communities, governments and other stakeholders to ensure that their interests are taken into account and their concerns are addressed. Implementing responsibility (CSR) to support the local communities in which it operates.	11, 17

(Source: developed by the author based on the company's sustainability report)

Shell has faced lawsuits (such as from a Dutch court that required more aggressive emissions cuts) and criticism for continuing to invest heavily in fossil fuels and failing to stick to some of its original production-cutting plans.

Shell is also investing in low-carbon and non-energy products that reduce emissions for customers. In 2023, it invested \$5.6 billion in low-carbon energy solutions, including biofuels, hydrogen, electric vehicle charging and renewable power generation; and \$2.3 billion in non-energy products such as chemicals, lubricants and consumer goods that produce no emissions when used by customers. This represented about a third of total capital expenditure in 2023.

#### **Chevron (Chevron 2025)**

Chevron is committed to protecting the environment, empowering people, and doing things the right way. Their sustainability reporting focuses on environmental, social, and governance (ESG) issues relevant to their business and stakeholders. Chevron produces crude oil and natural gas, manufactures transportation fuels, lubricants, petrochemicals, and additives, and develops technologies that improve business and industry.

We are working to provide affordable, reliable, and increasingly clean energy that powers human progress. To be the global energy company most respected for its people, partnerships, and performance. Chevron's strategic direction is to leverage its strengths to securely power a growing world with low-carbon energy. Chevron is committed to growing its oil and gas business, reducing the carbon intensity of its operations, and developing new businesses in renewable fuels, carbon capture and offsets, hydrogen, data center power generation, and new technologies.

Table 14. Chevron goals and strategy

Goals and strategy	Alignment with UN SDGs
Reduce the greenhouse gas emissions intensity of its operations (Scope 1 and 2) by 35-40% by 2030 compared to 2019 levels.	3, 7, 8, 9, 12, 13, 14, 15
Achieve net zero operational emissions (Scope 1 and 2) by 2050.	7, 13
Developing low-carbon businesses: Investment in research and development of technologies for the production and transportation of hydrogen, green hydrogen, biofuels, the production of renewable diesel fuel using animal waste and other biological sources, and in electrification technologies, such as the development of batteries and participation in electric vehicle charging projects.	13
Carbon Capture, Use and Storage (CCUS): Investing in CCUS projects, considering them a key tool for reducing emissions in the oil and gas industry and other sectors.	13
Incremental approach to decarbonization: Positioning its approach as incremental, focusing on making existing fuels cleaner and developing new, cleaner energy sources. Emphasizing the role of natural gas as a transition fuel that has lower CO <sub>2</sub> emissions than coal.	7, 13
Minimizing injuries and ensuring a safe working environment for all employees and contractors: Training, implementation of new technologies to prevent incidents, programs to strengthen the safety culture.	3, 8, 9

Creating a diverse and inclusive work environment that values employees of all races, genders, ages, perspectives and experiences: Programs to recruit and retain talented employees from diverse backgrounds, diversity and inclusion training, and ensuring equal opportunities for career advancement.	8, 5, 10
Be a responsible corporate citizen in the regions where we operate, making a positive contribution to the development of local communities: Investments in local infrastructure (education, healthcare, roads), support for local suppliers and small businesses, consultations with local residents and taking into account their interests when implementing projects.	4, 8, 11, 16, 17
Respect for human rights throughout the value chain, including relationships with suppliers and partners: Human rights policies, human rights risk assessments, staff training.	16, 17
Maintaining high ethical standards, combating corruption, ensuring transparency and accountability: Anti-corruption programs, independent boards of directors, transparent financial reporting.	16, 17
Bring profit to shareholders, ensure stable growth and dividends: Effective asset management, cost optimization, investments in profitable projects.	8, 12
To promote economic growth in the regions where companies operate through job creation, stimulating the local economy: Direct investment in local projects, job creation, support for local suppliers, payment of taxes and royalties.	9, 12
Biodiversity Conservation: Have a positive impact on biodiversity; strive for zero waste and use water, other resources and materials efficiently.	14, 15

(Source: developed by the author based on the company's sustainability report)

Chevron, one of the largest integrated energy companies in the United States, has goals and a sustainability strategy focused on reducing its carbon footprint and developing low-carbon solutions. Like other companies in the industry, Chevron faces the need to balance ensuring a reliable energy supply with reducing its environmental impact. Therefore, Chevron regularly evaluates its ambitions and plans to change or abandon some of these aspirations, goals, and other ambitions for a variety of reasons, including market conditions, strategy or portfolio, and financial, operational, political, reputational, legal, and other factors.

Like Saudi Aramco, Chevron has not yet made a global commitment to reduce emissions from the oil and gas it sells (Scope 3). The company states it will work to reduce Scope 3 emissions "as technology and economics advance," but this is less ambitious than that of other companies.

Table 15. Implementation of SDGs by major companies

UN SDGs	ExxonMobil	BP	TotalEnergies	Aramco	SHELL	Chevron	Total
1		1					1
2							
3	3	3	2	1	1	2	12
4	1	1			1	1	4
5	1		1	1	1	1	5
6	1			1	2		4
7	6	6	7	5	6	3	33
8	4	6	3	2	3	4	22
9	4	6	6	5	6	3	30
10	2	3	2	1	3	1	12
11	1	1	1	1	1	1	6
12	5	5	3	2	2	3	20
13	4	4	6	5	5	5	29
14	1	1	1	2	1	2	8
15	1	1	1	1	2	2	8

16	3	4	2		1	3	13
17	1		1		2	3	7

(Source: developed by the author based on the calculation of company data in accordance with the UN SDGs)

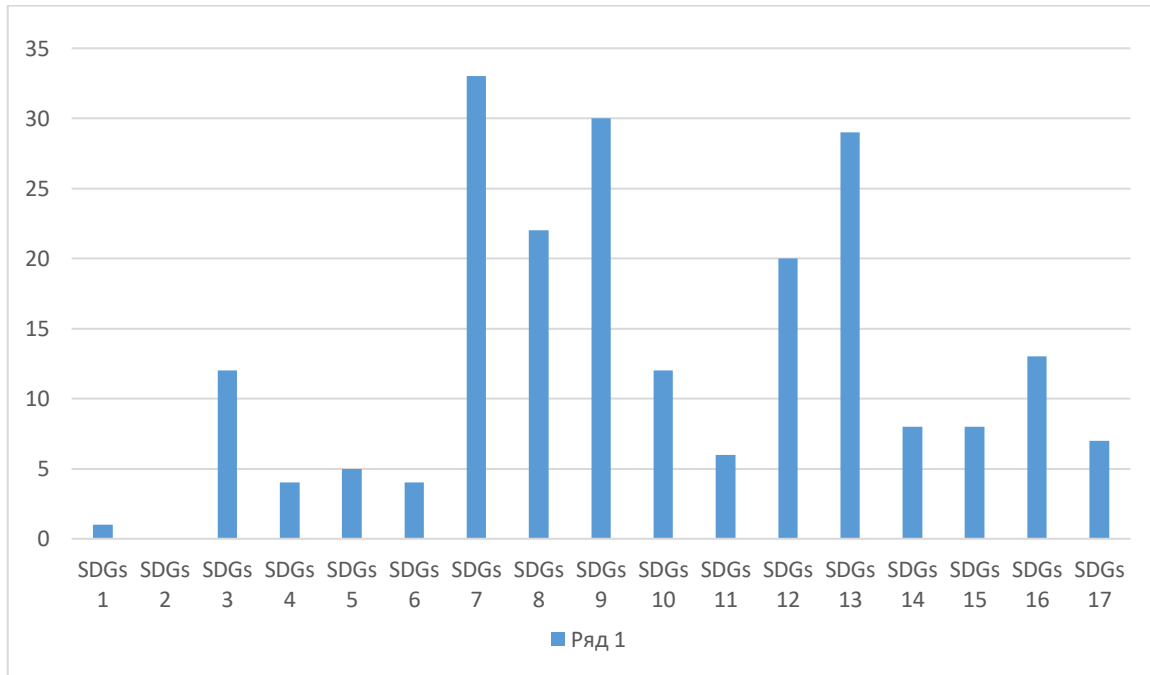


Figure 10. Major oil and gas companies' UN SDGs-based targets based on Table 15. (Source: developed by the author).

#### General conclusions and challenges:

All these companies face a monumental challenge: how to transform themselves from fossil fuel giants into sustainable energy companies without undermining their financial stability or leaving the world without the energy it needs during the transition.

1) Greenwashing: Companies are often criticized for the fact that their sustainability statements can be more ambitious than their actual actions and that they continue to invest heavily in fossil fuel projects.

2) Dependence on technology: Achieving net zero goals often depends on technologies that have not yet proven scalable and economically feasible (e.g., CCUS, green hydrogen).

3) Geopolitics and energy security: Wars and global crises can shift priorities towards energy security, which sometimes slows down the transition to renewable energy sources.

4) Investor expectations: Companies must balance the demands of decarbonization with investor expectations of the high returns that hydrocarbons have historically generated.

Overall, these companies are undergoing an active yet complex transformation, and their sustainability strategies will continue to evolve under pressure from a range of internal and external factors.

As we can see, the implementation of SDGs by major companies differs little. Thus, target benchmark 2 is completely absent among the majors. Less attention is paid to goals No. 4, 6 and 17 compared to other goals. Thus, the highest-priority sustainable development goals for oil companies, as reflected in their development strategies, are goals 7, 8, 9, 12, and 13. The least priority for achievement is goals 1, 2, 4, 5, 6, and 11.

### **3.2. Research on the impact of the implementation of sustainable development principles on the financial and non-financial performance of various companies**

In modern conditions, any enterprise, regardless of its size and industry specifics, is a complex socio-natural economic system in which the main strategic resources are organically linked: human, environmental, technological, informational, legal, material, and financial. In addition, in accordance with the concept of sustainable development, the integrity of an enterprise's behavior in the market depends on the social, environmental, economic, and institutional interactions and relationships within its internal and external environments, which are often contradictory.

The solution to these problems can be provided by multi-level strategic management, which creates certain types of behavior, “reactions” of the economic entity, conditioned by the chosen strategy.

An integrated financial and non-financial strategy that considers sustainable development goals contributes to a more equitable, environmentally friendly, and economically sustainable future. In turn, financial and non-financial integration in the sustainable development system and their results affect the very implementation of the principles of sustainable development.

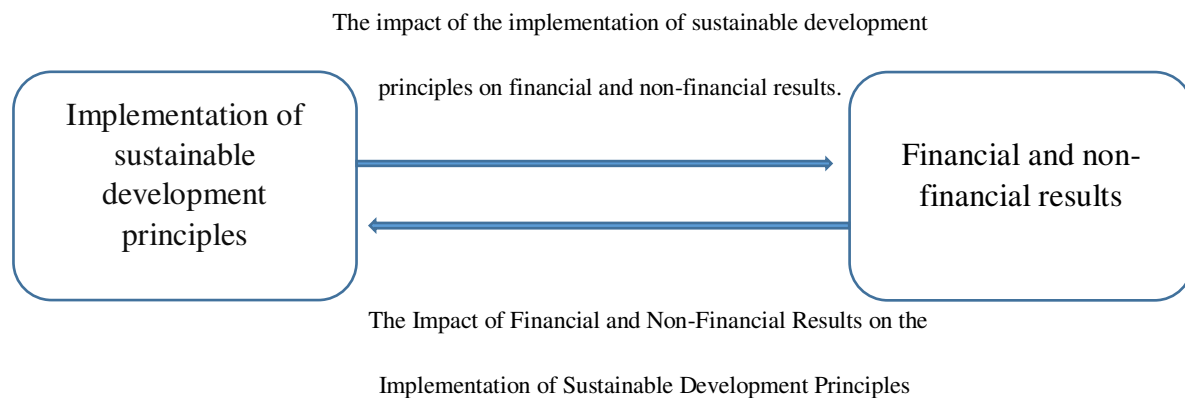


Figure 11. Interaction of the implementation of sustainable development principles with financial and non-financial results. (Source: developed by the author).

Research on the role and importance of ESG principles in corporate management (Bauer R. et al 2010); (SW. Setyahuni et al. 2020); (Fama E.F. 2021); (Danny Zhao-Xiang Huang 2022) and other demonstrate a tendency to “embed” the ESG concept into classical economic and financial theories. Such “embedding,” indicates recognition of the influence of not only operational, but also social and environmental activities on the financial condition of the company. Many researchers have studied the relationship between ESG and corporate financial performance (CFP).(Dhaliwal D. S et

al. 2011), (Yoon et al. 2018) and others assessed the company's commitment to ESG principles and the impact of ESG factors on individual financial indicators: net profit before interest on loans, income tax, depreciation and amortization (EBITDA), economic value added (EVA), market capitalization, weighted average cost of capital (WACC) and return on assets (ROA). In their studies, the authors found a statistically significant positive relationship between ESG factors and EVA, EBITDA, and market capitalization. Taliento, Favino, Netti studied the dependence of financial indicators and company size on the place in the ESG rating. The sample comprised 150 European companies assessed against ESG criteria by the Morningstar information agency. The study concluded that larger companies had higher ESG ratings solely because they attract greater stakeholder attention and are compelled to comply with ESG principles and to actively develop this area (Taliento 2019).

Table 16. Key financial indicators of the enterprise

Financial indicators	
Profitability	Net profit, return on sales, return on equity (ROE), return on assets (ROA). These indicators reflect the financial health of the company and its ability to generate profits.
Liquidity	Current assets, current liquidity ratio, quick liquidity ratio. These indicators show the company's ability to pay its short-term obligations.
Debt burden	Debt-to-weight ratio, interest coverage ratio. These indicators reflect the financial risk associated with the company's debt level.
Market value	Market capitalization, share price. These indicators reflect the perception of the company by investors.

Capital efficiency	Return on invested capital (ROIC), asset turnover. Shows the efficiency of capital use by the company.
Height	Revenue growth rate, profit growth rate, market growth rate. Reflect the dynamics of business development.

(Source: developed by the author).

Table 17. Key non-financial indicators

Non-financial indicators	
Innovations	Number of new products/services, number of patents, R&D investments. These indicators reflect the company's ability to innovate and develop.
Quality Management	Defect rate, number of complaints, customer satisfaction. Assess the quality of products/services and the level of customer satisfaction.
Human Resources Management	Employee turnover, employee satisfaction, and productivity. These indicators reflect the effectiveness of personnel management and employee motivation.
Sustainable Development (ESG)	Greenhouse gas emissions, water and energy consumption, waste, ethical practices, diversity, and social responsibility. Assess a company's contribution to sustainable development.
Reputation	Company ratings, customer reviews, media mentions. These indicators reflect the public perception of the company.
Client base	Number of clients, customer loyalty level, revenue per client (CLTV). Shows the effectiveness of work with clients.

Risk management	Number of risk-related incidents, risk management costs. Reflect the effectiveness of the risk management system.
-----------------	---

(Source: developed by the author).

The implementation of sustainable development principles in enterprises has a complex impact on both their financial and non-financial results. These two aspects are closely interrelated and often reinforce each other.

Table 18. Impact on financial results

Implementation of sustainable development principles	Possible results
Reducing operating costs	Energy efficiency: Reducing costs for electricity and heat.
	Preventing fines: Compliance with environmental and social standards reduces the risk of fines and sanctions.
	Efficient use of resources: Reducing costs for raw materials, water, waste disposal.
Improving access to capital and reducing the cost of financing	Attracting ESG investments: Investors are actively investing in companies with strong ESG indicators.
	Green Finance: Obtaining preferential loans and bonds for sustainable projects.
	Decrease in the cost of capital: Companies with low ESG risks are often perceived as less risky, which reduces the cost of raising capital.
Increase revenue and market share	Innovative products/services: Developing green products can open up new niches and revenue streams.
	Access to new markets: Some markets (e.g. government procurement, European market) require compliance with ESG standards.
	Customer acquisition: Consumers are increasingly choosing brands that are committed to sustainable development.

Attracting and retaining talented employees	Increased productivity: More motivated and loyal employees are more productive.
	Attracting the best specialists: A strong ESG brand attracts highly skilled workers.
	Reduced staff turnover: Employees who see the company's value in sustainable development are more loyal.
Increasing resilience and reducing risks	ESG risk management: Reducing financial losses from regulatory, reputational, physical, and operational ESG risks.
	Long-term financial stability: Strategies that focus on sustainability create a stronger foundation for long-term financial success.
	Supply chain resilience: Social and environmental responsibility of suppliers increases the reliability of the entire chain.

(Source: developed by the author).

Table 19. Impact on non-financial results

Implementation of sustainable development principles	Possible results
Governance	Risk Management: Integration of ESG risks into the overall risk management system.
	Ethics and Anti-Corruption: Implementation of codes of ethics, anti-corruption policies, ensuring the independence of the board of directors.
	Transparency and accountability: Open reporting on ESG indicators, clear management structure.
Social	Human rights: Respect for human rights throughout the supply chain.
	Local community development: Social investment, support for education, job creation, dialogue with stakeholders.
	Quality of products/services: Producing safer, more durable, and environmentally friendly products.
	Improving working conditions: Safety, health and safety, fair pay, staff training and development, non-discrimination, and an inclusive environment.
	Caring for your health and well-being: Employee health support programs, access to health insurance.
Ecological	Emission reduction: Implementation of low-carbon technologies, increasing energy efficiency, transition to renewable energy sources.

	Rational use of resources: Reducing the consumption of water, raw materials, minimizing waste generation, increasing recycling.
	Improving environmental management: Implementation of environmental management systems (e.g. ISO 14001), conducting environmental audits.
	Preservation of biodiversity: Responsible land management, minimizing impact on ecosystems.

(Source: developed by the author).

As written above, financial, and non-financial aspects are interconnected and often reinforce each other. For example, sufficient funding allows for investment in new environmentally friendly technologies, employee training programs, and social projects. On the other hand, creating an inclusive workplace, which is a non-financial indicator, helps attract and retain the best talent, which increases productivity, innovation, and financial results. As a financial indicator, reducing energy consumption lowers operating costs, which in turn are a financial outcome.

Non-financial results such as environmental, social and governance (ESG) indicators have a fundamental and often decisive influence on the success of the implementation of sustainability principles. They are not just a consequence, but a driving force and an indicator of the depth of a company's commitment to sustainability.

Successful companies are therefore moving from viewing financial and non-financial performance as separate to an integrated mindset in which sustainability is part of their core business strategy and creates cohesive value.

Thus, we can conclude that the implementation of sustainable development principles is not just an “expense”, but a strategic investment that leads to the improvement of both social and

environmental indicators, as well as to an increase in the financial efficiency and competitiveness of the enterprise in the long term.

The most important thing is to perform and offer before starting any operational actions. The structure for choosing a strategy and assessing the sustainable development of an enterprise must be analyzed and the ranges of zones for environmental, economic, and social sustainability must be determined.

To do this, we will take key indicators for each area:

Key sustainability indicators: Greenhouse gas emissions (tons of CO<sub>2</sub> equivalent/year), water consumption (m<sup>3</sup>/year), waste generation (tons/year), renewable energy use (%). In this case, according to its criteria, the enterprise can fall into different sustainability zones:

- 1) Critical Zone: The indicators significantly exceed permissible levels, which leads to serious negative impacts on the environment.
- 2) Warning zone: The indicators are approaching acceptable levels; measures to improve performance are needed.
- 3) Target area: The indicators align with the established Sustainable Development Goals.
- 4) Optimal zone: The indicators are significantly better than the targets, and the company demonstrates leadership in environmental sustainability.

Key indicators on social sustainability: Salary level (relative to the industry average), injury rate (number of cases/1000 employees), staff turnover (%), investment in staff training and development (per employee), participation in social projects (number of projects).

Stability zones:

- 1) Critical Zone: Low wages, high injury rate, high staff turnover, insufficient investment in personnel, few social projects.

2) Warning zone: The indicators are below the industry average; improvements are needed in the social sphere.

3) Target area: The indicators are in line with industry best practices.

4) Optimal zone: The company is a leader in social responsibility, offers the best working conditions and actively supports local communities:

Key indicators for economic sustainability: Return on assets (ROA), return on equity (ROE), return on sales (ROS), revenue growth rate (%), and customer base diversification (number of large customers).

Stability zones:

1) Critical zone: Low profitability, losses, dependence on a small number of clients, high income volatility.

2) Warning zone: Profitability is below the industry average; measures are needed to improve financial stability.

3) Target zone: Profitability is in line with the industry average, stable income growth.

4) Optimal Zone: The company demonstrates diversified sources of income, high profitability, sustainable growth and financial stability.

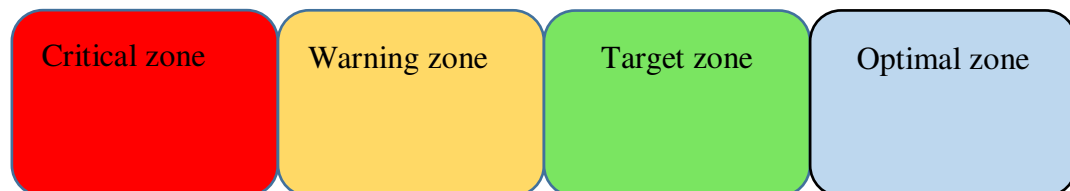


Figure 12. Stability zones financial and non-financial indicators (Source: developed by the author).

The concurrence of results across sustainable development dimensions across zones depends on internal and external factors. After assessing the current financial and non-financial indicators and determining the sustainability zone, various alternative strategies are developed:

Strategy 1: Focus on environmental sustainability.

Strategy 2: Focus on social sustainability.

Strategy 3: A balanced approach - investing in all three sustainability zones.

Strategy 4: Minimal improvement.

After developing various alternative strategies, financial and non-financial analyses are carried out, such as cost-benefit assessment, return on investment calculation, cash flow analysis, assessment of impact on environmental and social indicators, reputation, and employee engagement.

The next stage is a scenario analysis considering external factors and assessing the impact of each scenario on the financial and non-financial results of each strategy. In the final version, we should obtain a strategy that best meets the established priorities and criteria, considering the results of the scenario analysis. It is possible to make changes to the strategy if necessary, considering the results of monitoring and changes in the external environment.

This framework enables companies to comprehensively assess their opportunities and risks associated with sustainable development and choose a strategy where financial and non-financial results best match their goals and external conditions.

## **Chapter 4. Evaluation of sustainable development of companies based on the application of the fuzzy set method**

### **4.1. Methodological approach to determining the level of sustainable development of companies based on the use of fuzzy logic tools.**

In the assessing of the sustainability of a company, one of the main tasks is the integration of financial and non-financial, quantitative and qualitative indicators. Scientists have made a great contribution in this area. For example, the following studies can be specified: (V. Beretta et al. 2024), (M. Karami 2023), (Saini et al. 2022). One of the interesting methods for assessing the sustainability of companies is the fuzzy set method.

In recent years, interest in fuzzy set tools has increased significantly due to the increasing complexity of the systems being studied, the development of interdisciplinary approaches, and the integration of fuzzy logic with artificial intelligence and big data analysis methods. In the field of development, modern authors actively take into account fuzzy expert assessments, as well as neutrosophic levels; entrepreneurs consider not only the level of equipment, but also uncertainty, inconsistency, and a lack of expert information. This is particularly important when assessing climate risks, energy transitions and socio-environmental conflicts, where data are often fragmented and subjective.

Modern research highlights the effectiveness of hybrid models combining fuzzy logic with machine learning, neural networks, and evolutionary algorithms. Fuzzy multi-criteria methods of the new generation make it possible to take into account the dynamics of indicators, nonlinear dependencies and the interests of various groups of stakeholders. Their value lies in their ability to formalize linguistic variables and expert knowledge, which makes them particularly in demand

in the context of economic transformation, digitalization and the transition to sustainable development models. From modern sources it is possible to show: (Pacana et al. 2023), (Robati and Rezaei 2023), (Lin et al. 2025).

A fuzzy set is a concept introduced by Lotfi Zadeh in 1965 in his article "Fuzzy Sets" in the journal "Information and Control" (L.Zafeh 1965). He extended the classical concept of the set by proving that the characteristic function of it can take any value in the interval  $\{0,1\}$ , and not just 0 or 1. For example, not white and black, but from white to black, i.e. "white", "gray", "dark gray", "black". Fuzzy set theory is a basic concept of fuzzy logic (Zadeh Lotfi et al. 1996).

Fuzzy logic is a mathematical method that allows us to work with fuzzy or uncertain values. This method is based on the idea that any phenomenon or object can have several characteristics that can be described by fuzzy concepts such as "high", "very high", "warm", "cool", "low", "medium", etc. Fuzzy logic uses fuzzy sets and fuzzy rules that allow us to describe the relationships between different variables. For example, instead of saying that the temperature of the sea is 18 degrees, we can say that the temperature of the sea is "not warm" or "cooler" (L.Zadeh 1972).

Based on a fuzzy set, various calculations can be performed. If we work with one indicator, then a fuzzy system should be used for the work with fuzzy values, which consists of four main components: an expert block, an input block, a calculation block, and an output block. The expert block defines a fuzzy concept (linguistic variables), the input block accepts input data, the calculation block converts them into fuzzy values and defining the relationship between the input data (L.Zadeh 1975). The output block uses these rules to generate specific output values. Suppose an enterprise wants to present a report on economic growth using fuzzy concepts. The experts determine that the initial - low level of economic growth can be represented in a form of fuzzy

concept as "moderate growth", and the upper limit as "record-breaking growth". Moreover, among them there are can be many fuzzy concepts (linguistic variables):

- Stable growth
- Steady growth
- Dynamic growth
- Smooth growth
- Positive growth
- Progressive growth
- Significant growth
- Exponential growth

To determine the membership function of each linguistic variable, we use the following mathematical method. In our case, we can apply the linear interpolation formula.

Let us assume that, based on the expert decision, Moderate growth = 1 percent growth, the membership function  $\mu_A(x) = 0.2$ . And Record-breaking growth = 15 percent growth,  $\mu_A(x) = 1$ . Here is a fuzzy set from 0 to 1. Now we can apply the linear interpolation formula:

$\mu_A(x) = \mu_A(x_1) + [(x - x_1) / (x_n - x_1)] * (\mu_A(x_n) - \mu_A(x_1))$  to find the membership function of all fuzzy definitions that are between 0 and 1.

In the formula,  $\mu_A(x)$  is the membership function value for the number  $x$ ,  $x$  is the number itself (in our case, the growth percentage value),  $x_1$  is the lower limit of the range;  $x_n$  is the upper limit of the range.  $\mu_A(x_1)$  is the membership function value for the lower range,  $\mu_A(x_n)$  is the membership function value for the upper range. We will add 1.5 percent gradually and find the membership function for each percent.

For 2.5 percent it will be:  $\mu_A(2.5) = 0.2 + [(2.5 - 1) / (15 - 1)] * (1 - 0.2)$

$$\mu_A(2.5) = 0.2 + [(1.5 / 14) \times (0.8)]$$

$$\mu_A(2.5) = 0.2 + (0.11 \times 0.8)$$

$$\mu_A(2.5) = 0.29$$

For 4 percent it will be:  $\mu_A(4) = 0.2 + [(4 - 1) / (15 - 1)] \times (1 - 0.2)$

$$\mu_A(4) = 0.2 + [(3 / 14) \times (0.8)]$$

$$\mu_A(4) = 0.2 + (0.21 \times 0.8)$$

$$\mu_A(4) = 0.37$$

For 5.5 percent it will be  $\mu_A(5.5) = 0.2 + [(5.5 - 1) / (15 - 1)] \times (1 - 0.2)$

$$\mu_A(5.5) = 0.2 + [(4.5 / 14) \times (0.8)]$$

$$\mu_A(5.5) = 0.2 + (0.32 \times 0.8)$$

$$\mu_A(5.5) = 0.46$$

For 7 percent it will be:  $\mu_A(7) = 0.2 + [(7 - 1) / (15 - 1)] \times (1 - 0.2)$

$$\mu_A(7) = 0.2 + [(6 / 14) \times (0.8)]$$

$$\mu_A(7) = 0.2 + (0.43 \times 0.8)$$

$$\mu_A(7) = 0.54$$

For 8.5 percent growth it will be:  $\mu_A(8.5) = 0.2 + [(8.5 - 1) / (15 - 1)] \times (1 - 0.2)$

$$\mu_A(8.5) = 0.2 + [(7.5 / 14) \times (0.8)]$$

$$\mu_A(8.5) = 0.2 + (0.53 \times 0.8)$$

$$\mu_A(8.5) = 0.62$$

For 10 percent growth it will be:  $\mu_A(10) = 0.2 + [(10 - 1) / (15 - 1)] \times (1 - 0.2)$

$$\mu_A(10) = 0.2 + [(9 / 14) \times (0.8)]$$

$$\mu_A(10) = 0.2 + (0.64 \times 0.8)$$

$$\mu_A(10) = 0.71$$

For 11.5 percent growth, it would be  $\mu_A(11.5) = 0.2 + [((11.5 - 1) / (15 - 1)) \times (1-0.2)]$

$$\mu_A(11.5) = 0.2 + [(10.5 / 14) \times (0.8)]$$

$$\mu_A(11.5) = 0.2 + (0.75 \times 0.8)$$

$$\mu_A(11.5) = 0.8$$

For 13 percent growth it will be:  $\mu_A(13) = 0.2 + [((13 - 1) / (15 - 1)) \times (1-0.2)]$

$$\mu_A(13) = 0.2 + [((12 / (14)) \times (1-0.2)]$$

$$\mu_A(13) = 0.2 + (0.86 \times 0.8)$$

$$\mu_A(13) = 0.89$$

For 15 percent the growth will be:  $\mu_A(15) = 0.2 + [((15 - 1) / (15 - 1)) \times (1-0.2)]$

$$\mu_A(15) = 0.2 + [((14 / (14)) \times (1-0.2)]$$

$$\mu_A(15) = 0.2 + (1 \times 0.8)$$

$$\mu_A(15) = 1$$

In this way, the obtained membership function values can be distributed among the growth parameters, and assigned to linguistic variables. This called Fuzzification.

1. Moderate growth: 1 percent, where,  $\mu_A(x) = 0.2$
2. Stable growth: from 1 to 2.5 percent.  $\mu_A(x) = 0.29$
3. Steady growth: from 2.5 to 4 present.  $\mu_A(x) = 0.37$
4. Dynamic growth: from 4 to 5.5 present.  $\mu_A(x) = 0.46$
5. Smooth growth: from 5.5 to 7 present.  $\mu_A(x) = 0.54$
6. Positive growth: from 7 to 8.5 present.  $\mu_A(x) = 0.62$
7. Progressive growth: from 8.5 to 10 present.  $\mu_A(x) = 0.71$
8. Significant growth: from 10 to 11.5 present.  $\mu_A(x) = 0.8$
9. Exponential growth: from 11.5 to 13 present.  $\mu_A(x) = 0.89$

10. Record-breaking growth: from 13 to 15 present.  $\mu_A(x) = 1$

And to convert the values of the membership function to the standards of the sustainable development index assessment, where the indicators are indicated from 0 to 100, it is enough to multiply by ten.

As we know, many components, such as economic, social, and environmental, are used to determine the sustainable development of enterprises. In this case, a fuzzy system is used to process fuzzy values and consists of four main components: an expert block, an input block, a rule block, and an output block. The input block accepts input data and converts it into fuzzy values. The rule block defines the relationship between the input data and the output values. The output block uses these rules to generate specific output values. Fuzzy rules are one of the key elements of fuzzy logic. They are a set of rules that determine how fuzzy sets of input variables are mapped to output values. Fuzzy rules are usually written as If-Then rules, where the input variables are described by fuzzy concepts such as high, medium, or low, and the output variables are also fuzzy concepts. For example, if we want to create a fuzzy room temperature control system, we can use the following fuzzy rule: "If the temperature is above average, then reduce the heater power."

The input data for assessing the level of sustainable development was information published in the public domain by oil and gas companies in their annual sustainability reports. Despite the unified sustainability reporting system for the company (GRI), the amount of data and their units of measurement in the company reports differ greatly. Therefore, to bring everything to a single form, the reports were compared in order to identify the points of intersections, and a summary table of data was compiled on the same indicators, converted to the same units of measurement.

For clarity and simplicity of calculating the sustainable development index, it divided into 3 components, with the contribution of each block to the index total being equivalent:

1. Environmental index.
2. Social index.
3. Economic index.

Each index is measured on a scale from 0 to 1, and according to this metric, the higher the index value, the better the company's performance in a given area.

Different indicators are used to calculate the environmental index in oil and gas companies. To calculate the environmental index of sustainable development of oil and gas companies, it is necessary to use indicators that reflect their direct and indirect impact on the environment. Given the specifics of the industry, key aspects will be greenhouse gas emissions, water consumption and discharge, waste management, impact on soil and biodiversity.

In general, you can use the following list of key indicators:

Table 20. List of components of the environmental index of sustainable development

Indicators category	Scope	Indicators and properties
Air Emissions	Scope 1 GHG Emissions	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O and other greenhouse gases emitted directly from company-owned sources (fuel combustion, production processes, and methane leaks). Expressed in million tons of CO <sub>2</sub> equivalent (tCO <sub>2</sub> e).
	Scope 2 GHG Emissions	Emissions associated with the production of electricity, steam or heat consumed by a company. Expressed in million tCO <sub>2</sub> e.
	Flaring Volumes	Reflects the loss of valuable raw materials and associated gas emissions. Expressed in million m <sup>3</sup> or tCO <sub>2</sub> e.
	SO <sub>x</sub> and nitrogen (NO <sub>x</sub> )	Air pollutants causing acid rain and smog. Expressed in thousands of tons.
	VOCs	May be ozone precursors and toxic. Expressed in thousands of tons
	P.M.	Affect air quality and human health. Expressed in thousands of tons
Water Resources	Freshwater Withdrawal	The total volume of fresh water withdrawn by the company from sources. Expressed in million m <sup>3</sup> .
	Freshwater Withdrawal	The volume of water discharged after use in production processes. Expressed in million m <sup>3</sup> .

	Number and volume of oil and petroleum product spills	Accidental spills that have a serious impact on water bodies and soil. Expressed in the number of incidents and the volume of the spilled substance.
Waste and Land Use	Total Waste Generated	The total volume of hazardous and non-hazardous waste generated during the activity. Expressed in thousand tons.
	Area of disturbed lands	The area of land changed by infrastructure construction, drilling, and other operations. Expressed in hectares
	Area of cultivated land	The area of previously disturbed land restored by the company. Expressed in hectares.
Energy Efficiency and Resources	Specific energy consumption	The amount of energy consumed per unit of output (eg MJ/bbl OE).
	Share of renewable energy sources	The percentage of energy generated from renewable sources out of a company's total energy consumption.
Biodiversity	Number of incidents involving impacts on biodiversity	Qualitative indicator

	Implementation of biodiversity conservation projects	A qualitative indicator and an important one.
Environmental Penalties and	Penalties	Total number and amount of sanctions imposed for violation of environmental legislation
	Fines	Total number and amount of fines imposed for violation of environmental legislation

Source: developed by the author

It is important to note that to compare companies of different sizes, specific indicators such as CO<sub>2</sub> emissions per ton of oil or gas produced. For the comparing similar oil and gas companies, it is important to track not only absolute values, but also their changes over time. This will help us assess the company's progress or regression in sustainability. When constructing a sustainability index, different weights can be assigned to indicators, reflecting their relative importance (e.g., greenhouse gas emissions may carry greater weight than the volume of non-hazardous waste).

To calculate the environmental index, we will use the following company indicators as an example:

1. Direct emissions of greenhouse gases.
2. Indirect greenhouse gas emissions.
3. Consumption of fresh water for industrial needs.

Let's look at an example to show how the sustainability index of a company is measured. Depending on the enterprise's activities, the components may change. In this example, we present the measurements of the sustainable development index for oil companies using a fuzzy set. (The example uses prototypes of typical medium-sized energy companies).

Table 21. Components of the Sustainable Development Ecological Index

Indicators	UOM	Company 1			Company 2			Company 3		
		2022	2023	2024	2022	2023	2024	2022	2023	2024
Direct greenhouse gas emissions	mln. tons of CO <sub>2</sub> e	11,85	11,45	12,6	10,5	10,3	10,4	10,55	10,3	11,05
Indirect greenhouse gas emissions	mln. tons of CO <sub>2</sub> e	2,75	2,25	1,95	0,7	0,6	0,6	0,9	1,3	1,25
Fresh water consumption	mln. m <sup>3</sup>	27,6	27,1	26,5	19,5	19,3	18,4	16,7	21	20,75

Source: developed by the author

To solve this problem, we need to use another method with the corresponding formula. Unlike the linear interpolation formula, the formula of the linearly decreasing membership function is more consistent with this table. In the previous problem, we considered the economic growth of the enterprise, where higher growth corresponded to higher membership function and sustainability index values. However, in ecology, with such components as greenhouse gas

emissions and water consumption, the higher the values, the worse the sustainability index of the enterprise. In addition, linear decay functions are easy to understand, calculate, and interpret. They assume that the change in stability is proportional to the change in the indicator between two given threshold values, Lower Threshold and Upper Threshold. This is a good choice when there is no more complex expert knowledge about nonlinear dependencies. At all, there is no strictly fixed "number" of methods, since membership functions are primarily forms or types that can be adapted to a specific task. However, several of the most common and typical forms of membership functions can be identified: (NI 2023)

1. Sigmoidal Membership Function: They are S-shaped and used to represent concepts such as "greater than" or "less than". They smoothly transition from 0 to 1 (or vice versa).
2. Triangular Membership Function: They are simple, frequently used, and defined by three points: beginning, climax, and end.
3. Trapezoidal Membership Function: They are similar to triangular ones but have a "plateau" (interval) where the degree of membership is equal to 1. This allows us to determine the range of values that belong to the fuzzy set.
4. Z-shaped and S-shaped: In essence, they are special cases or modifications of sigmoid functions, often used to represent "no more than" and "no less than".
5. Generalized Bell Membership Function: A generalized form of the Gaussian function that is more flexible due to additional parameters that allow you to control the width and slope.
6. Gaussian Membership Function: Use a Gaussian function (bell curve). They are smooth and well-suited for continuous data where the transition between states should be smooth.
7. Linear Membership Function: They can be either increasing or decreasing. They are straight lines between two points.

In our case, the Linear Membership Function method, with a linearly decreasing membership function, will be used to solve this problem.

To do this, we need to determine:

1. A membership function for each indicator. Since lower values of emissions and water consumption are generally more desirable for sustainable development, we will apply a membership function that assigns higher values (close to 1) to low indicators and lower values (close to 0) to high indicators.

2. Thresholds (the points that define what is "very good," "average," and "poor" for each metric). These thresholds are often determined by experts or based on data analysis. For the purposes of this example, we will define them based on the range of values in our table 4.2.

3. Aggregation method for combining membership functions of all indicators into a common sustainable development index.

#### 1. Definition of the membership function for "Enterprise Sustainability"

We will use a linearly decreasing membership function, where:  $\mu(x) = 1$  if  $x$  is at a "very high" level (a low indicator, since the higher the above indicators, the worse the ecology).  $\mu(x) = 0$  if  $x$  is at a "very low" level (a high indicator). Between these points, the value of  $\mu(x)$  decreases linearly.

The formula for a linearly decreasing membership function is:

$$\mu_E(x) = (\text{Upper\_Threshold} - x) / (\text{Upper\_Threshold} - \text{Lower\_Threshold})$$

Where,  $\mu_E(x)$  is the membership function of the fuzzy set  $E$  by the current value of the indicator,  $x$  is the current value of the indicator.  $\text{Lower\_Threshold}$  is the value at which the indicator is

considered "very good" ( $\mu=1$ ). Upper\_Threshold is the value at which the indicator is considered "very bad" ( $\mu=0$ ).

2. Selection of threshold values (assumptions based on table data and experts):

Let's say experts suggest that Lower\_Threshold (the value at which  $\mu=1$ , i.e. perfectly stable) and Upper\_Threshold (the value at which  $\mu=0$ , i.e. completely unstable) for each indicator, based on the data range:

Table 22. Selecting threshold values

Indicators	UOM	Lower_Threshold ( $\mu=1$ )	Upper_Threshold ( $\mu=0$ )
Direct greenhouse gas emissions	mln. tons of CO <sub>2</sub> e	10	13
Indirect greenhouse gas emissions	mln. tons of CO <sub>2</sub> e	0,5	3
Fresh water consumption	mln. m <sup>3</sup>	16	29

*Note: These thresholds are selected based on the data analysis in the table to demonstrate the method. In a real situation, experts in the field of ecology and sustainable development should determine them.*

3. Calculation of membership functions for each indicator and the total (aggregation method):

Now let us apply these membership functions to each value in our table 4.1. To do this, we apply the formula:

$$\mu_E(x) = (\text{Upper\_Threshold} - x) / (\text{Upper\_Threshold} - \text{Lower\_Threshold})$$

Table 23.  $\mu$  values for the components of the ecological index of sustainable development

Ecological Indicators	UOM	Company 1			Company 2			Company 3		
		2022	2023	2024	2022	2023	2024	2022	2023	2024
Direct greenhouse gas emissions	mln. tCO <sub>2</sub>	(3-11,85)/3 = 0.38	(3-11,45)/3 = 0.51	(3-12,6)/3 = 0.13	(3-10,5)/3 = 0.83	(3-10,3)/3 = 0.9	(3-10,4)/3 = 0.92	(3-10,55)/3 = 0.81	(3-10,3)/3 = 0.9	(3-11,05)/3 = 0.65
Indirect greenhouse gas emissions	mln. tCO <sub>2</sub>	(3-2,75)/2,5 = 0.1	(3-2,25)/2,5 = 0.3	(3-1,95)/2,5 = 0.42	(3-0,7)/2,5 = 0.92	(3-0,6)/2,5 = 0.96	(3-0,6)/2,5 = 0.96	(3-0,9)/2,5 = 0.84	(3-1,3)/2,5 = 0.68	(3-1,25)/2,5 = 0.7
Fresh water consumption	mln. m <sup>3</sup>	(29-27,6)/13 = 0.11	(29-27,1)/13 = 0.15	(29-26,5)/13 = 0.19	(29-19,5)/13 = 0.73	(29-19,3)/13 = 0.75	(29-18,4)/13 = 0.82	(29-16,7)/13 = 0.95	(29-21)/13 = 0.62	(29-20,75)/13 = 0.63

To calculate the overall sustainability index for each company for each year, we can average the membership function values for all indicators. This is the simplest aggregation method, assuming equal importance for all sustainability indicators

$$\text{Index (SDI)} = (\mu_{DGG} + \mu_{IGG} + \mu_{FWC})/N \quad N\text{- Quantity of parameters}$$

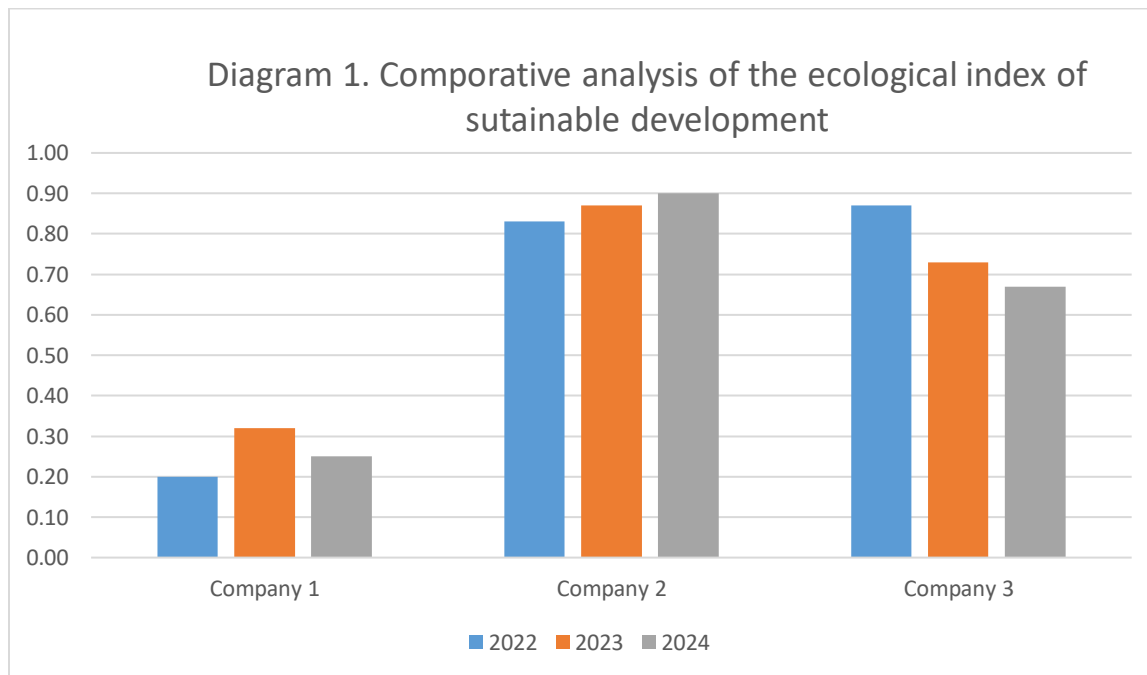
Table 24. SDI for the components of the ecological index of sustainable development

Company	2022	2023	2024
Company 1	$(0.38+0.1+0.11)/3 = 0.20$	$(0.51+0.3+0.15)/3 = 0.32$	$(0.13+0.42+0.19)/3 = 0.25$
Company 2	$(0.83+0.92+0.73)/3 = 0.83$	$(0.9+0.96+0.75)/3 = 0.87$	$(0.92+0.96+0.82)/3 = 0.9$
Company 3	$(0.81+0.84+0.95)/3 = 0.87$	$(0.9+0.68+0.62)/3 = 0.73$	$(0.65+0.7+0.63)/3 = 0.67$

The following conclusions can be drawn on sustainable development for these companies:

The higher the index value (closer to 1), the more sustainable the company's development is from an environmental point of view according to the specified criteria.

- Company 1: Shows a low level of environmental sustainability compared to other companies in all years. The worst indicators for indirect gas emissions in 2022 and water consumption in all years. In addition, in 2024 there is a very large deterioration due to the decrease in direct emissions.
- Company 2: Shows steady growth in environmental sustainability from 2022 to 2024. It is the most sustainable company among the companies presented. However, it lags slightly behind the third company in water consumption in 2022.
- Company 3: Starts at the highest sustainability level in 2022, but then sees a slight decline in 2023 and 2024. This is due to deterioration in indirect greenhouse gas emissions and water consumption in 2023.



Next steps and possibilities:

- Setting thresholds: Lower\_Threshold and Upper\_Threshold can be further customized based on industry benchmarks or sustainability goals.
- Weighting factors: If certain indicators are considered more important, they can be weighted when calculating the overall index (for example, if greenhouse gas emissions are more important than water consumption).
- Other membership functions: Other forms of membership functions (such as sigmoid or trapezoidal) can be used, which can also capture expert knowledge well.
- Fuzzy rules: For more complex assessments, fuzzy rules can be used (e.g. "IF direct emissions are HIGH AND water consumption is also HIGH, THEN sustainability is VERY LOW").

The solution to the problem indicated above is more suitable for determining the sustainable development index and comparative analysis between companies, but it is also possible to solve the problem related to finding the sustainable development index for social and economic tasks. This time, the Linear Membership Function method will also be used, but, already with the formula of a linearly increasing membership function. In this case, the function will look like this:

$$\mu(x) = (x - \text{Lower\_Threshold}) / (\text{Upper\_Threshold} - \text{Lower\_Threshold})$$

Where:

$x$  – The current value of the indicator (for example, social assistance or profit).

Lower\_Threshold – the value at which the indicator is considered “bad” or “insufficient” (membership degree  $\mu=0$ ).

Upper\_Threshold – the value at which the indicator is considered “very good” or “excellent” (membership degree  $\mu=1$ ).

As we can see, this formula is different from the previous one.

Thus, for "higher is better" metrics, a linearly increasing membership function is used, which is the mirror image of the linearly decreasing function used for "lower is better" metrics.

Calculating a social sustainability index for oil and gas companies requires taking into account their impact on employees, local communities, human rights, etc. Social indicators are often more difficult to quantify than environmental ones, but they are critical to overall sustainability.

Here are the main categories and indicators that can be used for a social index:

Table 25. List of components of the social index of sustainable development

Indicators category	Indicators
Labor Practices & Decent Work)	Occupational safety
	Lost Time Injury Frequency
	Total Recordable Incident Rate
	Volume of investments in labor protection and industrial safety
	Staff development and training
	Expenses for training and development of personnel
	Percentage of women
	Gender/ethnic pay gap
Community Engagement & Development	Employee Satisfaction
	Investing in communities
	The volume of financial and non-financial investments in social projects of local communities
	Percentage of local residents employed by the company
	Grievance Mechanisms
	Availability and accessibility of feedback channels
Human Rights	Impact on local infrastructure and services
	Existence and implementation of human rights policies
	Conducting a human rights risk assessment
	Training of employees and suppliers on human rights issues.
	Number of human rights violations recorded
Responsible Supply Chain	Freedom of association and collective bargaining
Product Responsibility	Percentage of suppliers that have passed social audit
	Availability and compliance with a Supplier Code of Conduct that includes social and ethical standards
	Supplier Sustainability Capacity Development Programs
	Safety of storage and transportation of products
	Informing consumers and the public

Table 26. Components of the social index of sustainable development

Social Indicators	UOM	Company 1			Company 2			Company 3		
		2022	2023	2024	2022	2023	2024	2022	2023	2024
Volume of investments in labor protection and industrial safety	mln. USD	42	35	32	28	29	41	17	21	25
The volume of financial and non-financial investments in social projects of local communities	mln. USD	13	14	13	22	15	12	11	15	17

Table 27. Selecting threshold values

Indicators	UOM	Lower_Threshold ( $\mu=1$ )	Upper_Threshold ( $\mu=0$ )
Volume of investments in labor protection and industrial safety	mln. USD	15	60
The volume of financial and non-financial investments in social projects of local communities	mln. USD	7	25

*Note: These thresholds were selected based on an analysis of the data in the table to demonstrate the method. In a real-world situation, they should be determined by experts in the field of social and sustainable development.*

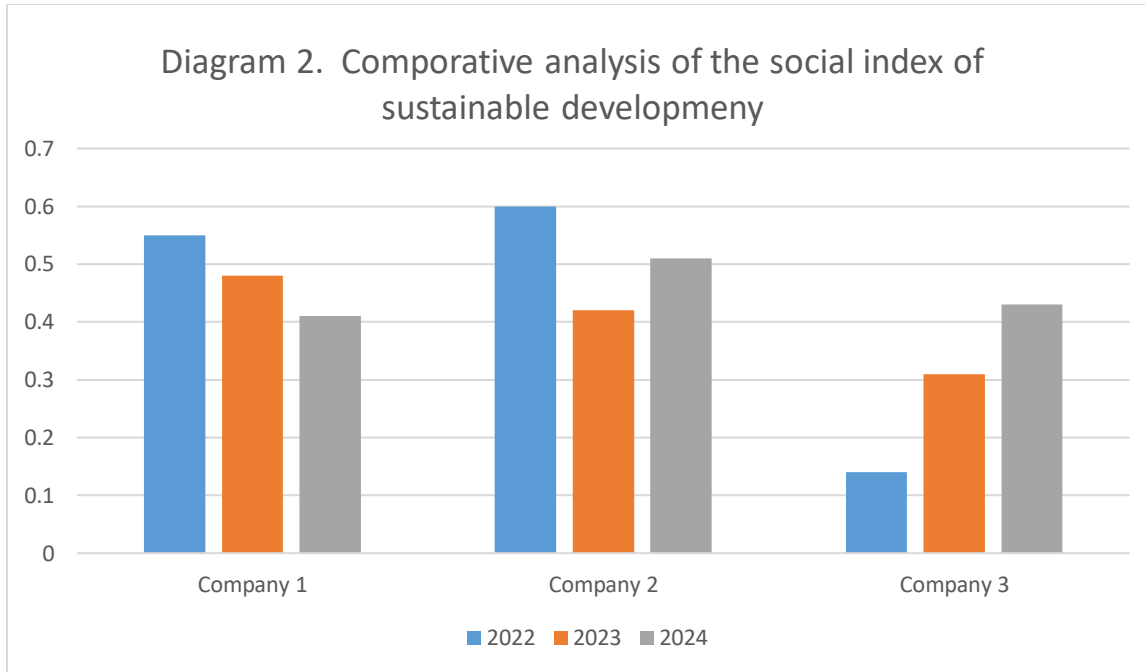
If the formula is:  $\mu(x) = (x - \text{Lower\_Threshold}) / (\text{Upper\_Threshold} - \text{Lower\_Threshold})$ , then

Table 28.  $\mu$  values for the components of the social index of sustainable development

Indicators	UOM	Company 1			Company 2			Company 3		
		2022	2023	2024	2022	2023	2024	2022	2023	2024
Volume of investments in labor protection and industrial safety	mln. USD	(42-15)/35= 0.77	(35-15)/35= 0.57	(32-15)/35= 0.48	(28-15)/35= 0.37	(29-15)/35= 0.4	(41-15)/35= 0.74	(17-15)/35= 0.06	(21-15)/35= 0.17	(25-15)/35= <b>0.29</b>
The volume of financial and non-financial investments in social projects of local communities	mln. USD	(13-7)/18= 0.33	(14-7)/18= 0.38	(13-7)/18= 0.33	(22-7)/18= 0.83	(15-7)/18= 0.44	(12-7)/18= 0.28	(11-7)/18= 0.22	(15-7)/18= 0.44	(17-7)/18= 0.56

Table 29. SDI by components of the social index of sustainable development

Company	2022	2023	2024
Company 1	$(0.77+0.33)/2 = 0.55$	$(0.57+0.38)/2 = 0.48$	$(0.48+0.33)/2 = 0.41$
Company 2	$(0.37+0.83)/2 = 0.6$	$(0.4+0.44)/2 = 0.42$	$(0.74+0.28)/2 = 0.51$
Company 3	$(0.06+0.22)/2 = 0.14$	$(0.17+0.44)/2 = 0.31$	$(0.29+0.56)/2 = 0.43$



Some properties need to be considered when constructing a social index:

- Qualitative vs. Quantitative indicators: Some social aspects are difficult to quantify (e.g. quality of community dialogue). They can be assessed by the presence of policies, procedures, independent assessments.
- Normalization: As in ecology, specific indicators are often needed, such as community investment per ton of output or per employee.
- Context: Social risks are highly dependent on the geography of operations (countries with a high risk of human rights violations, the presence of indigenous peoples, and conflict zones).

- Weighting factors: When constructing an index, it is essential to assign weights to the various indicators, reflecting their relative importance to the company and its stakeholders.

- Stakeholder involvement: It is essential to consider the views and needs of various stakeholders, such as employees, residents, and trade unions.

To calculate the economic sustainability index of oil and gas companies, it is necessary to assess not only their current financial performance, but also their ability to generate long-term economic value, resilience to external shocks (including those associated with the transition to a low-carbohydrate economy) and contribution to the economic well-being of society.

These are not just “financial indicators”, but also precisely financial and economic parameters, which reflect the sustainability of the company’s business model in a changing world.

Here are the main categories and indicators:

Table 30. List of components of the economic index of sustainable development

<b>Indicators category</b>	<b>Indicators</b>
Financial Performance & Stability	Revenue and its growth dynamics
	Net profit
	Operating Cash Flow
	Debt-to-Equity Ratio, Net Debt/EBITDA
	Current Ratio, Quick Ratio
	Capital Expenditures - CAPEX
	Market capitalization and stock price dynamics
	Credit ratings
Contribution to Economy & Value Creation	Tax deductions
	Number of jobs (direct and indirect)
	Labor costs
	Purchasing from local suppliers:
	R&D Spending
Transition Resilience & Diversification	Investments in low carbon assets/technologies
	Share of revenue from low carbon products/services
	Climate Risk Management Strategy
	Costs of decarbonization
Governance	Independence of the board of directors
	ESG-linked executive compensation
	Transparency of reporting

Table 31. Components of the Economic Index of Sustainable Development

Economic Indicators	UOM	Company 1			Company 2			Company 3		
		2022	2023	2024	2022	2023	2024	2022	2023	2024
Net profit	mln. USD	90	78	86	93	79	67	72	73	84
Tax deductions	mln. USD	27	21	24	28	22	18	20	20	23
Costs of decarbonization	mln. USD	13	18	8	22	16	16	13	14	16

Table 32. Selection of threshold values

Indicators	UOM	Lower_Threshold ( $\mu=1$ )	Upper_Threshold ( $\mu=0$ )
Net profit	mln. USD	65	100
Tax deductions	mln. USD	15	30
Costs of decarbonization	mln. USD	5	25

*Note: These thresholds were selected based on an analysis of the data in the table to demonstrate the method. In a real-world situation, they should be determined by experts in the field of social and sustainable development.*

If the formula is:

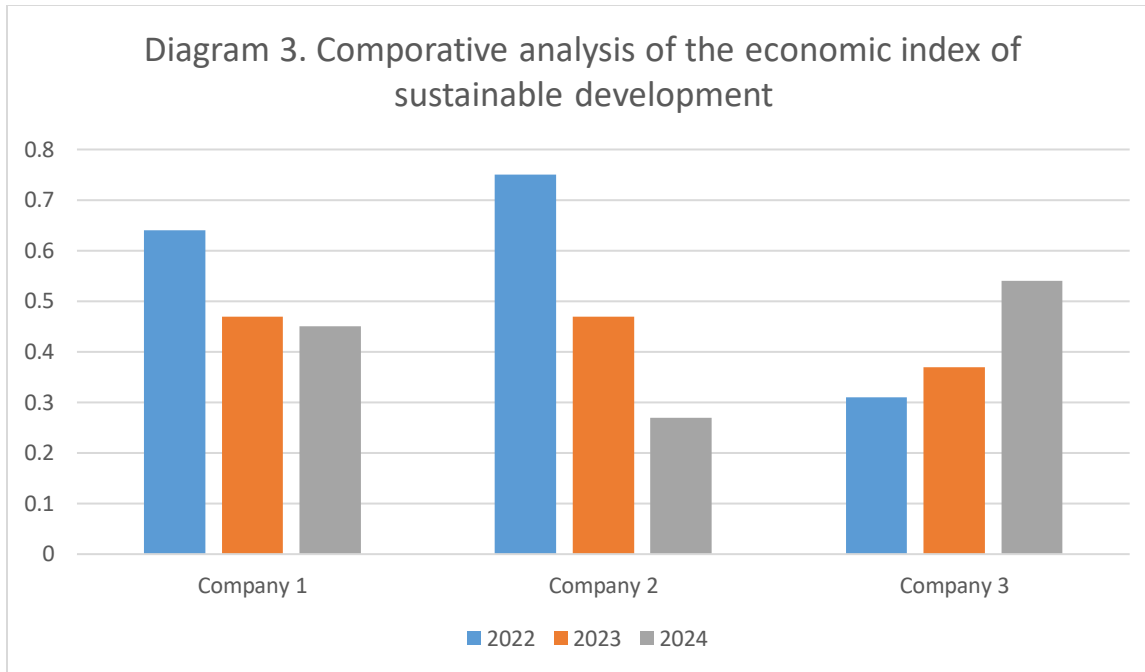
$$\mu_{(x)} = (x - \text{Lower\_Threshold}) / (\text{Upper\_Threshold} - \text{Lower\_Threshold}), \text{ then}$$

Table 33.  $\mu$  values by components of the economic index of sustainable development

Indicators	UOM	Company 1			Company 2			Company 3		
		2022	2023	2024	2022	2023	2024	2022	2023	2024
Net profit	millio n USD	(90- 65)/35= <b>0.71</b>	(78- 65)/35 = 0.37	(86- 65)/35= 0.6	(93- 65)/35 = 0.8	(79- 65)/35= 0.4	(67- 65)/35 = 0.06	(72- 65)/35= 0.2	(73- 65)/35 = 0.34	(84- 65)/35= 0.54
Tax deductions	millio n CO2	(27- 15)/15= 0.8	(21- 15)/15 = 0.4	(24- 15)/15= 0.6	(28- 15)/15 = 0.6	(22- 15)/15= 0.46	(18- 15)/15 = 0.2	(20- 15)/15= 0.33	(20- 15)/15 = 0.33	(23- 15)/15= 0.53
Costs of decarboniza tion	millio n USD	(13- 5)/20= 0.4	(18- 5)/20= 0.65	(8- 5)/20= 0.15	(22- 5)/20= 0.85	(16- 5)/20= 0.55	(16- 5)/20= 0.55	(13- 5)/20= 0.4	(14- 5)/20= 0.45	(16- 5)/20= 0.55

Table 34.  $\mu$  Value of the components of the sustainable economic development index

Company	2022	2023	2024
Company 1	$(0.71+0.8+0.4)/3 = 0.64$	$(0.37+0.4+0.65)/3 = 0.47$	$(0.6+0.6+0.15)/3 = 0.45$
Company 2	$(0.8+0.6+0.85)/3 = 0.75$	$(0.4+0.46+0.55)/3 = 0.47$	$(0.06+0.2+0.55)/3 = 0.27$
Company 3	$(0.2+0.33+0.4)/3 = 0.31$	$(0.34+0.33+0.45)/3 = 0.37$	$(0.54+0.53+0.55)/3 = 0.54$



In selecting and using economic indicators to assess sustainability, it is also necessary to consider a company's ability to adapt, invest in the future, and remain competitive in the long term. Furthermore, economic sustainability is closely linked to environmental (pollution fines, decarbonization costs) and social (skill drain, strikes, and other losses due to social conflicts) sustainability.

Table 35. Average value of membership functions for all indicators (environmental, social and economic) by companies and by years

<b>Company 1</b>			
	2022	2023	2024
Ecological	0.20	0.32	0.25
Social	0.55	0.48	0.41
Economic	0.64	0.47	0.45
<b>Total SDI/3</b>	<b>0.46</b>	<b>0.42</b>	<b>0.37</b>
<b>Company 2</b>			
	2022	2023	2024
Ecological	0.83	0.87	0.9
Social	0.6	0.42	0.51
Economic	0.75	0.47	0.27
<b>Total SDI/3</b>	<b>0.73</b>	<b>0.59</b>	<b>0.56</b>
<b>Company 3</b>			
	2022	2023	2024
Ecological	0.87	0.73	0.67
Social	0.14	0.31	0.43
Economic	0.31	0.37	0.54
<b>Total SDI/3</b>	<b>0.44</b>	<b>0.47</b>	<b>0.55</b>

Another idea is the priorities should be taken into account during calculating of company's sustainability index. Experts can assign different weights to indicators in the sustainability index. Let us assume that environmental indicators are prioritized over economic and social indicators. Moreover, economic priorities are higher than social ones. If we designate the weight value as  $w$ , then:

$$SDI = (SDI_e \times 0.85 + SDI_s \times 0.35 + SDI_e \times 0.60) / 3.$$

(The value,  $w = 0.85, 0.60, 0.35$  are random weight values - numbers chosen by the author). In this case, our sustainability index will receive other numbers:

Table 36. Average value of membership functions for all indicators (environmental, social and economic) by companies and by years after priority

<b>Company 1</b>			
	2022	2023	2024
Ecological	$0.20 \times 0.85 = 0.17$	$0.32 \times 0.85 = 0.27$	$0.25 \times 0.85 = 0.21$
Social	$0.55 \times 0.35 = 0.19$	$0.48 \times 0.35 = 0.17$	$0.41 \times 0.35 = 0.14$
Economic	$0.64 \times 0.60 = 0.38$	$0.47 \times 0.60 = 0.28$	$0.45 \times 0.60 = 0.27$
<b>Total SDI/3</b>	<b>0.25</b>	<b>0.24</b>	<b>0.21</b>
<b>Company 2</b>			
	2022	2023	2024
Ecological	$0.83 \times 0.85 = 0.71$	$0.87 \times 0.85 = 0.74$	$0.9 \times 0.85 = 0.76$
Social	$0.6 \times 0.35 = 0.21$	$0.42 \times 0.35 = 0.15$	$0.51 \times 0.35 = 0.19$
Economic	$0.75 \times 0.60 = 0.45$	$0.47 \times 0.60 = 0.29$	$0.27 \times 0.60 = 0.16$
<b>Total SDI/3</b>	<b>0.46</b>	<b>0.39</b>	<b>0.37</b>
<b>Company 3</b>			
	2022	2023	2024
Ecological	$0.87 \times 0.85 = 0.74$	$0.73 \times 0.85 = 0.62$	$0.67 \times 0.85 = 0.57$
Social	$0.14 \times 0.35 = 0.05$	$0.31 \times 0.35 = 0.11$	$0.43 \times 0.35 = 0.15$
Economic	$0.31 \times 0.60 = 0.19$	$0.37 \times 0.60 = 0.22$	$0.54 \times 0.60 = 0.32$
<b>Total SDI/3</b>	<b>0.33</b>	<b>0.32</b>	<b>0.35</b>

As you can see from the table, once priorities are set, the data changes.

Table 37. Comparative analysis of SDI data before and after priorities.

Company	SDI to Priority			SDI after priority		
	2022	2023	2024	2022	2023	2024
Company 1	0.46	0.42	0.37	<b>0.25</b>	<b>0.24</b>	<b>0.21</b>
Company 2	0.73	0.59	0.56	<b>0.46</b>	<b>0.39</b>	<b>0.37</b>
Company 3	0.44	0.47	0.55	<b>0.33</b>	<b>0.32</b>	<b>0.35</b>

If we analyze the SDI values before and after the priority, we can see that Company 3 has consistently improved its SDI positions. However, after the setting of priorities in the SDI calculations, this sequence was interrupted in 2023. In 2023, instead of becoming higher than in

2022, the SDI became smaller. Moreover, the challenge in 2023 is that Company 3 has significantly increased its freshwater consumption and indirect greenhouse gas emissions, leading to a decline in its Environmental Performance Index. Furthermore, the environment was our top priority. Therefore, a comparative analysis of the data before and after the priority makes it possible to make a more in-depth analysis.

Another method in fuzzy sets is to replace weights with fuzzy rules. Establishing fuzzy rules allows for more in-depth analysis. Adding fuzzy rules allows for a more flexible assessment of sustainability, taking into account the relationships between indicators, not just their arithmetic mean. In this case, the process in fuzzy logic typically looks like this:

1. Fuzzification: Transformation of crisp numerical values into fuzzy memberships of linguistic terms. We have already done this in the previous step, calculating  $\mu$  for each indicator.
2. Rule Base: A set of "IF-THEN" rules formulated by experts.
3. Inference Engine: Applying rules to fuzzy inputs to produce fuzzy outputs.
4. Defuzzification: Converting fuzzy output data back into a crisp value (if a single number is required) in the case of conversion to sustainability standards.

### **1. Fuzzification**

We have already calculated the membership degrees ( $\mu$ ) for each indicator above, i.e. we have completed this stage. Now we need to assign linguistic terms (e.g. "very low", "very high") to these  $\mu$  values.

**Let us define linguistic variables and their membership functions for input  $\mu$ :**

For simplicity, we will assume that each  $\mu$  (from 0 to 1) can belong to the following categories:

- Very low value:  $\mu$  in the range (0 – 0.2)
- Low value:  $\mu$  in the range (0.2 – 0.4)
- Average value:  $\mu$  in the range (0.4 – 0.6)
- Good value:  $\mu$  in the range (0.6 – 0.8)
- High value:  $\mu$  in the range (0.8 – 1.0)
- Very high value:  $\mu$  in the range (0.9 – 1.0)

## 2. Formulation of fuzzy rules (Rule base)

To create fuzzy rules, we first need to formulate them. Now we will formulate a series of "IF-THEN" rules that reflect expert knowledge about how different combinations of environmental indicators affect overall sustainability. For each stage, we can formulate suitable rules. As an example, we will create a rule base on ecology.

### Fuzzy rule base:

Rule 1. Critical condition: IF direct emission shows very low  $\mu$  value, OR indirect emission shows very low  $\mu$  value, THEN STABILITY = Very low.

*Comment: If one of the main emission categories is at a critically low sustainability level (very high actual values), this greatly reduces the overall sustainability.*

Rule 2. General low efficiency: IF direct emission shows low  $\mu$  value, AND indirect emission shows low  $\mu$  value, OR water consumption shows low  $\mu$  value, THEN SUSTAINABILITY = Low.

*Comment: Several indicators are at a poor stability level (high actual values), leading to low overall stability.*

Rule 3. Moderate work: IF direct emission shows average  $\mu$ , AND indirect emission shows average  $\mu$ , AND water consumption shows average  $\mu$ , THEN SUSTAINABILITY = Average Sustainability.

Comment: If the main indicators are in the average range, then the overall stability is average.

Rule 4. Good efficiency: IF All indicators show good  $\mu$  value, OR some indicators show high  $\mu$  value, THEN STABILITY = High Stability

Comment: If all or almost all indicators show good or excellent stability.

Rule 5. Outstanding efficiency: IF direct emission shows very high  $\mu$  value AND water consumption is very high value AND indirect emission is very high OR high THEN STABILITY = Very\_High\_Stability

*Comment: Very high or nearly very high scores in all categories.*

The same rule base can be created using table N, which reflects environmental, social and economic SDI.

Rules 1.Critical condition: IF the ecology shows a very low  $\mu$  value, OR the social indicator shows a very low  $\mu$  value, THEN SUSTAINABILITY = Very low.

*Comment: If the 2 main indicators, environmental and social indicators, are at a critically low level of sustainability, this greatly reduces the overall sustainability.*

Rule 2. General low efficiency: IF the ecology indicator has a low  $\mu$  value, AND the social indicator has a low  $\mu$  value, OR the economic indicator has a low  $\mu$  value, THEN SUSTAINABILITY = Low.

*Comment: Several indicators are at a poor level of sustainability, leading to low overall sustainability.*

Rule 3. Low efficiency: IF the ecology shows a very low  $\mu$  value, AND the social indicator AND the economic indicator show a medium  $\mu$  value, THEN SUSTAINABILITY = Low Sustainability.

Comment: In this case, ecology plays an important role.

Rule 4. Low efficiency: IF the ecology shows a good OR average  $\mu$  value, AND the social indicator shows a low  $\mu$  value, AND the economic indicator shows a low  $\mu$  value, THEN SUSTAINABILITY = Low Sustainability.

Comment: The company should pay attention to the social side.

Rule 5. Moderate work: IF the ecology shows a medium  $\mu$  value, AND the social indicator a medium  $\mu$  value, AND the economic indicator a low  $\mu$  value, THEN SUSTAINABILITY = Medium Sustainability.

*Comment: If the main indicators (ecology and social condition) are in the average range, and the economy is not lower than low, then the overall stability is average.*

Rule 6. Moderate work: IF the ecology shows an average value of  $\mu$ , AND the social indicator shows an average value of  $\mu$ , AND the economic indicator shows an average value of  $\mu$ , THEN SUSTAINABILITY = Average Sustainability.

*Comment: If the main indicators are in the average range, then the overall stability is average.*

Rule 7. Moderate work: IF the ecology shows a medium  $\mu$  value, AND the social indicator a medium  $\mu$  value, AND the economic indicator a low  $\mu$  value, THEN SUSTAINABILITY = Medium Sustainability.

*Comment: If the main indicators (Ecology and social condition) are in the average range, then the overall stability is average.*

Rule 8. Good efficiency: IF the ecology shows a good  $\mu$  value, AND the social indicator has an average  $\mu$  value, AND the economic indicator has an average  $\mu$  value, THEN SUSTAINABILITY = High Sustainability.

*Comment: If the ecology is in the good range, and the rest are not below average, then the stability is high.*

Rule 9. Good efficiency: IF the ecology shows a high  $\mu$  value, AND the social indicator has a good  $\mu$  value, AND the economic indicator has a good  $\mu$  value, THEN SUSTAINABILITY = Significantly High Sustainability.

Rule 10. Good efficiency: IF the ecology shows a high  $\mu$  value, AND the social indicator shows an average  $\mu$  value, AND the economic indicator shows an average  $\mu$  value, THEN SUSTAINABILITY = High Sustainability.

*Comment: If the ecology is in the high range, and the rest are not below average, then the stability is high.*

Rule 11. Good efficiency: IF the ecology shows a very high  $\mu$  value, AND the social indicator shows an average  $\mu$  value, AND the economic indicator shows a low  $\mu$  value, THEN SUSTAINABILITY = High Sustainability.

*Comment: If the ecology is in a very high range, and the social condition is not below average, then the sustainability is high. Although the economy is low, the company should be encouraged.*

Rule 12. Good efficiency: IF the ecology shows a high  $\mu$  value, AND the social indicator shows a very low  $\mu$  value, AND the economic indicator shows a low  $\mu$  value, THEN SUSTAINABILITY = Low Sustainability.

*Comment: If the ecology is in the high range and the rest are below average, then sustainability is low.*

Thus, it is possible to supplement with different rules. Of course, experts should do this.

### **3. Inference Engine:**

Now let us apply these rules to the data in our table 4.16 to obtain fuzzy output.

Company 1.

2022. Ecology: 0.20 – very low. Social status: 0.55 – average. Economy: 0.64 – average. Complies with Rule 3. SUSTAINABILITY = Low Sustainability.

2023. Ecology: 0.32 – low. Social status: 0.48 – average. Economy: 0.47 – average. Complies with Rule 3. SUSTAINABILITY = Low Sustainability.

2024. Ecology: 0.25 – low. Social status: 0.41 – average. Economy: 0.45 – average. Complies with Rule 3. SUSTAINABILITY = Low Sustainability.

Company 2.

2022. Ecology: 0.83 – high. Social status: 0.6 – good. Economy: 0.75 – good. Complies with Rule 9. SUSTAINABILITY = High Sustainability.

2023. Ecology: 0.87 - high. Social status: 0.42 - average. Economy: 0.47 - average. Complies with Rule 10. SUSTAINABILITY = High Sustainability

2024. Ecology: 0.9 – very high. Social status: 0.51 – average. Economy: 0.27 – low. Complies with Rule 11. SUSTAINABILITY = High Sustainability

Company 3.

2022. Ecology: 0.87 - high. Social status: 0.14 - very low. Economy: 0.31 - low. Complies with Rule 12. SUSTAINABILITY = Low Sustainability

2023. Ecology: 0.73 – good. Social status: 0.31 – poor. Economy: 0.37 – poor. Complies with Rule 4. SUSTAINABILITY = Low Sustainability.

2024. Ecology: 0.67 – good. Social status: 0.43 – average. Economy: 0.54 – average. Complies with Rule 6. SUSTAINABILITY = Average Sustainability.

#### **4. Defuzzification:**

Certainly, the Sustainability index reports require a numerical value. By using the fuzzy set method, we obtained an aggregated fuzzy set, which we described using a linguistic variable. We can describe them in different words, to help employees at these companies to remember it better, to understand, and strive to improve all of the indicators. Moreover, converting all these linguistic variables into numbers does not require much effort. Using a defuzzification program, they will be converted to numbers, since all linguistic variables are associated with numbers, and we will again obtain a value of  $\mu$ , which is in the range  $\{0,1\}$ . Multiplying by 10, we obtain the sustainability index value according to the sustainability index standard.

The advantage of this method is that, defined language is much closer to human thinking, including artificial intelligence, than other methods of classical mathematics. If this methodology is combined with artificial intelligence, then after a certain time, the artificial intelligence itself will create more rules that are suitable, weight values, etc., and recommend them to experts. Because artificial intelligence will take into account not only the interests of the company, but also current events in the world, such as environmental pollution, climate change, food security, and others.

#### **4.2. Conceptual comparative analysis of the fuzzy set method with other methods of assessing the sustainable development of companies**

It is important to note that the selection of a methodology and a specific method greatly affects the results of the assessment of the sustainable development index. The problem is that the concept itself is multifaceted and complex. It is necessary to integrate financial and non-financial

(ESG) factors. Quantitative and qualitative indicators are involved. There is often uncertainty, inaccuracy, and incompleteness in the source data, etc.

There are various methods for measuring a sustainability index, which identifies and highlights the current state and progress, strengths and weaknesses: traditional quantitative methods, qualitative methods, the fuzzy set method, and corporate sustainability assessments by specialized agencies (MSCI, Sustainalytics, etc.) based on their own proprietary methodologies. If we compare them all, it turns out that the fuzzy set method offers unique advantages for working with the uncertainty inherent in sustainability and qualitative information, complementing or surpassing traditional methods in many aspects. By analyzing the methods used to assess the sustainability index, we can understand the weaknesses of these methods.

**Methods based on weighted sums and indices (Omid Bozorg-Haddad et al. 2021).**

Weaknesses:

- Subjectivity in the assignment of scales (critical drawback).
- Loss of information during aggregation (different combinations of indicators can produce the same index).
  - They perform poorly when processing high-quality data without preliminary, often crude, digitization.
  - Difficulty in accounting for nonlinear relationships and threshold effects.
  - **Multicriteria methods of decision analysis (MCDA)** (Beate ZLAUGOTNE et al. 2020).

Weaknesses:

- Requires significant involvement of experts and decision-makers.
- Complexity for many criteria and alternatives.

- Subjectivity in pairwise comparisons (in AHP) and threshold determination (in ELECTRE/PROMETHEE).
- May be sensitive to changes in ratings.

### **ESG ratings (as a method of external assessment) (MSCI 2024).**

Weaknesses:

- Opacity of methodologies ("black box").
- Dependence on the quality of publicly disclosed information Differences in estimates between agencies.
- Possible bias (e.g. towards larger companies reporting better).
- Not always suitable for internal management analysis due to their generality.

### **Expert assessments and qualitative analysis (Confluence 2021).**

Weaknesses:

- Labor-intensive and expensive.
- High degree of subjectivity.
- Difficulty of formalization and comparison.
- Dependence on the qualifications and objectivity of experts.

### **Fuzzy set (Zadeh L 1973)**

Weaknesses:

- The assessment of UR often relies on the judgment and experience of experts.
- The choice of linguistic variables, term sets, form of membership functions, and, especially, the fuzzy rule base largely depends on the knowledge and preferences of the experts or model developers.

- Requires careful validation, possibly by a panel of experts, and it makes the model dependent on their expertise.

Nevertheless, the fuzzy set method has advantages:

- Allows you to represent the degree to which an item belongs to a set (e.g., "the degree to which a company's emissions are 'low' or 'high'"). This is more flexible than a binary yes/no.
- Using the fuzzy set method makes the model transparent and interpretable.
- All input indicators (regardless of their nature and units of measurement) are translated into a fuzzy format (degrees of belonging to linguistic terms). This creates a single basis for further processing.
- The use of linguistic variables and rules makes the logic of the model understandable not only to mathematicians, but also to managers and experts in the field of sustainable development.
- You can track which rules worked and what contribution they made to the final score that helps identify drivers and problem areas

However, there is a difficulty in implementing the fuzzy set method. If different organizations or researchers develop their own fuzzy models with distinct rules and membership functions, the direct comparison of their results may be difficult. Therefore, standardized industry-specific fuzzy SD models should be developed for each industry (a difficult yet promising task).

Table 38. Fuzzy application methods are compared to other methods.

Comparison criterion	ESG ratings	Expert Assessments	MCDAs	Weighted sum methods	Fuzzy set method
Working with Uncertainty	Depends on the agency's methodology	Average	Average	Low (requires clear data)	High (membership functions, linguistic variables)
Formalization of expert knowledge	Low (hidden in agency methodology)	Low (difficult to formalize for systematic analysis)	High (through hierarchy structure)	Low (indirectly through weights)	High (fuzzy IF-THEN rules)
Modeling nonlinearity	Depends on the methodology	Relatively low	Average (limited capabilities)	Low (usually linear aggregation)	High (flexibility of rules and membership functions)
Transparency	Low (black box)	High (for a specific case), low (for generalizations)	Average (the comparison process can be complex)	Medium (weights may be opaque)	High (rules and linguistic terms are clear)
Aggregation of heterogeneous data	High (but aggregation methodology is hidden)	Low (difficult to aggregate formally)	High (handles different criteria)	Average (requires normalization, may have problems)	High, into a single level format through fuzzification

Subjectivity	Present (selection of factors, weights by the agency)	Very high	High (pairwise comparisons)	High (purpose of scales)	Present but controlled
Data requirements	Dependent on public disclosure	Depends on access to information and experts	Requires the ability to compare	Requires complete, clear data	Flexible, accepts both precise and imprecise data

(Source: developed by the author).

The fuzzy set method offers a powerful and flexible tool for assessing the sustainability of enterprises, particularly valuable for its ability to address uncertainty, qualitative information, and nonlinear dependencies inherent in this field. It allows for the creation of more realistic and interpretable models than many traditional approaches.

. It should be noted that rating agencies seek to compare and measure key sustainability criteria for investors. The most well-known authors of sustainability ratings and environmental information for oil and gas companies are Sustainalytics, AK&M, MSCI, SIP Global, CDP (Carbon Disclosure Project), World Benchmarking Alliance (WBA), CSR Hub, and Expert RA. The problem is that a comparative analysis of these ratings allows one to conclude that the same company can occupy different positions across different ratings. Actual implementation practices for ESG factors vary widely, and most investment managers are far from fully integrated. Few firms use ESG factors to generate alpha returns, hence the paradox (Cappucci M., 2018).

In this regard, it is necessary to use tools that provide common indicators for all analyzed companies. Therefore, the proposed model can be used by rating companies to assess the sustainable development of oil and gas companies.

#### **4.3. Practical use of the fuzzy set method for assessing the level of sustainable development**

The fuzzy set method is a flexible and reliable tool for assessing enterprise sustainability, particularly useful in conditions of uncertainty, qualitative information, and nonlinear dependencies. (A.B. Кученкова 2014). Unlike traditional approaches, fuzzy logic allows for the development of more realistic and interpretable models that can account for inaccurate or incomplete data.

The aforementioned methodology provides an opportunity to adapt to the specific needs of enterprises and industries and takes into account environmental, social, and economic aspects. By combining quantitative and qualitative figures, the model strengthens objectivity while remaining manageable for practice. Expert opinions from different fields - management, risk analysis, ecology, sociology, and economics - are integrated into the assessment, ensuring validity.

The method is well-suited to programming and can be implemented using tools such as **Scikit-fuzzy** (a Python toolkit for fuzzy logic) or **MATLAB** (MathWorks 2025). While few companies explicitly report using fuzzy sets in ESG assessment, the method is inherently compatible with models that rely on expert judgment and imprecise data.

Industries where fuzzy set assessment is the most appropriate for application are:

1. Oil, gas, and coal companies have valuable environmental impacts.
2. Renewable energy companies face high uncertainty in production forecasts.
3. ESG consulting firms assist clients with sustainability evaluation.

4. Research institutions are developing sustainability models.
5. IT firms are creating ESG software incorporating fuzzy logic.

Overall, the fuzzy set method enables businesses and assessors to conduct detailed, actionable evaluations of sustainability performance, supporting an informed decision-making process even in the face of uncertainty.

## CONCLUSION

The conducted research confirms that in modern economic conditions, industrial companies operate in terms of structural contradiction: on the one hand, they remain one of the main sources of pressure on the environment, and on the other hand, they are key factors of economic growth, employment, and social development. This contradiction objectively limits the effectiveness of traditional corporate development models and necessitates a transition to management systems that integrate the principles of sustainable development into strategic and operational decision-making. Under increasing pressure from regulators, investors, and society, sustainable development has evolved from a reputation or reporting-oriented concept to a fundamental determinant of companies' long-term competitiveness.

This research generalizes approaches to sustainable development management by integrating economic, managerial, and institutional aspects into a single analytical framework. The evolution of the concept of sustainable development is systematized, and its applicability to modern corporate governance systems is investigated.

One of the key results of the research is the development and formalization of a comprehensive mechanism for managing sustainable development at the corporate level. The proposed mechanism covers the full management cycle, including the formulation of sustainable development goals, the selection and structuring of indicators, performance monitoring, and integrated assessment. This mechanism accounts for external regulatory requirements, production and economic constraints, and the balance of risks and opportunities, thereby ensuring the coordination of management decisions across functional areas and contributing to the improvement of companies' environmental, social, and economic performance.

The research also substantiates the significance of institutional and regulatory factors in shaping corporate sustainable development strategies. Based on the analysis of national and international regulatory frameworks, including emissions trading systems, carbon taxation mechanisms, and sustainability-linked green financial instruments, key barriers and drivers influencing the development of green financing at the corporate level are identified. The results obtained make it possible to determine priority directions of corporate activity within the energy transition, including energy efficiency improvement, greenhouse gas capture and storage, low-carbon transport and construction solutions, and the development of hydrogen energy.

A separate block of research is devoted to the analysis of the management of the sustainable development of the oil and gas sector in the context of the global energy transition. This research demonstrates that leading international oil and gas companies are actively adapting to changing regulatory, market, and investment requirements by modernizing production processes, transforming corporate governance structures, and using economic and financial mechanisms to stimulate projects in the field of energy efficiency, carbon capture and storage, energy storage technologies, etc., and clean energy. The results of the SWOT analysis and corporate strategy assessment confirm the gradual transformation of traditional energy companies towards more diversified and sustainability-oriented business models.

Based on an analysis of corporate reporting data for 2023-2024, priority sustainable development goals have been identified, embedded in corporate strategies, and a system of generalized indicators has been developed to reflect companies' progress in achieving these goals.

The obtained results confirm the increasing strategic importance of sustainable development in corporate planning and investment decision-making processes.

The methodological result of the research is the development of an approach to assessing the level of sustainable development of a company based on fuzzy logic tools. The proposed methodology, which includes the definition of linguistic variables, membership functions, and a base of rules for fuzzy inference, allows for a comprehensive assessment of quantitative and qualitative indicators of stability in terms of uncertainty and incompleteness of information. The calculation of environmental, socio-economic, and integral indicators of sustainable development confirms the practical applicability, flexibility, and universality of the proposed approach.

In general, achieving long-term corporate sustainability requires the systematic integration of sustainable development principles into production systems, business processes, and corporate governance structures, and their implementation across all levels of management. The alignment of strategic goals of sustainable development with operational activities creates conditions for increasing the competitiveness of the corporation, reducing environmental and social risks, and making a real contribution to sustainable economic and social development.

Table 39. Correspondence between research objectives and main conclusions

№	Research objectives	The results of research
1	To systematize and analyze approaches for the implementation of sustainable development goals in companies across various industries.	The research presents the generalization and analysis of the main theoretical and applied approaches to corporate sustainable development management, highlights their key characteristics and limitations in integrating the principles of sustainable development into strategic and operational decision-making.

2	To develop and formulate a comprehensive practical mechanism for sustainable development management at the corporate level.	A sustainable development management mechanism has been developed and formulated. It covered the full management cycle from setting goals and selecting indicators to monitoring and comprehensive assessment. The mechanism ensures the coordination of management decisions in functional areas and supports the alignment of sustainable development goals with the corporate strategy.
3	To identify and substantiate the relationship between the level of sustainable development and the performance indicators of companies.	The research substantiates the existence of a relationship between the level of sustainable development of the company and key performance indicators, including competitiveness and strategic stability. It shows that higher levels of sustainable development are associated with improved long-term performance and adaptability to external challenges
4	To apply a methodological approach based on fuzzy logic to assess the level of sustainable development of companies.	A methodological approach based on fuzzy logic was developed. This approach allows for a comprehensive assessment of quantitative and qualitative indicators of sustainability in terms of uncertainty and incompleteness of information, overcoming the limitations of traditional deterministic assessment methods.
5	To identify potential areas for the practical application	Key areas for the practical application of sustainability assessment results have been identified. The proposed

	of the results of the assessment of sustainable development in corporate governance systems.	evaluation results can be used to support management decisions aimed at improving the sustainability and competitiveness of the company.
--	--	--

### List of used sources

- A. Imashev. 2024. 'Strategic Management of Sustainable Development of Companies'. *Montenegrin Journal of Economics* 20 (3): 275. <https://doi.org/10.14254/1800-5845/2024.20-3.20>.
- A. Ismail et al. 2022. 'Strategy and Practice for Sustainability in Businesses in the Middle East and North Africa in a Global Perspective'. *Journal of Risk and Financial Management* 15 (7): 277. <https://doi.org/https://doi.org/10.3390/jrfm15070277>.
- A. McGrath et al. 2025. 'What Is Risk Management?' IBM. <https://www.ibm.com/think/topics/risk-management>.
- Aaron Finley et al. 2024. 'Analyzing the Effectiveness of Carbon Pricing Instruments in Reducing Carbon Emissions in Major Asian Economies'. *Sustainability* 16 (23): 1–20. <https://doi.org/10.3390/su162310542>.
- Adisa Azapagic et al. 2016. 'Towards Sustainable Production and Consumption: A Novel DEcision-Support Framework IntegRating Economic, Environmental and Social Sustainability (DESIREs)'. *ScienceDirect* 91 (August): 93–103. <https://doi.org/10.1016/j.compchemeng.2016.03.017>.
- An Official Website of the European Union. 2019. 'COMMUNICATION FROM THE COMMISSION. The European Green Deal'. November 12. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN>.
- An Official Website of the European Union. 2023. 'Overview of Sustainable Finance'. [https://finance.ec.europa.eu/sustainable-finance/overviewsustainable-finance\\_en#the-eu-sustainable-finance-framework](https://finance.ec.europa.eu/sustainable-finance/overviewsustainable-finance_en#the-eu-sustainable-finance-framework).
- An Official Website of the European Union. 2025a. 'An EU Compass to Regain Competitiveness and Secure Sustainable Prosperity'. January 29. [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_25\\_339](https://ec.europa.eu/commission/presscorner/detail/en/ip_25_339).
- An Official Website of the European Union. 2025b. 'Green Bonds in Europe. Published'. July 1. <https://www.eea.europa.eu/en/analysis/indicators/green-bonds-8th-eap>.
- Annual Report and Accounts*. 2024. Shell plc. [https://www.shell.com/investors/results-and-reporting/annualreport/\\_jcr\\_content/root/main/section/promo/links/item0.stream/1742873115632/6c20b811173\\_8b9a590ba145f0d1c4fa0e530dae0/shell-annual-report-2024.pdf](https://www.shell.com/investors/results-and-reporting/annualreport/_jcr_content/root/main/section/promo/links/item0.stream/1742873115632/6c20b811173_8b9a590ba145f0d1c4fa0e530dae0/shell-annual-report-2024.pdf).
- Apiday. 2024. 'How Are EU Taxonomy and SFDR Related? A Dive into Sustainable Finance'. October 30. <https://www.apiday.com/blog-posts/how-are-eu-taxonomy-and-sfdr-related-a-dive-into-sustainable-finance>.
- Aramco. 2025. 'Aramco. Investing in Growth. Innovating for Sustainability'. <https://www.aramco.com/-/media/publications/corporate-reports/sustainability-reports/report2024/english/2024-climate-change-and-the-energy-transition-en.pdf>.

- Aramco Sustainability Report 2024*. 2025. Aramco.  
<https://www.aramco.com/en/sustainability/sustainability-report>.
- Aurelio Pestel. 1977. *The Human Quality*. Club of Rome Publications.
- Azapagic, A., et al. 2016. 'A Novel DEcisionSupport Framework IntegRating Economic, Environmental and Social Sustainability (DESIREs).' Elsevier. *Computers and Chemical Engineering*. ScienceDirect.  
<http://dx.doi.org/10.1016/j.compchemeng.2016.03.017>.
- B. Commoner. 1972. *THE CLOSING CIRCLE. Nature, Man, and Technology*.  
[https://markstoll.net/HIST4323/2011/Commoner%3B\\_Closing\\_Circle\\_excerpt.pdf](https://markstoll.net/HIST4323/2011/Commoner%3B_Closing_Circle_excerpt.pdf).
- Barry Draycott. 2021. 'The Four Laws of Ecology'. *Ecological Landscape Alliance*.  
<https://www.ecolandscaping.org/01/developing-healthy-landscapes/climate-change/the-four-laws-of-ecology/>.
- Bauer R. et al. 2010. 'Corporate Environmental Management and Credit Risk'. September 21.  
<http://dx.doi.org/10.2139/ssrn.1660470>.
- Beate ZLAUGOTNE et al. 2020. 'Multi-Criteria Decision Analysis Methods Comparison'. *Environmental and Climate Technologies* 24 (1): 454–71. <https://doi.org/https://doi.org/10.2478/rtuct-2020-0028>.
- Beretta, Valentina, Maria Chiara Demartini, and Francesco Sotti. 2023. 'Board Composition and Textual Attributes of Non-Financial Disclosure in the Banking Sector: Evidence from the Italian Setting after Directive 2014/95/EU'. *Journal of Cleaner Production* 385 (January): 135561.  
<https://doi.org/10.1016/j.jclepro.2022.135561>.
- BP Sustainability Report 2024*. 2025. Bp.
- Brauns, Melody. 2015. 'The Management of Change in a Changing Environment – To Change or Not to Change?' *Corporate Board: Role, Duties and Composition* 11 (3): 37–42.  
<https://doi.org/10.22495/cbv11i3art4>.
- Brenner, Barbara, and Daria Drdla. 2023. 'Business Model Innovation toward Sustainability and Circularity—A Systematic Review of Innovation Types'. *Sustainability* 15 (15): 11625.  
<https://doi.org/10.3390/su151511625>.
- Brundtland Report. Our Common Future*. 1987. Report of the World Commission on Environment and Development. United Nations. <https://www.are.admin.ch/en/1987-brundtland-report>.
- C. Rae. 2024. 'Risk Acceptance'. ISMS.Online, April 19. <https://www.isms.online/glossary/risk-acceptance/>.
- C. Veljanovski. 2013. 'The Economics of Ronald Coase'. *SSRN Electronic Journal*, ahead of print, January.  
<https://doi.org/10.2139/ssrn.2340996%20Authors>:
- CarbonMajors. 2025. 'Carbon Majors: 2023 Data Update'. March.  
<https://carbonmajors.org/briefing/The-Carbon-Majors-Database-2023-Update-31397>.

- Chevron. 2025. '2024 Corporate Sustainability Highlights'. <https://www.chevron.com/-/media/shared-media/documents/chevron-sustainabilityhighlights-2024.pdf>.
- Climate Change Act, 27, Legislation.gov.uk (2008).  
<https://www.legislation.gov.uk/ukpga/2008/27/contents>.
- Climate Polisy Database. 2017. 'Clean Growth Strategy United Kingdom'.  
<https://climatepolicydatabase.org/policies/clean-growth-strategy>.
- Confluence. 2021. 'ESG RATING METHODOLOGY COUNTRIES & SUPRANATIONALS'. January.  
[https://www.confluence.com/wp-content/uploads/2022/01/Confluence\\_ECPI\\_ESG\\_Rating\\_Methodology\\_Countries\\_Supranationals-Version-1.9.pdf](https://www.confluence.com/wp-content/uploads/2022/01/Confluence_ECPI_ESG_Rating_Methodology_Countries_Supranationals-Version-1.9.pdf).
- Danny Zhao-Xiang Huang. 2022. 'Environmental, Social and Governance Factors and Assessing Firm Value: Valuation, Signaling and Stakeholder Perspectives'. *Wiley. Online Library, Account Finance*, vol. 62 (issue S1): 1983–2010. <https://doi.org/10.1111/acfi.12849>.
- Dhaliwal D. S et al. 2011. 'Voluntary Nonfinancial Disclosure and the Cost of Equity Capital: The Initiation of Corporate Social Responsibility Reporting'. *The Accounting Review* 86 (1): 59–100. <https://www.jstor.org/stable/pdf/29780225.pdf>.
- Düzel, İrem. 2025. 'Green Economy Strategies and Practices For Sustainable Development'. *Journal of Economic Research Foundation* 2 (1): 59–76. <https://doi.org/10.62844/jerf.20>.
- EcoStandard. Journal. 2023. 'Политика и Стратегия ESG: Как Создать?' May 23.  
<https://journal.ecostandard.ru/esg/ustoychivoe-razvitie/politika-i-strategiya-esg-kak-sozdat/>.
- Eduard Pestel. 1989. *Beyond the Limits to Growth*. Report to the Club of Rome. Milford: Universe Publishing Company.
- Environmental, Social & Governance Law Italy 2025 (2025). <https://iclg.com/practice-areas/environmental-social-and-governance-law/italy>.
- ExxonMobil. *Sustainability Report*. 2025. ExxonMobil. <https://corporate.exxonmobil.com/-/media/global/files/sustainability-report/2024/sustainability-report.pdf>.
- Fama E.F. 2021. 'Contract Costs, Stakeholder Capitalism, and ESG'. *European Financial Management* 27 (issue 2): 189–95. <https://doi.org/DOI:%2010.1111/eufm.12297>.
- Forrester, Jay W. 1971. 'Counterintuitive Behavior of Social Systems'. *Technological Forecasting and Social Change* 3 (January): 1–22. [https://doi.org/10.1016/S0040-1625\(71\)80001-X](https://doi.org/10.1016/S0040-1625(71)80001-X).
- Gov.UK. 2017. 'Green Investment Bank to Boost Support for Low Carbon Projects as Government Confirms Sale to Macquarie'. April 20. <https://www.gov.uk/government/news/green-investment-bank-to-boost-support-for-low-carbon-projects-as-government-confirms-sale-to-macquarie>.
- GRI. n.d. 'The Global Leader Sustainable Reporting'. <https://www.globalreporting.org/>.

- Haque, Azizul. 2024. 'Emerging Challenges and Opportunities in Shaping a Sustainable Future. Global Challenges, Opportunities and Solutions to Sustainability Future in Bangladesh and Across the Globe. Navigating the Path to a Sustainable Future from Local Action to Global Impact, a Sustainable Tomorrow, Unveiling Opportunities for a Sustainable Future. Seizing Opportunities for a Sustainable Bangladesh in the Changing World'. SSRN Scholarly Paper No. 4907365. Social Science Research Network, July 27. <https://doi.org/10.2139/ssrn.4907365>.
- HM Government. 2020. 'The Ten Point Plan for a Green Industrial Revolution'. November. [https://assets.publishing.service.gov.uk/media/5fb5513de90e0720978b1a6f/10\\_POINT\\_PLAN\\_BOOKLET.pdf](https://assets.publishing.service.gov.uk/media/5fb5513de90e0720978b1a6f/10_POINT_PLAN_BOOKLET.pdf).
- HM Government. 2021. 'Industrial Decarbonisation Strategy'. March. [https://assets.publishing.service.gov.uk/media/6051cd04e90e07527f645f1e/Industrial\\_Decarbonisation\\_Strategy\\_March\\_2021.pdf](https://assets.publishing.service.gov.uk/media/6051cd04e90e07527f645f1e/Industrial_Decarbonisation_Strategy_March_2021.pdf).
- Hrinko et al. 2022. 'Strategic Management of Sustainable Development of the Enterprise'. *Economics Finances Law* 9 (1): 5–8. [https://doi.org/10.37634/efp.2022.9\(1\).1](https://doi.org/10.37634/efp.2022.9(1).1).
- IBM. 2025. 'What Is Monte Carlo Simulation?' <https://www.ibm.com/think/topics/monte-carlo-simulation>.
- ICMA. 2021. 'The Sustainability Bond Guidelines (SBG)'. June. <https://www.icmagroup.org/assets/documents/Sustainable-finance/2021-updates/Sustainability-Bond-Guidelines-June-2021-140621.pdf>.
- ICMA. 2025. 'Social Bond Principles'. June. <https://www.icmagroup.org/assets/documents/Sustainable-finance/2025-updates/Social-Bond-Principles-SBP-June-2025.pdf>.
- InfluenceMap. 2025. 'Disclosure on Corporate Climate Policy Engagement. InfluenceMap's Metrics Highlight Global Underperformance on Disclosure. An InfluenceMap Investor Briefing'. July. <https://influencemap.org/briefing/A-Primer-on-Corporate-Climate-Policy-Engagement-Disclosure-33068>.
- Ipieca. 2025. 'The Global Oil and Gas Association for Advancing Environmental and Social Performance across the Energy Transition'. <https://www.ipieca.org/>.
- IRENA (International Renewable Energy Agency). 2019. 'A ROADMAP TO 2050. THIS REPORT AND ITS FOCUS'. [https://www.irena.org/-/media/Irena/Files/Macroeconomic-benefits/IRENA\\_Global\\_Energy\\_Transformation\\_2019.pdf](https://www.irena.org/-/media/Irena/Files/Macroeconomic-benefits/IRENA_Global_Energy_Transformation_2019.pdf).
- ISO. 2015. 'ISO 14001:2015 SME Success Package'. <https://www.iso.org/publication/PUB200140.html>.
- ISO. 2018. 'ISO 50001:2018'. <https://www.iso.org/standard/69426.html>.
- J. H. Dales. 1968. *Pollution, Property & Prices: An Essay in Policy-Making and Economics*. . University of Toronto Press,. <https://www.cambridge.org/core/journals/canadian-journal-of-political-science-revue-canadienne-de-science-politique/article/abs/j-h-dales-pollution-property-prices-an-essay-in-policymaking-and-economics-toronto-university-of-toronto-press-1968-pp-vii-111/08541C7FEA0D43C183BD6F835AC89630>.

- Jones, Benjamin L. H., Leanne C. Cullen-Unsworth, Maricela de la Torre-Castro, Lina M. Nordlund, Richard K. F. Unsworth, and Johan S. Eklöf. 2022. 'Unintended Consequences of Sustainable Development Initiatives: Risks and Opportunities in Seagrass Social-Ecological Systems'. *Ecology and Society* 27 (2). <https://doi.org/10.5751/ES-13063-270210>.
- Khanra, Sayantan, Puneet Kaur, Rojers P. Joseph, Ashish Malik, and Amandeep Dhir. 2022. 'A Resource-Based View of Green Innovation as a Strategic Firm Resource: Present Status and Future Directions'. *Business Strategy and the Environment* 31 (4): 1395–413. <https://doi.org/10.1002/bse.2961>.
- Koptyug V.A. 1992. 'UN Conference on Environment and Development (Rio de Janeiro, June 1992). Information Review'. June, 7.
- 'Kyoto Protocol to the United Nations Framework Convention on Climate Change'. 1998. <https://unfccc.int/resource/docs/convkp/kpeng.pdf>.
- Legislation.Gov.Uk. 1990. 'Environmental Protection Act'. <https://www.legislation.gov.uk/ukpga/1990/43/contents>.
- Lin, Yolanda C., Alex J. Webster, Caroline E. Scruggs, et al. 2025. 'Fuzzy SETS: Acknowledging Multiple Membership of Elements within Social-Ecological-Technological Systems (SETS) Theory - Ecology & Society'. *Ecology and Society* 30 (1). <https://doi.org/10.5751/ES-15764-300122>.
- Lyulyov Oleksii et al. 2023. *Stakeholders' Engagement in the Company's Management as a Driver of Green Competitiveness within Sustainable Development*. April. <https://doi.org/https://www.mdpi.com/2071-1050/15/9/7249>.
- L.Zadeh. 1972. 'A Fuzzy-Set-Theoretic Interpretation of Linguistic Hedges'. *Journal of Cybernetics* 2 (3).
- L.Zadeh. 1975. 'The Concept of a Linguistic Variable and Its Application to Approximate Reasoning — I'. *Information Sciences*. 8 (3): 199–249.
- L.Zafeh. 1965. *Fuzzy Sets*. Information and Control. 8 3. San Diego.
- M. Karami. 2023. '(PDF) Identifying Financial and Non-Financial Metrics Affecting Companies' Sustainability Performance: A Thematic Analysis Approach'. ResearchGate, December. <https://doi.org/10.61838/kman.ijimob.3.5.1>.
- M. Sartzetaki et al. 2025. 'Enterprise Strategic Management Upon Sustainable Value Creation: A Fuzzy Topis Evaluation Tool for Transport and Supply Chain Enterprises'. *MDPI Journal* 17 (11). <https://doi.org/doi.org/10.3390/su17115011>.
- MathWorks. 2025. 'MATLAB Coder Generate C and C++ Code from MATLAB Code'. <https://www.mathworks.com/products/matlab-coder.html>.
- Mesarović M., Mako D., Takahara Y. 1970. 'Theory of Hierarchical Multilevel Systems'. *New York: Academic*, 294.
- Mihajlo Mesarovic and Eduard Pestel. 1974. *Mankind at the Turning Point*. New York: E.P. Dutton&Co.

- Ministeres Transition Ecologique Amenagement Du Terriotoire Transports Ville et Logement. 2018. 'Stratégie Nationale Bas-Carbone (SNBC)'. <https://www.ecologie.gouv.fr/politiques-publiques/strategie-nationale-bas-carbone-snbc>.
- More Energy. Less Emissions Sustainability & Climate 2024 Progress Report*. 2025. TotalEnergies. [https://totalenergies.com/system/files/documents/2024-03/totalenergies\\_sustainabilityclimate-2024-progress-report\\_2024\\_en\\_pdf.pdf](https://totalenergies.com/system/files/documents/2024-03/totalenergies_sustainabilityclimate-2024-progress-report_2024_en_pdf.pdf).
- MSCI. 2024. 'ESG Ratings Methodology'. April. <https://www.msci.com/documents/1296102/34424357/MSCI+ESG+Ratings+Methodology.pdf>.
- NI. 2023. 'Creating Membership Functions'. LabVIEW PID and Fuzzy Logic Toolkit API Reference. February 21. [https://www.ni.com/docs/en-US/bundle/labview-pidand-fuzzy-logic-toolkit-apiref/page/lvpidmain/creating\\_memfuncs.html?srltid=AfmBOoovA1RC6CcczoYZJAMmat1kDUyUurRta1h\\_hBMZ6S521b-CBZEA](https://www.ni.com/docs/en-US/bundle/labview-pidand-fuzzy-logic-toolkit-apiref/page/lvpidmain/creating_memfuncs.html?srltid=AfmBOoovA1RC6CcczoYZJAMmat1kDUyUurRta1h_hBMZ6S521b-CBZEA).
- Omid Bozorg-Haddad et al. 2021. 'A Handbook on Multi-Attribute Decision Making Methods'. *ResearchGate*, ahead of print, March. <https://doi.org/10.1002/9781119563501>.
- P. Bertoldi. 2022. *Policies for Energy Conservation and Sufficiency: Review of Existing Policies and Recommendations for New and Effective Policies in OECD Countries*. Energy and Buildings.
- Pacana, Andrzej, Dominika Siwiec, and Jacek Pacana. 2023. 'Fuzzy Method to Improve Products and Processes Considering the Approach of Sustainable Development (FQE-SD Method)'. *Sustainability* 15 (13). <https://doi.org/10.3390/su15139927>.
- Partnership for Carbon Accounting Financials. 2025. 'Enabling Financial Institutions to Assess and Disclose Greenhouse Gas Emissions Associated with Financial Activities.' <https://carbonaccountingfinancials.com/>.
- Patrick Criqui et al. 2019. 'Carbon Taxation: A Tale of Three Countries'. *Sustainability*, November 8, 21. <https://doi.org/10.3390/su11226280>.
- QuantStart. 2022. 'Bayesian Statistics: A Beginner's Guide'. April. <https://www.quantstart.com/articles/Bayesian-Statistics-A-Beginners-Guide/>.
- R. Moro Visconti. 2021. 'DCF METRICS AND THE COST OF CAPITAL: ESG DRIVERS AND SUSTAINABILITY PATTERNS'. URL:<https://www.morovisconti.com/wp/dcf-metrics-and-the-cost-of-capitalesg-drivers-and-sustainability-patterns/>.
- 'Report of the Conference of the Parties on Its First Session, Held at Berlin'. 1995. <https://docs.un.org/en/FCCC/CP/1995/7>.
- 'Report of the International Conference on Population and Development Cairo'. 1994. September 5. [https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/a\\_cofnf.1\\_71\\_13\\_rev.1.pdf](https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/a_cofnf.1_71_13_rev.1.pdf).

- Report of the Secretary-General Proposes Global Compact on Human Rights, Labor, Environment, in Address to World Economic Forum in Davos*. 1999.  
<https://press.un.org/en/1999/19990201.sgsm6881.html>.
- Report of the United Nations Conference on Environment and Development Rio de Janeiro*. 1992.  
<https://documents.un.org/doc/undoc/gen/n92/836/55/pdf/n9283655.pdf>.
- 'Report of the World Summit on Sustainable Development'. 2002. (Johannesburg, South Africa), September 26. <https://earthcheck.blob.core.windows.net/media/50622/report-of-the-world-summit-on-sustainable-development.pdf>.
- Robati, Maryam, and F. Rezaei. 2023. *Evaluation and Ranking of Urban Sustainability Based on Sustainability Assessment by Fuzzy Evaluation Model*. February 9, 3.
- Roger Harrabin. 2021. 'Climate Change: UK to Speed up Target to Cut Carbon Emissions'. BBC. April 20.  
<https://www.bbc.com/news/uk-politics-56807520>.
- Royston Parkin. 2024. 'What Is Goodwill in Accounting? Explained: Valuation, Calculation, and Accounting Principles'. October 28. <https://roystonparkin.co.uk/what-is-goodwill-in-accounting-explained-valuation-calculation-and-accounting-principles/#:~:text=How%20is%20Goodwill%20Calculated?,than%20just%20its%20physical%20assets>.
- Saini, Neha, Monica Singhanian, Morshadul Hasan, Miklesh Prasad Yadav, and Mohammad Zoynul Abedin. 2022. 'Non-Financial Disclosures and Sustainable Development: A Scientometric Analysis'. *Journal of Cleaner Production* 381 (December): 135173.  
<https://doi.org/10.1016/j.jclepro.2022.135173>.
- SASB. 2025. 'SASB STANDARDS'. <https://sasb.ifrs.org/>.
- Sedovs, Edgars, Tatjana Volkova, and Iveta Ludviga. 2025. 'Sustainable Development and Strategic Management - What Is on the Horizon in Our Non-Ergodic World Research?' *Sustainable Futures* 9 (June): 100414. <https://doi.org/10.1016/j.sftr.2024.100414>.
- SW. Setyahuni et al. 2020. 'On the Value Relevance of Information on Environmental, Social, and Governance (ESG): An Evidence from Indonesia'. *Journal of Critical Reviews*, issue 12, vol. 7: 50–58. <https://doi.org/DOI:%2010.31838/jcr.07.12.09>.
- Taliento. 2019. 'Impact of Environmental, Social, and Governance Information on Economic Performance: Evidence of a Corporate "sustainability Advantage" from Europe'. *Sustainability*, 1738, vol. 11 (6). <https://doi.org/10.3390/su11061738>.
- Tatyana Ponomarenko et al. 2020. 'An Assessment of the Applicability of Sustainability Measurement Tools to Resource-Based Economies of the Commonwealth of Independent States'. *ResearchGate*, ahead of print, July 10. <https://doi.org/10.3390/su12145582>.
- 'The Earth Summit: Introduction'. 1992. June 3.  
[https://www.mauricestrong.net/index.php?option=com\\_content&view=article&id=167&Itemid=](https://www.mauricestrong.net/index.php?option=com_content&view=article&id=167&Itemid=)

- 'The SDGs Explained for Business'. 2015. September. [https:// unglobalcompact.org/sdgs/about#](https://unglobalcompact.org/sdgs/about#).
- Tim Vipond. 2025. 'Scenario Analysis'. CFI.  
URL:<https://corporatefinanceinstitute.com/resources/financial-modeling/scenario-analysis/>.
- Tomislav Klarin. 2018. 'The Concept of Sustainable Development: From Its Beginning to the Contemporary Issue'. *ResearchGate*, May, 67–94. <https://doi.org/10.2478/zireb-2018-0005>.
- UN. Environment Programme. 2025. 'Principles for Responsible Banking'.  
<https://www.unepfi.org/banking/bankingprinciples/>.
- UNEP. 2009. 'Guidelines for Social Life Cycle Assessment of Products'.  
<https://wedocs.unep.org/bitstream/handle/20.500.11822/7912/-Guidelines%20for%20Social%20Life%20Cycle%20Assessment%20of%20Products-20094102.pdf?sequence=3&amp%3BisAllowed=>.
- United Nation. 2020. 'Towards Sustainable Renewable Energy Investment and Deployment Trade-Offs and Opportunities with Water Resources and the Environment'.  
[https://unece.org/sites/default/files/2025-01/UNECE\\_publication\\_Nexus.pdf](https://unece.org/sites/default/files/2025-01/UNECE_publication_Nexus.pdf).
- United Nations Global Compact. 2011. 'The Ten Principles of the UN Global Compact'.  
<https://unglobalcompact.org/what-is-gc/mission/principles>.
- United Nations Global Compact. 2017. 'Transforming Partnerships for the SDGs'.  
<https://www.accenture.com/content/dam/accenture/final/capabilities/strategy-and-consulting/supply-chain---operations/document/Accenture-Transforming-Partnerships-for-the-SDGs.pdf>.
- V. Beretta et al. 2024. '(PDF) From Sustainability to Financial Performance: The Role of SDG Disclosure'. *ResearchGate* 29 (6). <https://doi.org/10.1108/MBE-05-2024-0054>.
- 'Vienna Declaration and Program of Action'. 1993. Paper presented at the World Conference on Human Rights in Vienna. June 25. [https:// www.ohchr.org/en/instrumentsmechanisms/instruments/vienna-declaration-and-programme-action](https://www.ohchr.org/en/instrumentsmechanisms/instruments/vienna-declaration-and-programme-action).
- 'What Is Emissions Trading?' 2011. <https://www.theguardian.com/environment/2011/jul/05/what-is-emissions-trading>.
- World Bank Group. 2025. 'State and Trends of Carbon Pricing Dashboard'.  
<https://carbonpricingdashboard.worldbank.org/compliance/instrument-detail>.
- World Economic Forum. 2022. 'Explainer: Which Countries Have Introduced a Carbon Tax?' July 8.  
<https://www.weforum.org/stories/2022/07/carbon-tax-emissions-countries/>.
- 'World Summit for Social Development'. 1995. (Copenhagen, Denmark), March 6.  
<https://www.un.org/en/conferences/social-development/copenhagen1995>.
- Yoon et al. 2018. 'Does ESG Performance Enhance Firm Value? Evidence from Korea'. *Sustainability*, Article 3635, vol. 10 (10). <https://doi.org/doi.org/10.3390/su10103635>.

- Zadeh L. 1973. 'Outline of a New Approach to the Analysis of Complex Systems and Decision Processes'. *IEEE Transactions on Systems, Man and Cybernetics* 3 (1): 28–44.  
<https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5408575>.
- Zadeh Lotfi et al. 1996. *Fuzzy Sets, Fuzzy Logic and Fuzzy Systems: Selected Papers by Lotfi A Zadeh*. World Scientific Publishing.
- А.В. Кученкова. 2014. 'О МЕТОДЕ КАЧЕСТВЕННОГО СРАВНИТЕЛЬНОГО АНАЛИЗА С ИСПОЛЬЗОВАНИЕМ НЕЧЕТКИХ МНОЖЕСТВ'. Cyberleninka.  
<https://cyberleninka.ru/article/n/o-metode-kachestvennogo-sravnitel'nogo-analiza-s-ispolzovaniem-nechetkih-mnozhestv-1/viewer>.