

The Economic Perspective on Sustainability: Beyond GDP

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Acknowledgments

In writing this book, I received a great deal of support and inspiration from my immediate and broader professional communities, from participants at conferences both in Hungary and abroad, and from the anonymous reviewers of my publications. I would like to express my gratitude to all my colleagues who, through their insights, critical remarks, valuable comments, and suggestions, have shaped my perspective and who have contributed, directly or indirectly, to the creation of this book. Special thanks are due to Sir Partha Dasgupta, professor at the University of Cambridge, whose decades of work, as well as our personal conversations and correspondence, provided direct inspiration for my research and the writing of this book. I thank Eli Fenichel, professor at the Yale School of the Environment, for our numerous and valuable exchanges of ideas.

I would like to thank the Center for Economic Geography and Urban Marketing at János Neumann University, as well as all my colleagues, for providing the inspiring intellectual environment necessary for my work. Special thanks go to Professor Sándor Kerekes for his critical comments, which greatly aided my efforts to contribute to the teaching of environmental economics in Hungary through this book.

Finally, and most of all, I owe my thanks to my family for their patience, for providing a home, and for their love—which, ultimately, gives meaning to all my work.

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Introduction

Sustainability—or the pursuit of sustainability—is perhaps the most exciting topic of the past few decades, one that has rightly permeated scientific, political, and public discourse. However, interpreting and measuring sustainability poses a challenge for every academic discipline, including economics. Traditionally, GDP has been the widely used indicator for measuring development and growth; it represents the output and income generated by a country's economy over the course of a year. However, by its very nature, GDP does not provide information about the economy's future performance. The wealth-based approach to sustainability evaluates economic performance based on how the total wealth that forms the basis of the economy's performance has changed over a given period—whether one year, five years, or even ten years. Within this framework, it is possible to examine not only the economy but also the functioning of the socio-economic system as a whole—more specifically, whether the socio-economic system operated sustainably during a given period. Examining changes in wealth (stock) rather than income (flow) is thus a distinction that fundamentally sets the wealth-based approach to sustainability apart from the GDP-based analysis of economic growth.

Environmental economics has long been part of the economics curriculum; however, the economics of sustainability—and particularly its wealth-based approach—has only recently reached the level of maturity necessary to become an integral part of economics education. Reaching this level of maturity means that this discipline, built on theoretical foundations, has entered the practical phase: sufficient data is now available for asset-based research on sustainability, empirical analysis, and the policy planning based on these findings. The System of Environmental Economic Accounting (SEEA) provides a suitable data source for all of this; as an international standard, it has been part of national statistical systems for several decades. The asset-based approach to sustainability can serve as an appropriate framework for planning and evaluating environmental and sustainability policies, as well as for examining the interrelationships between climate change, biodiversity loss, and demographic trends affecting human capital.

Building on the foundations of classical economics, the asset-based approach is a central element of the economics of sustainability. As a branch of applied economics, the capital-based approach to sustainability—that is, asset-based economics—is organically and substantially linked to numerous other disciplines, such as philosophy, ecology, sociology,

and psychology. The asset-based perspective on sustainability, as well as the cultural, religious, and

Understanding its philosophical roots and scientific foundations is particularly important for leading professionals and policymakers. This knowledge is crucial in both the public and private sectors, so it must not be missing from economics education.

Why was this book written?

It is no exaggeration to say that the issue of sustainability has always been a concern for individuals and communities. Its imprint can be found in the traditions of every culture, and since the 18th century, it has become part of scientific thought as we understand it today.

The author of this book was led to write it by decades of work and a thirst for knowledge. On this journey, it was not primarily awareness that guided him, but rather professional and personal interest, instinctive intuition, and curiosity.

In the 1980s, in the aftermath of the oil crises, as a recent engineering graduate, I became fascinated by the structural solutions for innovative, extremely low-temperature energy storage. Soon, however, my attention turned in a different direction: Who wants to store energy, and why? At the time, I had no idea that this question would continue to occupy the fields of engineering, economics, and politics alike even forty years later. In a broader sense, then, I was already grappling with the fundamental questions of sustainability.

I spent an extended period of time in Japan during the 1980s and 1990s. As a structural engineer, I was fascinated by traditional Japanese temple architecture—the marvelous world of wooden structures that hold themselves together without nails. I first learned about these joints—as engineering nodes—from Professor Gengo Matsui’s book, and it was an honor for me to translate the book into English¹. In Japan, the halls of Buddhist temples and Shinto shrines are rebuilt at regular intervals. László Krasznahorkai beautifully captures this process in his writing¹. After demolition, timber harvested from the temple’s own forests is used for reconstruction. The building’s materials are new, but the structure continues to embody an ancient spirituality, wisdom, and knowledge that transcend the physical materials. The forest tended by the temple lives on, nurturing new timber for the next reconstruction.

¹ Sumiyoshi, Torashichi & Matsui, Gengo (1991). *Wood Joints in Classical Japanese Architecture*. Tokyo: Kajima Institute Publishing Co., Ltd. English translation from the Japanese by Ferenc Kovacs, 1991. Originally published in Japanese as **Mokuzō no tsugite to shiguchi**, Kajima, 1989.

Modern environmental economics would describe this today as a circular economy, sustainable forest management, the ecosystem, and the protection of forest biodiversity. Perhaps the concept of “non-growth” might also come up. We could say that Japanese temples have lived in the spirit of non-growth over the centuries. But did they really not grow? Or did they? Did “growth” simply mean something different to them—the preservation and advancement of knowledge, and the deepening of spirituality, free from the compulsion of material growth? What does growth mean to modern people?

Decades later, my studies in philosophy, political science, and economics shed light on an eternal enigma: why does the world exist within a system where economic rationality contradicts our universal need for sustainability? Why does breaking away from GDP—the metric that drives the economy toward material, physical growth—seem impossible?

My intention with this book is not only to help readers better understand this issue but also to guide them toward a shared way of thinking that will further shape our perspective.



Japanese-style bookbinding. Source: AI-generated illustration created using Meta AI based on the author's instructions, 2026.

Foreword

Sustainability is a complex concept, and numerous attempts have been made to interpret it over the past decades. It is familiar to everyone, yet its meaning varies across different academic disciplines, politics, the economy, communities, and individuals. The best-known and most widely cited “high-level abstraction” definition is found in the Brundtland Report (Chapter 1), prepared for the United Nations, which also serves as the basis for practical formulations across numerous scientific disciplines. The economic approach focuses on development trajectories, resource conservation, and a long-term perspective:

“...the pursuit of a development path that can be sustained over the long term—that is, one along which we do not deplete the reserves and opportunities for future ways of life as we progress.” (Fleischer, 2014)

The asset-based approach to sustainability follows this economic line of thought: it offers tools and methodologies for a long-term description of the functioning of the socio-economic system—one that complements and goes beyond the traditional GDP-based approach. The aim of this book is to provide an overview of sustainable development, the essence of which is non-declining wealth: that is, if, over a given period, the total capital assets available to society—the sum of man-made, human, and natural capital—does not decrease. In the literature, this framework is referred to as the wealth-based economic perspective or *the wealth economy*.² The wealth-based perspective is a conceptual approach to sustainability whose roots date back to the 18th century and which remains an important area of theoretical research in macroeconomics to this day. It is a theoretically grounded framework designed to assess the sustainability of a nation’s economy—or, more precisely, the sustainability of its socio-economic system—from a comprehensive, long-term perspective. The concept of sustainability, therefore, refers in a narrower sense to environmental sustainability, while in a broader sense it characterizes the functioning of the totality of social, economic, and environmental systems.

The framework of the wealth-based economy offers a tool for the long-term assessment of the sustainability of economic growth and development—one that goes “beyond GDP.” Modern economics defines sustainability as a matter of intra-generational equity and intergenerational justice, extending to the issue of well-being across generations; in other words, that

² A loose translation of the technical term “*wealth economy*.”

how goods are distributed across geographical and social space, as well as over time. Wealth—that is, the totality of capital assets—is the source of current income. Natural capital stocks provide the primary goods and services necessary for the functioning of the socioeconomic system, and the “non-depletion” of renewable natural capital stocks is key to the sustainability of the system’s operation. This is the essence of the asset-based economy, which enables the study of sustainability within a theoretically sound and robust framework.

The asset-based economy is a multidisciplinary framework that enables the interpretation of research findings from various natural and social sciences within a common framework, thereby facilitating a long-term, sustainability-oriented, synthesized assessment of the functioning of the economy and society. Another advantage of this framework is that it provides a practical, causally grounded mathematical interpretation of the interactions between human and natural systems. The availability of global time-series data on national accounts—including non-market but monetized natural capital assets—enables rigorous empirical analysis and policy planning based on it. Economic growth models, supplemented by natural capital as a factor of production, allow for an integrated approach to the complex interactions between human and natural systems. As environmental problems caused by human activity have come to the forefront, the asset-based approach to sustainability has also entered the mainstream of economic thought and has become an important area of education as part of the curriculum at many universities around the world. This approach has evolved rapidly in recent decades, providing a solid theoretical foundation for the development programs of the United Nations and the World Bank, as well as for the expansion of national statistical systems to include wealth accounts, including natural capital accounts.

The book **The Asset Approach to Sustainability: Beyond GDP** is recommended reading for students of environmental economics and other related disciplines at the undergraduate and graduate levels. The book expands the traditional boundaries of environmental economics in a way that provides a well-defined, comprehensive sustainability framework for students and practitioners in other disciplines as well. Beyond education, it offers a fresh perspective on sustainability for economic and political actors, as well as for a broader interested audience. It is recommended for the media, which is ready to convey scientific knowledge to a broader audience, thereby helping the public understand and strive toward a more sustainable future.

Budapest, June 2026

Antal Ferenc Kovács

Technical Terms in English

Adjusted Net Savings – Adjusted net savings

Capital approach to sustainability – Capital approach to sustainability

Comprehensive wealth – Comprehensive

wealth *Genuine savings* – Genuine savings

Inclusive wealth – Inclusive wealth

Intergenerational wellbeing – Intergenerational wellbeing

Revealed preference method – revealed preferences method (valuation of ecosystem services)

Stated preference method – method of revealed preferences (valuation of ecosystem services)

Steady-state – steady state (Thomas Malthus, David Ricardo)

Steady-state economy (Herman Daly)

Strong criteria of sustainability – strict criteria for sustainability *System*

approach to sustainability – systems approach to sustainability *Weak*

criteria of sustainability – weak criteria for sustainability *Wealth*

accounting – wealth accounting

Wealth economy – literally, an economy based on wealth; in this context, it refers to a wealth-oriented approach to sustainability

Welfare – well-being

Well-being

Introduction

Sustainability is a concept that describes whether the functioning of an economic system—or, in a broader sense, a socio-economic system—is sustainable. Since the 1960s and 1970s, when the global-scale degradation of the natural environment became apparent, interest in sustainability issues has grown rapidly, and research into these issues has accelerated across numerous academic disciplines. The rapid increase in the number of textbooks, articles, and journals reflects the academic world's growing interest; at the same time, sustainability has also become part of public discourse and global politics.

The emergence of the concept of sustainability in economics is not a recent phenomenon, as it has been at the center of economists' attention for more than two centuries. In the 18th century, Malthus (1766–1834), in his famous book **An Essay on the Principle of Population**³ (Malthus, 2024), took a pessimistic view of the issues of population growth and food production, because, in his view, the trend of population growth could not be offset by a sufficient increase in food production, which would result in famine, epidemics, and wars. Adam Smith, a Scottish economist and philosopher, examined the sustainability of development and economic growth by studying in detail the nature of human behavior as the ultimate driving force behind economic growth and development⁴. In his view, human behavior takes shape as a synthesis of two components: personal, social behavior and impersonal, economic behavior. In the development of economic thought, the latter was emphasized in the formation of the concept of utilitarianism.

Until recently, there was widespread agreement that the goal of development was economic growth, which is the source of improved well-being. Following the economic crisis of the 1930s and World War II, economic performance—specifically, national income—became the yardstick of progress, measured by GDP as a universal indicator. Since its introduction, however, it has been widely recognized that GDP, as a flow of income, does not provide adequate information on many aspects of progress; yet it has remained the dominant indicator for measuring economic growthⁱⁱ. At the same time, the need to develop alternative metrics has become apparent.

³ Malthus, T. R. (1902). *An Essay on the Principle of Population*. Politzer Zsigmond and Son

⁴ **The Theory of Moral Sentiments** (1759); **An Inquiry into the Nature and Causes of the Wealth of Nations**

(1776).

Research on the development of alternative indicators has gained momentum recently, spurred by growing political interest. Much of this research focuses on developing and promoting new indicators, sometimes overlooking the wide range of existing indicators and, most importantly, the need for a solid theoretical foundation. As a result, few alternative indicators have proven their validity or garnered sustained political interest. At the 2007 conference titled “*Beyond GDP*,” the European Commission stated that further work was needed in the area of alternative measures and, to this end, established the *Commission on the Measurement of Economic Performance and Social Progress*. Shortly thereafter, in 2009, the Stiglitz-Sen-Fitoussi Report (Stiglitz et al., 2009) was published, whose main finding was that, to measure economic performance, indicators focusing on social well-being, sustainability, and the quality of life of individuals should be used instead of GDP. Also in 2009, the OECD initiated an active dialogue among researchers and policymakers to discuss proposals for alternative approaches to measuring economic and social development.

Recently, it has been questioned whether economic growth—which has traditionally been at the center of mainstream economic thought—is, in and of itself, the ultimate goal of social development. In this sense, therefore, the definition and development of “beyond GDP” indicators require a different approach. The wealth-based approach to sustainability offers precisely such a unique, theoretically grounded alternative, which enables a long-term, sustainability-oriented comparative assessment of nations’ development. An example of this alternative perspective is that, from a wealth-based perspective, spending on health care or education represents savings—that is, investments that increase the value of human capital—in contrast to the traditional macroeconomic view, in which such spending is treated as consumption.

In 2019, the United Kingdom’s Department for Finance commissioned Partha Dasgupta to prepare a comprehensive report on the current state of sustainability research. Published in 2021 as **The Economics of Biodiversity: the Dasgupta Report** (Dasgupta, 2021)—which appeared in Hungarian under the title **A Biodiverzitás Gazdaságtana: the Dasgupta Report** (Dasgupta, 2025), views sustainability as a problem of asset management that requires a synthesized study of human behavior, philosophy, and economic thought, including economic growth, the valuation of natural capital, institutions, etc.ⁱⁱⁱ. It is clear that this “beyond GDP

n” problem leads much further than the development and selection of appropriate indicators. The problem leads to an examination of the fundamental issue of economic activity. What is the nature and purpose of economic development?

In recent decades, the number of publications dealing with the measurement of sustainability has steadily increased. Numerous indicators and indices have been developed to assess trends in ecology, the economy, and other areas of society from a sustainability perspective. These assessments pertain to past developments and the current situation, but typically do not provide information about the future and still lack a precise definition of sustainability in a comprehensive sense. It has become clear that assessing the sustainability of economic and social systems requires a metric that is fundamentally different from GDP and that also incorporates information about the future. However, in order to select the appropriate metric, we must first precisely define what we are measuring. Since sustainability is at the center of this study, we first need a sufficiently precise definition of sustainability. In the second decade of the second millennium, the widely accepted conceptual basis for sustainability is the highly abstract definition formulated by the United Nations *World Commission on Environment and Development (WCED)*, better known as the Brundtland Commission:

“... development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (Brundtland, 1987, 1988)

Based on this definition, from a philosophical perspective, sustainability is a matter of intergenerational justice, whereas economics frames the issue along temporal and spatial dimensions: the distribution of goods and services among present and future generations, as well as within the present generation. These are the concepts of *intergenerational well-being* and *intragenerational equity*. This book discusses both concepts in detail.

Two main approaches facilitate the practical implementation of the concept of sustainability: the system approach and the *capital approach*; both approaches advocate for the integration of findings from other disciplines into a coherent framework (Barbier & Burgess, 2025). Using the systems approach, policy can aim to achieve predetermined economic, social, and environmental goals; the best-known example of this is the 17 Sustainable

Development Goals (SDGs) set by the United Nations. In contrast, the asset-based view of sustainability sets a single goal: it encourages the growth of physical, human, and environmental capital, which ultimately form the basis of economic development and underpin income generation, the production of goods, and the provision of services for present and future generations.

The discourse on sustainability continues unabated in both academic and political circles: in 2023, for example, the European Parliament organized a conference titled “Pathways to Sustainable Well-being in the EU”⁵, which provided a policy platform for dialogue on the transition toward goals beyond growth (Jensen, 2023).

The wealth perspective is an important alternative approach to the concept of sustainability; it is theoretically grounded and forms part of modern economic thought. This is also evidenced by the steady increase in the number of journals and books devoted to the topic, a tradition to which this book belongs.

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⁵ “Pathways toward sustainable prosperity in the EU”

1. Chapter Sustainability in the World's Religious Traditions

Learning Objectives

This chapter presents the fundamental teachings of three world religions—Christianity, Buddhism, and Islam—regarding economic thought and the relationship between humanity and nature.

The structure, interrelationships, operational mechanisms, and the organization and functioning of institutions in economics and politics reflect society's worldview and way of thinking. Since more than 80% of the world's population lives in societies rooted in strong religious traditions, religions play a fundamental role in shaping economic thought, economic policy, and the everyday behavior of individuals. Consequently, religious traditions also strongly influence society's perspective on sustainability through their ethical frameworks.

Beyond religious traditions, the philosophical foundations of sustainability are to be found not only in the utilitarian tradition of Western thought, its Greco-Roman roots, Judeo-Christian culture, and the Enlightenment. While these directly laid the foundation for modern economics, various interpretations of sustainability can also be found in Buddhist, Islamic, and other traditions. Thus, the study of development and sustainability, as well as the relationship between them, can be approached from numerous perspectives. This chapter primarily addresses the issue of sustainability from a Western philosophical perspective; however, it also briefly discusses the relevant teachings of other religions. The chapter seeks answers to questions such as the nature of well-being as a concept and the purpose of development. What is the significance of intergenerational justice, which ultimately determines the principles according to which the means of satisfying needs can be distributed among generations? With this latter question, the philosophical problem extends into the realm of economics. In the context of sustainability, Western philosophical thought seeks to understand what intergenerational justice means, what its purpose is, and how it can be achieved (Gutwald et al., 2014; Sen, 2021). Economic thinking rooted in the classical tradition defines sustainability—by definition—as the “non-decline” of well-being across generations (Barbier, 2016; Dasgupta, 2019; Sen, 2021).

In most societies, religious traditions play a key role in establishing the intellectual foundations of the sociocultural system. The prevailing view of the economy also rests on

underlying ethical framework and philosophical traditions rooted in religion. In other words, religious tradition and philosophy can, directly or indirectly, have a decisive influence on the social and economic functioning of individuals and communities, in both the narrower and broader senses. As environmental degradation becomes increasingly evident on a global scale, issues of sustainability and the interdependence and interconnectedness of human and natural systems are becoming ever more pressing. In this regard, the teachings of Christianity, Buddhism, Islam, etc., as well as philosophical ideas, represent key building blocks in the fields of human ecology and environmental ethics (Baritz, 2025).

Over the past few centuries, the global economic system and its institutions have been built upon the traditions of Western culture. Nevertheless, there is growing interest in the academic and political spheres in how perspectives and teachings from other traditions can be integrated into the toolkit of evolving political philosophy and economic thought, with a focus on issues of sustainability, economic development and growth, and well-being. There is broad consensus that the utilitarian tradition of Western economic thought is, in many respects, ineffective in addressing the worsening social and ecological crises facing humanity—such as climate change, the loss of biodiversity, global pandemics, famine, mass migration, and so on. Neoclassical economics and its institutions require a significant reevaluation to better reflect human behavior, values, and the ethics of the relationship between humans and natural systems. The moral paradigms and ethical reflections of religions offer an invaluable contribution to responses to modern challenges, such as the global degradation of the natural environment and the broader sustainability dilemmas of the socio-economic system.

The economics of religion is a relatively new branch of the social sciences that can bring a fresh perspective to various areas of economics, including the macroeconomics of growth and economic development. As an important new development, this discipline also focuses on religions outside the Western world. However, a distinction must be made between the economics of religion and “religious economics.” The latter examines economics from a religious perspective, such as the moral implications of economic growth. Although the economics of religion, as a subfield, is relatively new, the study of its role in the functioning of social systems is not. It is a widely accepted view that the development of modern economics has been strongly influenced by religious traditions. For example, Adam Smith referred to Christian ethics in both of his famous works, **The*

Theory of Moral Sentiments and **The Wealth of Nations**, he referred to Christian ethics. Later, in the nineteenth and twentieth centuries, numerous thinkers discussed religion in the context of economics, including Schumpeter in his work **A History of Economic Analysis** (1954). More recently, in his widely cited work **Economics: A Moral Inquiry with Religious Origins**, Benjamin Friedman argues that there continues to be a constant interplay between religious thought, public discourse, and public policy (Friedman, 2011; Gajdócsi, 2018).

Christian Teaching

Over the past two centuries, the development of modern national and international institutional systems has been grounded in Western economic thought, whose roots date back to the 18th century, the Age of Enlightenment. Western economics is built on Western philosophical thought, which is rooted in the traditions of ancient Greek and medieval Christian philosophy and later took shape within the utilitarian tradition. In Christian theology, the development of the individual is framed by the roles of faith and grace, sin and redemption, which define the relationship between theology, culture, the individual, and society. In this context, Christian virtue ethics emphasizes the importance of an ethical perspective in policymaking in the broader sense, ethical responsibility toward nature and the disadvantaged poor, and a critical approach to consumption. Christian virtue ethics provides a framework and a fundamental, actionable code of ethics for moral growth and personal development, the ultimate goal of which is to attain salvation, the path to which is revealed in the Holy Bible. This is the core of Christian teaching.

Christian economic thought encompasses a rich tradition that integrates theological principles with economic practices, focusing on concepts such as stewardship, wealth, poverty, and the role of government in economic matters.

This tradition draws upon the biblical scriptures, the early Church Fathers, medieval scholastics, and modern theological discourse, reflecting the questions that have arisen throughout economic history.

The roots of Christian economic thought are to be found in the Bible, particularly in the Old and New Testaments. The Old Testament emphasizes the importance of justice, fairness, and care for the poor, while the New Testament highlights the dangers of wealth, as well as the importance of charity, sound financial management, and good stewardship.

The early Church Fathers, such as Basil the Great and John Chrysostom, further developed these ideas, advocating for the responsible use of wealth and the obligation to help those in need. Medieval scholastics, including St. Thomas Aquinas, built upon these foundations; by integrating Aristotelian philosophy with Christian theology, they developed concepts such as the just price and the condemnation of usury. During the Reformation, figures such as Martin Luther and John Calvin contributed to economic thought; Luther emphasized the importance of work, while Calvin advocated for the responsible management of wealth.

In the modern era, papal encyclicals such as Leo XIII's **Rerum Novarum** and John Paul II's **Centesimos Annus** addressed contemporary economic issues, emphasizing the dignity of work, the importance of social justice, and the need for a moral framework in economic life. Bolberitz, a representative of contemporary Christian thought and Christian philosophy in Hungary, analyzes in detail the questions of existence and development, including through a comparison of the works of Heidegger and St. Thomas Aquinas, who addressed the same questions of human existence, although they used entirely different “languages” and lived in different eras (Bolberitz, 1981). Pope Francis's highly influential encyclical⁶ published in 2015, **Laudato Si'**, analyzes the roots of the problem of sustainability and possible solutions within the doctrinal framework of the Catholic Church (Francesco, 2015; Francis, 2019). The encyclical was published in the year the *Paris Agreement* was signed and conveys important messages—directly related to climate change—about the relationship between humans and the environment (Szabó, 2017).

Praise Be (Laudato Si'): Pope Francis's Encyclical

“...Laudato Si', On Care for Our Common Home, is a truly remarkable document that is both original and faithful to the tradition of Catholic social teaching. Drawing from a very specific religious tradition and grounded in it, yet within the literary framework of the encyclical genre, it seeks to initiate a dialogue about caring for our common home “with everyone who lives on this planet.” Starting from the urgency of addressing global climate change, it summarizes the harms that vulnerable groups—the poor and the marginalized—are suffering disproportionately as a result of the current environmental crisis

⁶ Papal Statement

suffer as a result of the current environmental crisis. It analyzes the root causes of environmental degradation, mapping out the complex interrelationships and tensions between globalization, economic growth, liberalized trade, unsustainable consumption and production patterns, environmental degradation, forced migration, impoverishment, and growing inequality.

In this regard, the encyclical can serve as a useful position paper for the upcoming Paris climate talks or as background reading for a course on climate change or sustainable development. When properly interpreted, however, this is not its true purpose. In a deeper sense, the encyclical is rather a call to all of humanity to heed “the cry of the earth and the poor,” to reject a culture that encourages the rapid discarding of goods, and to embrace a culture of care and a commitment to integral ecology. In other words, the work is a call for ecological conversion: a call addressed not only to the individual, but to the individual living in community.” (Porrás, 2015)^{iv}



Castel Gandolfo, papal gardens near Rome

Source: (Pope Launches "Borgo Laudato Si" Project in Castel Gandolfo - Vatican News, 2023)

The Main Principles of Christian Economic Thought

There is a vast body of literature on the people-centered economic model of Christian economic thought (Baritz, 2025; Zamagni & Bruni, 2013), and its central principles can be summarized as follows:

1. Good stewardship

The concept of stewardship plays a central role in Christian economic thought. God regards human beings as stewards of *creation*, entrusted with the responsibility of managing resources wisely and justly. This principle emphasizes that wealth and property are not ends in themselves, but rather means for serving the common good and promoting human flourishing.

2. Common Good

The common good is a fundamental principle of Christian economics, which highlights the importance of economic systems in serving the well-being of all people, especially the most vulnerable. This principle is closely linked to the idea of distributive justice regarding the equitable distribution of resources and opportunities.

3. The Dignity of Work

Christian economic thought highly values the dignity of work, viewing it as a means of human fulfillment and a way to contribute to the common good. This perspective emphasizes the importance of fair wages, safe working conditions, and the protection of workers' rights.

4. Caring for the Poor and the Vulnerable

The Bible emphasizes in numerous passages the importance of caring for the poor and the vulnerable, which also plays a central role in Christian economic thought. This principle advocates for economic systems that prioritize the needs of the marginalized and ensure that every person has access to the resources necessary for a life of dignity.

5. Moderation and Restraint

Christian economic thought advocates the principles of moderation and restraint in the economic sphere, warning of the dangers posed by greed, materialism, and exploitation. This principle, which also exemplifies the teachings of early Christian thinkers, is closely linked to the ideal of a simple and virtuous life.

The Buddhist Tradition

Buddhist teachings offer an integrated economic perspective that emphasizes the connection between ethics and material wealth, which is of great significance in terms of sustainability.

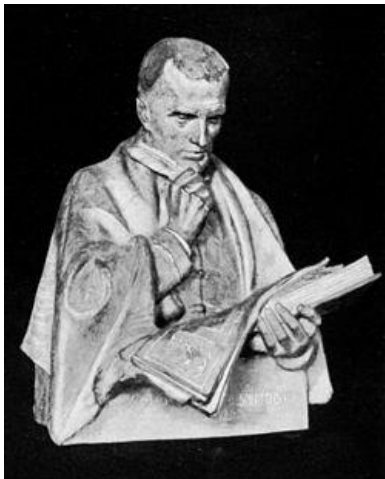
Buddhist economics examines economic activities from the perspective of the fundamentals of Buddhist thought. In contrast to the mainstream principles of Western economics—including a focus on material values, profit maximization, competitive markets, the satisfaction of consumers' ever-growing desires and needs, the utilitarian exploitation of the world, and an ethics based on self-interest — Buddhist economics follows the recognition of the interdependence of all beings, the minimization of suffering, the voluntary simplification of desires, the practice of the principle of non-harm, selfless service to others, sincere care, and generosity (Lennerfors, 2015; Schumacher & Schumacher, 1965; Zsolnai, 2022).

The Fundamental Teachings of Buddhism

The main teaching of Buddhism is the Four Noble Truths: (1) existence is not free from suffering; (2) the cause of suffering is craving; (3) suffering can be ended by attaining Nirvana, that is, Enlightenment; (4) The method for ending suffering is to follow the Noble Eightfold Path, which encompasses ethical principles, mental discipline, and wisdom.

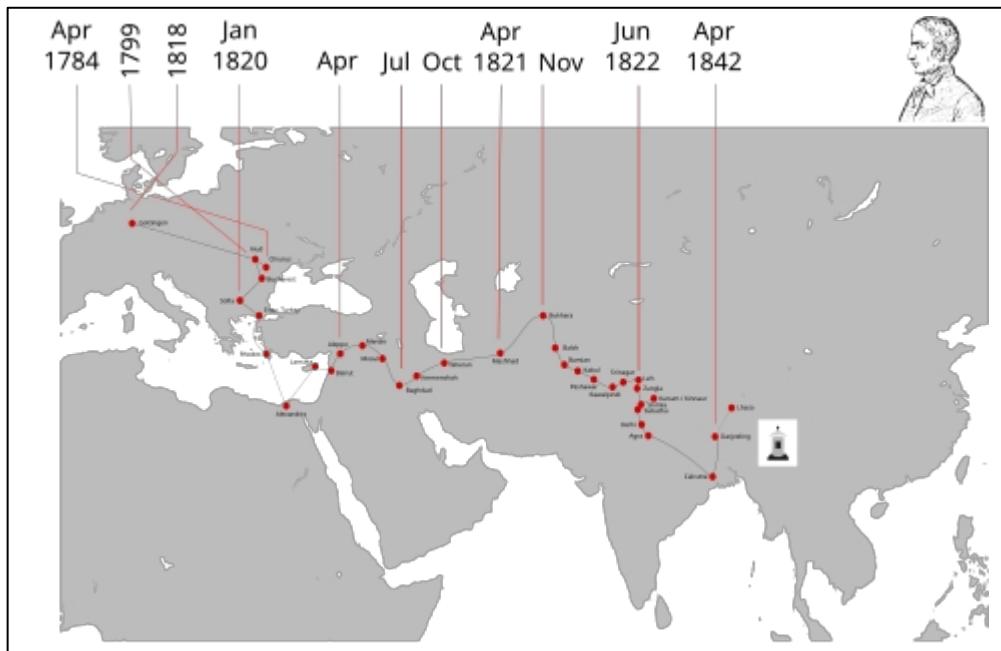
The West's first scholarly encounter with Buddhist teachings came through the Hungarian philologist and orientalist Sándor Kőrösi Csoma (1784–1842), author of the first Tibetan-English dictionary and grammar.

Sándor Kőrösi Csoma (1784–1842)



Sándor Kőrösi Csoma was born in Kőrös, Transylvania (now Romania). He considered himself a Székely, a descendant of Attila the Hun, whose people settled in Transylvania in the 5th century A.D. He studied Eastern languages in Göttingen for two years (1816–1818). In 1820, he set out for Asia with the intention of

hope of discovering the original homeland of the Székelys and the Hungarians. He studied the Tibetan language and Buddhist philosophy, and is today regarded as the founder of Tibetology. He died in Darjeeling in 1842.



After crossing the Mediterranean Sea, Csoma traveled from Syria—mostly on foot or by caravan—through what are now Iraq, Iran, and Afghanistan, eventually reaching Kashmir. In 1834, he was elected an honorary member of the Bengal Asiatic Society in Calcutta. In 1833, the Hungarian Society of Scholars (today’s Hungarian Academy of Sciences, MTA) also elected him a corresponding member. He had planned to travel to Lhasa, Tibet, but died of malaria in Darjeeling in 1842. In 1920, the Kőrösi Csoma Society, dedicated to the study of the East, was founded under the auspices of the MTA. In 1933, he was declared a bodhisattva (Buddhist saint) in Japan, and his statue was placed in the sanctuary of Tokyo Buddhist University. In 1992, the Dalai Lama consecrated his stupa in the village of Tar in northern Hungary.

Source: Hungarian Academy of Sciences

A key concept in Buddhist thought is “*mindfulness*” (conscious presence, alertness), which is the subject of ongoing discourse in various historical and cultural contexts around the world. Accordingly, the Buddhist tradition’s approach to sustainability is based on inner transformation and the recognition of a deep interconnectedness with all that exists. This approach is embodied in the principle of *interdependence*, according to which all beings and phenomena are mutually dependent on one another. Harming the environment, therefore,

directly amounts to harming ourselves. The

principle of *non-harm* encourages us to refrain from taking life, which, in its modern interpretation, also extends to the preservation of ecosystems and promotes the protection of biodiversity. The principle of *the Middle Way* involves maintaining a balance between excessive asceticism and unrestrained consumption. Buddhism advocates *contentment* rather than the pursuit of our desires, which constitutes a radical critique of overconsumption. The goal of mindfulness is to remain constantly aware of the consequences of our actions; accordingly, it encourages the reduction of waste and the pursuit of an ethical, responsible lifestyle.

E. F. Schumacher developed economic concepts based on Buddhist teachings—primarily the Noble Eightfold Path—in the 1960s and 1970s, drawing on his experiences in Asia, particularly in India and Burma (now Myanmar). His famous book, **Small Is Beautiful: A Study of Economics As if People Mattered**, was published in 1973, in which he criticized “gigantism” and the consumption of natural resources as an inexhaustible source of income rather than as capital (Schumacher, 1991).

Ernst Schumacher (1911–1977)



*Ernst Friedrich Schumacher, a German-born British economist and philosopher, is best known for his influential 1973 book, *Small Is Beautiful*, which fundamentally challenged the growth-oriented ideal of modern industrial society. He is considered one of the most important intellectual fathers of the sustainability and environmental movements. At Oxford,*

and later at Columbia University in the United States. As a young man, he was a protégé of John Maynard Keynes. He was forced to flee Nazi Germany. During World War II, he was interned in the United Kingdom and worked on a farm. This experience strongly influenced his personal development from a rational economist to a spiritual thinker. Throughout his career, he integrated elements of Buddhist philosophy into his economic theories and identified as a Buddhist, but later his focus shifted to the study of St. Thomas Aquinas and other Catholic philosophers, and in the 1970s he converted to Catholicism.

Source: EBSCO

An eternal Buddhist teaching for humanity is that liberation from suffering is achieved through the purification of the mind and character and the practice of the moral duty to love and care for all living beings, rather than through the subjugation of nature. Buddhist economic practice, inspired by the ideals of simplicity and nonviolence, seeks to meet basic needs and achieve a reasonable standard of living through the prudent use of ecological resources. The need for material goods should be met primarily through local production based on local resources.

Deep Ecology

The West has come to know Buddhism as a philosophy aimed at achieving inner peace a way of thinking aimed at achieving peace of mind, in contrast to the capitalist world, where an individualistic and competitive attitude leads to success. Deep ecology, rooted in Buddhist thought, is a philosophical and environmental movement that fundamentally questions modern society's relationship with nature. The term was coined by the Norwegian philosopher Arne Næss.

Arne Næss (1912–2009)



Arne Dekke Eide Næss, a Norwegian philosopher, was an important intellectual and inspirational figure in the environmental movement and the coiner of the term “deep ecology.” As a professor of philosophy at the University of Oslo, he traveled extensively throughout Europe, visiting important academic centers, including the Vienna Circle. His views were strongly influenced by Gandhi’s philosophy of nonviolence and the teachings of the Buddhist tradition. He distinguished between deep and shallow ecological thinking.

Næss was a passionate mountaineer. In 1950, he led the first expedition to the 7,708-meter-high Tirich Mir peak in Pakistan.

He spent a significant part of his life in Tvergastein, a secluded mountain cabin in central Norway, where he developed his own philosophy, Ecozoology. The cabin is open to visitors.

Source: Deep Ecology Platform

In contrast to the prevailing utilitarian pragmatism of Western market actors and governments, Næss argued that a true understanding of nature leads to a perspective that recognizes the intrinsic value of all living beings, acknowledging each being’s interdependence with other creatures within the complex web of interactions in the natural world.

The Eight Principles of Deep Ecology⁷:

1. ***Intrinsic Value***: The flourishing of human and nonhuman life on Earth is a value in and of itself (intrinsic value). The value of nonhuman life forms is independent of their usefulness for human purposes.
2. ***Richness and Diversity***: The richness and diversity of life forms contribute to the realization of these values and are valuable in and of themselves.
3. ***Necessity***: Humans have no right to diminish this richness and diversity, except to the extent necessary to meet their vital needs.
4. ***Population***: The flourishing of human life and cultures is compatible with a significant reduction in the human population. Such a reduction is necessary for the flourishing of nonhuman life.
5. ***Interference***: Human interference in the nonhuman world is currently excessive, and the situation is rapidly worsening.
6. ***Policy Change***: Therefore, policies must be changed. These policy changes will affect fundamental economic, technological, and ideological structures. The resulting situation will be radically different from the current one.
7. ***Quality of Life***: Ideological change is manifested primarily in an appreciation of quality of life—the experience of inner life situations that are valuable in and of themselves—rather than an insistence on an ever-higher standard of living. There will be a profound realization of the difference between the great and the magnificent.
8. ***Obligation to Act***: Those who agree with the points above must participate, directly or indirectly, in efforts to implement the necessary changes.

Islamic Teachings

According to Islam, the approach to sustainability is primarily a spiritual matter, not a technological problem. The foundation of Islamic sustainability thinking is the view that the natural environment is not the property of humans, but a sacred gift entrusted to humanity by God. Islamic ecological ethics is a holistic system based on several pillars.

⁷ Source: Deep Ecology Platform, Rainforest Information Centre. There are several versions of the critique of deep ecology and the Hungarian translation of its basic principles, e.g., in the writings of András Lányi.

Islamic Ecological Ethics

- ***Khalifa*** (Stewardship): Humans do not rule over the Earth but are its stewards. It is their duty to protect nature and pass it on to future generations.
- ***Amana*** (Sacred Trust): The environment is a trust bestowed by God, for which humanity will be held accountable in the afterlife.
- ***Mizan*** (Balance): God created the world in perfect balance and harmony. Any excessive exploitation disrupts this cosmic balance, leading to disasters.
- ***Tawhid*** (Unity): The unity of God extends to the unity of creation. All beings (animals, plants, waters) form a community that proclaims God's praise; therefore, they possess intrinsic value, independent of human utility.

To ensure that these principles are realized in everyday life, Islam employs practical prohibitions and incentives:

- ***Israf and Tabzir*** (Prohibition of Waste): It strictly prohibits the waste of resources, especially water, even in times of abundance.
- ***Fasad*** (Prohibition of Destruction): Environmental pollution and the destruction of nature are considered “fasad,” that is, the corruption of the earth, which the Quran condemns.
- ***Sadaqa*** (Charity): Planting a tree or giving water to an animal is considered a continuous act of charity for which the believer receives a reward.

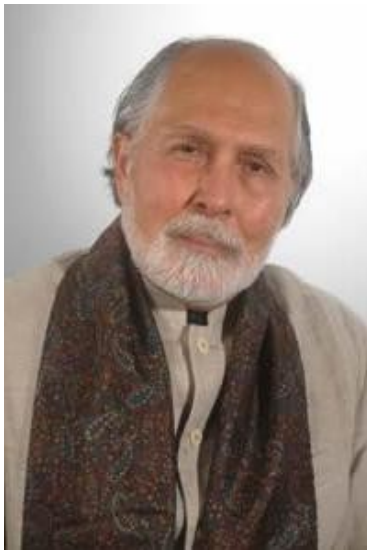
Throughout history, Islamic thinking on environmental protection has been institutionalized in various ways. For example, protected areas known as hima were designated, where hunting and logging were prohibited; to prevent water pollution, sacred zones, or haram, were designated around water sources, as well as religious “endowments,” or waqf, which historically served to maintain community gardens, wells, and irrigation systems.

In summary, according to Islam, sustainability is not merely a technical issue but a spiritual obligation. The cause of the modern crisis is humanity's loss of inner balance, and the solution lies in regaining humility and moderation in our relationship with nature. According to Hossein Nasr, a contemporary Islamic thinker, the problem is not rooted in technology but

in what he calls modernity, which has rejected transcendence and treats nature as nothing more than “lifeless, exploitable matter” (Quadir, 2011).

As a universal teaching, it draws on the shared wisdom of other religions—namely, Christianity, Buddhism, etc.—and asserts that nature is sacred and that the purpose of human existence is spiritual fulfillment, not endless material growth. According to Nasr (1990), Islamic metaphysics, particularly Sufism, can serve as the foundation for modern environmentalism. Islamic philosophers argue that environmental protection and sustainability, as outlined in the United Nations’ 17 Sustainable Development Goals, have been embedded in Islamic thought from the very beginning and have been practiced for centuries (Bsoul et al., 2022).

Seyyed Hossein Nasr (1933–)



Seyyed Hossein Nasr is an Iranian-born American philosopher and world-renowned scholar of Islam. Professor Nasr holds the Chair in Islamic Studies and *Perennial Philosophy*⁸ at the Columbian College of Arts & Sciences at George Washington University. He earned a BA in physics and mathematics from MIT. He studied geology and geophysics at Harvard, then earned a Ph.D. in the history and philosophy of science and Islamic cosmology.

⁸ The essence of the *Perennial Philosophy* is that all the world’s major religions and spiritual traditions stem from a single, common source and teach the same universal truth.

In 1958, he returned to Iran, where he became a professor at the University of Tehran and founded the Royal Academy of Philosophy.

Many of Professor Nasr's writings have been published in Hungarian, primarily in the journal *Ars Naturae Online*:

The Wisdom of the Body (2020)

Some Answers Regarding Religion and the Environment (2020)

On the Question of Biological Origins (2021)

The Influence of Sufism on Traditional Persian Music (2021)

Source: George Washington University; Ars Naturae Online

The teachings of various religions share many common features regarding sustainability and the relationship between humans and the environment. Table 1-1 summarizes these principles, highlighting the differences in perspective:

1- Table 1: Environmental and Sustainability Teachings of World Religions

	Christianity	Buddhism	Islam
Individual Development	within the framework of faith and grace, sin and redemption	Mindfulness, awareness, and consideration of the consequences of one's actions	purifying the soul and cultivating good character
The goal of personal development	Attaining salvation	Attaining enlightenment	To attain divine joy and well-being in the afterlife
Teachings on the Economy	Good stewardship, the common good, the dignity of work, caring for the poor and vulnerable, moderation, and restraint	Contentment rather than the pursuit of desires	social justice, moral responsibility, and the equitable distribution of wealth
Attitude toward nature	"our common home," nature is sacred; protection of creation; the world is God's creation; humans are not the owners of nature, but its responsible stewards (steward).	Recognition of the interdependence of all beings; the practice of non-harm	a deep religious and moral bond (between humans and nature); the believer is not the owner of the earth, but its steward and protector
S concept of concept	Integrated ecology; listening to the cry of the poor and of nature; solidarity; intergenerational justice	Sustainability lies in one's worldview and ethical attitude: the interdependence of all things; non-harm; moderation and simplicity	A spiritual commitment rather than a technological problem; the cause of unsustainability: the loss of people's inner balance; the solution is humility and

Discussion Topic

What is the essence of the common ethical teachings of the world's religions regarding the relationship between human and environmental systems?

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2. Chapter The Concept of Sustainability in Economics

Learning Objectives

This chapter provides an overview of the development of Western economic thought beginning in the 17th century, with particular emphasis on reflections on economic development, growth, and sustainability in each historical period.

Ever since the first reports on human-caused environmental damage were made public in the 1970s, the discourse on environmental risks attributable to human activity has been a constant presence in academic, political, and public life. The concept of sustainability was articulated in the Club of Rome's landmark report, **The Limits to Growth**, and later in the United Nations' 1986 Brundtland Report, **Our Common Future**. The latter document proposed an abstract definition of sustainability that has since been widely used and interpreted⁹. In practice, however, sustainability has remained a vague concept, as has sustainable development, which is difficult to interpret in policymaking without an explicit definition. How can one design the appropriate policy or select from among the many possible options if the problem is not clearly defined? According to Kerekes (2023), sustainable development is not a well-structured (*"tame"*) problem that can be addressed with simple policies, but rather a *"wicked"* problem for which there is no optimal solution. However, experience would allow us to act in accordance with the "best policy options" formulated on the basis of mistakes, errors, and the positive and negative outcomes of various measures.

The concept of sustainable development is complex and is characterized by the following features:

- It is not an exact concept; there is no consensus on what the problem is;
- There are no well-defined policy options to choose from;
- There is no ultimate goal; that is, the problem cannot be solved by implementing specific policies;
- The outcomes of solving the problem are not "good" or "bad," but rather "better" or "worse";
- etc.

⁹ The text of the definition is in the Introduction chapter.

Sándor Kerekes (1948–)



Sándor Kerekes is an economist, professor emeritus at Corvinus University of Budapest, and an active researcher and lecturer at János Neumann University, the Kőszeg Institute of Higher Education, and the Hungarian University of Agricultural and Life Sciences. He is a member of the Hungarian Academy of Sciences and vice president of the Hungarian Society of Natural Sciences. He is a leading international figure in environmental economics. In 2014, he was awarded the Albert Szent-Györgyi Prize, and in 2018, the *Justitia Regnorum Fundamentum* Prize, in recognition of his decades of outstanding scientific and educational work in the fields of environmental protection, sustainable development, and the protection of the rights of future generations.

According to the tradition of Western philosophical thought, the goal of progress and economic development is to achieve happiness, prosperity, and freedom for everyone, and achieving these requires the pursuit of justice and fairness both in the present and across generations. Neoclassical economics describes development in a narrower sense as growth measured by GDP, although in a broader sense, growth is more than a macroeconomic concept: it is a holistic worldview. This chapter presents the theoretical foundations of sustainable development based on Western traditions, including the modern framework of the wealth perspective (wealth economy).

Early Western Thinkers

To study current economic issues, it is important to understand past economic thought. It is easier to navigate the complex problems of modern economics if we understand the foundations laid by economists of the past. The ideas of influential philosophers and economists of their time—such as Francis Bacon, Adam Smith, Thomas Malthus, David Ricardo, J.S. Mill, Marx, Keynes, etc., remain relevant today. As a possible classification, historians highlight four major schools of economic thought: the classical, Marxist,

neoclassical, and Keynesian schools, which emerged in different eras yet offer valuable insights into the recurring economic problems of the present day. Despite their differences in approach, the teachings of the various

economic traditions are interconnected. It is therefore important to understand the historical context in which these economists operated, as this helps us grasp the nature of modern economic challenges, current economic debates, and issues, including the interconnections between human and environmental systems, as well as the problem of sustainability.

Classical Economics

The designation of Smith, Ricardo, and a few earlier economists as “classical” stems from a canonization that originated in Karl Marx’s critique of political economy. There is ongoing debate about what the term “classical economics” encompasses, particularly regarding how classical economics relates to neoclassical economics.

Classical economics, or classical political economy, flourished primarily in Great Britain in the late 18th century and the early to mid-19th century. The philosopher Francis Bacon is widely regarded as the most significant figure of the era, having laid the intellectual foundations as early as the 16th century for the later works of Adam Smith, David Ricardo, Thomas Malthus, John Stuart Mill, and others. These economists established the theoretical foundations of the market economy, largely as a self-regulating system governed by the natural laws of production and exchange—a concept Adam Smith captured with the metaphor of *the invisible hand*.

Francis Bacon (1561–1626)



Francis Bacon (1561–1626) was born in London into an influential political family during the reign of Queen Elizabeth I, in the *Golden Age*. He studied at Trinity College, Cambridge, and served as Lord Chancellor of England from 1618 to 1621, having been a lawyer, statesman, philosopher, and master of the English language. His philosophy emphasized the importance of experience as the primary source of knowledge. He also outlined an inductive method of thinking, which involves the collection and classification of data in order to determine the ~~the~~ causes of phenomena. Bacon

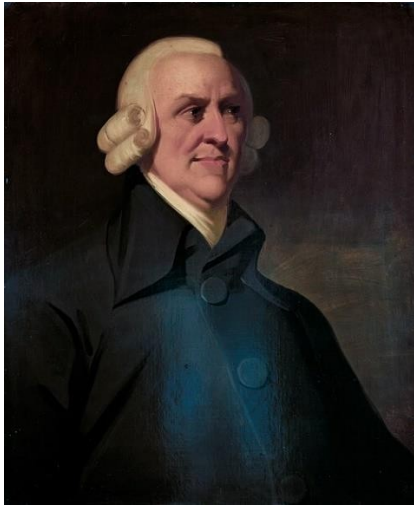
became one of the most influential figures of his time, renowned for his role in the scientific revolution, and he promoted scientific experimentation as a way to glorify God.

Source: *Encyclopedia Britannica*

Adam Smith's **The Wealth of Nations** (Smith, 2011, 2016), published in 1776, is perhaps the best-known scholarly work in the history of economics. It covered the full range of economic topics, from the theory of prices to public finance. In another significant but lesser-known work, **The Theory of Moral Sentiments** (Smith, 2010), published in 1759, he developed a theory of moral psychology that served as the foundation for Smith's economics. The two books argue that people live in two worlds: a personal, social world (**The Theory of Moral Sentiments**) and an impersonal economic world (**The Wealth of Nations**). Studying these two books together allows for a better understanding of human behavior. According to Smith, this is the core of how societies function and how markets operate—a concept described today by microeconomic theory.

Adam Smith's **The Wealth of Nations** is generally regarded as marking the beginning of the era of classical economics. The fundamental message of Smith's book was that a nation's wealth is determined not by the gold held in its treasury, but by its national income. This income is based on people's labor, which is efficiently organized through the division of labor and the use of accumulated capital. This became one of the central concepts of classical economics.

Adam Smith (1723–1790)



Adam Smith was a Scottish social philosopher and political economist who played a key role in the rise of classical liberalism. Adam Smith is perhaps the most prominent and most frequently cited figure in the history of economic thought. **An Inquiry into the Nature and Causes of the Wealth of Nations** (1776) is the first comprehensive work on political economy. He studied at the University of Glasgow—the cradle of the Scottish Enlightenment—and at Balliol College, University of Oxford. He was a lecturer at the University of Edinburgh, later a professor of logic in Glasgow, and then, from 1752, a professor of moral philosophy. He traveled extensively throughout Europe and met with the most important intellectual figures of his time. In opposition to mercantilism, he laid out the fundamental principles of the classical free market.

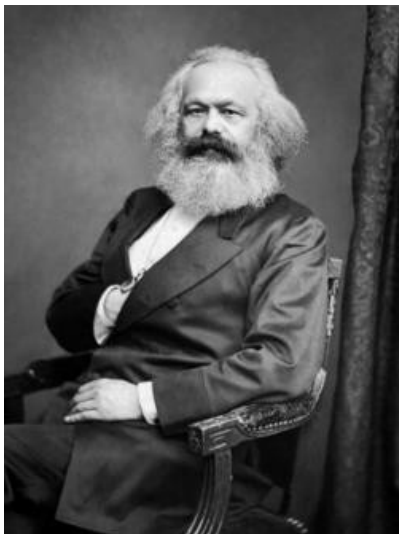
From the perspective of economic policy, classical economists were pragmatic liberals who advocated for market freedom, although they also considered the role of the state important in ensuring the common good. Smith acknowledged that there are areas where the market is not the best means of serving the public interest, and he took it for granted that the wealthy should bear the lion's share of the costs of the common good. He repeatedly warned of the dangers of monopolies and emphasized the importance of competition. With regard to international trade, classical economists were advocates of free trade, which distinguishes them from their mercantilist predecessors, who supported protectionism. (Schabas, 2022).

Source: *Encyclopedia Britannica*

Marxist Economics

Marxist economics is an economic perspective based on the work of the 19th-century economist and philosopher Karl Marx. Marx argued that two main flaws in capitalism lead to exploitation: the chaotic nature of the free market and surplus labor. Marxian, or Marxist, economics focuses on the role of labor in economic development. It takes a critical stance toward Adam Smith's classical approach to wages and productivity. Marx argued that the specialization of the labor force, combined with a growing population, drives down wages. He added that the value of goods and services does not accurately reflect the true cost of labor.

Karl Marx (1818–1883)



Karl Marx was a German philosopher, political theorist, economist, journalist, and revolutionary socialist. He was born in Trier, Prussia, and studied at the universities of Bonn and Berlin. He earned his doctorate in Jena. Marx's thinking was strongly influenced by Hegel, a prominent philosopher of his time. His most influential works are **The Communist Manifesto** (1848), co-authored with Friedrich Engels, and **Capital** (1867), a critique of classical political economy. He was involved with socialist movements and the International Workingmen's Association. He died in London and was buried in Highgate Cemetery.

Source: Encyclopedia Britannica

Marxist economics derives largely from Karl Marx's seminal work, **Capital**, first published in 1867, which many consider his most important work. In this book, Marx outlined his theory of the capitalist system, its dynamism, and

its tendency toward self-destruction. In much of the work, Marx elaborates on his concept of the “surplus value” of labor and its implications for capitalism. According to Marx, it was not pressure from workers’ communities that drove wages down to the subsistence level, but rather the large number of unemployed, and he therefore blamed the capitalists. He argued that, under the capitalist system, labor is merely a commodity that can yield only wages sufficient for subsistence. Capitalists can force workers to spend more time working than is necessary for their basic livelihood. They can then appropriate the surplus product—or surplus value—created by the workers. Marx argued that workers create value through their labor but do not receive adequate compensation. He said that their hard work is exploited by the ruling classes, who generate profits not by selling their products at higher prices, but by paying workers less than the value of their labor.

Marxist economics rejects the classical view of how the economy works, as developed by economists such as Adam Smith. Smith and other classical economists believed that the free market and the economic system are driven by supply and demand, requiring little or no government regulation, and that profit maximization automatically serves the good of society. In contrast, Marx argued that capitalism consistently benefits only a select few. He also argued that the ruling class enriches itself by extracting value from the cheap labor provided by the working class through the dominant economic model and its institutions. In contrast to classical approaches to the functioning of the economy, Marx supported government intervention. He argued that economic decisions should not be made by producers and consumers, but should instead be carefully directed by the state in the interest of all. He predicted that capitalism would ultimately destroy itself, as more and more people are forced into the status of workers, leading to revolution. Ultimately, control over production would pass into the hands of the state.

Neoclassical Economics

The spread of neoclassical economics can be traced back to the early 1900s. Its principal founders include Alfred Marshall, Léon Walras, William Stanley Jevons, Carl Menger, and Vilfredo Pareto.

In contrast to the production-oriented approach of classical economics, neoclassical economics operates within a framework defined by the mathematical description of behavior and markets, which expresses the interaction of supply and demand based on the theories of marginal utility, marginal productivity, and universal scarcity. The latter is a consequence of the substitution assumption, which posits that any non-scarce good will become scarce if substituted for other goods. According to neoclassical economics, the production, consumption, and pricing of goods and services are determined by supply and demand. Accordingly, the value of goods and services is determined by the hypothetical maximization of utility for income-constrained individuals and of profits for firms, based on production costs, available information, and factors of production.

Neoclassical economics is based on three assumptions:

- Individuals have rational preferences that can be identified and that have value;
- Individuals seek to maximize utility, while firms seek to maximize profit;
- Individuals make independent decisions based on complete and relevant information.

Neoclassical microeconomics and Keynesian macroeconomics together form the neoclassical synthesis, which has dominated mainstream economics since the 1950s as “neo-Keynesian economics.”

Keynesian economics

Keynesian economics, named after the British economist John Maynard Keynes, is a school of macroeconomics that emphasizes government intervention—particularly the role of fiscal and monetary policy—to stabilize the economy. It recommends that during an economic downturn, governments should increase spending and cut taxes to stimulate demand and create jobs. During an economic expansion, taxes should be raised and government spending reduced to cool the economy and prevent inflation.

According to Keynesianism, aggregate demand is the primary driver of economic activity, which can be influenced by government policies. Keynesian models often incorporate a multiplier effect, whereby changes in spending lead to larger changes in output and employment.

The main principles of Keynesian economics are as follows:

- *Government intervention*: the government must play an active role in stabilizing the economy through fiscal and monetary policy;
- *Aggregate demand*: plays a key role in determining economic output and employment;
- *Sticky prices and wages*: prices and wages adjust slowly to changes in supply and demand, which can lead to potential shortages or surpluses, particularly in the labor market;
- *Multiplier effect*: Changes in spending can amplify their impact on the economy through the multiplier effect;
- *Fiscal policy*: Keynesian economics often advocates deficit spending (government spending that exceeds tax revenue) during a recession to stimulate demand; during an expansion, it advocates tax increases and spending cuts to curb inflation;
- *Monetary policy*: Keynesians recognize the role of monetary policy—such as adjustments to interest rates—in influencing investment and spending.

Welfare

In the world of neoclassical economics, there is generally agreement that the goal of economic and social development is to create welfare—or, in more recent terms, well-being—for as many people as possible. It is therefore important to explore what these concepts mean from the perspectives of various academic disciplines.

The concept of welfare can be interpreted at both the individual and societal levels. At the individual level, it expresses utility and consumer satisfaction with regard to the goods and services consumed. Societal welfare is the synthesis of individual welfare at the societal level, which is the subject of research in *welfare economics*.

Exploring the meaning of the other concept—well-being—necessarily extends beyond the realms of economics and philosophy. In psychology, for example, empirical research on the concept of subjective well-being has developed significantly in recent decades (Diener et al., 2018; Frey & Stutzer, 2010), interpreting individual preferences as a function of mental state. With regard to

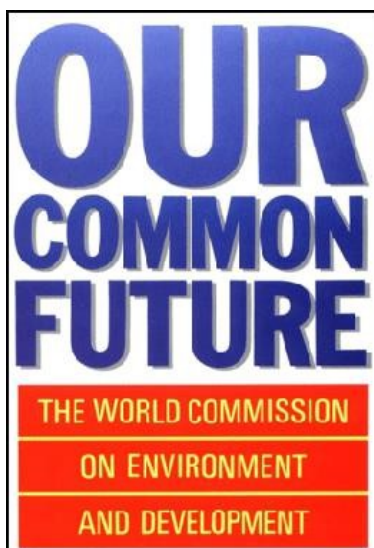
sustainability—and particularly the environmental pillar of sustainability—the interaction between humans and the environment, as well as the relationship between ecosystem services and well-being, is an important area of research. From a psychological perspective as well, the relationship between ecosystem services and well-being is a noteworthy area of study in the interaction between humans and the environment (Roberts et al., 2015). The Brundtland Report (Brundtland, 1987, 1988), commissioned by the United Nations in 1987, has become a widely accepted reference for the interpretation of sustainability, which removes sustainability from the context of economic well-being, broadens its interpretation, and directly introduces the issues of natural resource use, the state of nature, and intergenerational equity into scientific and public discourse ¹⁰:

Gro Harlem Brundtland (1939–)



Gro Harlem Brundtland, a Norwegian politician, served as Norway's first female prime minister for three terms (1981, 1986–89, and 1990–96) and later as Director-General of the World Health Organization (WHO; 1998–2003). She graduated as a physician and became known as an advocate for women's rights in the areas of public health and environmental protection. In 1983, she became chair of the United Nations World Commission on Environment and Development, better known as the Brundtland Commission, which introduced the concept of sustainable development in its 1987 report, **Our Common Future**.

¹⁰ The definition of sustainability according to the Brundtland Report is described in the Introduction chapter.



Source: *Encyclopedia Britannica*

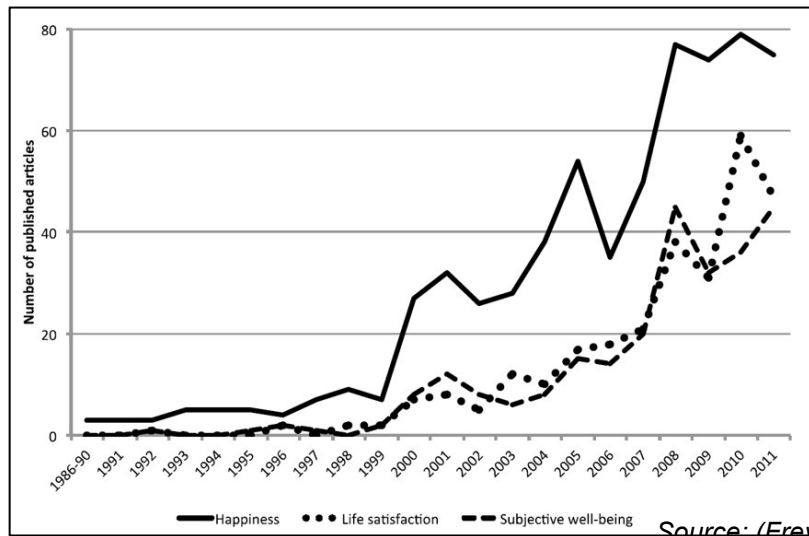
In line with the definition in the Brundtland Report, Western philosophy views sustainability as a matter of intergenerational justice, the goal of which is *well-being that spans generations* (Gutwald et al., 2014). In the European tradition, reflections on well-being date back to the Greek philosophers. *Eudaimonia* (Greek for “happiness”) has been a key concept in ethical thought since Socrates. Aristotle regarded happiness as an end in itself, which became the general starting point for modern philosophical thought. Hörcher addresses the questions of happiness and well-being in numerous works: he regards them as transcendent values that, as part of cultural tradition and community ties, are indispensable for individual fulfillment (Hörcher, 2020, 2021).

Happiness—Life Satisfaction—Subjective Well-Being

In recent decades, there has been intensive research in the field of economics on the empirical study of happiness. The *economics of happiness* has become a thriving area of economic research, arguing that people’s subjective well-being has political implications. Numerous studies address the measurement of happiness and its connection to welfare economics, which, according to Frey & Stutzer (2010), is based on four factors: income, employment, social capital, and health.

A significant body of literature is available on the use of life satisfaction as a measure of happiness. The figure illustrates the relationship between happiness (continuous line), life satisfaction

and subjective well-being (dashed and dotted lines), respectively, between 1986 and 2011.

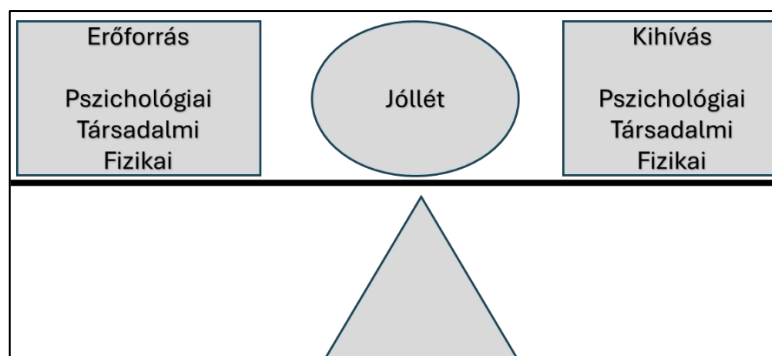


Source: (Frey & Stutzer, 2010)

According to Dodge, conceptualizing well-being as a theoretically grounded state is extremely problematic, as it is difficult to define and even more difficult to measure (Dodge et al., 2012). Therefore, he proposes describing it as a kind of state of equilibrium, citing, among other things, Csíkszentmihályi’s work on flow, which he articulates as follows:

“...we speak of stable well-being when individuals possess the necessary psychological, social, and physical resources to overcome a given psychological, social, and/or physical challenge. When challenges outweigh resources, the balance of well-being is disrupted, and vice versa...” (Dodge et al., 2012).

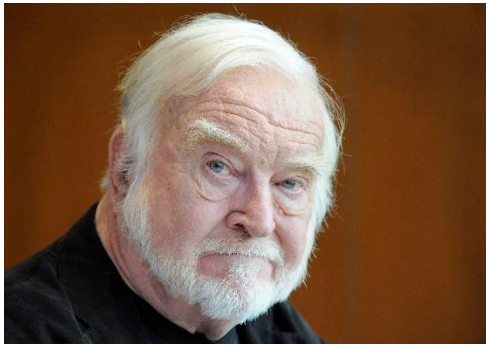
2- Figure 1: Well-being Balance



Source: Adapted by the author (based on Dodge et al., 2012)

Dodge's definition of well-being (Figure 2-1) is thus a multidimensional psychological construct composed of positive and negative influences. Similar to this theory focusing on balance, Amartya Sen proposes a capability-based approach to well-being and views the measurement of well-being in terms of capabilities and functioning (Gutwald et al., 2014).

Mihály Csíkszentmihályi (1934–2021)



A Hungarian-American psychologist and recipient of the Széchenyi Prize. Creator of the psychological concept of the “flow experience,” a state of focused consciousness. Recipient of the Grand Cross of the Order of Merit of Hungary and an external member of the Hungarian Academy of Sciences. He conducted significant research in the fields of developmental and educational psychology, creativity, and giftedness.

Source: Hungarian Academy of Sciences

Meyer (2021), within the framework of well-being, draws on the ancient philosophical traditions of intergenerational justice and intergenerational ethics, as well as the utilitarian tradition, highlighting the work of Sidgwick, Ramsey, Rawls, and Parfit. Based on this, he poses three central questions:

1. Does the present generation have any obligations regarding justice toward past and future generations?
2. Should other moral considerations guide those living in the present in their dealings with those who lived in the past and those who will live in the future?
3. How should injustices committed in the past be interpreted in terms of our responsibility toward the descendants of their direct victims?

The answers to these questions are influenced by numerous factors:

- the lack of direct reciprocity between generations—that is, decisions made by future generations have no effect on the current generation;

- power asymmetry between people of the present, the distant past, and the future, which means that the decisions of those who lived in the past affect those living today and in the future, but the decisions of those living today do not affect those who lived in the past, nor do the actions of those living in the future have a retroactive effect on those living in the present and the past;
- the existence, population, and identity of people living in the future depend on the decisions and actions of people living in the present;
- our knowledge of the future is limited.

According to Meyer, two relevant debates emerge from these questions: on the one hand, regarding the principles of intergenerational equity, and on the other, regarding the measurement of value; ultimately, the question is how to measure differences in well-being across generations. Such a comparison of value may concern how basic needs, capabilities, and preferences can be satisfied. The question of preferences leads, on the one hand, to subjective well-being and, on the other, to the realm of impersonal resources.

John Rawls (1921–2002)



An American philosopher, he was a professor of political philosophy and political theory at Harvard University. In his youth, he studied theology and prepared for a career in the clergy, but the horrors of World War II distanced him from religion and the priesthood, leading him to turn toward secular moral philosophy. He is the author of numerous frequently cited works, including **A Theory of Justice**, **Political Liberalism**, and **Justice as Fairness**. His ideas have influenced not only philosophers but also economists, legal scholars, and political scientists. ^v

Source: Stanford Encyclopedia of Philosophy

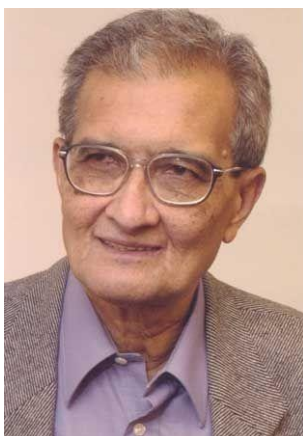
One example of the interaction between political philosophy and economics is that, inspired in part by the issue of sustainability, Rawls attempted to extend his own theory of justice across

generations, as is also reflected in the early

writings. From an economic perspective, these two authors essentially examined a possible normative model for the intergenerational distribution of wealth through the works of Rawls, Nash, and Pareto (Arrow, 1973; Dasgupta, 1974); however, according to these attempts, Rawls's theory of justice did not prove to be a suitable foundation for a utilitarian economic interpretation of intergenerational justice and sustainability. This reinforces the conclusion that the question of the intergenerational distribution of wealth—which is the source of income, consumption, and happiness at any given point in time—rightly belongs to the realm of ethics (Dasgupta, 2011). It is important to note, however, that the utilitarian approach to this problem—which serves as the starting point for dominant neoclassical Western economics—is merely one of many possible approaches, each drawing on different cultural traditions.

According to Amartya Sen's theory of justice (Sen, 2009), the means of achieving well-being as a developmental goal is the pursuit of justice across the intergenerational space-time continuum. Sen's work stems from John Rawls's theory of justice, much like that of many other philosophers, at the intersection of 20th-century philosophy and economics. According to Sen's conception of freedom, the pursuit of intergenerational justice leads to freedom—and, in essence, to the attainment of well-being—which is the goal of development (Anand & Sen, 2000). This is perhaps the most influential, yet also the most controversial, liberal ideological proposition of recent decades.

Amartya Sen (1933–)



Amartya Sen is an Indian-born American economist and professor at Harvard University. In 1998, he was awarded the Nobel Prize in Economics for his contributions to welfare economics and the theory of social choice. Sen's research focuses on how individual values can be taken into account in collective decision-making, as well as how well-being and poverty can be measured.

The continuous expansion of the literature reflects changes in scientific, political, and public discourse regarding development, the goals of development, and well-being. Roger Scruton's book **Green Philosophy** (Scruton, 2014, 2018) addresses numerous questions in its multifaceted, historically grounded approach to the world, the environment, and sustainability—questions that, according to the author, demonstrate that one's general worldview is fundamental to understanding sustainability (Kovács, A. F. (2021). The message of Scruton's work may explain why a conceptual perspective and a philosophical way of thinking are crucial for expanding our knowledge of sustainability, and what methodological tools we use for this purpose in science and in broader professional thinking. This is illustrated by the diversity of indicators used to assess sustainability, their highly varied structures, and the way in which an indicator describes sustainability, depending on the sub-areas it captures and the message it seeks to convey (Agarwala et al., 2014; Bartus, 2013).

Roger Scruton (1940–2020)



Roger Scruton was an English philosopher, writer, and aesthetician, as well as a university professor; he was one of the most influential figures in conservative philosophical thought, with an exceptionally broad range of interests. In addition to political theory, he engaged deeply with music, architecture, religion, and literature. In his view, conservatism is not a rigid ideology but a natural human instinct that seeks to preserve existing values and traditions. He criticized left-wing views that deny absolute truth. In 2016, Queen Elizabeth II knighted him for his philosophical and public service work. In recognition of his close ties to Hungary, he was awarded the *Middle Cross of the Order of Merit of Hungary with Star* in 2019.

Toward the end of his career, in particular, he wrote extensively on issues of environmental protection and sustainability. The bibliography of his book **Green Philosophy: How to Think Seriously About the Planet** (2014) is quite extensive: among other works, it includes a large number of his own writings on this topic dating back to the 1980s. Each essay addresses a different aspect of sustainability: psychology, religion, globalization, international institutions, urbanization, architecture, economic development, inequality, and, of course, politics. **Green Philosophy** is, in a certain sense, a synthesis of these works.^{vi}

On the one hand, Scruton's green philosophy is academically mature and firmly grounded, thus providing a reliable reference point for discourse on the environment and sustainability. On the other hand, the book's intellectual threads are not finite or closed off, but rather open to expansion: they provide a framework within which environmental thought can be further developed along any narrow thematic line, yet can be traced back to the pragmatism of conservative philosophy, its "here and now" approach, and its reliance on the accumulated experience of the community as opposed to revolutionary, "redemptive" ideas.

Sources: (Hörcher, 2025; Kovács, 2021; Zimniewicz, 2017)

In neoclassical economic thought, the goal of development is to increase prosperity, a prerequisite for which is economic growth, traditionally measured by GDP (Gross Domestic Product). However, the traditional concept of prosperity is gradually being replaced by the concept of *well-being*, which challenges the traditional approaches of numerous academic disciplines—particularly political philosophy and economics—with the need for a new metric that complements and goes beyond GDP.

"Beyond GDP"

At the 2016 World Economic Forum, Nobel Prize-winning economist Joseph Stiglitz, among others, emphasized that GDP is not a good measure of either economic performance or well-being. Many leading economists agreed that GDP is not a good estimate of the state of the economy because it does not take into account the costs of generating economic income, such as the environmental damage caused by economic activity. The world is changing, and the way we measure progress must change as well. GDP was developed by Simon Kuznets, who warned as early as the 1930s that GDP is not a good measure of a country's development. GDP is an estimate of the value of goods and services produced by a country's economy; however, it does not provide an adequate picture of the various dimensions of development, sustainability, or well-being.

Scholarly discourse in recent decades suggests that Western philosophy, built on the tradition of the Enlightenment, conceives of sustainability in terms of justice and its intergenerational interpretation, while neoclassical economics interprets the Brundtland concept as a problem of the intergenerational distribution of wealth. In his work **The Economics of Biodiversity: The Dasgupta Review**, Partha Dasgupta discusses the intergenerational distribution of wealth at the intersection of political philosophy and economics (Dasgupta, 2021):

“...Utilitarianism, drawing on John Rawls’s maximin theory of justice,² examines how decisions regarding savings are—or should be—implemented in the national economy; that is, how national income should be allocated between current consumption and wealth-enhancing investments intended to serve the consumption of future generations. Through the approaches of Henry Sidgwick, János Harsányi, and later Tjalling Koopmans [1957], he ultimately concludes that, rather than a synthesis of individual utilities, the decision—the optimal composition of the wealth portfolio—is made by the so-called “citizen investor,” that is, an abstract entity that manages society’s asset portfolio with a perspective spanning generations, and which—when designing the ideal investment portfolio—perceives and interprets the need for sustainability in the investment decisions of the government and private companies, as well as in social issues such as population growth, education, or healthcare—when formulating the ideal investment portfolio. The Dasgupta Report devotes considerable space on several occasions to describing the nature of the community investor, but the point is that it highlights the fact that traditional economic thinking—the search for equilibria based on the sum of momentary individual utilities—does not align with a long-term perspective on sustainability...” (Kovács, 2022).

Partha Dasgupta: The Economics of Biodiversity: The Dasgupta Report



Sir Partha Dasgupta (1942–), a British economist born in India, is the Frank Ramsey Professor of Economics at the University of Cambridge. His main areas of research are ecological economics and environmental economics. His book, commissioned by the United Kingdom government, **The Economics of Biodiversity: the Dasgupta Review**, was published in 2021. An abridged version of the book has also been published in Hungarian (Dasgupta, 2025).

The central theme of the Dasgupta Report is sustainability and its foundations, biodiversity and its asset-based perspective, and the asset-based economy. It synthesizes various disciplines to analyze the relationship between the biosphere and human systems, summarizing them within the framework of an economic theory and a macroeconomic growth model.

If we view the sustainability dilemma as a global strategic problem—for which numerous ideas, proposals, programs, and international agreements have been put forward to solve it, or at least to move toward a solution, largely to no avail—the message of Dasgupta’s work can be summarized as follows: “Let’s change the rules of the game.” In other words, to grasp the essence of sustainability, we must move beyond traditional economic thinking, rewrite the fundamentals, and reinterpret development—all in a form that can be described mathematically and studied empirically.

Source: (Kovács, 2022)

If, from a philosophical perspective, we define the goal of development as increasing well-being—which we call sustainability—then this aligns closely with Sen’s theory of freedom. According to this theory, an individual’s situation should not be judged by the utility of the goods available to them, but rather by the extent to which they are able to live a life they rightly consider valuable. This significantly broadens the concept of freedom, and with this capability-based approach, Sen’s theory of freedom offers an alternative to traditional welfare economics.

The question may arise as to why, compared to Western cultures, the unity of philosophy, economics, and politics appears much more coherent in other cultures around the world, and why these cultures have not seen an explicit separation of politics and religion or the establishment of secular institutional systems. Why are institutions and institutional systems based on Western ways of thinking the driving forces of globalization, and yet why do we seek answers in the traditions of other cultures to questions that Western tradition seemingly cannot

answer? In light of all this, what might the Western conception of development, the ideal of sustainability, and its wealth-centered approach mean?

In the wealth-based approach to sustainability, inclusive wealth—or changes in it—serves as an appropriate indicator of sustainability. (Dasgupta & Mäler, 2000; Hamilton & Clemens, 1999) demonstrated that intergenerational well-being does not decline if—and only if—inclusive wealth does not decline. This proposition, rooted in the utilitarian tradition, establishes a link between the concept of well-being and sustainability. It also lends support to the argument that changes in inclusive wealth serve as a universal sustainability indicator, as they are independent of how the goal of development (well-being or freedom) is interpreted by a particular worldview, scientific definition, or religious tradition or doctrine.

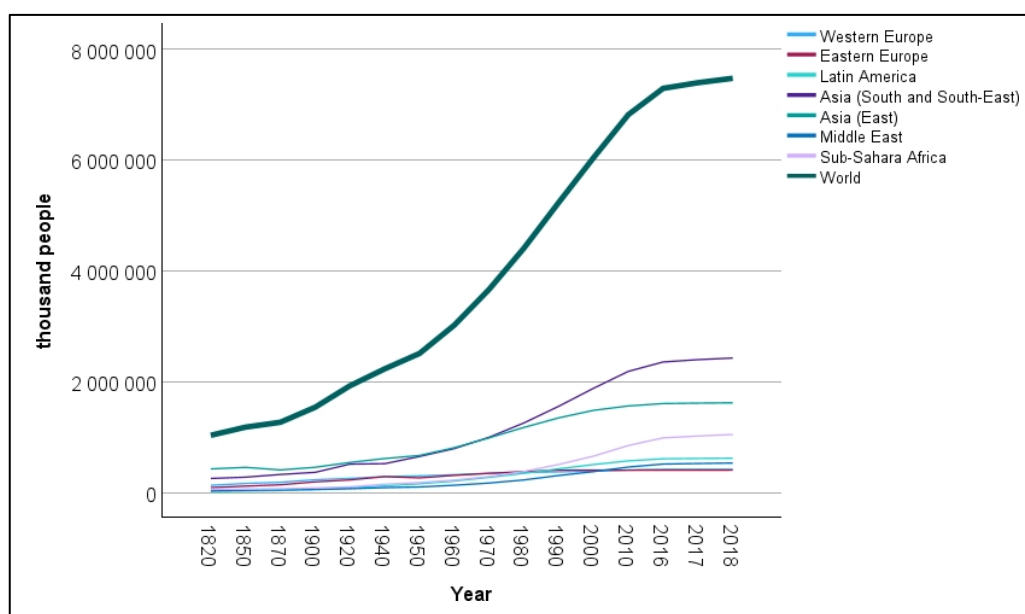
Economic Development and Growth

The literature (Diebolt & Perrin, 2016; Galor, 2005; Maddison, 2006) describes three stages of economic growth globally, particularly in Western societies (Figure 2-2). Throughout history, essentially until the beginning of the Industrial Revolution—during the so-called Malthusian stagnation—technological progress was very slow, and population growth was minimal, at around 0.1–0.2% per year. Per capita income averaged \$450–670 per year, which meant a relatively stable standard of living.

In the 19th century, from the beginning of the Industrial Revolution onward, both technological progress and population growth accelerated in the post-Malthusian era. The growth in per capita output

reached 1.3% annually by the early 20th century (Maddison, 2006)¹¹. As population growth slowed, a period of stagnant growth began, characterized by a divergence between per capita income and the rate of population growth (Figures 2–3).

2- Figure 2: Global Population Change, 1920–2018

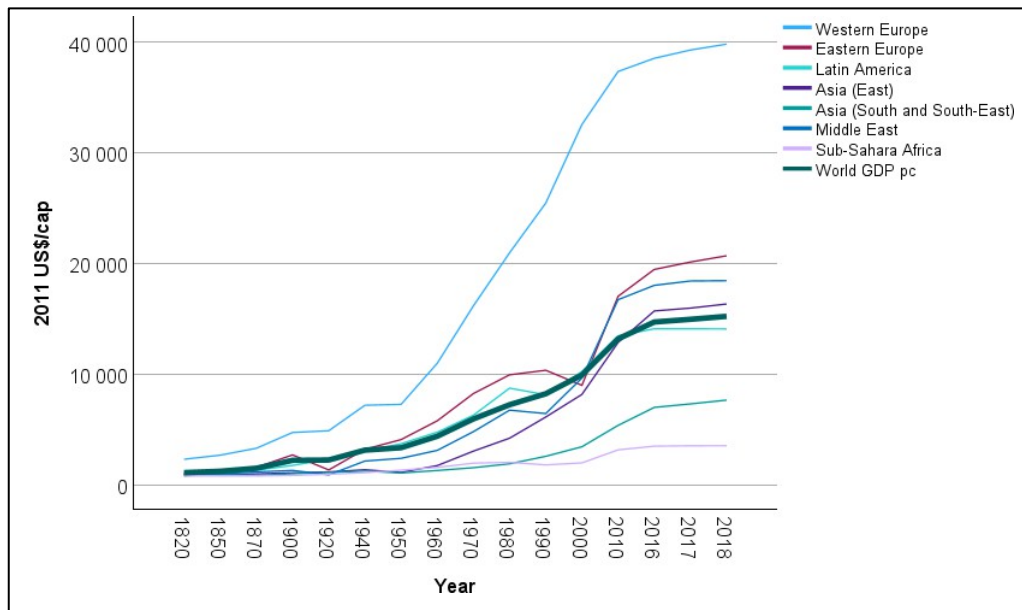


Source: (Bolt & Van Zanden, 2025)

¹¹ The *Maddison Historical Statistics Project* collects historical economic statistics, such as data on GDP, labor productivity, etc. Operated by the University of Groningen *Maddison Project* and Penn World Tables

(<https://www.rug.nl/ggdc/historicaldevelopment/maddison/?lang=en>) are the primary sources for global

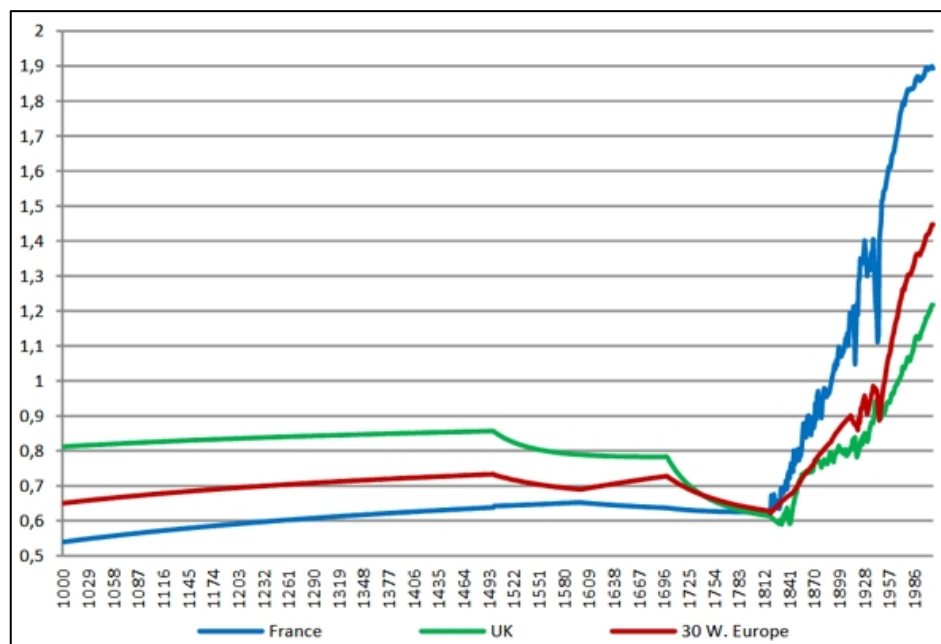
2- Figure 3: Changes in Income Across World Regions, 1820, 2018



Source: (Bolt & Van Zanden, 2025)

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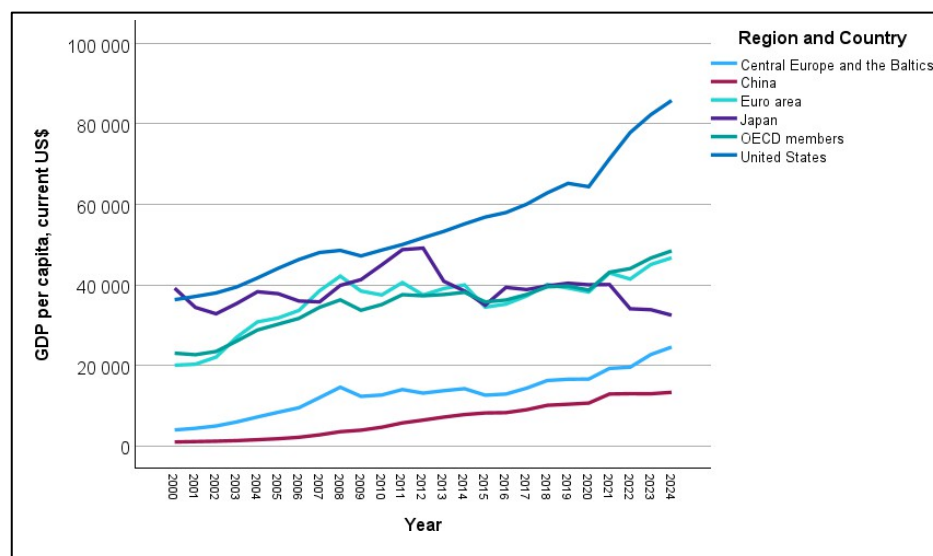
2- Figure 4: Income and population growth rates in Western countries, 1000–2008



Source: (Diebolt & Perrin, 2016), citing (Maddison, 2006)

Figures 2-5 and 2-6 show changes in per capita national income and the rate of income growth between 1974 and 2023. Per capita national income has essentially doubled, but its growth rate has stagnated at around 2% in the long term. The impact of the 2008 economic crisis and the 2019 COVID-19 pandemic on incomes and income trends is clearly visible.

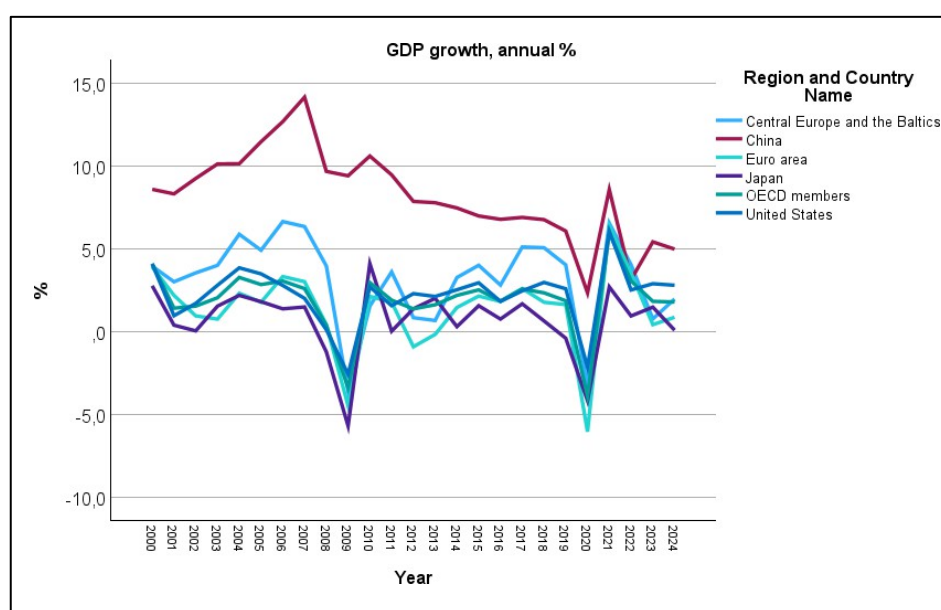
2- Figure 5: Global Changes in Income, Countries and Regions, 2000–2024, Current US\$ per Capita



Source: World Bank, World Development Indicators

Welfare economics seeks to capture development as an increase in economic welfare by using traditional indicators, such as GDP and others, as well as indicators from the consumption side of economic activity. In their widely cited article, “*Is Growth Obsolete?*” (Nordhaus & Tobin, 1971), argued that economic growth (following World War II) was the dominant trend in political economy, but thinking on this subject had shifted because it had become apparent that the pursuit of growth alone distorts national priorities, worsens income distribution, and harms the environment. The need for a broader concept of development, and subsequently the concept of well-being rather than mere prosperity, entered academic discourse.

2- Figure 6: Growth in global national income, countries and regions, 2000–2024, %



Source: World Bank, World Development Indicators

The pursuit of well-being focuses on human and ecological well-being rather than mere material growth. This means that political economy has entered the realm of approaches to development that go beyond growth. The central thesis of the OECD’s study **Beyond Growth: Towards a New Economic Approach** (OECD, 2020) is that the 2008 global financial crisis revealed the unsustainability of traditional (neoclassical) economic thinking, theory, and practice. According to the document, the failure to address social problems and environmental challenges stems from the prevailing economic narrative, as evidenced by the slowdown in productivity and per capita income growth. As an alternative, the OECD study proposes a new,

people-centered narrative based on social, economic, and environmental analyses grounded in a broad concept of development, with a sufficiently multifaceted set of objectives. Accordingly, the focus of economic policy must shift from the traditional concept of growth measured by GDP toward a multidimensional economic policy that sets economic, social, and environmental goals and strives to achieve them to the greatest extent possible. The OECD study therefore recommends *a systems-based approach* to sustainability, rather than the narrative of growth measured by GDP.

In addition to the recommendations of the OECD and numerous other sources¹², another conceptual approach to the sustainability narrative is the *asset-based approach* (or capital-based approach), which aims to promote the growth of three types of assets: physical (or man-made), human, and natural capital. This perspective is based on the premise that the source of a socio-economic system's current income is its available capital stock—that is, the totality of physical (produced), human, and natural capital elements.

This asset-based approach is represented by the book **The Economics of Biodiversity: The Dasgupta Review** (Dasgupta, 2021), which, as a synthesis of knowledge from numerous academic disciplines, presents a new political-philosophical and economic narrative to replace the GDP growth paradigm. Dasgupta's work is based on several decades of economic theory and rests on two fundamental concepts: first, that economic performance should be measured by changes in the stock of wealth—that is, the stock of assets—rather than by the flow of income. Second, that sustainability can essentially be viewed as an asset portfolio management problem. Efforts aimed at increasing (or at least not decreasing) the value of the asset portfolio can ensure that assets meet the needs of both current and future generations; thus, the capital-based sustainability narrative is fully consistent with the wording of the Brundtland Report described earlier. An additional advantage of the asset-based narrative is that it is universally applicable, even in conjunction with other approaches to sustainability. The preservation of wealth as a goal, along with the measurement of changes in asset values as a tool, provides a framework that

¹² For example, the proposal by the UN body established in 2025 as the “High-Level Expert Group on Beyond GDP” (<https://www.un.org/en/beyondGDP>)

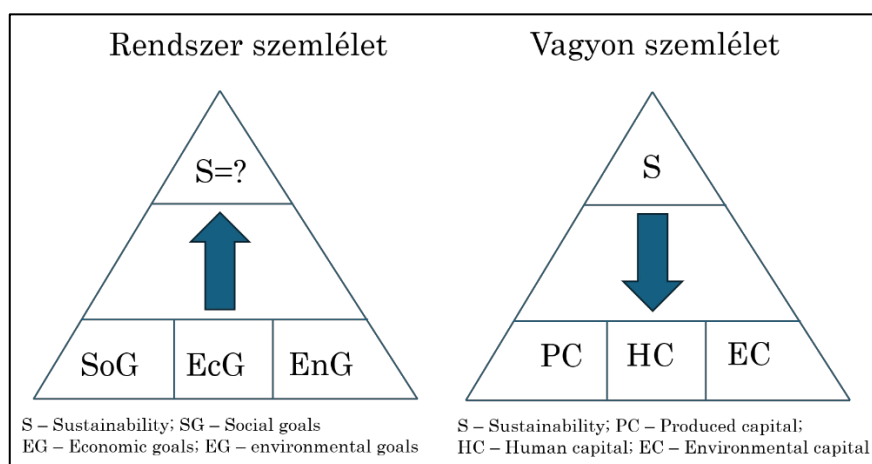
within which, for example, the numerous negative social and economic phenomena listed in the OECD study can be interpreted, and policies to address them can also be developed¹³.

The OECD study and the Dasgupta Report explain the reasons for the need for a new narrative on development and sustainability from different perspectives, but ultimately agree that the negative social and economic trends of recent decades stem from a way of thinking rooted in political philosophy and the principles of neoclassical economics. According to the OECD, this is the reason for the failure of the GDP growth narrative, which can be resolved by reinterpreting the development of the socio-economic system through a system of goals formulated along the three dimensions of social, economic, and environmental considerations. The OECD's bottom-up proposal undoubtedly suggests a highly complex system of objectives (Figure 2-7, left-hand triangle), whose components are synthesized by the concept of sustainability at the apex of the triangle. However, the approach proposed by the OECD does not provide a precise definition of sustainability; thus, it does not specify the criteria or methods for measuring whether the economy is truly developing along a sustainable path as progress is made through this complex system of goals.

The practical application of the OECD's concept is the United Nations' 17 Sustainable Development Goals (SDGs, Agenda 2030), which comprise 169 targets and more than 200 indicators. Intuitively, this diversity of goals is appealing; however, beyond practical feasibility, the complexity of the goals raises numerous theoretical questions. There is no doubt that the individual goals are scientifically grounded; however, there are challenges in making progress toward them. One such challenge is that the various goals are not independent of one another; while they may complement each other, trade-offs may also arise between them (Barbier & Burgess, 2019). Another criticism concerns the lack of an indicator that would assess whether progress toward the Sustainable Development Goals, taken as a whole, actually represents a step toward sustainability (Dasgupta et al., 2015).

¹³ That is, which policies, if implemented, would lead to an increase in assets.

2- Figure 7: The sustainability framework and the asset-based approach



Source: Compiled by the author

(S – sustainability; Left triangle: SoG – social goals, EG – economic goals, EnG – environmental goals; Right-hand triangle: PC – produced capital, HC – human capital, EC – environmental capital.)

The idea of an asset-based approach to economic development and sustainability, which is becoming increasingly integrated into economic discourse, is closely linked to the concept of *intergenerational well-being*, as supported by economic theory. Neoclassical economics interprets the Brundtland definition of sustainability as a problem of the intergenerational distribution of wealth, according to which sustainability requires that intergenerational welfare not decline (Arrow et al., 2010). This means that the current generation must allocate its income between consumption and savings in such a way that the resulting accumulation of wealth—which serves as the source of income for future generations—does not decline. This is the wealth- or asset-based approach to sustainability, which highlights the need to develop indicators that go “beyond GDP” and adopt a long-term perspective on development. This need is articulated in Target 17.19 of the United Nations Sustainable Development Goals, which calls for the development of new indicators to complement GDP (Mulholland et al., 2018). Indicators that can provide information on the long-term sustainability of the socioeconomic system. *The economics of sustainability* evolved from this need and deals with two fundamental issues in an integrated manner

: resource economics and environmental economics—that is, the problem of the depletion of natural resources and the problem of environmental protection.

The economics of finite natural resources, based essentially on Hotelling’s rule (Hotelling, 1931), deals with the efficient use of natural resources and how extraction can be reconciled with long-term sustainability^{vii}.

Environmental economics describes the relationships between the environment and the economy using market models: it examines the conditions for the sustainability of optimal levels of production and consumption, as well as whether the economy and well-being can grow despite obvious environmental externalities (Kerekes et al., 2018). By integrating these two approaches, the wealth-based perspective offers a way to examine sustainability. The wealth-based perspective on sustainability is grounded in an economic definition of intergenerational well-being and an integrated growth model that incorporates natural capital as a factor of production. The central tenet of this approach is that intergenerational well-being changes in tandem with changes in the wealth available for the functioning of the socioeconomic system.

Since changes in intergenerational well-being follow changes in total wealth, changes in total wealth—also known as inclusive wealth—serve as an appropriate indicator for measuring sustainability. This explains the connection between the Western philosophical concept of well-being and growth as defined by neoclassical economics. This may also provide a basis for the logical argument that a wealth-based perspective—extended to include the non-monetary attributes of wealth—can enable an interpretation of sustainability that goes beyond a utilitarian framework, integrating other intellectual, cultural, and religious traditions relevant to development and well-being.

According to Dasgupta, the analysis of how the economy functions focuses on the following questions (Dasgupta, 2009):

1. How does the economy function in the present?
2. How did it function in the past?
3. How is it expected to function under different policy alternatives?
4. What is the preferred policy alternative?

To answer questions 1 and 2, GDP is traditionally used, which is a short-term, flow-type indicator. However, GDP is not suitable for answering questions 3 and 4 because, since it

does not take into account the

economic, social, and environmental costs associated with income generation, it does not provide a long-term, accurate picture of the economy's condition, nor does it adequately indicate the economy's expected performance.

GDP is traditionally used to measure the annual income of the national economy. Total wealth, or inclusive wealth *stock*, represents the sum of all capital elements available for the functioning of the socio-economic system: the sum of physical (produced), human, natural, and social capital. GDP is a short-term measure of economic activity over a given period (one year), but it does not include information on changes in the resources used in the production of income, the depletion of raw material reserves, the depreciation of machinery and infrastructure, changes in the quantity and quality of human resources, changes in the natural environment, or social conditions, such as wealth and income inequalities. Changes in inclusive wealth, at least in theory, encompass these changes. The analysis of wealth-based sustainability is based on the microeconomic and macroeconomic models of neoclassical economics. In the context of environmental economics, microeconomics typically deals with markets, market failures, supply and demand relationships, prices, values, valuation methods, and the interfaces between human and natural systems. Macroeconomics provides methods for analyzing economic growth and growth prospects while taking into account the relationship between nature, humans, and the environment. In this approach, the natural environment can be understood as a system of ecosystems that provides services to human systems, the economy, and society, as well as to individuals. In this way, the natural environment constitutes a factor of production within the framework of expanded macroeconomics.

Intergenerational Well-Being

The issue of well-being—or intergenerational well-being—raises the following questions: How do we define the concept of well-being, and how do we interpret well-being over time, across generations? How should we take into account the interests of people in the distant future when making decisions? What proportion of a nation's output (income) should be allocated to financing investments whose benefits will be enjoyed by future generations? In what types of assets should these investments be made? What proportion of a generation's future-oriented investments should be financed by private, public, or community sources? How much should the world spend on mitigating climate change—that is, on increasing resilience? On what

basis should sustainability-oriented policies be evaluated? On what basis should individual sustainability-oriented projects be evaluated?

These questions had already been occupying philosophers and economists long before the issue of climate change arose. Building on classical utilitarianism, Sidwick (1907) argued that the value of a good is the sum of the benefits enjoyed over time and across generations. Ramsey's famous 1928 paper formulated the testability and answerability of the above questions in mathematical terms (Dasgupta, 2009). Ramsey pointed out that the concept of "pleasures" used in utilitarianism must be replaced with the broader concept of "*well-being*," and he formulated the social discount rate for calculating the present value of future benefits using the following formula:

$$r = \delta + \sigma * g$$

whose components reflect the ethical perspective of present-day society toward future societies and generations.

r – social discount rate;

δ – time preference, which expresses how much, in society's view, a good consumed in the future is worth compared to one consumed today. According to Ramsey, the value of δ must be zero from an ethical standpoint;

σ – marginal utility elasticity, which expresses how the value of additional consumption decreases as wealth increases;

g – the rate of growth in consumption, that is, the expected rate of economic growth.

The concept of well-being can be interpreted as an extension of the concept of welfare. According to Nordhaus and Tobin (Nordhaus & Tobin, 1971), within the framework of well-being, the range of consumer goods and services must be supplemented with consumption services derived from the natural environment, as well as "negative" consumption resulting from pollution.

Let us consider well-being as a numerical quantity (Dasgupta, 2019). Let $U(\tau)$ be well-being at time $\tau > t$, and let $V(t)$ be the present value of the temporal and intergenerational flow of well-being at time t . Following the original propositions of Sidgwick and Ramsey:

$$V(t) = \int_t^{\infty} [U(\tau)] d\tau$$

$V(t)$ is *intergenerational well-being* at time t . Applying a positive constant discount rate ($r \geq 0$), $V(t)$ is the present value of future feelings of well-being or pleasures¹⁴ $U(\tau)$:

$$[1] \quad V(t) = \int_t^{\infty} [U(\underline{C}(\tau))e^{-r(\tau-t)}]d\tau, \quad \delta \geq 1$$

$U(\tau) = U(\underline{C}(\tau))$, where $\underline{C}(\tau)$ is the vector of welfare consumption, which, in addition to market goods and services, includes the “consumption” of recreation and culture, as well as the benefits associated with health status and ecosystem services. $e^{-r(\tau-t)} < 1$ is the time factor, which approaches zero exponentially as t tends to infinity ($t \rightarrow \infty$).

Determining the discount rate for future “consumption” and well-being is an ethical question, based on which the optimal savings rate for the current generation can also be determined¹⁵. Intergenerational economic thinking regarding well-being has thus essentially adopted Ramsey’s framework and further developed it. As an example, we present two conceptual variations of the modification of Equation [1]:

Bretschger and Valente (2023) extended Equation [1] by expressing the present value of intergenerational welfare, U , as a function of the consumption of market goods and services (c), the demographic index (n), and environmental quality (q)¹⁶:

$$V(t) \equiv \int_0^{\infty} U(c(t), q(t), n(t))e^{-r(n(\tau)dt)}dt,$$

Smulders and Van Soest (2023) propose the following version of equation [1]:

$$V(t) = \int_0^{\infty} U(c(t+s), N(t+s))e^{-rs}ds$$

where U , the welfare at any given time, is a function of market goods and services $c(t)$ and ecosystem services $N(t)$ ($s = \tau - t$).

It is evident that philosophical and economic thought can define the concept of intergenerational well-being in many different ways with regard to the details, but conceptually, the key is sustainability

¹⁴ The English literature uses the term “*felicities*.”

¹⁵ For further details, see (Dasgupta, 2019)

¹⁶ The variables in the equation presented in Bretschger and Valente (2023) differ from the variable notation used in

Equation [1].

criterion, according to which, at a given time t , the present value of the stream of future “well-being” must not decrease over time:

$$[2] \quad \frac{dV(t)}{dt} > 0.$$

Total Wealth

Due to its obvious complexity, it is difficult to formulate the concept of intergenerational well-being in a way that is empirically measurable and testable. Instead, Arrow et al. (2010) argue that intergenerational well-being moves in tandem with aggregate wealth; therefore, the attributes of total wealth are suitable for assessing whether an economy’s development is sustainable or not. In this sense, therefore, changes in total wealth, or inclusive wealth, serve as an appropriate indicator of sustainability (D. W. Pearce & Atkinson, 1993). Total investment, or inclusive investment—that is, the change in total wealth or inclusive wealth—measures how rapidly intergenerational well-being changes over time (Dasgupta, 2009, p. 17).

In theory, the economy seeks to optimize present and future well-being, consumption, and investment (savings) (Weitzman, 1976). Intergenerational well-being thus changes over time as a function of changes in the stock of capital, but it also depends on other exogenous factors, such as terms of trade, technological changes, population growth, and institutional changes, etc. By definition, the total stock of capital—that is, total wealth or inclusive wealth—is the shadow-price-weighted sum of the economy’s (comprehensive) capital stock (Dasgupta, 2009, p. 24).

Wealth consists of three basic types of capital:

- (i) Physical, man-made, or produced capital: machines, instruments, buildings, infrastructure;
- (ii) Human capital: which depends on people’s education, skills, knowledge, and health;
- (iii) Natural capital:
 - a. Non-renewable natural capital elements: minerals, energy sources;
 - b. Renewable natural capital elements: forests, fish stocks, mangroves, and arable land;

Different classification systems may include additional assets:

- (iv) Intellectual property: contracts, patents and trademarks, software, databases;
- (v) Social/institutional capital: internal factors such as the quality of institutions, the rule of law, and various forms of social capital that contribute to the production of goods or the quality of services;
- (vi) Net financial assets: the net sum of cross-border liabilities and claims.

According to the above, the theoretical total wealth, or inclusive wealth, at time t , $W(t)$, is the sum of the capital components weighted by their shadow prices:

$$W(t) = r(t)t + \sum p_i(t)K_i(t),$$

where $r(t)$ is the shadow rate of time ¹⁷. $p_i(t)$ is the shadow rate of the capital component K_i at time t .

The shadow price of an asset is a conceptual theoretical price that depends on the total stock of capital assets, as well as the economy's current and expected future conditions. It depends on the extent to which different assets are substitutable for one another, not only today but also in the future. With regard to intergenerational well-being, calculating the present value of future benefits—that is, choosing the discount rate—is a crucial ethical issue. For example, a high discount rate mitigates the significance of future shortages of various capital assets.

By definition, the shadow price of produced, human, and natural capital at time t is expressed by the following equations:

$$p(\underline{S}, t) = \frac{\partial V(\underline{S}, t)}{\partial K(t)}$$

$$q(\underline{S}, t) = \frac{\partial V(\underline{S}, t)}{\partial L(t)}$$

$$n(\underline{S}, t) = \frac{\partial V(\underline{S}, t)}{\partial N(t)}$$

where $\underline{S}(t)$ is the vector representing the state of the economy:

$$\underline{S}(t) = (K(t), L(t), N(t)).$$

¹⁷ This component of wealth reflects exogenous, time-dependent increases in wealth components that result from changes in institutions, technological levels, preferences, and terms of trade (Smulders, 2012).

where K , L , and N represent, respectively, the stock of aggregate produced, human, and natural capital. Shadow prices also reflect the relationship between the stocks of different capital elements, such as substitutability. Certain critical elements of natural capital, such as ecosystems, cannot be substituted with other forms of capital—such as produced or human capital—which reinforces the value of ecosystems and thus increases their shadow price. The shadow price, therefore, regardless of the current market price, reflects the social value that a given asset represents for society in the context of intergenerational well-being and sustainability. Given knowledge of individual assets, total wealth and changes in total wealth constitute a theoretical sustainability indicator that can be approximated and estimated using practical indicators (such as “Total Wealth” in the World Bank database or “Inclusive Wealth” (Inclusive Wealth)¹⁸ . Practical indicators are approximate values of theoretical indicators calculated using a specific methodology, and their “quality” depends on that methodology and the quality of the source data. The latter typically come from national statistics.

Criteria for Sustainability

Measuring sustainability necessarily requires the use of indicators selected within a framework supported by an appropriate theory. Such a framework is provided by the asset theory of sustainable development—the asset- or capital-based approach to sustainability discussed earlier. This theoretical approach took shape in academic discourse beginning in the early 1990s, laying the groundwork for theoretical research in the following decades. The theory, summarized by David Pearce, Kirk Hamilton, and Giles Atkinson in a 1996 study, distinguishes between weak and strong sustainability (D. Pearce et al., 1996).

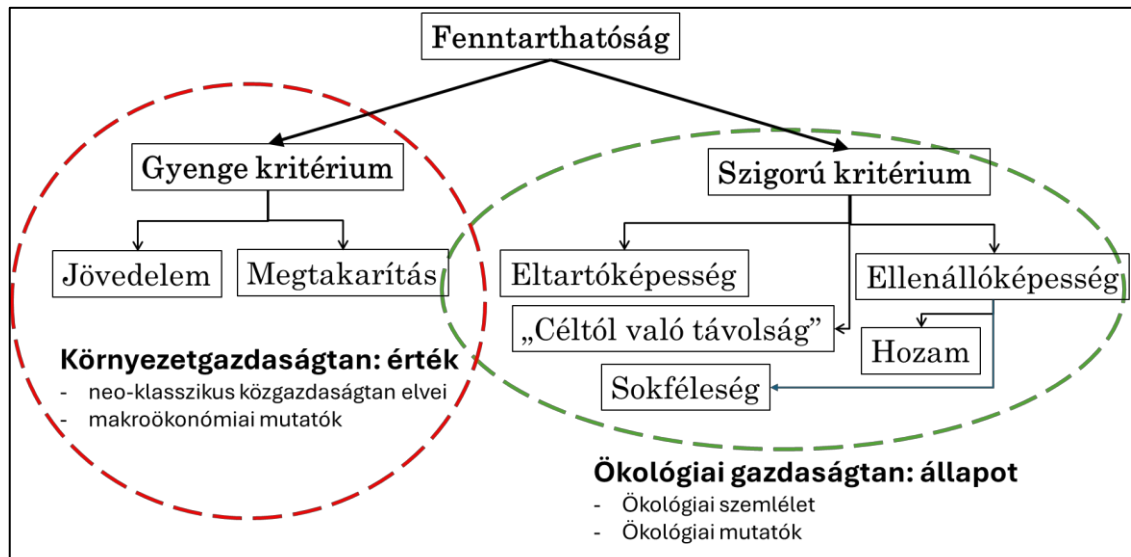
The criterion of weak sustainability essentially accepts the substitutability of natural capital with manufactured (machinery, buildings, infrastructure) or human capital, meaning that an economic system is sustainable if the decline in natural capital is offset by an increase in manufactured or human capital. The strict sustainability criterion allows for the substitution of non-renewable natural capital assets (mineral raw materials, energy sources) with other types of capital; however, the strict sustainability criterion is not met if critical elements of renewable natural capital are depleted. These two criteria essentially define the

¹⁸ See Chapter 1

conceptual conditions of sustainability and the corresponding sustainability indicators, as shown in Figures 2–8.

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Figures 2–8: Criteria and Indicators of Sustainability



Source: Compiled by the author (based on D. Pearce et al., 1996) and

others

Weak sustainability essentially follows the principles of neoclassical economics using macroeconomic indicators—namely, income, savings, and capital—while strict sustainability focuses on the state of the environment from an ecological perspective. Strict sustainability uses indicators that characterize ecological resources, functions, and processes. As such, it emphasizes the limits to the degradation of natural assets (the biosphere). Carrying capacity compares nature’s supply capacity with the demand for its goods and services. The distance to the target captures the deviation from a target that is still considered sustainable. Developing resilience indicators is a complex task that typically identifies two main lines of research: the close causal relationship between biodiversity and carrying capacity, and—particularly in the case of agricultural areas—indicators based on yield variability as a proxy for resilience.

The characteristics that define sustainability and the state of the environment are subject to numerous uncertainties; therefore, it is a matter of judgment which indicator best suits the purpose of the analysis in a given case, and whether weak or strict sustainability criteria should be applied. However, when it comes to the monetary valuation of natural capital assets, the two

approaches converge. The economic (or monetary) value of natural capital stocks—such as forests, watersheds, and fish stocks—depends on ecological quality: indicators of the selected ecological characteristics influence the monetary value of natural capital assets through the monetary valuation method. Therefore, the selection of a monetary valuation method is crucial for the integration of ecological indicators.

David Pearce (1941–2005)



David William Pearce, an English economist and professor emeritus at University College London, made a lasting contribution to the fields of sustainable development and the economic valuation of natural resources. He was the author of more than 50 books and 300 scientific articles. He worked as an environmental consultant for the United Kingdom government and numerous large corporations. He played an active role in the establishment of the Intergovernmental Panel on Climate Change (IPCC). From 1991 to 2001, he served as co-director of CSERGE (Center for Social and Economic Research on the Global Environment). In 2000, he was appointed an Officer of the Order of the British Empire (OBE).^{viii}

Source: University College London, (Kerekes, 2007)

The weak sustainability paradigm accepts the substitutability of produced, human, and natural capital assets and applies the principles of neoclassical macroeconomics, but also takes ecological considerations into account when calculating changes in total wealth and income as indicators. According to the ecological approach, real income is that which takes into account the extent of resource use—that is, the depreciation of productive capital and the degradation of nature resulting from economic activity. Thus, modified traditional income indicators (GDP, GNI) that account for the depletion of natural capital, as well as the loss in value of physical and human capital due to climate change, can be considered sustainability indicators.

Changes in capital assets can be empirically tracked by interpreting real savings in a way that takes into account both the factors that increase and those that decrease the value of capital components

. In the case of human capital, spending on education and health care are capital-enhancing factors, while health damage caused by emissions of pollutants generated as byproducts of economic activity is a capital-reducing factor.

The Condition for Weak Sustainability

A weak criterion for the sustainability of a socio-economic system is expressed by the following formula (D. W. Pearce & Atkinson, 1993):

$$\frac{dW}{dt} = \frac{dW_P}{dt} + \frac{dW_H}{dt} + \frac{dW_N}{dt} + \frac{dW_S}{dt} > 0,$$

where W_P , W_H , W_N , and W_S represent, respectively, the stock of produced, human, natural, and social capital. The inequality expresses that, in order to satisfy the criterion of weak sustainability at time t , the sum of the changes in the capital stock components must be greater than zero. The inequality also expresses the condition of substitutability; that is, for example, a decrease in natural capital can be offset by an appropriate increase in either produced capital or human capital, or both. Thus, the inequality is modified as follows:

$$\frac{dW}{dt} = \frac{d(W_P + W_H + W_S)}{dt} > 0,$$

According to Pearce and Atkinson, the weak sustainability criterion can also be described by the following formula:

$$Z = \frac{S}{Y} - \frac{\delta_P * W_P}{Y} - \frac{\delta_N * W_N}{Y}$$

where S is savings, Y is income, δ_P , and δ_N are the depreciation rates of produced and natural capital, respectively.

The Strict Sustainability Condition

The strict sustainability condition requires that the value of critical natural capital assets—that is, ecosystems—not decrease. This also means that critical natural capital assets cannot be substituted with other forms of capital; therefore, their decline is not permitted even if it is accompanied by a corresponding increase in produced or human capital:

$$\frac{dW_N}{dt} > 0,$$

which inequality can be transformed in the manner used for the weak sustainability criterion:

$$\frac{\delta_N * W_N}{Y} > 0,$$

Topic for Discussion

What characterized economic thinking in different eras regarding the factors determining economic growth and the relationship between human and natural systems?

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3. Chapter Growth and Sustainability

Learning Objectives

This chapter provides a historical overview of the development of the concept of sustainable economic growth, from early economic thinkers through neoclassical economics to the latest growth models, which now take into account the relationship between the natural environment and the economy.

The issues of growth and sustainability play a central role in the discourse on development. Measuring growth, the sustainability of growth, and sustainable development are complex problems, the examination of which necessitates precise definitions of these concepts. Thinking about economic growth has undergone remarkable development since the 18th century. Numerous attempts and proposals have been made to explain growth patterns and the drivers of growth—both in the short term (on an annual basis) and in the long term (measured over decades). Traditionally, economic development was interpreted as economic growth measured by income; later, it became clear that development has many other aspects besides growth.

Sustainability is a matter of well-being that spans time and space: (1) well-being that does not decline across generations, and (2) the pursuit of equity in the present for all people living under different economic conditions in societies and in various geographic regions of the world. In practice, sustainability can be approached through a systems perspective and measured along various ecological, economic, and social dimensions. The other approach, the capital perspective, focuses on changes in wealth—that is, the capital elements available to the socio-economic system. Accordingly, the criterion for sustainability—that is, sustainable economic growth—is the non-declining value of wealth and well-being over time (Barbier & Burgess, 2025; Dasgupta, 2021; Pearce & Atkinson, 1993).

In the classical Smithian ¹⁹ framework, the accumulation of factors of production was viewed as the engine of growth; however, due to the limitations of the division of labor, increases in production efficiency were considered finite (Begović, 2017), which led to economic stagnation

¹⁹ The economic thought established by Adam Smith.

In the neoclassical framework, more advanced growth models describe trends in economic growth and explain possible growth trajectories, taking into account developments in physical capital, human capital, and population, as well as changes in technology and natural resource stocks, etc. Long-term growth trends spanning decades are determined by supply-side factors—namely, technological progress, capital accumulation, and changes in the labor force, as opposed to demand-side factors—namely, changes in spending, shifts in consumer and business confidence, etc.—which account for short-term business cycles. Modern explanations of economic growth emphasize the role of technological progress and useful knowledge, as proposed by 2025 Nobel laureate Joel Mokyr, who highlights the importance of the interactions between science, technology, institutions, and culture (Mokyr, 2005).

Joel Mokyr (1946–)



Joel Mokyr is an Israeli-American economist and economic historian, and a professor at Northwestern University (USA) and Tel Aviv University (Israel). In 2025, he shared the Nobel Prize with Philippe Aghion and Peter Howitt for their work in elucidating the role of technological progress in sustainable development. He emphasized the importance of technological progress and the expansion of useful knowledge as prerequisites for sustainable economic growth, highlighting the need for societies to be open to new ideas and change.

Source: Northwestern University; Encyclopedia Britannica; Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2025.

This chapter begins with a historical overview of growth theory, then presents the neoclassical growth model and the Solow growth model, followed by their extensions to include natural resources.

Early Growth Theories

The question of economic growth was already occupying thinkers in the early 1800s, as increases in production had become noticeable in certain sectors of the economy, particularly in industry and agriculture. With the advent of the Industrial Revolution, however, the nature of growth changed in a distinctive way, fundamentally in three respects. First, until the first half of the 18th century, growth was limited to specific geographic areas (typically capital cities) and certain economic sectors, such as agriculture. Second, before 1750, growth was driven primarily by institutional changes—namely, the establishment of the rule of law, wider access to credit, the institutionalization of trade, the enforceability of contracts, etc.—which enabled a broad expansion of wealth, exchange, and investment. Ultimately, in the pre-Industrial Revolution era, growth was not sustainable in today’s sense; it was characterized by fragility and recessions. From the second half of the 18th century, however, technological progress became the engine of economic growth, which was accompanied by the continuous development of the institutions necessary for this transformation. These formed the foundation of the Industrial Revolution. Compared to the preceding era, the most significant difference during the Industrial Revolution was the spread of useful knowledge—or, in Mokyr’s terminology, propositional knowledge (Mokyr, 2005).

Beginning in the period immediately preceding the Industrial Revolution, the unprecedented generation and dissemination of knowledge were based on Bacon’s so-called “three Cs” program ²⁰: *calculation*, *classification*, and *cataloging*. This was the Age of Enlightenment, a component of which—the Industrial Enlightenment—unfolded through knowledge, which was inextricably intertwined with culture, that is, with the defining sentiment and belief of the era that progress and economic growth could be achieved through knowledge, which goes hand in hand with the development of morality, justice, and freedom. Based on Bacon’s ideas, it was believed that material progress could be achieved by mastering and harnessing nature through science—that is, through ever-expanding knowledge. Bacon, who was perhaps the most influential figure of the Enlightenment, laid the foundation for the concept of economic growth and, in connection with this, for the significance of the relationship between humanity and nature for future generations.

²⁰ The “Three Cs” program: counting, classifying, cataloging

The Mercantilists

The approximately two-century period preceding the Industrial Revolution was characterized by the rise of nation-states, the globalization of international trade, and colonization. The prevailing economic view was mercantilism, which was characterized by the “zero-sum” perspective—that is, that a nation could gain an advantage only at the expense of other nations. Growth was accompanied by the accumulation of gold and other precious metals, such as silver, mined domestically or in the colonies, and nations competed to achieve a trade surplus. They used their growing wealth to finance wars and encouraged population growth, primarily to meet the needs of an expanding military and to populate the colonies, while they sought to maintain competitiveness in international trade by keeping domestic wages low.

Classical Economics

Classical economists believed that economic growth would eventually reach its limits, the economy would slow down, and then, as the population stagnated, economic growth would come to a halt. As for the finite nature of the natural environment, they took into account the limited availability of agricultural land. In their view, real incomes would eventually stagnate at the subsistence level, although technological progress might delay the onset of economic stagnation.

The era of classical economics spans approximately a century, beginning with Adam Smith’s magnum opus, **The Wealth of Nations** (1776), followed in the early 1800s by Thomas Malthus and David Ricardo, and finally John Stuart Mill, who remained active until the end of the century. These thinkers explained their views on economic growth, sustainability, and the role of the natural environment through various models of the economic system.

Adam Smith

Smith explained economic growth based on the division of labor, meaning that workers specialize in different stages of the production process, and that individual firms and nations specialize in the production and trade of certain goods. Such a division improves both efficiency and quality, resulting in greater competitiveness. In addition, more goods can be sold in these expanded markets, which further strengthens the potential for specialization. The expansion of the market is aided by improvements in transportation between geographic regions, which can promote the growth of the domestic economy. In contrast to the mercantilist view

, Smith emphasized that international trade is a “positive-sum game” and is therefore beneficial to all nations. Overall, market expansion promotes the division of labor and specialization in production and trade, which increases profits (due to a decrease in unit production costs). Capital formation increases in tandem with rising labor productivity and growing demand for labor. As a result, wages and real per capita income rise—in other words, the economy grows.

Adam Smith (1723–1790)



Adam Smith was a Scottish philosopher and political economist, and a leading figure in modern economic thought and classical liberalism. He earned his degree from the University of Glasgow, where he was strongly influenced by the ideas and work of scholars of the Scottish Enlightenment, including Francis Hutcheson. He studied at Balliol College, Oxford, and after returning to Scotland, he taught various subjects—including rhetoric, history, and economics—in Edinburgh. At the age of 27, he was appointed professor of logic, and later of moral philosophy, at the University of Glasgow, which allowed him to teach other subjects as well, including theology, ethics, and political economy. In this vibrant and inspiring academic environment, he became a well-known intellectual with a wide circle of influential friends in the worlds of politics and business. In 1763, he resigned from his academic position, moved to France, and took a position as a private tutor for a wealthy family. He traveled extensively throughout Europe and met many famous thinkers of his time, including Voltaire. After returning to London, he worked for the Minister of Finance. He was elected a Fellow of the Royal Society.

Source: Encyclopedia Britannica

Smith nevertheless concluded that economic growth would eventually reach its limits, that is, it would reach a stationary state. In his view, an increase in per capita income initially stimulates population growth, which leads to a rise in the birth rate and a decline in the death rate. With the increased labor supply, wages—and subsequently per capita income—decline. In addition, profits also decline due to fiercer competition and because it becomes increasingly difficult to find profitable investment opportunities. As a result, real wages and capital formation also decline, leading to an economic slowdown and stagnation.

The Utopians

The philosophers of the 18th-century utopian school were optimistic about future progress and believed that humanity would achieve a state of harmony. According to the French philosopher Marquis de Condorcet (1743–1794), equality among nations and within nations would promote social progress and ultimately lead to the “perfection of humanity.” To achieve this, he argued, a more equitable distribution of wealth, social security, and universal free education for both men and women were necessary. This would increase the population, but the growing demand for food would be balanced by an even faster increase in food production. William Godwin (1756–1836), an English philosopher, predicted a future of equality and a classless society characterized by goodwill and a sense of justice. In his view, wars and crime would cease, and indeed, there would be no need for the administration of justice or government.

Thomas Malthus

Thomas Malthus’s first work was published anonymously in 1798: **An Essay on the Principle of Population as It Affects the Future Improvement of Society with Remarks on the Speculations of Mr. Godwin,* M. Condorcet, and Other Writers*. In this work, he expressed serious disagreement with the optimism of the utopians and similarly rejected the worldview of the mercantilists.

Malthus was an economic pessimist. His famous assertion, known as Malthusianism, is that the population will always outgrow food supplies, and therefore it is impossible to achieve a better life for everyone without administrative control over reproduction. It follows from his observations that population growth will far exceed the basic goods necessary for subsistence,

particularly the growth in food production. According to his economic model, as the economy grows and technology advances, per capita income will rise, leading to an increase in the birth rate and population growth due to improved healthcare, declining mortality rates, and better nutrition. However, due to the increased labor supply and limited land area, food prices will rise, causing real wages to fall to the subsistence level, and population growth will come to a halt. As a result of all this, economic growth also comes to a halt. Malthus made a significant contribution to the economic thought of his time; nevertheless, in his predictions, he failed to take into account either technological advances in agriculture or the decline in birth rates accompanying economic development—factors that ultimately had a major impact on trends in economic growth.

Thomas Malthus (1766–1834)



Thomas Malthus, an English economist and demographer. He was born into a wealthy, intellectual family. He was deeply influenced by the views of David Hume and Jean-Jacques Rousseau, two great thinkers of the 18th century. He was initially educated at home, then in 1784 he was admitted to Jesus College, Cambridge. In 1804, he became a professor of history and political economy at Haileybury in Hertfordshire. He traveled throughout Europe and befriended the English economist David Ricardo. In 1819, he was elected a member of the Royal Society; in 1833, he was elected a member of the French Académie des Sciences Morales et Politiques and the Royal Academy of Berlin. Malthus was one of the co-founders of the London Statistical Society.

Source: Encyclopedia Britannica

David Ricardo

David Ricardo made significant contributions to the development of economic theory, including theories of trade and economic growth. Like many other contemporary thinkers, he accepted Malthus's views on population growth; however, his main contribution was the further development of the concept of a steady state. He believed that, in the long run, sustained economic growth would not be possible due to the diminishing returns to labor, the limited amount of land available for agricultural production, and the decline in rates of profit. When income reaches the subsistence level, population and economic growth come to a halt²¹

²¹ For further details, see Hess, 2016, p. 98)

David Ricardo (1772–1823)



David Ricardo, an English economist, was born into a Jewish family in the Netherlands. His family emigrated to England and amassed a great fortune on the London Stock Exchange. He broke ties with his father for religious reasons. He remained a member of the stock exchange and, within a few years, amassed enough wealth to devote himself to his interests in mathematics and chemistry. Influenced by the work of Adam Smith, he began publishing articles and books primarily on finance. His work **Principles of Political Economy and Taxation** was published in 1817. He befriended many influential economists of his time, including James Mill and his son, John Stuart Mill, Jeremy Bentham, and Thomas Malthus. He died at the age of 51.

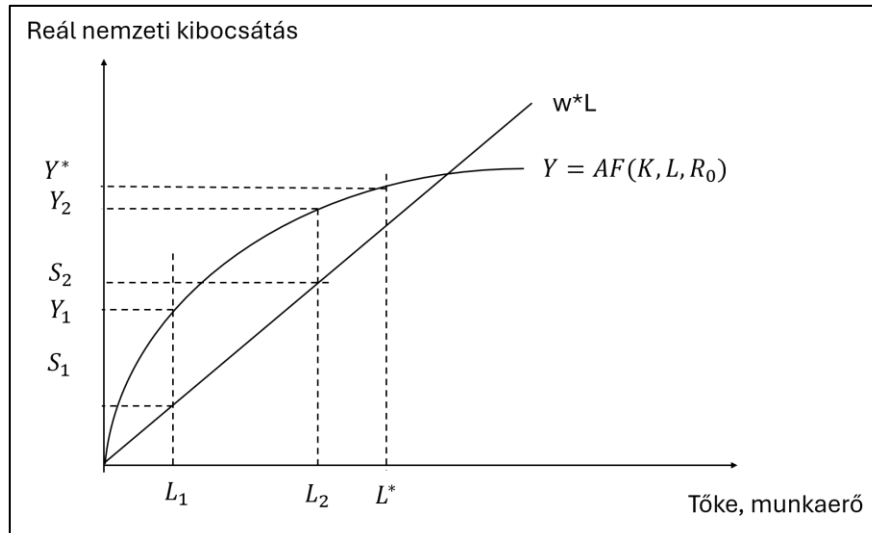
Source: *Encyclopedia Britannica*

The Steady State

Both Malthus and Ricardo envisioned that limited economic growth would eventually lead to a steady-state, or stationary, condition, as illustrated in Figure 3-1.

The concave curve represents the economy's aggregate output (vertical axis) as a function of physical capital and the labor force (horizontal axis)²² The linear curve represents the aggregate wage sum: $w \cdot L$, the total wage bill.

3- Figure 1: Stylized representation of the steady state



Source: Based on the author (Hess, 2016)

Y – real national output, the production function: $Y = AF(K, L, R_0)$, where

A – technology index

L – labor force K –

physical capital

R – natural resources, R_0 fixed supply of agricultural land w –

real subsistence wage minimum per worker

S – total (aggregate) subsistence wage: $S = w \cdot L$

According to the Malthusian model, if wages rise above the subsistence minimum, the population grows: the birth rate rises, and the death rate falls. As the population grows, so does the demand for food, either through more intensive use of existing land (employing more labor) or through the expansion of agricultural production onto (presumably lower-quality) land. Both options lead to declining rates of return, and thus to the

²² The horizontal axis represents physical capital and fixed agricultural land. For the sake of simplicity, labor (the labor force) is denoted by L and physical capital by K on the horizontal axis, since Ricardo assumed that the ratio of labor to physical capital is constant.

This leads to a decline in the rate of return on labor. As profits fall and the supply of labor increases, wages decline, returning to the subsistence level.

S_1 and Y_1 represent the total subsistence wage mass and output, respectively $L_1 \cdot Y_1 - S_1$. The difference between the two curves represents the owners' profit, which they either reinvest in new physical capital or distribute to workers as extra wages.

Since the principle of diminishing returns to labor applies, as the labor force (population) grows, the profit of the owners of physical capital eventually declines at point L^* , reaching a level equal to the depreciation of physical capital. From this point onward, there is no further investment in physical capital, the labor force does not grow (at the subsistence wage, the population does not grow), and the economy reaches a steady-state, stationary condition.

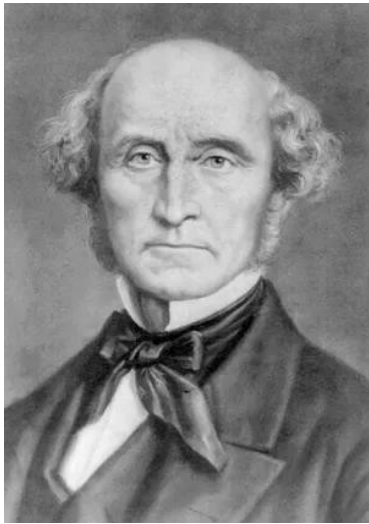
John Stuart Mill

Like Malthus and Ricardo, Mill accepted the concept of the stationary state, but he distinguished between the nature and concepts of economic growth and development. He emphasized that human progress, in various forms, can be effectively achieved independently of economic growth through the development of culture and the social environment and the practice of the arts.

“...The stationary state as interpreted by Mill refers to an average income level higher than that necessary for subsistence, a better distribution of income, and more responsible consumption, in which people would strive to improve their lives through personal development, as opposed to the increased consumption of goods and services.” (Free translation by the author) (Hess, 2016, p. 102).

In summary, classical economists developed a scientific approach to sustainability through their study of development and economic growth. Malthus's ideas failed in practice in a certain sense because, due to the agricultural revolution and technological advances, food production ultimately outpaced population growth. In reality, over the past two centuries, rising living standards, education, social inclusion, and a more equitable distribution of goods and services have positively influenced demographic trends, while famines, the spread of plant diseases and pests, wars, and so on have had a negative impact. Ricardo and Mill both theoretically confirmed the limits of growth, while at the same time enriching the principle of steady state with new insights.

John Stuart Mill (1806–1873)



John Stuart Mill was an English philosopher and economist, a well-known proponent of the utilitarian perspective. Born into an intellectual family, he read the works of Greek and Latin philosophers, statesmen, and historians from a young age. He studied logic, geometry, and algebra, and examined the works of the great philosophers of his time, including Adam Smith, David Ricardo, and Jeremy Bentham. He held various administrative positions in government, and in 1822–23 he founded the Utilitarian Society. He was a theoretical scholar but was also active as a publicist. His major works include **Principles of Political Economy**, **Autobiography**, **On Liberty**, **System of Logic**, and **Utilitarianism**.

Source: *Encyclopedia Britannica*

Theories of Growth in the 20th Century

The Limits of Growth

Humans have always been dependent on the natural environment. Classical economists also recognized this dependence, particularly the limited availability of agricultural land. For modern economics, environmental goods and services were long taken for granted as being freely available. In the 1960s, the view that humanity depends on nature came to the forefront of academic and public discourse. Rachel Carson's famous book, **Silent Spring** (1962), played a significant role in launching modern environmental movements and establishing the first environmental protection agencies. Around the same time, Kenneth Boulding's

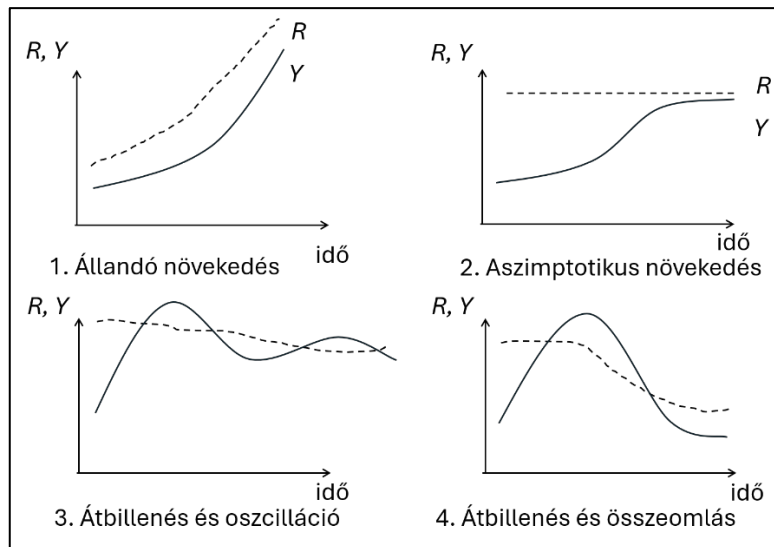
's "spaceship metaphor" (1966) aptly described the Earth's limited capacities, both in terms of resource stocks (minerals and energy sources) and pollution absorption^{ix}. As a precursor to the later *circular economy*, he advocated for the creation of *cyclical* ecological systems. In 1972, the Club of Rome published its first report, titled **Limits to Growth**, in which it argued that unlimited growth is not possible on a finite planet and warned of economic and social collapse in the foreseeable future if "business as usual" (business as usual).

"If current trends in world population, industrialization, pollution, food production, and resource depletion remain unchanged, then sometime in the next hundred years our planet will reach the limits to growth. The most likely symptom of this will be a dramatic decline in industrial production and population." (Free translation by the author) (Meadows et al., 1972, pp. 23–24).

The 2004 edition of **The Limits to Growth** (Meadows et al., 2005) includes a revised version of World3, a complex dynamic model. The model simulated the interactions between the world's population, industrialization, pollution, food production, and the depletion of natural resources, presenting 10 different scenarios projecting into the future up to the year 2100. The simulation led to the conclusion that under the "business-as-usual" scenario—that is, if continuous growth continues—Earth's systems will experience "overshoot" within the foreseeable future, and even their collapse, unless trends in population growth and resource consumption can be significantly altered.

Figure 3-2 illustrates four of the 10 scenarios depicting the possible interaction between the Earth's carrying capacity and the economy (R represents the Earth's carrying capacity; Y represents the physical dimensions of the population and the economy). According to Scenario 1, the growth of carrying capacity, population, and the economy follows a similar trend (Constant Growth). According to Scenario 2, the growth trends of population and the economy converge toward a given carrying capacity but do not exceed it (Asymptotic Growth). In Scenario 3, rapid population and economic growth are accompanied by a gradual decline in carrying capacity, resulting in fluctuating population and economic growth (Tipping and Oscillation). According to Scenario 4, population and economic growth trigger a rapid decline in carrying capacity, resulting in a collapse-like decline in both population and economic activity (Tipping Point and Collapse).

3- Figure 2: Four baseline scenarios, World3 model



Source: Author, based on (Kerekes et al., 2018)

The World3 model's 9th optimistic scenario is characterized by a stabilizing population and per capita industrial production. Waste management, pollution reduction, and agricultural technologies improve significantly. In addition to resource conservation and the protection of agricultural land, land productivity increases. The resulting society is sustainable: according to the report, the Earth's population will stabilize at around eight billion, with a high standard of living and a steadily decreasing ecological footprint.

*Steady-State Economy*²³

In his famous work **Steady-State Economy**²⁴ (Daly, 2008), Herman Daly also addressed the issue of the limits to growth and proposed the concept of a steady-state economy as an alternative path of development. Based on the first and second laws of thermodynamics, Daly argued that the problem of economic growth is ultimately a problem of entropy. Entropy is a measure of disorder or randomness, and of energy unsuitable for performing useful work (high-entropy energy). In his view, economic activity—that is, the production of goods and services—requires low-entropy

²³ In Hungarian academic literature, the terms “steady-state economy” or “stationary economy” are also used to translate the English term “*steady-state economy*.”

²⁴ The concept of a steady-state economy differs from the principle of a steady-state economy as defined by classical economists.

It requires resources and energy, during which high-entropy matter and energy are returned to nature. Since the Earth's capacity to absorb and recycle waste is limited, Daly proposed the steady-state economy—which he defined conceptually as follows—as an alternative to economic growth:

$$\frac{\textit{Service}}{\textit{Throughput}} \equiv \frac{\textit{Service}}{\textit{Stock}} * \frac{\textit{Stock}}{\textit{Throughput}}$$

where “*service*” refers to the satisfaction of needs, which is produced through the use of stocks of goods and labor. “*Throughput*” refers to the entropic, cyclical flow of matter and energy originating from nature, which is transformed by human activity and the economy, and then returned to nature as a “sink.” *Service*, therefore, is the benefit, while *throughput* is the cost of economic activity. In a steady-state economy, stocks and population are constant, which means that population and economic growth are zero. Increasing the left side of the equation (*Service / Throughput*) can essentially be achieved by changing or developing technology—that is, by increasing the benefit-to-stock (*Service/Stock*) ratio. This, however, also means increasing the stock-to-throughput (*Stock / Throughput*) ratio—that is, reducing throughput while maintaining a given stock level. These goals can be institutionalized by setting the following policy objectives:

- (1) halting population growth: the ideal fertility rate is 2.1;
- (2) maintaining stock levels;
- (3) reducing high-entropy flows (raw materials and energy sources).

Administrative measures to achieve objective (1) are controversial; therefore, each country must determine these measures by taking its own circumstances (population growth, fertility rate, etc.) into account. Objective (2) can be achieved by strengthening the role of renewable energy sources and increasing renewable energy production. To reduce resource use (3), the adoption of a circular economy is already a central objective of national economies worldwide.

Critics of Daly's steady-state economic model argue that there are no limits to scientific and technological progress, so the depletion of non-renewable natural resources can be offset or those resources can be replaced by others^x.

Environmental Macroeconomics

Environmental macroeconomics is a field of study that examines the interactions between economic development and the natural environment, focusing on the complex relationships among economic growth, pollution, climate change, economic policy, technological progress, and so on. Environmental macroeconomics is a new interdisciplinary field that integrates research findings from ecology and other branches of the natural sciences on a neoclassical economic foundation.

Macroeconomics has traditionally not taken into account the relationship between the economy and the ecological system; however, since the 1970s, the integration of nature into macroeconomic models has become a key area of theoretical thought. Although environmental macroeconomics is a relatively new field of study, philosophers and economists have been paying attention to the relationship between the economy and the natural environment—primarily (agricultural) land as a resource—since the 18th century. Other resources, however, such as other components of the biosphere—air, water, or ecosystems—were largely ignored. Later, in his famous work **The Wealth of Nations**, Adam Smith criticized the notion that only land was valuable and argued that other sectors of the economy also generate wealth. Much later, in the first half of the 20th century, as neoclassical economics gained prominence, some economists, such as Marshall²⁵, acknowledged that nature provides resources for the economy. The environment was gradually incorporated into the framework of macroeconomic analysis: Pigou emphasized the impact of the natural environment on welfare, while Fisher²⁶ defined the components of nature as elements of natural capital. After World War II, particularly in Western countries, rapid economic growth led economics to focus exclusively on issues of economic growth. The macroeconomic model of the era, the original Solow-Swan model, used physical capital and labor as factors of production, while nature was considered exogenous and did not appear in the model's production function. Although environmental problems such as desertification, water pollution, and air pollution were acknowledged, they were not considered a threat to economic growth. The limits to growth were not recognized until

²⁵ Alfred Marshall (1842–1924), English economist

²⁶ Irving Fisher (1867–1947), American economist, statistician, and a leading figure in econometrics

had expressed concern until the scarcity of certain natural resources, such as oil, caused a genuine global economic downturn during the two oil crises. In addition, the demand for environmental protection spread worldwide, and following the 2008 global financial crisis, the possibility of unlimited growth was essentially called into question.

It has become clear that, as the economy continues to expand, the degradation of ecological systems, climate change, the loss of biodiversity, and other factors will limit economic growth. While a new, consistent macroeconomic theory that adequately describes the relationship between economic growth and the environment is still pending, it appears that the predicted “decoupling”²⁷ between income (GDP) and energy consumption is not materializing. It appears that economic growth, as we understand it today, is incompatible with the principles of sustainability, which are necessary for maintaining a healthy global economic system.

The Kuznets curve, named after Simon Kuznets, is an important tool for analyzing economic development. Based on empirical data, the Kuznets curve describes the relationship between economic growth and changes in inequality (Kuznets, 1955). The essence of this is that, as the economy develops, income inequality initially increases and then decreases once the economy surpasses a certain level of development, corresponding to an inverted U-shaped curve.

²⁷ Decoupling: the amount of energy required to produce a unit of income decreases

Simon Kuznets (1901–1985)



Born in Ukraine, Simon Kuznets emigrated to the United States in 1922 and earned his Ph.D. from Columbia University. He taught at the University of Pennsylvania, Johns Hopkins University, and Harvard University. He worked at the National Bureau of Economic Research, where he conducted pioneering work in the field of national income accounting and laid the fundamental groundwork for research on economic growth. Kuznets was awarded the Nobel Prize in Economics in 1971 *“for his empirically grounded interpretation of economic growth, which has provided new and deeper insights into economic and social structures and the process of development.”* He is credited with developing GDP as a measure of economic performance.

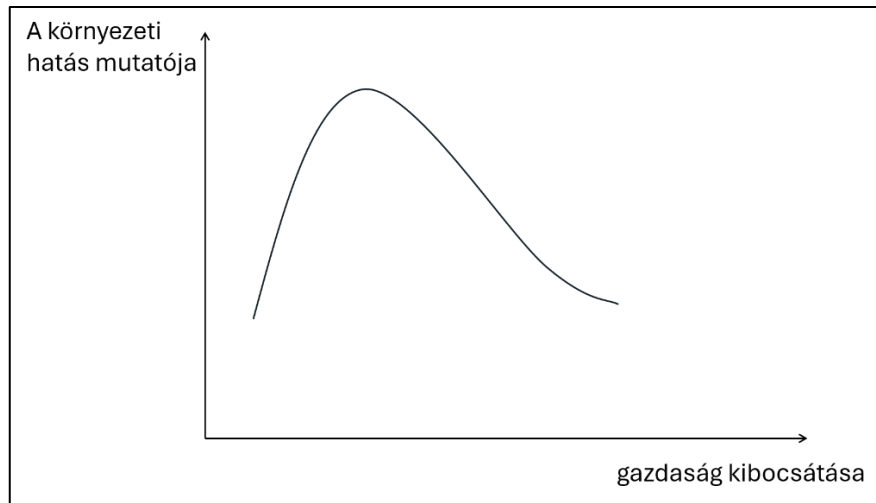
Source: Encyclopedia Britannica; Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1971. <https://www.nobelprize.org/prizes/economic-sciences/1971/kuznets/facts/>

The recognition of this relationship was far ahead of its time for two reasons. First, social inequality—alongside intergenerational well-being—is one of the key factors in sustainability, as sustainability was defined roughly half a century later. Second, trends following the shape of the Kuznets curve were observed in empirical studies of the relationship between economic development and environmental degradation and pollution associated with economic activity. Figure 3-3 shows the theoretical shape of the Environmental Kuznets Curve (EKC). In the initial stage of economic development (growth), the economy’s impact on the environment increases. After reaching a peak, further economic development leads to a decrease in the

negative impact on the environment. According to research conducted

research conducted approximately 20 years later found that negative environmental impacts are typical up to a per capita national income level of approximately \$8,000–\$10,000, and that above this level, pollution and other negative environmental impacts decrease.

3- Figure 3: Stylized Environmental Kuznets Curve



Source: the author

(Grossman & Krueger, 1995) analyzed pollution trends by examining four environmental indicators: urban air pollution, oxygen balance, and concentrations of fecal matter and heavy metal pollutants in river watersheds. The results of the analysis showed that the trends in these indicators follow the EKC pattern.

To empirically examine EKC-type trends in pollution, a linear regression model with a quadratic form for the independent variable is typically used:

$$y_{it} = \alpha_i + \beta x_{it} + \gamma x_{it}^2 + u_{it}$$

where y_{it} is an environmental pollution index in country i at time t , x_{it} is the per capita national income in country i at time t , and u is the error term that captures the effects of all other *exogenous* variables that influence the dependent variable but are not included in the

are not included in the equation. The variables are typically expressed in logarithmic form, representing percentage changes. α , β , and γ are the regression coefficients.²⁸

Recently, computable general equilibrium (CGE) models have been used in macroeconomic research to simulate the effects of policy interventions and to examine the complex interactions between natural and human systems—that is, to quantitatively describe the changes in the natural environment caused by economic activity. The most famous environmental CGE model is DICE (Dynamic Integrated Climate Economy), developed by Nobel laureate William Nordhaus.

William D. Nordhaus (1941–)



William Nordhaus is an American economist, Sterling Professor Emeritus at Yale University, a member of the National Academy of Sciences, a member and senior advisor to the Brookings Economic Activity Panel in Washington, D.C., and a member of the Congressional Budget Office's panel of economic experts and other important academic bodies. He is the author and co-author of numerous books and journal articles on economic policy, global warming, and energy issues. In 1972, in his widely cited article "*Is Growth Obsolete?*", co-authored with his colleague James Tobin, he introduced the ISEW (Index

²⁸ The purpose of the regression model analysis is to demonstrate a causal relationship between economic growth and environmental degradation. The analysis either confirms or rejects the null hypothesis, according to which the values of the regression coefficients (α , β , γ) are zero.

of Sustainable Economic Welfare), and in 2018, he was awarded the Nobel Prize jointly with Paul Romer “for integrating climate change into long-term macroeconomic analysis”^{xi}.

Source: William Nordhaus | Yale Department of Economics; Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2018.

With advances in computing and access to large, diverse, and rapidly growing databases, governments and international organizations—such as the European Central Bank, the World Bank, the OECD, etc., have developed and are applying dynamic stochastic general equilibrium (DSGE) models that, building on new principles of modern economics—such as rational expectations and dynamic optimization— to integrate macroeconomic analysis—that is, economic growth, business cycles, and fiscal and monetary policy—with microeconomic behavior.

One of the “cradles” of modern economics



Hillhouse Avenue, New Haven, Connecticut, United States

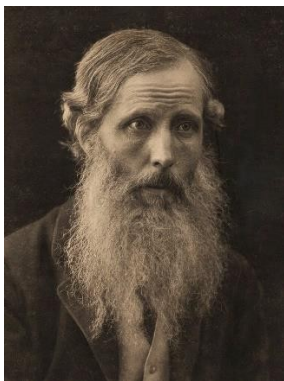
Hillhouse Avenue is a prominent site in the history of modern economics at Yale University, where numerous influential 20th-century macroeconomists worked: Irwin Fisher (1867–1947), James Tobin (1918–2002), Paul Samuelson (1915–2009), William Nordhaus (1941–), and others.

The Neoclassical Growth Model

Modern philosophy and economics both address the relationship between economic growth and sustainability. The formulation of intergenerational well-being as a fundamental concept of sustainability dates back to the intellectual traditions of the early 20th century, such as the work of Sidgwick, Ramsey, and Harrod, who treated the problem of the intergenerational distribution of goods and services as a moral obligation. The ethical approach to sustainability is of fundamental importance from the perspective of modern economic policies, because decisions made today determine the well-being of future generations, particularly with regard to natural resources, climate change, and biodiversity.

By the 1950s, the foundations of neoclassical economics had already been laid, including modern growth theory, Ramsey's intertemporal utility function, the Cobb-Douglas form of production functions, and the Solow-Swan model (Németh, 2017a, 2017b). The latter has since been further developed to account, to a certain extent, for the limits of growth within a constrained environment—the biosphere. Furthermore, the inclusion of the environment as a factor of production in growth models came to the fore with the emergence of environmental economics, and from the 1970s onward, natural capital increasingly became a central focus of interest for theoretical environmental economists.

Henry Sidgwick (1838–1900)



Henry Sidgwick was an English philosopher and economist who served as professor of moral philosophy at the University of Cambridge. He founded and supported numerous scholarly societies to promote women's participation in higher education. He was a follower of the intellectual tradition of Immanuel Kant and John Stuart Mill. His major work, **The Methods of Ethics**, is, among other things, the

utilitarianism as a framework for moral decision-making, which later became a defining perspective in economic thought. She argued for pure time preference, meaning that a zero discount rate should be applied when calculating the present value of the well-being of future generations.

Source: *Encyclopedia Britannica*

Ramsey Frank Ramsey (1903–1930)



Frank Plumpton Ramsey, an English mathematician and the founder of modern growth theory, lived an extremely short life. He was a brilliant mind whose work was far ahead of his time. His most renowned collection of essays, published posthumously, **The Foundations of Mathematics and Other Logical Essays**, contains Ramsey's most important philosophical and mathematical writings. His article "*A Mathematical Theory of Saving*" serves as an important reference point for optimal taxation and growth models; to this day, it continues to have a major influence on economic thought regarding how much societies should save in light of the future. Based on Ramsey and Sidgwick's ethical principles, he formulated the concept of welfare using a mathematical formula grounded in utilitarianism; like Sidgwick, he also proposed the use of a zero discount rate (pure time preference) to calculate the present value of the utility and welfare of future generations. His works have not been published in a standalone volume in Hungarian; references, analyses, and studies can be found in academic journals and university lecture notes ^{xii}.

Source: *Stanford Encyclopedia of Philosophy, (Tóth and Horváth, 2023)*

Roy Harrod (1900–1978)



Sir Roy Harrod, an English economist, made significant contributions to the development of modern growth theory (the Harrod–Domar model) and to the application of ethical concepts in macroeconomic policy with regard to future generations. He was a dedicated scholar of the work of John Maynard Keynes.

Source: Encyclopedia Britannica

Economic research on sustainability is significantly advanced by developments in growth models and information technology: numerous proposals have been put forward to extend the neoclassical growth model to include environmental factors in order to describe the relationships between human systems and the natural environment, thereby enabling the synthesis of findings from the fields of natural resource economics, environmental economics, and ecology—and even sociology and demography—to be synthesized. Rapidly advancing information technology greatly facilitates the empirical analysis of growth models, enabling the use of data provided by “big data” and new statistical systems²⁹.

Growth models consist of a production function and dynamic stock-flow equations. The latter describe changes in production factors and the interactions among them. The literature on neoclassical growth models is quite extensive, with numerous books and other publications devoted to their description and analysis (Acemoglu, 2009; Barro & Sala-i-Martin, 2004; Hess, 2016; Halmai, 2023).

²⁹ The international standard developed by the United Nations, the System of Environmental-Economic Accounting (SEEA), and its extensions, the Ecosystem Accounts.

The general form of the production function:

$$[3] \quad Y = F(K, L, T),$$

where Y is output, which is a function of capital, K , labor, L , and technology, T . In a closed economy, output is spent either on consumption, $C(t)$, or on investment, $I(t)$:

$Y(t) = C(t) + I(t)$, or, after rearrangement:

$$S(t) \equiv Y(t) - C(t) = I(t).$$

$S(t)$ represents savings, which is output minus consumption, and is equal to investment $I(t)$. Let s be the savings rate, that is, the proportion of output allocated to investment.

$$S(t) = s * Y(t)$$

$1 - s$ is the proportion of output allocated to consumption. s is an exogenous variable, a complex function of the variables describing the state of the economy. Let the savings rate be constant and $0 < s < 1$. By definition, the production function is *neoclassical* if it satisfies the following conditions:

(1) Constant returns to scale:

$$[4] \quad F(\lambda K, \lambda L, T) = \lambda * F(K, L, T) \text{ for all } \lambda > 0,$$

which means that output increases by the same proportion as the multiples of capital and labor. K and L are rival goods, while technology T is a non-rival good³⁰.

(2) For all factors, there are positive and diminishing marginal returns:

$$[5] \quad \frac{\partial F}{\partial K} > 0, \frac{\partial^2 F}{\partial^2 K} < 0 \qquad \frac{\partial F}{\partial L} > 0, \frac{\partial^2 F}{\partial^2 L} < 0$$

[5] describes in mathematical form the assumption that, given a constant level of technology and a constant labor force, every unit increase in capital results in a positive change in output (the first derivative of the function is positive), which decreases as the number of capital increases rises (the second derivative of the function is negative).

(3) Inada condition:

³⁰ The same capital or labor can be used by only one economic agent (producer), so these are rival goods. A single technology can be used by many producers, so technology is a non-rival good.

The marginal product of capital (or labor) approaches infinity as capital (or labor) approaches zero, and approaches zero as capital (or labor) approaches infinity.

$$[6] \quad \lim_{K \rightarrow 0} \left(\frac{\partial F}{\partial K} \right) = \lim_{L \rightarrow 0} \left(\frac{\partial F}{\partial L} \right) = \infty \quad \lim_{K \rightarrow \infty} \left(\frac{\partial F}{\partial K} \right) = \lim_{L \rightarrow \infty} \left(\frac{\partial F}{\partial L} \right) = 0$$

(4) Essentiality:

An input to production is *essential* if a positive quantity of that input is required to generate a positive quantity of income.

[3] [4] and [5] mean that every input is essential.

Two stock-flow equations describe the changes in capital and labor over time. The net change in the capital stock at a given point in time is gross investment minus depreciation:

$$[7] \quad \dot{K}(t) = I(t) - \delta K(t) = sF[K(t), L(t), T(t)] - \delta K(t),$$

Let δ be the rate of depreciation, and $\dot{K}(t)$ be its derivative with respect to time K . Labor, L , is a function of population, fertility, the mortality rate, and migration. Assuming that the population

$\frac{L}{L} = n \geq 0$ grows at an exogenous rate, normalized by the population size and labor

from $t = 0$ to 1, the change in the labor force over time is described by the following equation:

$$[8] \quad \dot{L}(t) = e^{nt}$$

The intensive form of the production function

Countries can vary greatly in terms of their capital and labor force, yet due to geographical differences and population size, such aggregate quantities do not reveal much about whether a given country is rich or poor—in other words, about the amount of capital or income per capita. Therefore, it is necessary to restructure the model using per capita values in order to examine the dynamic changes in capital and income over time and in a comparative manner across countries.

$$[9] \quad Y = F(K, L, T) = L * F(K/L, 1, T) = L * f(k),$$

where $k \equiv K/L$, i.e., the stock of capital per unit of labor, $y \equiv Y/L$, i.e., output per unit of labor, and since the condition of constant returns to scale holds for all values of λ

, including $\lambda=1$, $f(k) = F(k, 1, T)$. T is a constant, so the intensive (i.e., per capita) form of the production function in [3] is as follows:

$$[10] \quad y = f(k),$$

which satisfies all the conditions of a neoclassical production function. Equation [10] is free of scale effects ³¹, so the dynamic relationships among production factors can be examined without scale effects. This means that large countries such as Russia or Indonesia have lower per capita output than small countries such as Austria or Finland, whose aggregate output is smaller than that of countries with large land areas and populations.

The Cobb-Douglas Model

The *Cobb-Douglas-type neoclassical model* is a linear homogeneous function in which the elasticity of substitution between factors is equal to one (Douglas, 1976):

$$[11] \quad Y = AK^\alpha L^{1-\alpha},$$

where the level of technology is $A > 0$ and α is a constant: $0 < \alpha < 1$. α and $1 - \alpha$ represent the *factor income* shares, meaning that α indicates what proportion of total income goes to capital. By definition, $1 - \alpha$ is the share of labor. Douglas (1976) reports various values of α for n economies in the first half of the 20th century, including the United States, Canada, and New Zealand, where the relevant data were available: typical values of α fell within the range of 0.3–0.4. Following the initial empirical studies, the literature on the Cobb-Douglas function expanded significantly, and factor shares were determined for various time periods across numerous countries and economic sectors (Valentinyi & Herrendorf, 2008).

The intensive form of the Cobb-Douglas production function, with values calculated per unit of labor:

$$[12] \quad y = Ak^\alpha,$$

where y is the income (output) per worker, and k is the capital per worker, i.e., the capital-labor ratio. [12] This satisfies the conditions of the neoclassical production function.

³¹ that is, independent of the size of the economy

The Solow-Swan Model

The basic Solow-Swan model ³²consists of the production function and three dynamic equations. It includes physical capital and labor as production factors (i.e., inputs) and takes into account the savings rate, the population growth rate, and technological progress as exogenous factors. The Cobb-Douglas production function:

$$[13] \quad Y(t) = K(t)^\alpha L^{1-\alpha}$$

The equation expressing the equality between investment and savings:

$$[14] \quad I(t) = S(t)$$

Savings is the product of the savings rate and income:

$$[15] \quad S(t) = sY(t)$$

The equation describing the change in the labor force:

$$[16] \quad L(t) = L_0 e^{nt}$$

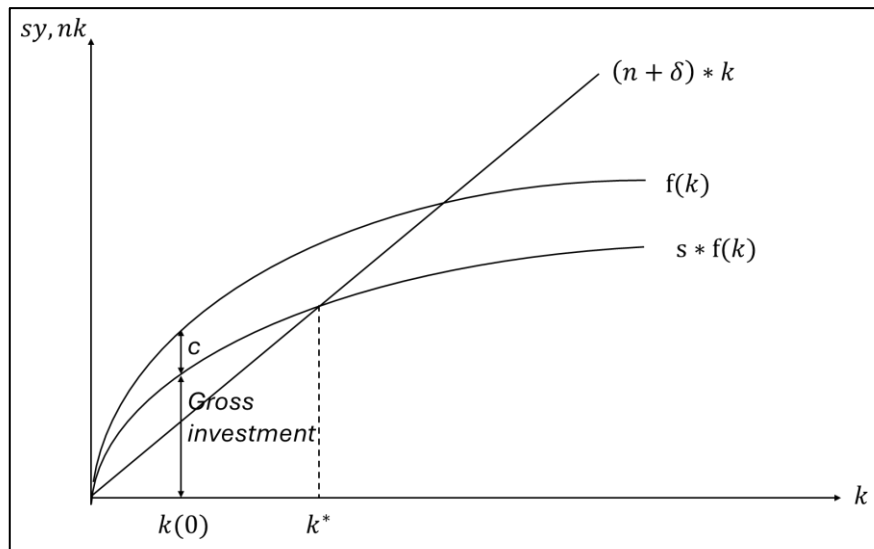
In a steady state with a constant capital-labor ratio, the Solow model can be rewritten in intensive form as:

$$[17] \quad \frac{\partial k}{\partial t} = s * f(k) - (n + \delta) * k,$$

the fundamental differential equation of the Solow-Swan model, which depends only on k . This means that capital accumulation depends on the amount of capital per worker, the exogenous savings rate, and effective depreciation. The latter is $n + \delta$, that is, the rate of population change plus the rate of physical capital depreciation. In a steady state, capital accumulation per worker is zero, that is, when savings equal effective depreciation: $s * f(k) = (n + \delta) * k$:

³² The neoclassical growth model was published almost simultaneously but independently by two economists, Robert Solow and Trevor Swan, in 1956. Robert Solow was awarded the Nobel Prize in 1987 for his contributions to the theory of economic growth.

3- Figure 4: The Solow-Swan Model



Source: Based on the author (Hess,

2016)

In Figures 3–4, the investment curve $s * f(k)$ is proportional to the production function $f(k)$. At $k(0)$, income is divided between investment and consumption (c). k^* is the steady state, when effective investment equals savings.

In the steady state, the capital-labor ratio is constant, which depends on the savings rate s and the labor force growth rate n , assuming that the employment rate is constant, so the labor force grows in proportion to the population. This means that different combinations of s and n result in different steady-state values of k^* . According to the model, economies move toward a steady state where, ultimately, the ratio of factors of production to labor remains constant. If $k < k^*$, that is, if k lies to the left of k^* , then it moves to the right; if $k > k^*$, that is, if k lies to the right of k^* , then it moves to the left, until it reaches the value k^* . This means that output (income) per worker increases until k reaches the value k^* , at which point it takes on the value y^* , and then ceases to grow further.

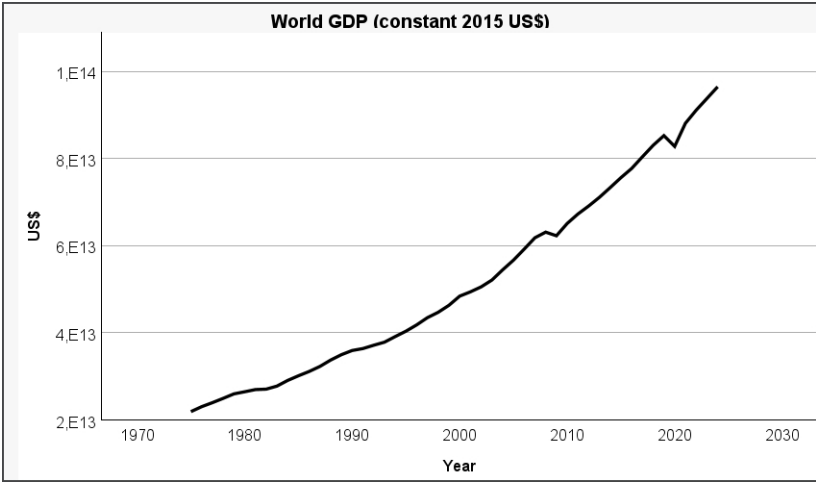
The Global Economy in a Closed Natural Environment

Economic and Population Growth Trends

Over the past half-century, global GDP has grown exponentially (Figures 3–5), and while the world's population has doubled (Figure 3–6), the global average GDP per capita has risen from US\$5,000

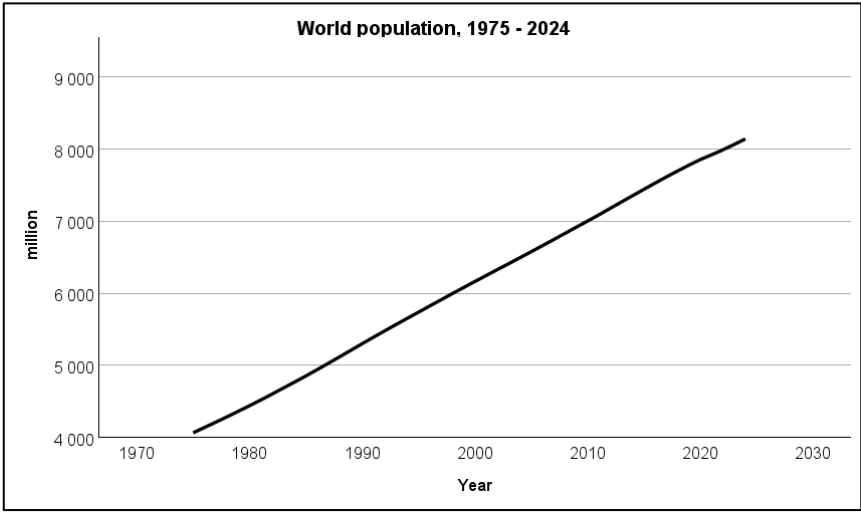
(five thousand U.S. dollars) to US\$11,000 (eleven thousand U.S. dollars) (Figure 3-7)³³ .

3- Figure 5: Changes in Global GDP, 1975–2024



Source: World Bank Open Data

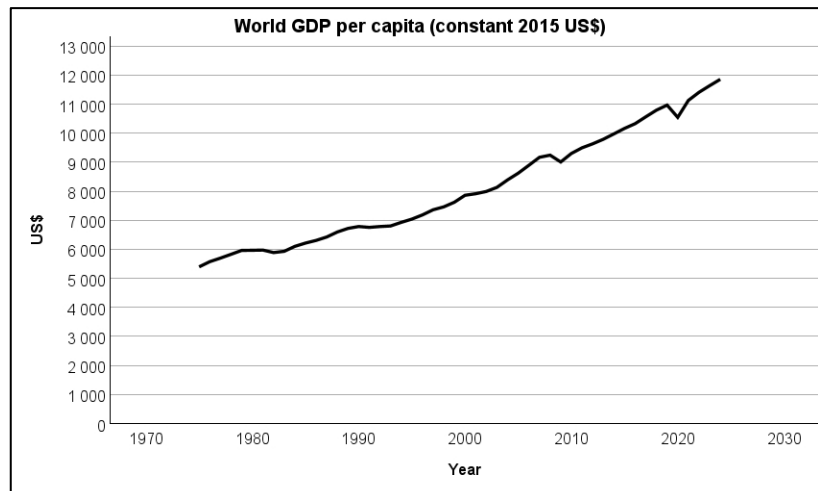
3- Figure 6: Changes in the global population, 1975–2025



Source: World Bank, World Development Indicators

³³ International organizations such as the United Nations, the World Bank, and the OECD report Gross Domestic Product (GDP) data using various units of measurement, e.g., in local currency (LCU), in current U.S. dollars, and at constant U.S. dollar exchange rates for a given reference year. Depending on the unit of measurement, GDP data may vary.

3- Figure 7: Change in average global GDP per capita, 1975–2025

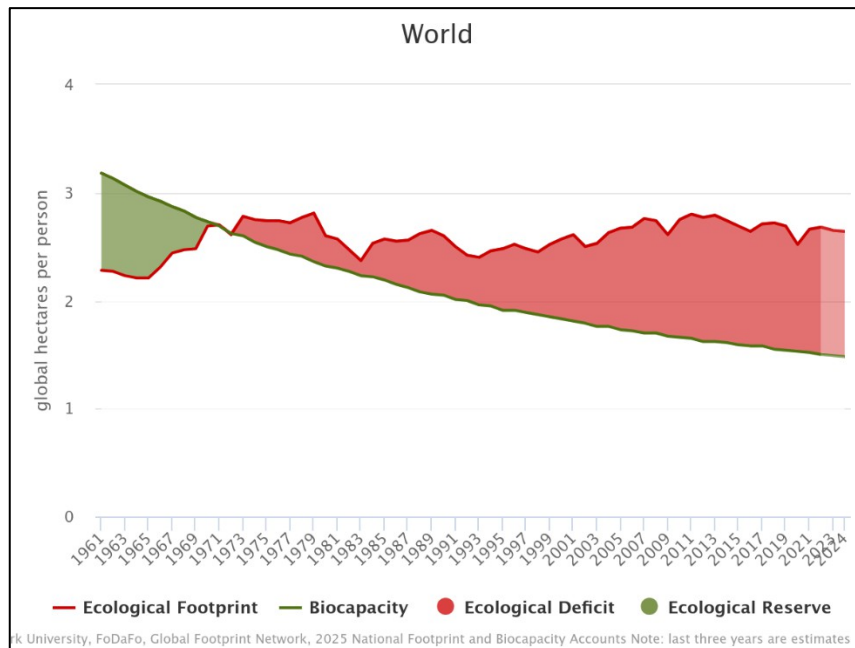


Source: World Bank, World Development Indicators

The Impact of Human Activity on the Natural Environment

Alongside the spectacular growth in GDP, the global economy's impact on the biosphere has increased dramatically. The *ecological footprint* is a widely used indicator of this impact, representing a numerical measure of human systems' demand on nature. The *ecological deficit* is a measure of the difference between the ecological footprint and nature's regenerative capacity (supply). As shown in Figures 3–8, global nature's supply exceeded global demand until the late 1970s, after which the difference between the two indicators suddenly turned negative. Since then, the ecological deficit has been steadily increasing and reached 1.7 times by the 2020s, meaning that humanity's demand for the Earth's resources is 1.7 times greater than the biosphere's capacity for regeneration.

3- Figure 8: Global Ecological Deficit, 1975–2025



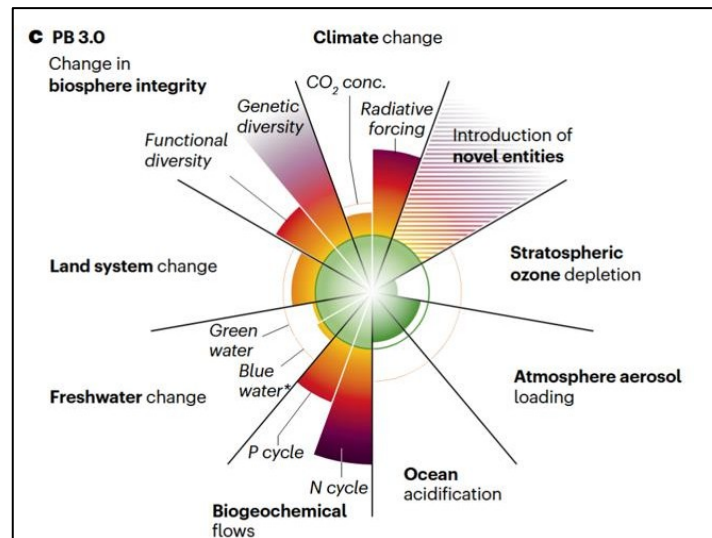
Source: Global Footprint Network

To describe the global environmental impacts of human activity, Rockström identified nine critical Earth system processes and their corresponding planetary boundaries, and drew attention to the fact that by the first decade of the 21st century, humanity had already exceeded the safe operating space for six of these nine planetary boundaries:

- climate change;
- biosphere integrity;
- land-use change;
- freshwater use;
- biochemical flows;
- ocean acidification.

Figures 3–9 illustrate the state of these critical systems: green indicates the safe operating space, while the transition from yellow to red and then to deep red indicates zones of increasing risk.

Figures 3–9: Changes in the integrity of the biosphere, Rockström’s planetary boundaries



Source: (Rockström et al., 2024)

Another stylized representation of the impact of human activity on nature is the so-called IPAT formula, attributed to Paul Ehrlich and John Holdren:

$$I = P * A * T$$

where I (impact) is the global environmental impact of human systems, P is the global population; A represents consumption (affluence), and T is the efficiency of technology, which expresses the efficiency of resource use—that is, the amount of environmental damage caused by a unit of economic output.

Impact Inequality

Impact inequality is another stylized model, but one that is more detailed than the IPAT formula, which describes the functioning of human systems within a finite biosphere. The model incorporates human systems’ demand for the goods provided by the biosphere, the biosphere’s capacity for regeneration, and changes in population and technological level as external factors.

Global Aggregate Demand for Natural Resources

The ecological footprint expresses the demand of human systems—that is, the economy—for the goods and services of natural systems, namely the biosphere. Let N denote the global population, and while it is widely accepted that GDP is an inadequate measure of sustainable development, let y denote the economy’s per capita emissions measured in GDP

. The global ecological footprint (EF) can be expressed by the following equation:

$$EF = N * y/\tau,$$

where τ represents the impact of human systems and the economy on natural systems, which consists of two components: (1) the efficiency of converting natural resources into global income, τ_X , and (2) τ_Z , a quantitative measure of the extent to which nature is transformed into a sink for global pollution. Based on all of this, the ecological footprint can be expressed by the following formula:

$$EF = \frac{N_y}{\tau_X} + \frac{N_y}{\tau_Z}$$

Global supply of natural goods and services and the imbalance of impacts

The maximum quantity of goods and services provided by global natural systems to human systems depends on the size of the global natural system—the biosphere—as a stock. Let B denote the book value of the global biosphere as a stock of natural assets, and let $G(B)$ denote the rate at which global natural capital is regenerated per unit of time (one year).

The global impact imbalance—that is, the imbalance between supply and demand for the goods and services provided by global natural systems—is expressed by the following conceptual formula:

$$[18] \quad EF = \frac{N_y}{\tau_X} + \frac{N_y}{\tau_Z} = \frac{N_y}{\tau} \geq G(B)$$

If EF exceeds the value of $G(B)$ —which is the reality at the beginning of the 21st century—then B , the global stock of natural capital, shrinks, causing $G(B)$, nature's capacity for regeneration, to decline as well. Equation [18] is an abstract formulation of unsustainable economic growth using economic concepts, which projects two economic perspectives:

- (1) viewing ourselves as separate from nature, we focus on increasing N_y —that is, global output—by converting the resources provided by the biosphere into economic output at an ever-increasing rate, and then returning the remainder to the biosphere in the form of various wastes and pollution. In such a system, rising income is necessary to finance the protection of an environment that is in a state of continuous decline and to address growing social inequalities.

- (2) In line with its embeddedness in natural systems, the socio-economic system places emphasis on increasing τ_x and τ_z . This means it makes efforts to develop technologies that make the conversion of natural resources into economic output more efficient and that help reduce the release of waste and pollution into the biosphere.

The approach described in Perspective (1) results in an increase in impact inequality, whereas in the case of Perspective (2), the value of the numerators in the inequality decreases as the denominators increase, which implies a decline in demand for natural resources—that is, the inequality narrows. Although a policy based on perspective (2) would be ideal, in reality, some sort of optimal combination of perspectives (1) and (2) may lead to the development of a balanced, socially acceptable, and enforceable sustainability policy.

Sustainability research essentially seeks to design trajectories that can transform impact inequality into equality—that is, when the demand of human systems for natural resources does not exceed the regenerative capacity of natural systems. In other words, using the terminology of “planetary boundaries” as they apply to Earth’s systems, the environmental impacts of economic and social development must not exceed the “safe operating space.” The examination of possible trajectories addresses both sides of the equation (impact-inequality). On the right-hand side of the equation, ecological and economic research focuses on the biophysical processes and regenerative capacity of natural systems, as well as their interrelationships with human systems. On the left-hand side of the equation, research focuses on demographic processes, as well as technological and institutional development.

An Extension of the Solow Model: Technology

The original Solow (Solow–Swan) model [13] reflects the view that human systems are external systems outside the biosphere. In the neoclassical growth model [3], technology is a non-rival factor of production. Accordingly, the Solow model can be extended to include technology in addition to capital and labor ³⁴ :

$$[19] \quad Y(t) = A(t)[K(t)]^\alpha [L(t)]^{1-\alpha},$$

³⁴ Theoretical and empirical references: Aghion & Howitt, 2007; Mankiw et al., 1992), as well as (Tőkés, 2022).

which, in intensive form, is:

$$y = A(0)e^{gt} * k^{\alpha}$$

assuming that technology, $A(0)$, grows at an annual rate g at time $t = 0$. Thus, the fundamental Solow equation is as follows:

$$dk = s * A(0)e^{gt} * k^{\alpha} - nk$$

The capital-labor ratio k is a function of the exogenous variables s and n , as well as t , since the technology index grows at a rate of g over time. In empirical research, the Total Factor Productivity (TFP) index is used to describe A .

Total Factor Productivity

The Total Factor Productivity (TFC) index is a measure used in empirical research on economic growth within the neoclassical economic framework. It traditionally represents the portion of output (national income expressed as GDP) that cannot be attributed to the quantitative growth of production factors, quantitative growth of capital and labor, but rather encompasses factors such as technological advancement, institutions, markets, and the efficiency of other elements of the socio-economic system. In the OECD database ⁽³⁵⁾, TFP is referred to as *Multifactor Productivity* (MFP). TFC in the traditional sense—and thus the OECD's MFP indicator ⁽³⁶⁾—does not incorporate a sustainability perspective; that is, it does not account for the negative environmental impacts of economic activity: CO_2 , or equivalent greenhouse gas emissions, as well as various types of pollution and waste emissions ³⁷.

Another OECD indicator, *Environmentally Adjusted Multifactor Productivity* (EAMFP), takes into account the negative effects of environmental degradation on the functioning of the socioeconomic system. Specifically, it accounts for emissions (air pollution) resulting from the undesirable

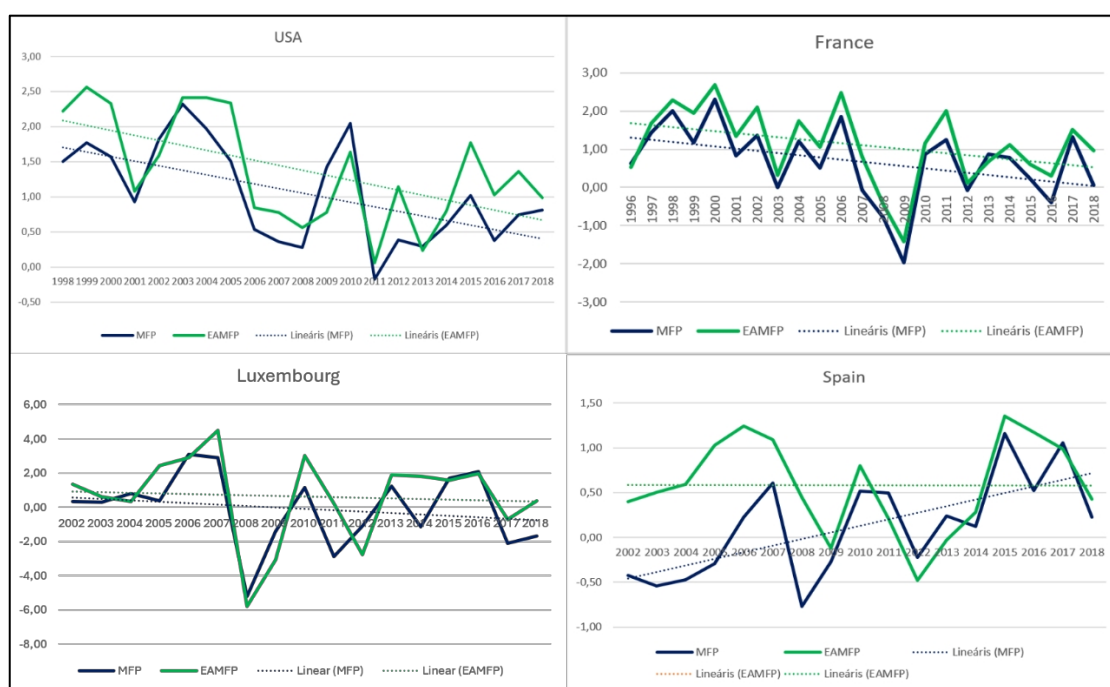
³⁵ Organization for Economic Cooperation and Development

³⁶ The OECD publishes MFP data in the form of indices and other units of measurement, as well as on a sector-specific basis.

³⁷ The OECD's 2026 productivity report: OECD (2026), *OECD Compendium of Productivity Indicators 2026*, OECD Publishing, Paris, <https://doi.org/10.1787/734a5e68-en>.

It treats by-products as such and considers natural capital, along with man-made (produced) capital and human capital, to be factors of production. Figure 3.11 shows three trends emerging in developed OECD countries: in the case of the United States and France, both MFP and EAMFP are in positive territory but are declining; in the case of Luxembourg, productivity is stagnating; in the case of Spain, MFP—starting from negative territory—is growing rapidly, while EAMFP has stagnated throughout the entire period. The EAMFP trend lines lie above the MFP trend lines in all four countries, albeit to varying degrees, which suggests a positive impact of the natural environment on economic development, even despite varying degrees of environmental degradation. Nevertheless, for methodological reasons, the values of the two indicators are not directly comparable: MFP is calculated based on highly detailed national statistical data, while EAMFP is derived using macroeconomic proxy indicators.

3- Figure 10: MFP and EAMFP Trends, Advanced OECD Member Countries, 1996–2018

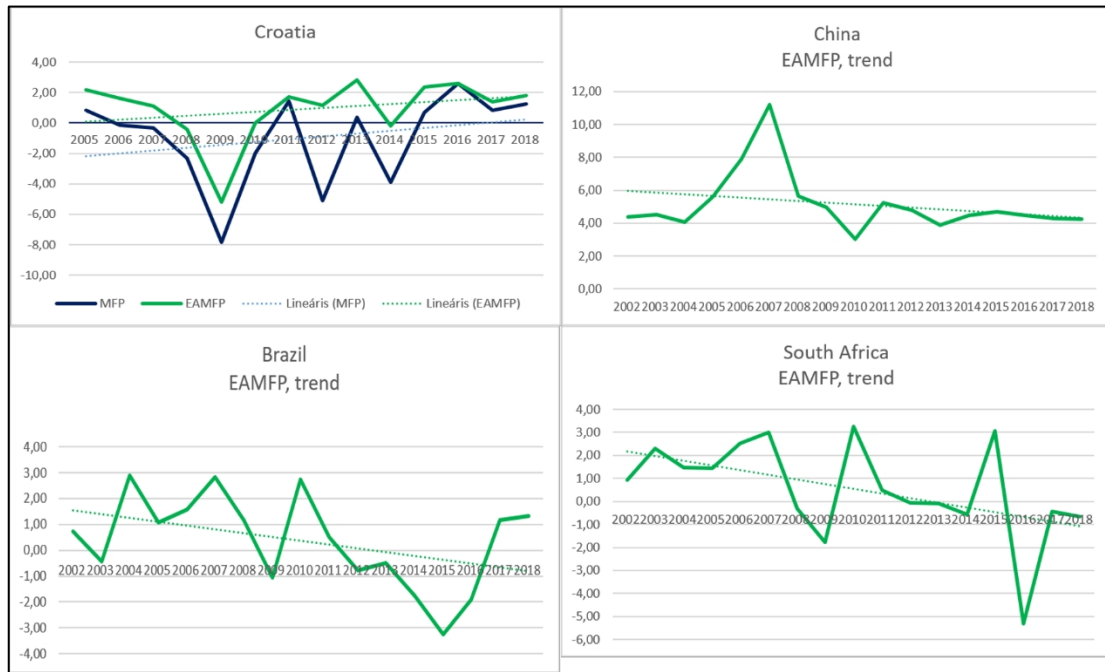


Source: Compiled by the author based on OECD data

Figure 3-11 shows productivity trends in non-OECD countries. For Croatia, both MFP and EAMFP data are available in the OECD database. For China, Brazil, and South Africa, MFP data are not available; therefore, the figure shows only EAMFP trends. As shown in the figure, productivity in Croatia is nearly stagnant but is growing slightly. In China, productivity growth is significant but is slowing slightly.

In Brazil and South Africa, productivity growth, which started from a moderate level, has slowed to zero over the course of two decades.

3- Figure 11: Productivity Trends, Non-OECD Countries, 2002–2018



Source: Compiled by the author based on OECD

data

Overall, with regard to sustainability, longer-term trends are the determining factor for both MFP and EAMFP; nevertheless, uncertainties related to measurement, methodology, and data harmonization remain key issues.

The Solow Model Extended to Include Natural Capital

The basic Solow model [13] , extended to include natural capital as a factor of production, is expressed as

the natural capital component $\underline{R}(t)$:

$$\underline{R}(t) = e^{ht} R(t) = e^{ht} R(0)e^{-ut} = R(0)e^{(h-u)t}$$

that is, the flow of natural goods at time $t = 0$ multiplied by a time-varying index that incorporates the qualitative change in nature (h) and the rate of depletion

(u). The extended Solow model includes *neutral technological progress* ³⁸, effective natural capital, and effective physical and human capital ³⁹. In the extended model, the production function is in Cobb-Douglas form, supplemented by the dynamic stock-flow equations for the factors of production:

$$[20] \quad Y(t) = A(t) * [\underline{K}(t)]^{\alpha}, [\underline{L}(t)]^{\beta}, [\underline{R}(t)]^{\gamma}$$

Where:
e:

- $A(t) = A_0 e^{gt}$ (g—the rate of neutral technological progress)
- $\underline{K}(t) = e^{jt} K(t)$ (j – the rate of qualitative growth of capital)
- $\underline{L}(t) = e^{mt} L(t)$ (m – the rate of qualitative growth of the labor force)
- $\underline{R}(t) = e^{ht} R(t)$ (h – the rate of growth in the quality of natural resources)

The dynamic stock-flow equations:

- (1) $I(t) = S(t)$ (the macroeconomic equilibrium condition)
- (2) $S(t) = sY(t)$ (s – savings rate)
- (3) $L(t) = L_0 e^{nt}$ (n – the natural growth rate of the labor force)
- (4) $R(t) = R_0 e^{-ut}$ (u – rate of depletion of natural resources)

Using the dynamic factor flow functions (1) through (4), the transformed and simplified production function is as follows (without the t notation):

$$Y = A(0)e^{\theta t} K^{\alpha} L^{\beta} R^{\gamma},$$

where $\theta = g + \alpha j + \beta m + \gamma h$,

the comprehensive growth rate of Total Factor Productivity. Using this, the growth in output per unit of labor is described by the following formula:

³⁸ technological progress that does not alter the relative proportions of production factors in the production process; that is, physical capital and labor are used in the same proportions in the production of more output.

³⁹ “Effective” refers to changes in time and quality.

$$\frac{dy}{y} = \theta + \left[\frac{sy-nk}{k} \right] - (1-\alpha-\beta) * n - \gamma - \frac{u}{y}$$

Due to labor efficiency, economic growth, $\frac{dy}{y} > 0$, can be achieved if:

$$[21] \quad \theta + \left[\frac{sy-nk}{k} \right] > (1-\alpha-\beta) * n + \gamma + \frac{u}{y}$$

Equation [21] is an important expression of the condition for sustainability, which means that, in the long run, sustainability must be balanced by advancements in technology, physical capital, and labor (human capital), as well as natural resources (renewable and non-renewable natural capital) must, in the long run, offset or exceed the loss of labor productivity and the diminishing returns to labor (diminishing returns to labor)—as the economy approaches a steady state, i.e., the value of k^* shown in Figures 3–4.

Based on the above, economic growth $\frac{dy}{y}$ can be described by the following conceptual relationship:

$$\frac{dy}{y} = f(\overset{+++}{g}, \overset{+++}{j}, \overset{+++}{m}, \overset{+++}{h}, \overset{+++}{s}, \overset{+++}{\alpha}, \overset{+++}{\beta}, \overset{+}{\gamma}, \overset{-}{n}, \overset{-}{u})$$

On the right-hand side of the equation, the symbols above the factors indicate a causal relationship between each factor and changes in emissions: changes in per capita emissions have a positive causal relationship with technological progress (g), changes in the quality of production factors (j , m , h), the savings rate (s), and the partial output elasticities of physical capital and labor (α and β)⁴⁰. Empirical data do not support a clear relationship between the level of economic development (γ) and economic growth; however, economic growth is negatively affected by the growth of the labor force, n , and the rate of depletion of natural resources, u (Hess, 2016).

⁴⁰ In other words: factor income share.

The Dasgupta Growth Model

Dasgupta proposed an extension of the general production function [3] by distinguishing between renewable and non-renewable natural capital as factors of production (R and NR, respectively) (Dasgupta, 2021), which, in the form of the Cobb-Douglas function ⁴¹, is as follows:

$$[22] \quad Y = A * R^\beta * K^a * H^b * NR^{(1-a-b)}, \text{ where } \beta > 0; a, b, (1 - a - b) > 0.$$

Compared to the neoclassical growth model (equations in [3], [7], and [8]), the variables in the Dasgupta model [22] have the following meanings:

A represents technological progress, which is a public good and is represented in economic analyses by total factor productivity (TFP). K^a , H^b , and $NR^{(1-a-b)}$ are the factors of production: K is man-made capital. It is important to note that, unlike in Equation [3], it is not L (labor) but H (human capital) that appears here. NR represents the flow of non-renewable natural capital resources (minerals and energy sources: coal, oil, and gas), as well as the flow of renewable components of natural capital, namely the provisioning services provided by ecosystems (timber, fibers, fish, etc.)⁴². The factors' coefficients—the factor shares, whose sum is 1—express constant returns to scale and the substitutability among factors. $A * R^\beta$ is total factor productivity, which expresses the economy's constraints—that is, the fact that human systems and the global economy are embedded in a finite biosphere. R is natural capital (the “stock” of ecosystems), which provides sustaining and regulating services to human systems (the socio-economic system): climate regulation, soil regeneration, disease control, regulation of the water, carbon, and nitrogen cycles, etc.:

“... (sustaining and regulating services)—their mere presence makes human existence possible. In contrast, the economy ‘draws upon’ provisioning (and cultural) services. It is essential to distinguish between our existence in nature and our dependence on nature...”
(translated by the author (Dasgupta, 2021)).

⁴¹ The variables are time-dependent (t), which is omitted from the equation for the sake of simplicity.

⁴² Environmental economics classifies the services provided by ecosystems into provisioning, regulating, and

supporting services, as well as cultural services (Haines-Young & Potschin-Young, 2018).

Similar to the neoclassical growth model, the Dasgupta model consists of a production function and stock-flow functions describing the dynamic changes in production factors⁴³ :

$$[23] \quad Y = A(t)R^\beta(t)K^a(t)H^b(t)NR^{1-a-b}(t), \quad \beta > 0; a, b, (1-a-b) > 0.$$

$$[24] \quad \frac{dR(t)}{dt} = G(R(t)) - f(NRR(t)) - \frac{Y(t)}{\alpha_z(A)}, \quad \alpha^* > \alpha_z(A) > 0$$

Equation [24] describes the change in natural capital, which depends on the renewability of natural capital, G , which in turn depends on the stock of natural capital, R , minus the degradation resulting from the depletion of non-renewable natural capital stocks $NRR(t)$, and minus the degradation resulting from natural capital's function as a sink for waste and pollution.

The regenerative capacity of the closed biosphere is therefore a function of natural capital, R , as expressed by the following equation:

$$G(R) = rR(1 - \frac{R^*}{R})(R - T)/R^*, \text{ where } r, R^*, T, (R^* - T) > 0$$

R^* represents a stable equilibrium state of the natural system; T represents an unstable threshold. Therefore, R approaches zero when $R < T$, and tends toward R^* when $R > T$ (Dasgupta, 2026).

$NRR(t)$ consists of two components: the non-renewable component of natural capital (minerals and energy sources) and the provisioning services of renewable natural capital (ecosystems) (timber, fibers, fish). The degradation of natural capital also depends on economic output $Y(t)$ and the efficiency parameter α_z , which expresses the level of efficiency (A) of technologies and institutions: a quantification of how the biosphere is transformed as a result of global waste and pollution. With improving technology and

institutional standards α_z , the $\frac{Y(t)}{\alpha_z(A)}$ decreases, which represents a reduction in the negative impacts

α_z is bounded from above, so it cannot exceed the value α^* , which means that the negative impact on nature resulting from waste and pollution never disappears.

⁴³ The domain of validity of the Dasgupta model is the safety zone of the planetary boundaries described by Rockström.

$NRR(t)$ also depends on the efficiency of converting natural resources into income, α_X , which is a function of the level of technology.

$$(A): NRR(t) = Y(t)/\alpha_X.$$

$$[25] \quad \frac{dR(t)}{dt} = G(R(t)) - \frac{Y(t)}{\alpha_X(A)} - \frac{Y(t)}{\alpha_Z(A)}$$

According to Equation [25], technological and institutional progress affects environmental degradation in two ways: natural resources can be converted more efficiently into economic output (income), and the amount of waste and pollution can be reduced while maintaining the same level of economic output. In this way, Dasgupta's growth model stylizedly reflects the circular economy model.

The dynamics of changes in the global population $N(t)$ are described by Equation [26]. $h(t)$ represents per capita human capital, so $H(t) = h(t) * N(t)$. Population change cannot be directly regulated: the possibility of indirect regulation lies in investing in human capital, which involves investment in education (including improving educational opportunities for women), healthcare, and the knowledge industry, as well as promoting access to modern family planning services for the broadest possible segments of society. These factors determine the number of children families plan to have, and thus the long-term population size, J , which decreases as per capita human capital increases.

$$[26] \quad \frac{dN(t)}{dt} = N(t)[J(h) - N(t)], \quad J > 0, \quad \frac{dJ(h)}{dh} < 0$$

$$[27] \quad \frac{dH(t)}{dt} = \frac{N(t)dh(t)}{dt} + \frac{h(t)dN(t)}{dt} = \overset{(t)}{H}$$

A According to Equation [27], the change in human capital is equal to investment in human capital, I_H , which is equal to the sum of the product of the population, which varies as a function of per capita human capital, and the product of per capita human capital, which varies as a function of the change in population.

Equation [28] describes the change in so-called produced capital: the change in produced capital is equal to the difference between output (income), $Y(t)$, and consumption, $C(t)$, and the depreciation of man-made capital assets, $\lambda K(t)$.

$$[28] \quad \frac{dK(t)}{dt} = Y(t) - C(t) - \overset{H}{I}(t) - \overset{A}{I}(t) - \lambda K(t)$$

$I_A(t)$ is the sum of investments in technology and institutions [29].

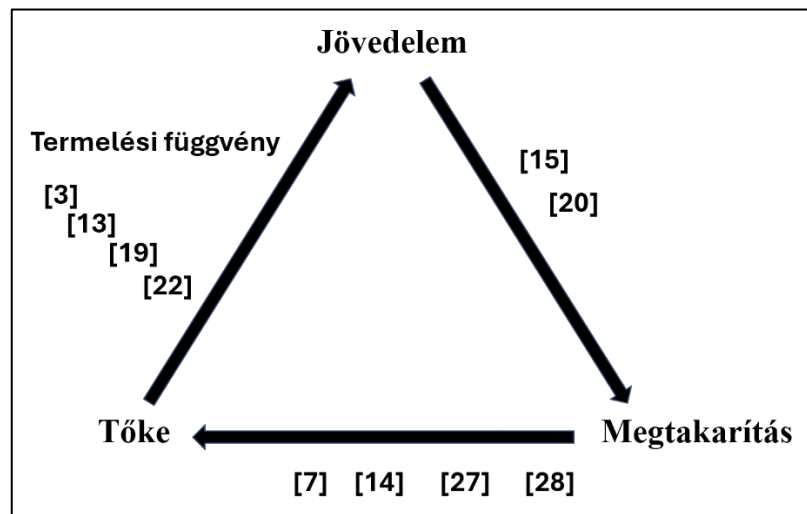
$$[29] \quad \frac{dA(t)}{dt} = I_A(t).$$

Equations [23], [25], [26], [27], [28], and [29] together form the highly stylized growth model proposed by Dasgupta.

Macroeconomic Analysis

The relationships between output (income), savings, and capital are central to the study of economic growth, as illustrated in Figure 3-12. The basic concept is that capital forms the basis for income generation, and this income is then divided between consumption and savings. Savings are invested in various forms of capital, which constitutes capital accumulation. The increased capital then enables the generation of increased income, and so on.

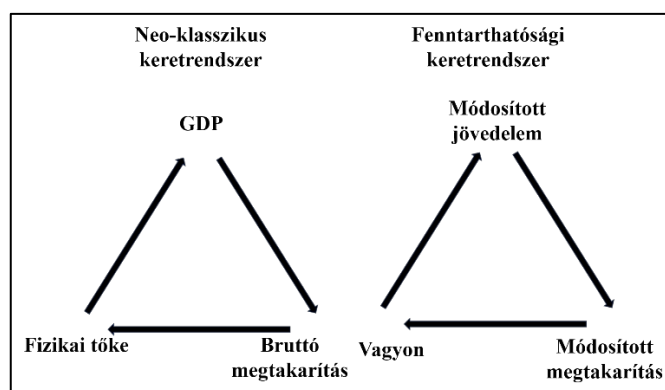
3- Figure 12: The Macroeconomic Business Cycle



The key issue in growth accounting—namely, how the accumulation of different types of capital affects income growth—is expressed by the production function located on the capital-income side of the growth triangle: the equation of the neoclassical model [3]; the equation of the basic Solow model [13]; the production function of the technology-extended basic Solow model [19]; and the production function of the Dasgupta model [22]. The relationship between income and savings is expressed by the equations in [15] and [20], while capital accumulation is expressed by dynamic stock-flow functions, the latter of which are located on the *Savings–Capital* side of the triangle: [7], [14], [25], [27], and [28].

In traditional empirical analyses of economic growth within the neoclassical framework, the indicators shown on the left side of Figure 3-13 are used: GDP⁴⁴ is used to measure income; savings are characterized by the gross savings indicator; and capital refers to physical, man-made fixed capital in the traditional sense. The data for these indicators come from national statistics, and their time series stretching back several decades are also published by international databases such as the Penn World Table ⁴⁵, the data banks of international organizations, the OECD, the World Bank, etc. From a sustainability perspective, the problem with these indicators is that their calculations do not take into account either the depreciation of physical capital (machinery, equipment, buildings, infrastructure) or the environmental damage caused by economic activity.

3- Figure 13: Indicators of the macroeconomic growth cycle in the neoclassical and sustainability frameworks



Source: Compiled by the author

The sustainability indicators are located within the triangle shown on the right side of Figures 3–13, in the sustainability macroeconomic framework: income and savings, which are modified versions of the income and savings indicators used in the neoclassical framework; wealth includes not only man-made fixed capital but also human and natural capital. The sustainability framework differs from the neoclassical system in two ways: (1) it takes into account the costs arising from economic activity—that is, from the production of output,

⁴⁴ Gross Domestic Product (GDP)

⁴⁵ The PWT is one of the most important data sources for economic analysis. It was originally developed at the University of Pennsylvania and is currently maintained by the Groningen Growth and Development Centre at the University of Groningen (<https://www.rug.nl/ggdc/productivity/pwt/?lang=en>).

depreciation, social, and environmental costs. Furthermore, (2) in addition to fixed capital and labor, other elements of human capital and natural capital also contribute to the generation of income. In practice, the compilation of sustainability indicators is problematic for two reasons: on the one hand, it is a highly complex task to determine exactly which assets should be included in the total stock of wealth; on the other hand, when valuing different assets—especially non-market goods—it is very difficult to develop generally accepted methodologies. Nevertheless, the databases of international organizations and some innovative national statistics provide an increasingly wide range of approximate data, such as the World Bank Open Data database or the OECD database.

Discussion Topic

What is the fundamental conceptual difference between neoclassical and sustainable growth models? What is the significance of this difference in terms of economic growth?

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4. Chapter Natural Capital as Wealth

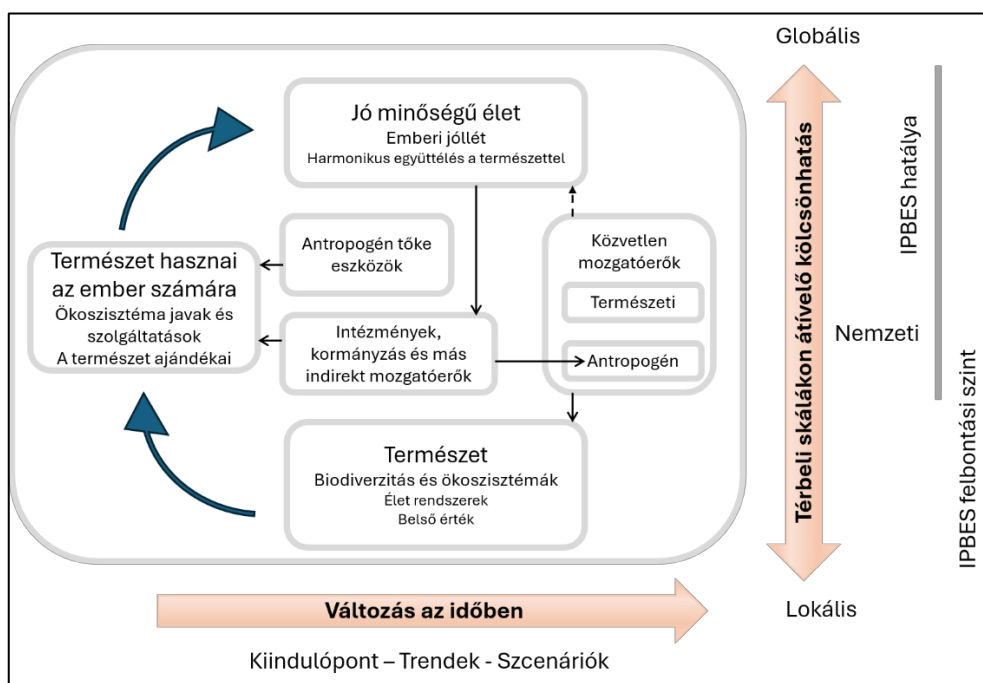
Learning Objectives

This chapter explains why and how the natural environment is treated as a capital asset in modern economics. It presents a conceptual framework for understanding ecosystems and ecosystem services and describes the characteristics of urban ecosystems. It describes the benefits nature provides to human systems and explains how to interpret the key criteria for sustainability. It discusses methods for valuing natural capital, the challenges associated with them, and the opportunities offered by artificial intelligence.

The Concept of Natural Capital

To study the complex interactions between human and natural systems, the first task is to define the relationship between humans and their natural environment. The United Nations Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) has developed a conceptual framework that synthesizes multiple objectives (Figure 4-1), primarily for the purpose of assessing and generating the knowledge necessary for policy planning.

4- Figure 1: Conceptual framework of the relationship between human and natural systems



Source: Compiled by the author (based on Díaz et al., 2015)

The model shown in the figure illustrates the connection between human and natural systems:

- *Nature is the natural world characterized by the diversity of living organisms and their interactions with one another and their environment. Nature encompasses categories and functions: biological diversity, ecosystems, ecosystem functioning, the biosphere, living natural resources, anthropogenic assets, tools, built infrastructure, institutions, knowledge, technology, financial instruments, etc.;*
- *Benefits derived from nature: benefits that individuals, communities, nations, etc., derive from nature—ecosystem goods and ecosystem services;*
- *Indirect driving forces: institutions and systems of management and governance through which people, communities, and societies organize their interactions with nature;*
- *Direct driving forces: natural and anthropogenic factors beyond human control, such as climate and weather, and extreme natural events (droughts, tropical cyclones, earthquakes, volcanic eruptions, etc.);*
- *The good life: the realization of a fulfilled human life, which can vary significantly depending on the nature of individual societies. At the same time, the vision of a high-quality life and a successful society have a decisive influence on institutions, systems of governance, and how these influence the direct drivers.*

Elements of Natural Capital

Modern environmental economics views nature, along with man-made physical capital and human capital, as a form of capital that provides the primary resources necessary for the functioning of the socio-economic system. What distinguishes natural capital from other forms of capital is that certain of its components cannot be substituted with other types of capital assets, such as human or physical capital. In neoclassical economic growth models, physical or produced capital (machinery, equipment, buildings, and infrastructure) and labor (i.e., human capital) are *exclusive* factors of production; that is, a given capital asset is used exclusively by a single economic entity. In contrast, technology is a non-exclusive factor of production, because a given technology can be used by multiple economic agents.

Economists have long viewed nature as playing a role in the functioning of human systems and the economy. Macroeconomic theory integrates natural capital as a factor of production that determines economic output. Similar to human capital

(as discussed in the box below), natural capital differs conceptually in many respects from man-made (produced or physical) capital, and its characteristics are as follows:

- certain components of natural capital are limited resources, and, like other types of capital, are not indispensable: they can be substituted with other types of capital assets, such as manufactured or human capital;
- other components of natural capital, particularly renewable natural capital, are essential capital assets that cannot be substituted with other types of capital assets, such as produced or human capital;
- certain elements of renewable natural capital can be utilized indefinitely: for example, the generation of electricity or thermal energy from solar energy does not deplete the resource;
- other elements of renewable natural capital are capable of regeneration...

Human Capital

In neoclassical economic thought, human capital refers to the labor force, which is defined by the number of people in the labor market, as well as their skills, education, and health. The question is whether human capital encompasses only those employed in the manufacturing and service sectors, or whether it also includes a broader segment of society, such as those who perform some other value-added activity outside the formal labor market—for example, domestic workers, mothers or relatives raising children, and others who provide the conditions necessary for the family to function. Economics traditionally views human capital as a narrowly defined factor of production, whose “asset” value is calculated as the present value of expected future earnings. It is much more difficult to determine the value of human capital for those outside the labor market. This problem arises, for example, in the calculation of GDP, when non-market activities—such as household work or caring for the sick within the family, which are clearly valuable activities—are not taken into account as part of national income. How can we consider the value of goods and services produced in non-traditional markets as part of the income generated by society, and how should we regard those who produce non-market goods and provide non-market services as part of human capital?

Natural capital is the totality of natural resources available to the socio-economic system.

Definition: "...Natural resources are those resources available to a given community at a given point in time or during a given period that are either completely independent of voluntary human activity or whose existence is inseparably and decisively dependent on natural factors." (Kerekes et al., 2018) (Translated by the author).

Natural capital consists of exhaustible (non-renewable) and non-exhaustible (renewable) components. Non-renewable natural resources include mineral deposits and fossil fuel reserves: however, only identified, economically extractable reserves are considered part of natural capital, as opposed to hypothetical or speculative resources, or those that cannot be extracted economically. The components of renewable natural capital include arable land, forest and fish stocks, as well as all other natural resources, regardless of whether they or not. An *ecosystem* is a concept that encompasses all natural resources within a specific, defined geographical area.

The concept of a natural ecosystem

"... An ecosystem is a geographic area, a system composed of living organisms interacting with their living and non-living environment. The biotic (living) and abiotic (non-living) components of an ecosystem are interconnected through the flow of nutrients and energy. Biotic factors include plants, animals, and other living organisms. Abiotic factors include rocks, temperature, and humidity. Every part of an ecosystem depends directly or indirectly on every other part of the ecosystem. Changes in an ecosystem's temperature influence the types of plants that live there. Herbivorous animals must adapt to these changes: they either move to a different ecosystem or perish. ... Ecosystems can range from large and extensive to very small. Tidal pools—the pools left behind by the ocean when the tide goes out—are, for example, complete, tiny ecosystems. In tidal pools, seaweed, which is a type of algae, carries out photosynthesis. The formation and change of tidal pools depend on changes in the ocean's water level. The organisms in tidal pools are able to survive while submerged in seawater and amid the clashing ocean currents that occur at low tide. As the tide recedes, these organisms survive exposure to sunlight and higher temperatures. For example, seaweed has a protective coating that prevents it from drying out in the sun. In this way, the biotic components of the ecosystem depend on and adapt to abiotic factors."

The entire surface of the Earth is a network of interconnected ecosystems. Ecosystems are often linked to one another as parts of larger biomes. Biomes are large geographical units of land, sea, or atmosphere defined by climate, geography, and the plants and animals that inhabit them. The five main biome types are deserts, aquatic habitats, tundras, grasslands, and forests. Humans are also part of ecosystems: indigenous communities, for example, have lived as part of local ecosystems for many generations without overexploiting the resources provided by those ecosystems.”

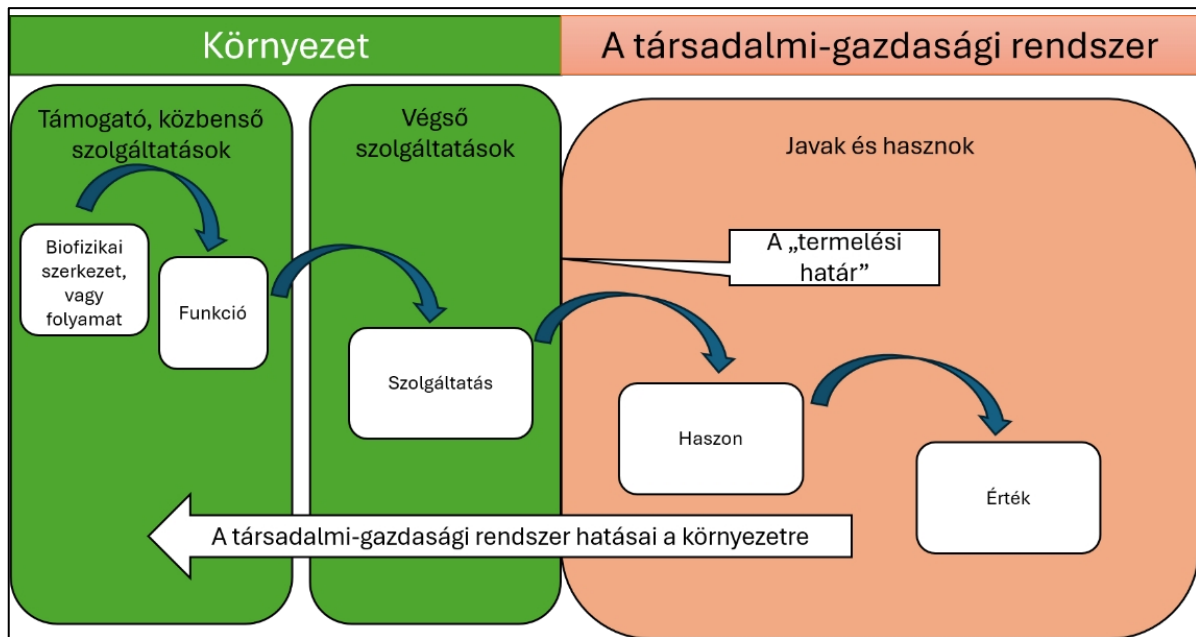
Source: National Geographic <https://education.nationalgeographic.org/resource/ecosystem/>

Ecosystem Services

The concept of an ecosystem captures the functioning of the system itself, while ecosystem services refer to the direct and indirect benefits that the socio-economic system derives from nature and its processes. The ecosystem goods and services produced by ecosystems through the interaction of biotic and abiotic processes contribute to the functioning of the socio-economic system and to human well-being.

The *Common International Classification of Ecosystem Services* (CICES) is a universally accepted, standardized classification system developed by the European Environment Agency that provides a framework for designing ecosystem accounts.

4- Figure 2: The CASCADE model of ecosystem services



Source: Adapted by the author, based on (Potschin & Haines-Young, 2011)

CICES⁴⁶ interprets the steps of the CASCADE model—the “production chain”—as follows (Figure 4-2):

- Ecosystems consist of physical, biological, and chemical components, such as soil, water, plant and animal species, and nutrients. The interactions among and within these components enable the ecosystem to perform certain functions. Ecosystem functions, in turn, determine the system’s ability to provide services and benefits to human systems. The building blocks of ecosystem functions are the interactions between structure and processes, which can be physical (e.g., water infiltration, sediment transport), chemical (e.g., reduction, oxidation), or biological (e.g., photosynthesis, denitrification), where “biodiversity” plays a role to a greater or lesser extent in all of them, although the exact details of the relationship are often unclear.
- - The capacity to provide a service is independent of whether there is a demand for it or not. According to the cascade model, this capacity only becomes a service when it is clearly

⁴⁶ Common International Classification of Ecosystem Services: a standardized international classification system for ecosystem services developed under the guidance of the European Environment Agency.

who benefits from it. The combination of structures, processes, and functions generates the services that ultimately benefit humans by supporting the functioning of society and the economy and promoting human well-being

- *To avoid the problem of “double counting,” a distinction must be made between ecological phenomena (functions), their direct and indirect contributions to human well-being (services), and the welfare benefits generated by these services. The key point is that the valuation of benefits should be limited to what is directly “consumed or used” by the beneficiary, as this already incorporates the value of the associated ecological structures and processes.*

The “services” of ecosystems refer to the goods and services produced by ecosystems. The latest version of the Common International Classification of Ecosystem Goods and Services (CICES, V5.2) distinguishes *between ecosystem services* (Table 4-1) (biotic/biophysical) and *geosystem outputs* (Table 4-2). The former are biotic/biophysical services, while the latter are abiotic/geophysical services. Both consist of three broad thematic categories of outputs:

- *provisioning;*
- *regulating and sustaining;*
- *cultural;*

The outputs can be further classified into nine general classes under these categories. CICES is a reference classification system designed to include equivalence tables linked to the ecosystem accounts system, which is part of the Environmental Economic Accounting System ⁴⁷.

4- Table 1: Ecosystem Services, CICES V5.2

Ecosystem services	Provisioning (Biotic/biophysical)	biomass
		Genetic resources derived from biota
		other provisioning services
		Conversion of biochemical and physical inputs into ecosystems

⁴⁷ System of Environmental-Economic Accounting (SEEA), an international statistical standard developed by the United Nations Statistics Division.

	Regulatory and sustaining (Biotic / biophysical)	regulation of fundamental flows and extreme events (erosion control, wind protection, protection against flash floods and fires)
		Regulation of physical, chemical, and biological conditions (habitat protection, protection of genetic resources)
		other regulatory and maintenance services
	Cultural (Biotic / biophysical)	Physical and experiential interaction with the natural environment (health, rejuvenation, enjoyment)
		Intellectual interactions with the natural environment (scientific research, ecological studies, education)
		Spiritual, symbolic, and other cultural interactions with the natural environment
		Other

Source: www.cices.eu

4- Table 2: Geo-system-level outputs, CICES V5.2

Geosystem-level outputs	Supply (abiotic/geophysical)	water
		Non-aquatic ecosystem outputs
	Regulatory and sustaining (abiotic / geophysical)	Conversion of biochemical or physical inputs into an ecosystem
		Regulation and maintenance of geophysical processes
		other regulating and supporting services
	Cultural (abiotic / geophysical)	Physical and experiential interactions with the natural environment (health, rejuvenation, enjoyment)
		Intellectual interactions with the natural environment (scientific research, ecological studies, education)
		Spiritual, symbolic, and other cultural interactions with the natural environment
		Other

Source: www.cices.eu

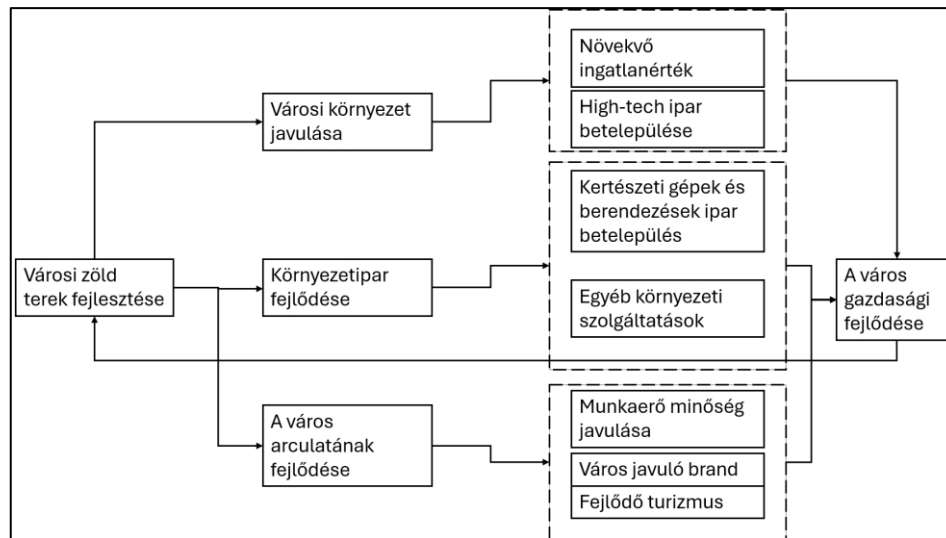
Ecosystems, as capital assets, when properly “maintained,” are capable of providing the socio-economic system with essential goods such as timber, marine and freshwater fish, medicinal plants, and raw materials for medicines, as well as vital services such as pollination and water purification. Furthermore, the natural environment—with its aesthetic beauty and tranquility—is an indispensable service for human existence. Thus, ecosystems are essentially capital stocks that have the potential to provide essential goods and services for the functioning of the socio-economic system, both now and in the future.

Urban Ecosystems and Ecosystem Services

Communities living in cities form social and economic units whose functioning is fundamentally shaped by their organic connection to their natural environment—urban ecosystems—a relationship characterized by close interdependence and mutual interaction. Thus, the city is one of the most important venues for the conservation, development, and enhancement of the natural resources available to the socioeconomic system, where the services provided by natural systems and ecosystems directly influence the quality of life and well-being of the urban population, and, in a broader sense, the functioning and performance of the socioeconomic system, in both positive and negative ways. The city is the most direct site of connection between humans and the natural environment, where the interaction between human and natural systems is most intense. The impact is reciprocal: the condition and extent of urban ecosystems significantly influence the city’s functioning, the well-being of its population, and the economy; conversely, the city’s functioning has a significant impact on the condition of the urban natural environment.

Urban ecosystems are complex ecological systems in which living organisms and their non-living environment function as an organic whole, in close interaction with the human-made environment. Figure 4-3 illustrates the interplay between the city and the development of urban green spaces and ecosystems:

Figure 4- 3. The Impact of the Development of Urban Green Spaces on a City's Economic Development



Source: Compiled by the author (based on Zhou et al., 2022)

Urbanization has both direct and indirect effects on a city's natural environment and vegetation. The direct effect is generally negative: a decrease in natural land cover with vegetation and an increase in impervious surface cover that prevents precipitation from penetrating the ground. The latter prevents the absorption and storage of stormwater in the soil and vegetation. The indirect impact of urbanization on vegetation is generally characterized by higher air temperatures, caused by the city's built-up areas and economic activities. The unique nature of the interaction between human and natural spaces is reflected in the specific classification of urban ecosystem services:

Provisioning urban ecosystem services:

- Urban food production (urban and suburban farms, rooftops, backyards, community gardens)
- Water supply: water storage and regulated water

flows Regulating urban ecosystem services:

- Regulation of urban temperature (buffer zones to prevent the formation of heat islands);
- Air purification, reduction of air pollution;
- Noise reduction;
- Temperature reduction;
- Stormwater drainage;

- Pollination;

- Pest control, promoting seed dispersal;
- Mitigation of extreme weather events;
- Contribution to global climate regulation;

Cultural urban ecosystem services:

- Recreation;
- Aesthetic experience;
- Impact on the human psyche;
- Strengthening ecological awareness
- Increased value of homes (rising real estate prices)
- Strengthening social cohesion

Biodiversity

Ecosystems are elements of ecological capital that, unlike traditional, human-produced physical or manufactured capital, have three important distinguishing features: (1) the range of goods and services provided by ecosystems is very broad; (2) the value of ecosystem capital assets, similar to that of produced capital assets, can be increased through investment, such as various nature conservation projects and nature-based *solutions*. Ecosystem degradation often results from habitat loss, changes in land use, or pollution, and their restoration is not an investment project in the traditional sense; (3) The depletion of ecosystems leads to the irreversible destruction of ecological structure, and if restoration is not feasible due to high costs, this irreversible transformation increases the risk of ecological collapse. In other words, shock events or prolonged interventions can trigger processes that lead to the crossing of an ecological threshold, causing the ecosystem to shift from one operational state to another. It is possible that, under certain circumstances, the system will return to its original state, but it is also possible that the change will become permanent. These processes depend to a large extent on the state of nature, which is described by the concept of biological diversity. Partha Dasgupta refers to biological diversity as the foundation of sustainability.

<i>The</i>	<i>Dasgupta's</i>	<i>report:</i>
<i>sustainability,</i>	<i>biodiversity</i>	<i>and wealth-</i>
<i>oriented economic development</i>		

Partha Dasgupta, an English economist of Indian origin and Frank Ramsey Professor Emeritus at the University of Cambridge, is the editor and, to a large extent, the author of this approximately 600-page work commissioned by the United Kingdom's Treasury..., whose central theme is sustainability and whose foundation is biodiversity. By synthesizing various scientific disciplines, he analyzes the relationship between the biosphere and human systems, summarizing his findings in the form of a framework, an economic theory, and a macroeconomic growth model.

Sustainability—and its readily apparent components, such as climate, biodiversity, and their changes—have taken center stage in the interests of science, politics, and public opinion in recent decades, and it has become clear that there is a need for a comprehensive interpretation of their social and economic causes and consequences, precise definitions of their concepts, and a new growth model that enables empirical research. Dasgupta ... offers just that.

...According to Dasgupta, the pursuit of sustainability involves the intergenerational management of the portfolio of resources available for the functioning of the socioeconomic system. This is “inclusive wealth”—the sum of produced, human, environmental, and social capital—which serves as the source of present and future incomes. If this wealth increases over a given period, then the socioeconomic system has changed in a sustainable direction; if it decreases, it has not. This is the essence of the wealth-based approach to sustainability, and the significance of the Dasgupta model lies in the fact that, with the appropriate data, sustainability can be empirically examined based on the model. As a result, this model—and the wealth-based approach developed by Dasgupta, which builds on the earlier work of other renowned economists—has entered the mainstream of economic thought and has also become a tool of global development policy. This is evidenced by the World Bank's public database supporting the model, which spans approximately three decades and draws on data sources including the System of Environmental-Economic Accounting (SEEA) developed by the United Nations Statistics Division. The integration of the SEEA into national statistical systems is currently underway in many countries around the world, including Hungary, and is expected to improve the accuracy of data on the capital components of environmental assets in particular.

The model is based on two fundamental principles: first, that the socio-economic system is embedded in the biosphere; and second, that the finite nature of the biosphere imposes a limit

on economic growth. This differs fundamentally from traditional models that imply unlimited growth; therefore, it fundamentally changes economic thinking and, as a result, economic modeling as practiced to date, particularly with regard to the long-term perspective. A critical

question is what we consider the long term, and to what extent and over what time horizon the toolkit of traditional economics can be applied to economic performance, trade, distribution issues, savings, etc. Especially since, due to climate change, the loss of biodiversity, and the dramatic increase in social inequalities, the “long-term” problems are coming ever closer...”

Source: (Kovács, 2022)

The issue of biodiversity has long been a key concern in international environmental policy. The United Nations Convention on Biological Diversity ⁴⁸, adopted in 1993 in Rio de Janeiro by 196 UN member states and the European Union, defines biodiversity as *“the variability among living organisms from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems themselves”* (Source: Act LXXXI of 1995) ⁴⁹. The 15th Conference of the Parties to the Convention adopted the *Kunming-Montreal Global Biodiversity Framework* in 2022, which set ambitious goals for the period leading up to 2050:

- ... its vision is a world where people live in harmony with nature, where biodiversity is valued, conserved, restored, and wisely used, where ecosystem services are maintained, and where a healthy planet is preserved to ensure that the basic needs of all people are met...
- ...its mission is as follows: to take urgent action to halt and reverse the loss of biodiversity; to restore nature for the benefit of people and the planet through the conservation and sustainable use of biodiversity, as well as ensuring the fair and equitable sharing of benefits arising from the use of genetic resources, and by providing the necessary means to implement all of these...

The three main objectives of the Convention on Biological Diversity are as follows:

⁴⁸ United Nations Convention on Biological Diversity

⁴⁹ The United Nations Convention on Biological Diversity was promulgated in Hungary by Act LXXXI of 1995.

1. The conservation of biological diversity;
2. The sustainable use of the components of biological diversity;
3. The fair and equitable
4. Fair and equitable sharing of the benefits arising from the use of genetic resources.

These broadly defined objectives are articulated in the four specific goals detailed in the text box:

The Goals of the Kunming-Montreal Framework Agreement on Biodiversity by 2050

Goal A: To conserve, enhance, or restore the integrity, connectivity, and resilience of all the Earth's ecosystems, significantly increasing the area of natural ecosystems; To halt the human-caused extinction of known threatened species and reduce the extinction rate and risk for all species to one-tenth of current levels; Increase the abundance of native, wild species to healthy and resilient levels; maintain genetic diversity within populations of wild and domesticated species, preserving their adaptability.

B Objective: Biodiversity must be used and managed in a sustainable manner; the benefits that nature provides to people, including ecosystem functions and services, must be valued, maintained, and enhanced, and those currently in decline must be restored, thereby supporting sustainable development for the benefit of present and future generations.

C Objective: Monetary and non-monetary benefits arising from the utilization of genetic resources and digital sequence information on genetic resources, as well as, where applicable, traditional knowledge associated with genetic resources, must be shared fairly and equitably, including, where applicable, with indigenous peoples and local communities. The adequate protection of traditional knowledge associated with genetic resources must be significantly enhanced, thereby contributing to the conservation and sustainable use of biological diversity, in accordance with internationally accepted principles of access and benefit-sharing...

Goal D: ... for all Parties, in particular developing countries, least developed countries, and small island developing States... adequate means necessary for full implementation must be ensured—including financial resources, capacity-building, technical and scientific cooperation, and access to technology...

Valuation of Natural Capital and Ecosystems

According to the conceptual framework discussed above, ecosystems are natural assets and capital resources that provide various goods and services—in other words, *ecosystem services*—to human systems, thereby contributing directly or indirectly to human well-being, welfare, and a good life. Ecosystems, as a collection of diverse, interrelated natural elements, function as the source of ecosystem

function as sources of services—that is, primary goods and services—and provide these goods and services in the form of various flows of goods and services to the economy and, in a broader sense, to the socioeconomic system. The economic value of ecosystems is therefore determined by the value of the goods and services they provide, that is, the extent to which they contribute to the functioning of the socioeconomic system—through interactions with other types of capital (both human-made physical capital and human capital)—in pursuit of the goal of human well-being (Costanza, 2020). Thus, the economic value of ecosystems is determined by the value of the temporal flow of goods, products, and services they provide. Conceptually:

At a given time t , the economic value of natural capital to the socioeconomic system is the present value of the total stream of benefits provided over time, from the present to infinity (t to ∞).

Methods for valuing ecosystem services can be categorized in several ways ⁵⁰ : however, in practice, three main methodological approaches can be distinguished (Marjainé Szerényi & Kovács, 2018)

1. *Valuation at market prices*: this method can be applied when a market for the natural resource or service exists.
2. *Cost-based valuation*: This method is also based on market prices, but the value is determined based on the value of environmental goods or services that are closely linked to the asset being valued (for example, the cost of increasing productivity on agricultural land, or the cost of restoring damage that has been avoided);
3. *Revealed preference method*: an estimation of the value of a natural asset by inference, e.g., using *the travel cost method*⁽⁵¹⁾ or other *hedonic pricing methods*⁽⁵²⁾;

⁵⁰ Previously, the value of natural assets was captured by the concept of “*total economic value*,” which is very similar to the ecosystem approach. (Marjainé Szerényi & Kovács, 2018).

⁵¹ For example, determining the value of a recreational site (e.g., a hiking destination) based on how much time (opportunity cost) and money visitors are willing to spend to visit the site.

⁵² For example, how proximity to a beautiful natural environment is reflected in real estate prices.

4. *Stated preference method*: used to estimate the value of non-market goods and services (e.g., determining the existence value of certain species). People's preferences are typically assessed using a questionnaire-based method.

Methods for valuing natural goods and services, as well as natural capital, are constantly evolving, particularly with advances in statistical systems and environmental accounting (see Chapter 5).

The website of the United Nations Statistics Division provides a detailed, up-to-date description of valuation methods for various types of ecosystems and ecosystem services ⁵³.

Artificial Intelligence in the Protection of Natural Capital

The application of artificial intelligence (AI) enables the real-time processing and interpretation of vast amounts of data, which has the potential to revolutionize the assessment of ecosystem services and the nature conservation and economic decision-making supported by it. AI is primarily used to monitor the state of ecosystems, track changes, quantify and monetize various ecosystem services based on these changes, and describe and model potential future changes. Examples of key areas of AI application: ⁵⁴ :

- Automated data collection and analysis: Artificial intelligence algorithms (such as deep learning and computer vision) are capable of analyzing satellite imagery, drone footage, and data from various sensors to monitor and track changes in land use, forest cover, biodiversity, etc.;
- Quantification of Ecosystem Services: The ARIES (Artificial Intelligence for Environment & Sustainability) platform uses machine learning and semantic modeling to spatially map and assess the supply, demand, and flow of ecosystem services (e.g., carbon sequestration, water retention, pollination) to map and assess their supply, demand, and flows.

⁵³<https://seea.un.org/>

⁵⁴ Source: Google AI

- Natural Capital Accounting: “ARIES for SEEA Explorer,” supported by the United Nations and other organizations, enables the standardized measurement of economic benefits provided by nature based on the System of Environmental-Economic Accounting (SEEA) framework.
- Predictive modeling: Artificial intelligence helps predict the impacts of climate change or human intervention on ecosystems, identifying critical points and areas worthy of restoration.

Discussion Topic

How does natural capital differ from other types of capital? What are the main methods for valuing natural capital?

How are ecosystem accounts structured within the SEEA EA system?

What is the significance of applying artificial intelligence to the valuation of natural capital?

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5. Chapter Assessing Sustainability in Practice

Learning Objectives

This chapter presents the practical application of the principles and theory of asset-based sustainability. Within the framework of asset accounting, we demonstrate how natural capital accounts complement traditional statistical systems and national accounts. Finally, we show how asset accounts can be used to assess sustainability.

Asset Accounting

Asset accounting quantifies the value of assets essential for long-term growth and helps track changes in these assets over time: their accumulation and depletion.

Capital accounting is a statistical framework for measuring a country's total capital stock, including the sum of man-made, physical, or fixed capital, as well as human and natural capital. In the context of national wealth accounting, produced capital refers to the monetary value of physical capital (equipment and machinery, buildings, infrastructure). Human capital, similar to traditional statistics, is broader than the concept of labor force as defined in neoclassical economics: it encompasses the entire population, taking into account educational attainment and the health status of the population. In theory, human capital can also encompass numerous other elements, such as a nation's intellectual capital—including its historical heritage, art collections, museums, etc.—which can indirectly influence the functioning and effectiveness of the socio-economic system. However, evaluating these forms of capital from a sustainability perspective is not straightforward even in theory, and thus they do not appear in statistics. Natural capital refers to the monetary value of environmental assets, based on the view that nature provides essential primary goods and services to society. In addition to the three exclusive types of capital⁵⁵ (produced, human, and natural), technology plays a role in the production process; in a general sense,

⁵⁵ Exclusive: a given capital asset (e.g., machinery, equipment, or arable land) can be used by only one economic actor.

encompasses both the level of technological development and institutions. Technology, which is not an exclusive good,⁵⁶ determines the efficiency with which other types of capital participate in the functioning of the economy and in the production process—that is, the productivity of all other capital assets in contributing to economic output, or the generation of income. The broader purpose of asset accounting is to provide an alternative metric, alongside the GDP-centered statistical system, for measuring the performance of the economy (society) from a sustainability perspective.

In the system of asset accounting, assets—including elements of natural capital—are assigned a value that contributes to well-being over time and across generations. These asset values differ conceptually from the market-based values used in traditional statistics. *Accounting or social value* expresses the value that a capital asset represents for society, including its contribution to well-being as understood in the long term.

Target 17.19 of the UN’s 2030 Agenda (Sustainable Development Goals) sets forth the following objective:

“By 2030, building on existing initiatives, develop methods to measure progress toward sustainable development that complement GDP...” (UN GA, 2015)

There is broad consensus among economists that GDP is inadequate for measuring the sustainability of economic development, as it ignores the costs incurred in the generation of output and income—particularly the direct and indirect costs of environmental damage resulting from the production process. Furthermore, GDP is a flow-type indicator that measures economic performance over a one-year period; however, it says nothing about future income flows or the prospects for economic growth. The Brundtland Commission’s definition of sustainability⁵⁷ does not mention wealth per se, but implies that well-being must not decline across generations—a concept that modern economics refers to as the

⁵⁶ Multiple economic actors may have access to a given technology or institution.

⁵⁷ See: Preface

as the fair distribution of wealth across generations⁵⁸. Comprehensive wealth—that is, the totality of capital assets—constitutes the economy’s “productive base.” Since intergenerational well-being changes in tandem with comprehensive wealth, changes in comprehensive wealth can be regarded as the appropriate sustainability indicator. Wealth accounting provides a framework for measuring a country’s wealth—that is, its produced, human, and natural capital—as well as changes in that wealth. Wealth statistical accounts provide data for assessing whether a nation’s socioeconomic system operated sustainably during a given period, as well as basic information for budget planning, ex-post evaluation, and the preliminary analysis of policy alternatives.

Two main problems arise in the implementation of asset accounting: (1) which capital assets should be included in the list of assets that form the current and future basis for the functioning of the socio-economic system; (2) how best to estimate the theoretical accounting—that is, social—value of the various types of assets based on theoretical shadow prices. In the case of produced capital, defining the list of assets is straightforward; however, asset valuation can be highly complex, as the value of an asset depends on the economic and social environment in which it operates. Data from national accounts (System of National Accounts, SNA) cannot, in most cases, be used directly to estimate theoretical values. Compiling and valuing a list of human and natural capital assets is an even more complex task.

The System of National Accounts

The System of National Accounts (SNA) is an international statistical standard developed by the United Nations Statistics Division and adopted worldwide in national statistical systems. Several updated versions have been published since the 1950s.

The System of National Accounts:

“The System of National Accounts (SNA) is an internationally standard standard set for compiling measures of economic activity. The SNA is

⁵⁸ In the English-language literature, the terms “just” and “equitable” distribution are both used.

describes a coherent, consistent, and integrated set of macroeconomic accounts within the context of internationally accepted concepts, definitions, classifications, and accounting rules.

In addition, the SNA provides an overview of economic processes...how output is distributed among consumers, businesses, the government, and foreign countries. It shows how income from production, adjusted for taxes and transfers, flows to these groups and how it is allocated among consumption, savings, and investment. Consequently, national accounts are the building blocks of macroeconomic statistics, which form the basis for economic analysis and policymaking.

The SNA was designed for universal application, taking into account the needs of countries at different stages of economic development. The SNA also provides a comprehensive framework for standards in other areas of economic statistics, facilitating the integration of these statistical systems to achieve consistency with the national accounts.”

The responsibilities of the National Accounts Section of the United Nations Statistics Division:

“...to contribute to the internationally coordinated development and modernization of the system of national accounts; to conduct methodological research on issues included in the SNA research program, in collaboration with the Intersecretariat Working Group on National Accounts (ISWGNA)...

... It supports the SNA implementation program by developing and updating the necessary normative standards, training materials, and guidelines. It supports the maintenance of economic statistics and the economic statistics knowledge base...

... Implements a statistical capacity-building program: organizes regional and interregional workshops and seminars and carries out ad hoc, national technical assistance missions...

...It collects and publishes statistics on countries’ annual national accounts ...”

Source: www.unstat.un.org

Environmental Accounting

The SNA primarily supports GDP-focused economic analyses. It includes accounts for inputs from nature and waste outputs, based on the view that nature is an external, unlimited resource system and, at the same time, an unlimited waste sink. Environmental accounting supplements traditional statistics with environmental *satellite* accounts that reflect the

complex

interrelationships. Environmental accounting includes biophysical and monetary accounts for the components of natural capital, as well as flows of goods and services between the economy and natural systems. The System of Environmental-Economic Accounting (SEEA) is a global standard developed and regularly updated by the United Nations Statistics Division.

The System of Environmental-Economic Accounting

“ ...The System of Environmental-Economic Accounting (SEEA), developed by the United Nations Statistics Division, is a framework that integrates economic and environmental data to provide a more comprehensive and multifaceted view of the economy and the environment, as well as the interactions between the stock and stock changes of environmental assets, capital assets and changes in their stocks... The SEEA is based on internationally accepted standard concepts, definitions, classifications, accounting rules, and tables for the production of internationally comparable statistics and accounts, and follows the System of National Accounts.... The SEEA is a multipurpose system that produces a wide range of statistics, accounts, and indicators to serve a variety of potential analytical applications... a flexible system that can be adapted to countries’ priorities and policy needs...”

Source: <https://seea.un.org/>

Ecosystem Accounting

The “ecosystem” is a metaphor for nature: the totality of resources that provide essential goods and services—ecosystem services—to the economy and, in a broader sense, to the socio-economic system. Ecosystem accounting is a more advanced form of environmental accounting. The main difference between the two statistical systems is that environmental accounting includes accounts for resources provided by nature and used by the economy—such as mineral resources, energy, timber, fish, etc., while ecosystem accounts measure the condition (health) of geographically defined, holistic natural systems (i.e., ecosystems), as well as the biophysical and financial metrics of the goods and services provided by ecosystems (Table 5-1).

Table 5- 1 Environmental and Ecosystem Accounting System

Attribute	Environmental Accounting	Ecosystem Accounting
Focus	Mineral material s, energy sources, wood, fish, water, etc.	Goods and services provided by a geographically defined ecosystem.
Perspective	The economic interpretation of natural resources and waste from an economic perspective	An environmental perspective on the functions of from an environmental perspective.
Spatial Approach	Non-spatial accounts of natural resources	Spatial Delimitation
Measurement	Physical stocks and flows	The extent, condition, and services of ecosystems
Valuation	Market-Based Valuation	The market-based and non- non-market-based valuation

Source: www.seea.un.org/ecosystem-accounting

The SEEA Ecosystem Accounts (*System of Environmental Economic Accounting Ecosystem Accounts, SEEA EA*) are an extension of the SEEA, an international standard developed by the United Nations Statistics Division. These accounts contain data on ecosystems and ecosystem services related to the functioning of the socio-economic system, as well as their biophysical and monetary values. The SEEA EA comprises five types of accounts, which are compiled based on data and information from geographic information systems (GIS):

- *Ecosystem Extent Account*: The defined spatial extent of various ecosystem types (e.g., forests, wetlands, croplands, etc.). Unit of measurement: hectares or km²;
- *Ecosystem Condition Account*: Reflects the quality and health of ecosystems based on selected ecological indicators (e.g., nutrient content for soils, tree species diversity for forests, and chemical purity of water bodies). Unit of measurement: biophysical indicators.

- *Physical Service Accounts*: The physical quantity of an ecosystem service (e.g., carbon sequestered, water purified). Units of measurement: metric tons, cubic kilometers;
- *Monetary Value Account of Ecosystem Services*: The value of the account is determined based on direct market prices, replacement costs, indirect prices, or estimated prices calculated using the methods listed above.
- *Monetary value of ecosystem stocks*: Conceptually, the value of this account is the present value of the total value of ecosystem services provided by the ecosystem over time, taking into account the ecosystem's lifespan and costs, using a justifiable discount rate.

Inclusive Wealth Index

Inclusive Wealth, or the *Inclusive Wealth Index* (IWI), is a sustainability indicator developed in conjunction with the United Nations Environment Programme (UNEP). In the structure of the IWI, in addition to conventional wealth components (produced capital, human capital, natural capital), institutions, knowledge, social capital, and time are also interpreted as forms of wealth: for example, the quality of institutions influences how these capital components contribute to well-being. Time represents the value of expectations, in conjunction with technological progress, changes in the prices of resources, demographic shifts, and other exogenous factors affecting the economy, which determine the shadow price of capital assets. The IWI *measures* comprehensive wealth, that is, a practical estimate—based on a specific methodology—of the theoretical shadow price value of all wealth components; it is a composite measure that has become widely known, particularly following the 2018 publication of the UNEP Inclusive Wealth Report (Managi & Kumar, 2018). The IWI is suitable for examining the long-term prospects for economic growth and well-being, with the wealth-based approach to sustainability discussed in Chapter 3 serving as its theoretical foundation. The IWI:

- aligns with the call set forth in Target 17.19 of the United Nations General Assembly's Agenda 2030 resolution (Sustainable Development Goals), which urges the development of indicators that complement GDP and characterize the sustainability of development;
- measures changes in a nation's wealth by taking into account the foundations of production, as well as development, well-being, and long-term sustainability;

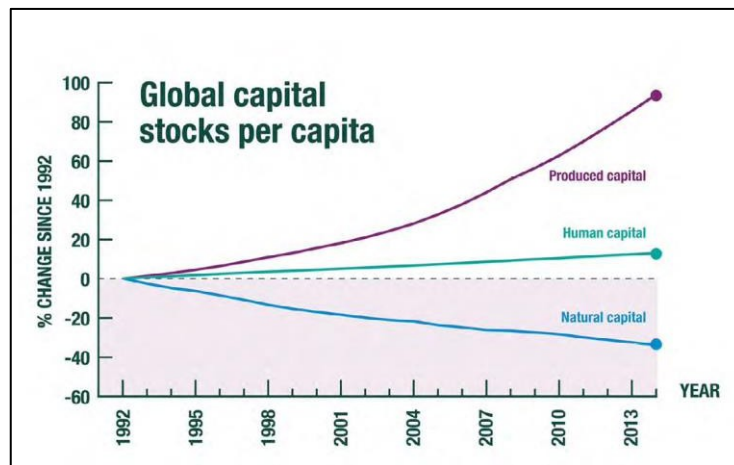
- measures the capital assets that underpin human well-being: changes in man-made capital, human capital, and natural capital.

By definition, the Inclusive Wealth Index is the shadow-weighted sum of the quantitative totals of the different types of capital (produced, human, and natural capital):

$$IWI = \rho_K K + \rho_H H + \rho_N N$$

where K, H, and N represent produced, human, and natural capital, respectively; and ρ_K , ρ_H , and ρ_N are the shadow prices of the produced, human, and natural capital components, respectively.

5- Figure 1: Changes in the value of global inclusive wealth capital components per capita, 1992–2013

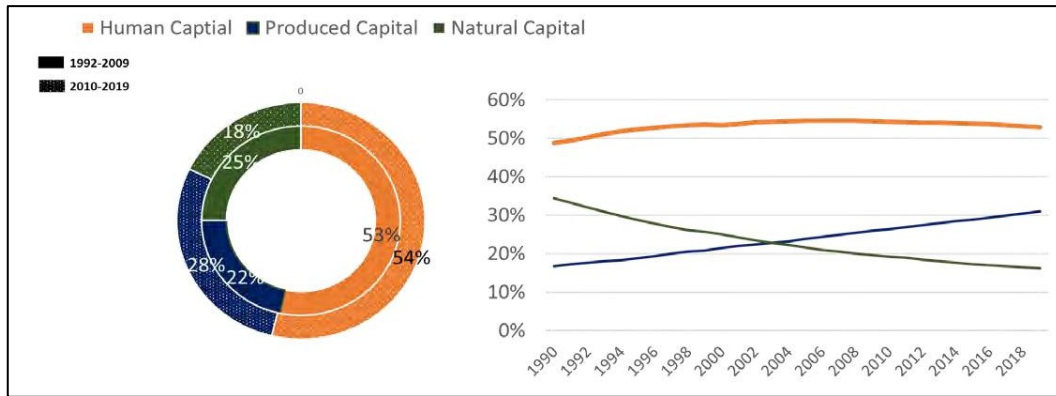


Source: (UNEP, 2023)

According to Figure 5-1, the components of global Inclusive Wealth changed significantly and to varying degrees during the 1992–2013 period. In terms of per capita values, physical capital—that is, man-made capital—doubled, human capital showed relatively modest growth, while natural capital declined significantly, by approximately 40%. During this period, global per capita income measured in terms of GDP grew spectacularly (Figure 5-3), as did global Inclusive Wealth; however, due to population growth and the global degradation of the natural environment, global per capita natural capital declined radically.

Figure 5-2 shows the changes in the proportions of the components of global Inclusive Wealth. It is striking that during the period under review (1990–2014), the shares of produced and human capital increased, while the share of natural capital fell from 35% to approximately 20%.

5- Figure 2: Changes in the Composition of Global Inclusive Wealth, 1990–2018



Source: (UNEP, 2023)

In the comparative sustainability analysis, changes in Inclusive Wealth and the Inclusive Wealth Index are expressed as per capita values, according to the following formula:

$$\frac{\dot{a}_t}{a_t} = \alpha_{K,t} \left(\frac{K_t}{K_t - L_t} \right) + \alpha_{H,t} \left(\frac{H_t}{H_t - L_t} \right) + \alpha_{N,t} \left(\frac{N_t}{N_t - L_t} \right)$$

where $\dot{a}_t$ is the change in Inclusive Wealth (a_t) per capita at a given point in time,

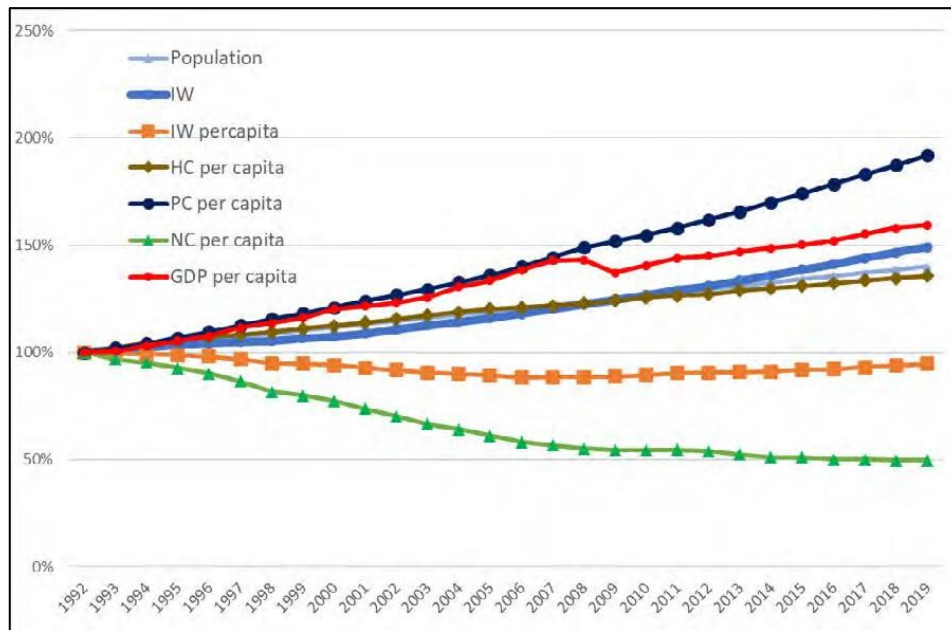
so the expression $\left(\frac{\dot{a}_t}{a_t} \right)$ represents the rate of change. The other dot-noted variables and fractions represent the rates of change in produced, human

and natural capital wealth, adjusted by the rate of population change $\left(\frac{L_t}{L_t} \right)$. In

In practice, this corresponds to the annual change at a given point $\frac{\dot{a}_t}{a_t} = \frac{\rho_K K_t}{A_t}$, the share of produced wealth

in the growth rate of Inclusive Wealth, $\alpha_{H,t}$ and $\alpha_{K,t}$ represent, respectively, the shares of human capital and natural capital.

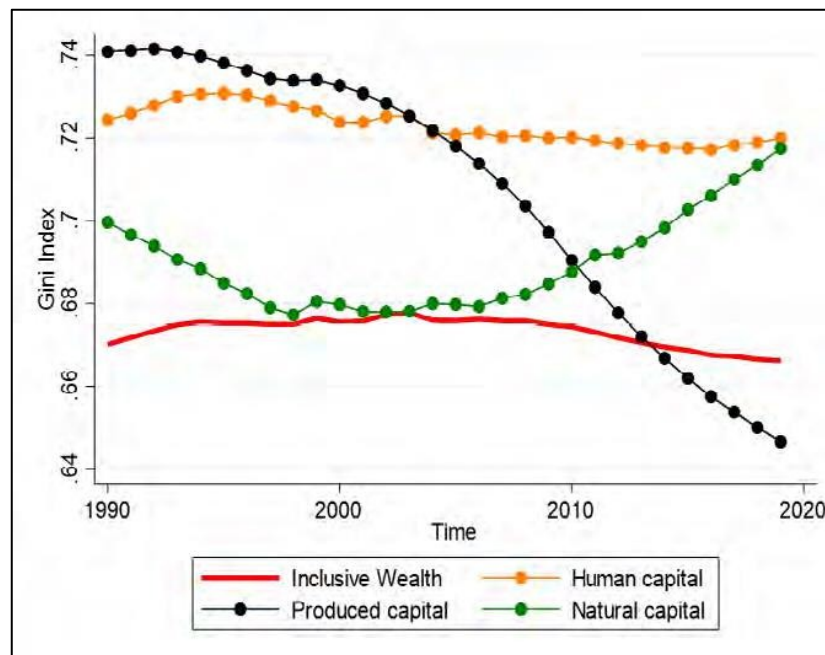
5- Figure 3: Changes in global inclusive wealth per capita and other indicators



Source: (UNEP, 2023)

The subtitle of the 2023 Inclusive Wealth report (UNEP, 2023) is: “Measuring Sustainability and Equity” essentially refers to the socio-spatial dimension of sustainability—that is, the correlation between trends in natural capital components and social inequality. With regard to inclusive wealth inequality among nations, as compared using the Gini coefficient, the report makes the following observations (Figure 5-4):

5- Figure 4: Global Wealth Inequality Across Nations: Changes in the Gini Index for Inclusive Wealth and Its Components



Source: UNEP, 2023

- Per capita inclusive wealth inequality among countries increased slightly during the 1990–2010 period and decreased slightly after 2010.
- The decline in inequality following the period after 2010 can be attributed to the rapid decline in inequality in capital stock. This was a period of intensive accumulation of capital stock, particularly in developing countries such as China and India. Inequality in human capital across nations increased in the 1990s and then stabilized after 2000. In 2019, however, inequality in human capital was the highest among all forms of wealth inequality.
- Global inequality in per capita natural capital has been rising since 1998 (from a Gini index value of 0.67 in 1998 to 0.72 in 2019), indicating deepening inequality among countries in terms of per capita natural capital.
- The trend in inequality in per capita natural capital among countries since 1998 is expected to continue as nature shrinks and the population grows steadily and unevenly, resulting in a decline in per capita natural capital.

- Since natural capital—particularly renewable natural capital—and ecosystems are difficult to replace with any other type of capital, inequalities in per capita natural capital among countries and the global decline in per capita natural capital may in the future lead to unequal competitive conditions among the world's nations regarding access to critical natural resources, which could trigger local, regional, and global conflicts.
- The global downward trend in natural capital must be reversed, which requires investments aimed at protecting and restoring renewable natural capital, as well as the resources to finance them, along with technological innovation and the widespread adoption of clean energy technologies.

The report concludes that the sustainability of natural capital is key to achieving the UN Sustainable Development Goals (SDGs). It points out, however, that due to countries' differing economic development paths, significant global and regional natural risks must be anticipated.

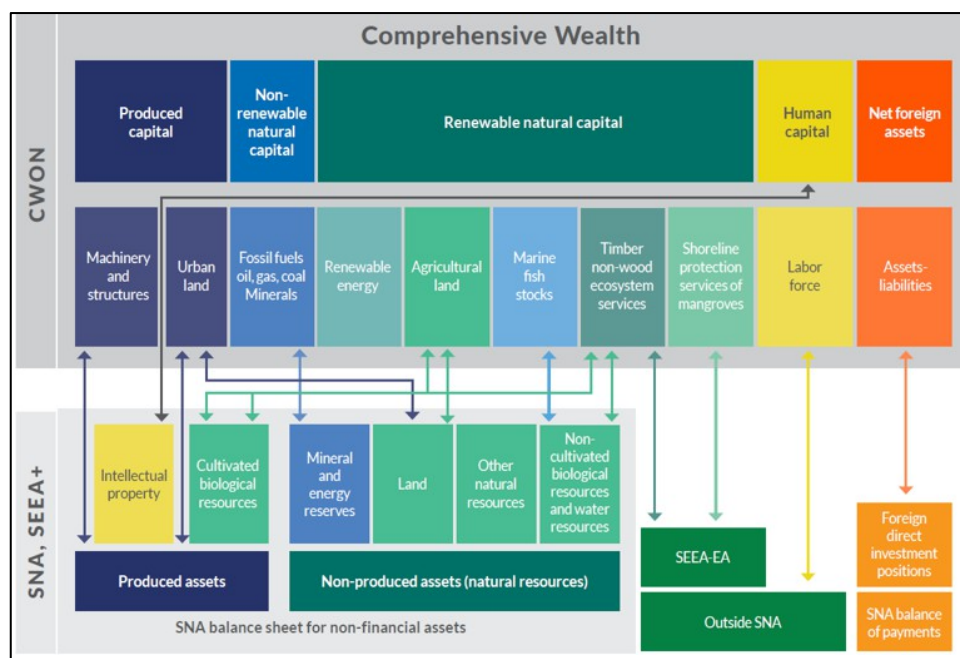
The Wealth of Nations

“The Changing Wealth of Nations” (CWON) is the title of a report by the World Bank's Global Sustainability Program and also refers to a database containing the national wealth accounts of UN member states. As an alternative to the GDP-centric approach, CWON supports analyses related to the sustainability of economic development. CWON is a pioneering project that manages theoretically grounded, regularly updated data on the comprehensive wealth of nations and its components, including man-made, human, and natural capital, as well as foreign assets. The valuation of individual capital components follows the valuation principles of the SNA and the SEEA, which ensures the methodological consistency of CWON and its comparability with other indicators of development, such as GDP. The CWON accounts follow the general principle of providing the highest-quality approximate data possible for estimating the theoretical shadow price of capital assets; therefore, different types of assets are valued using specific methods. Determining the values of generated capital and net foreign assets is straightforward: they can be derived from market data and observed transactions. The value of natural capital and human capital assets is based on estimates. As a general approach, non-market-based valuation follows the concept that the value of an asset corresponds to the present value of the discounted stream of expected net income over its useful life.

To better approximate theoretical shadow prices, the CWON database supplements the nominal estimates of asset values with real asset estimates using the Törnquist volume index, which better captures... “relative changes in volume resulting from the depletion or growth of asset stocks, relative price changes due to shifts in productivity or relative scarcity, as well as cross-price and cross-volume effects among various substitute assets...” (The World Bank, 2024).

The CWON database, updated and revised in 2024, contains time-series data for 5 types of capital across 151 countries for the period 1995–2020: produced capital, human capital, non-renewable and renewable natural capital, and foreign asset stock (Figure 5-5).

5- Figure 5: Structure of the CWON database, 2024



Source: (The World Bank, 2024)

Produced capital: Machinery, equipment, buildings, intangible assets (e.g., intellectual property), and urban land;

Non-renewable natural capital: reserves of fossil energy resources (crude oil, natural gas, coal); minerals, metals, and their ores (bauxite, copper, gold, iron, lead, lithium, nickel, tin, zinc, etc.);

Renewable natural capital: arable land, forests (based on the value of timber and non-timber forest ecosystem services: recreation, fishing, hunting, freshwater services), mangroves, marine fish stocks, renewable energy capacities;

Human capital: The labor market value (present value) of the working-age population's education and experience, calculated over the entire duration of employment;

Net foreign assets: claims on and liabilities to foreign countries, capital assets, foreign direct investment (FDI), and reserve assets.

Wealth and Sustainability – Global Trends

The fifth edition of the World Bank's global (comprehensive) wealth report was published in 2024 under the title **The Changing Wealth of Nations (CWON): Measuring Sustainable Development in the New Millennium** (The World Bank, 2024). The report's preface explains in detail that GDP is an inadequate measure of economic development because it ignores the costs of economic growth, particularly the depreciation of capital assets, such as the degradation of natural capital. GDP is a short-term measure of income flow. The goal of the CWON program is to provide a long-term, sustainability-oriented alternative to GDP that complements it.

The 2024 World Bank report, based on the CWON database and covering the period from 1995 to 2020 for various income groups, ⁵⁹makes the following observations:

- Changes in per capita wealth and its components, calculated in real terms, as well as their trends, are key to assessing the sustainability of the economy and the socioeconomic system;
- Wealth remains concentrated in rich countries: more than two-thirds of total global wealth is held by high-income countries;
- Low- and lower-middle-income countries, which account for half of the world's population, hold only 7% of total global wealth;
- Growth in real wealth per capita across all regions and income groups was driven by significant increases in human capital and physical capital.

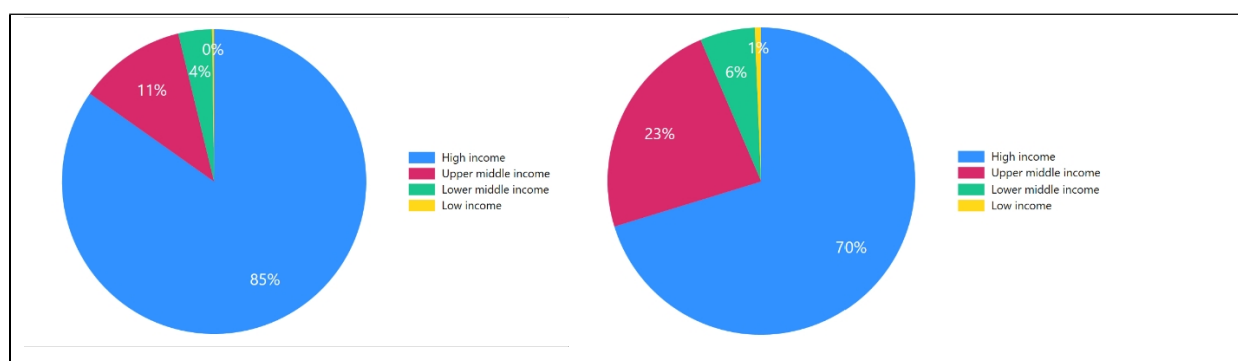
⁵⁹ The income country groups defined by the World Bank (2024) are as follows: For the Low-income group, per capita GNI is less than 1,135 USD; for the Lower-middle-income group, GNI ranges from 1,136 USD to 4,495 USD; in the Upper-middle-income group, GNI ranges from \$4,496 to \$13,935; in the High-income group, GNI is higher than \$13,935. Source: <https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html>

- Total wealth per capita increased significantly in two-thirds of the countries, meaning that economic development in these countries met the criterion of weak sustainability;
- In approximately 20% of countries (including all income groups), wealth stagnated or declined, indicating unsustainability according to the “weak” development criterion.

The CWON database includes both nominal and real accounts of capital components; for the former, it uses current USD values, and for the latter, it applies the Törnquist index based on the 2019 base period. The capital accounts also enable comparative and trend analysis of the sustainability of national economies’ operations, according to both the weak and strict criteria. A key indicator of weak sustainability is the change in the total volume of capital over a given period—that is, the change in the sum of produced capital, human capital, natural capital, and net foreign assets relative to population change (i.e., on a per capita basis), which is referred to in the CWON as “domestic comprehensive wealth per capita”

As shown in Figures 5–6, during the period from 1995 to 2020, global wealth remained concentrated in high-income countries, which accounted for more than two-thirds of global wealth. The share of upper-middle-income countries doubled during the period under review, while the shares of lower-middle- and low-income countries increased only slightly. Overall, wealthy countries maintained or increased their share of global wealth, while low-income countries showed modest or minimal growth in absolute terms.

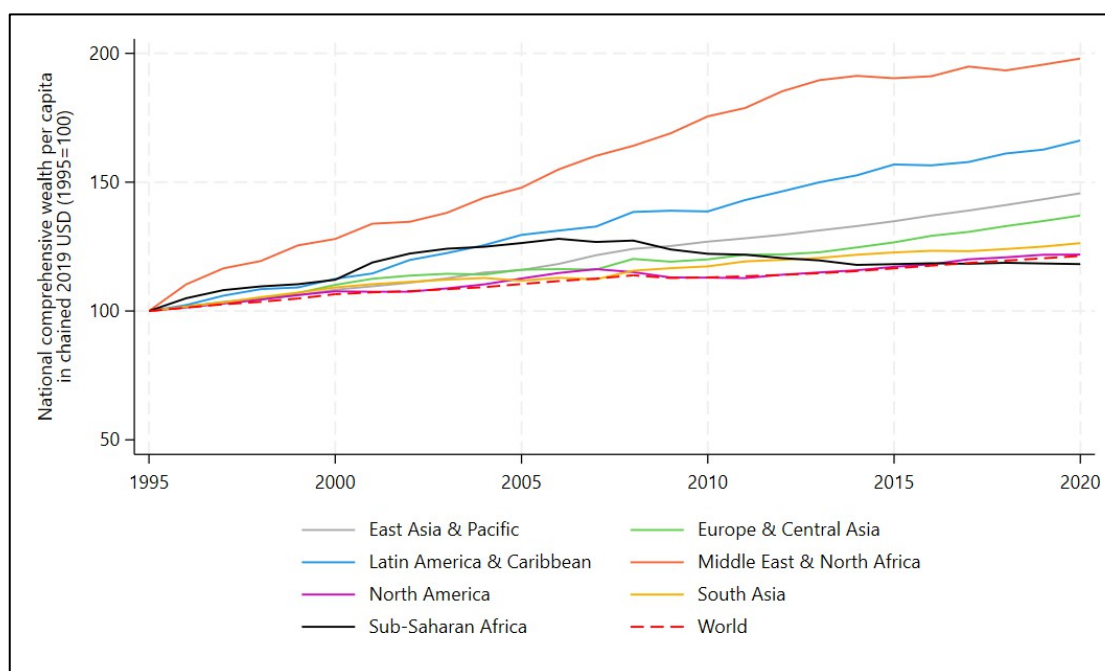
5- Figure 6: Distribution of Global Wealth, Nominal Values, 1995 and 2020)



Source: (The World Bank, 2024)

Wealth calculated in real terms (Figures 5–7) shows significant growth in the Middle East and North Africa, followed by Latin America and the Caribbean throughout the entire period. In Sub-Saharan Africa, wealth growth reversed around 2005, slowed, and stagnated through 2020. In South Asia, growth slowed throughout the entire period, while growth in Europe, Central Asia, East Asia, and the Pacific region was moderate. In North America, the growth trend was roughly in line with the global average.

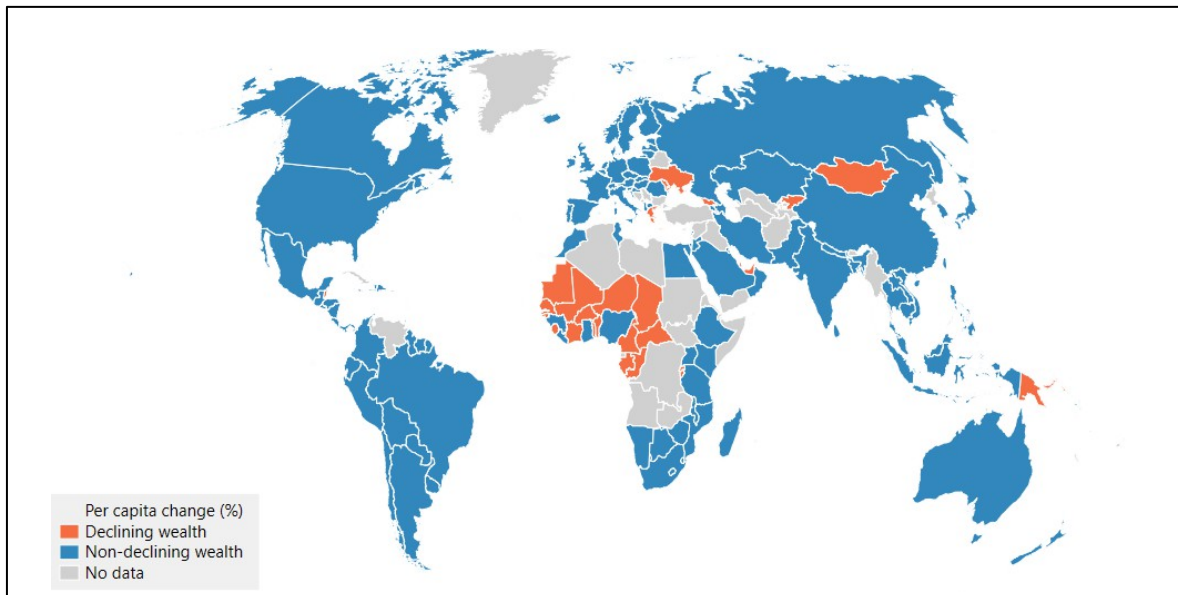
5- Figure 7: Trends in wealth across world regions, 1995–2020, Törnquist Index based on 2019



Source: (The World Bank, 2024)

Figures 5–8 show countries around the world categorized by whether their per capita wealth decreased or not (indicated in orange and blue, respectively). While per capita wealth increased in all regions of the world (Figures 5–7), it decreased or stagnated in more than a quarter (40 countries) of the 151 countries included in the CWON database.

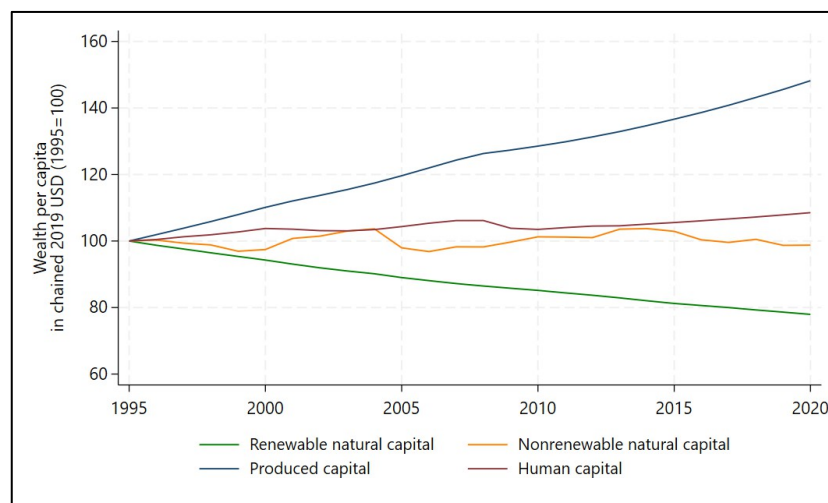
Figures 5– Figure 8: Declining and non-declining per capita wealth in countries around the world, 1995–2020



Source: (The World Bank, 2024)

The trend in changes to total per capita wealth points to the sustainability of economic growth based on the weak criterion. Furthermore, changes in critical components of natural capital indicate whether a country’s socioeconomic system operated sustainably during a given period—according to the strict criterion. As shown in Figures 5–9, per capita capital stock increased significantly globally between 1995 and 2020, human capital grew moderately, non-renewable capital stock stagnated, and renewable natural capital stock, however, declined significantly.

5- Figure 9: Global Changes in Types of Capital, 1990–2020, Törnquist Index (2019 base), US\$ per capita



Source: (The World Bank, 2024)

Weak sustainability

According to the *weak criterion*, a socio-economic system functioned sustainably during a given period if the total wealth (comprehensive wealth or inclusive wealth) did not decrease during that same period. The sustainability of nations can be examined globally using the CWON database. Table 5-2 shows, by income country group, the number of countries that meet and those that do not meet the weak criterion of sustainability. The indicator of weak sustainability is DCWpCrg⁶⁰, the geometric growth rate of *Domestic Comprehensive Wealth* (DCW) calculated for the period 1995–2020 (Törnquist index based on 2019) ⁶¹⁶². The weak criterion for sustainability is the validity of the following inequality: DCWpCrg > 0. The use of the geometric growth rate as an indicator allows for a comparative analysis of countries' sustainability and their ranking according to sustainability (ANNEX A – ANNEX D).

According to the weak criterion, during the 1995–2020 period, the proportion of unsustainable countries was 75% in the low-income country group, 33% in the lower-middle-income country group, 13% in the Upper-middle-income group, and 10% in the High-income group (Table 5-2, Figure 5-10). Globally, 25% of countries (38 out of 151) did not meet the weak sustainability criterion.

5- Table 2 Global Sustainability, Income Country Groups, Weak Criterion, 1995–2020

Indicator / Income Country Group	Low	Lower-middle	Upper-middle	High	Total
DCWpCrg>0	4	28	32	46	110
DCWpCrg<0	14	14	5	5	38
JAG	37%	37%	13%	13%	100%
NAJCS	74%	33%	13%	10%	25%
No data	1	1	1	-	3
Total	19	43	38	51	151

Source: Author's analysis based on CWON

JAG – Proportion of income country groups among the number of globally unsustainable countries;

⁶⁰ DCWpCrg: Real growth in domestic comprehensive wealth per capita

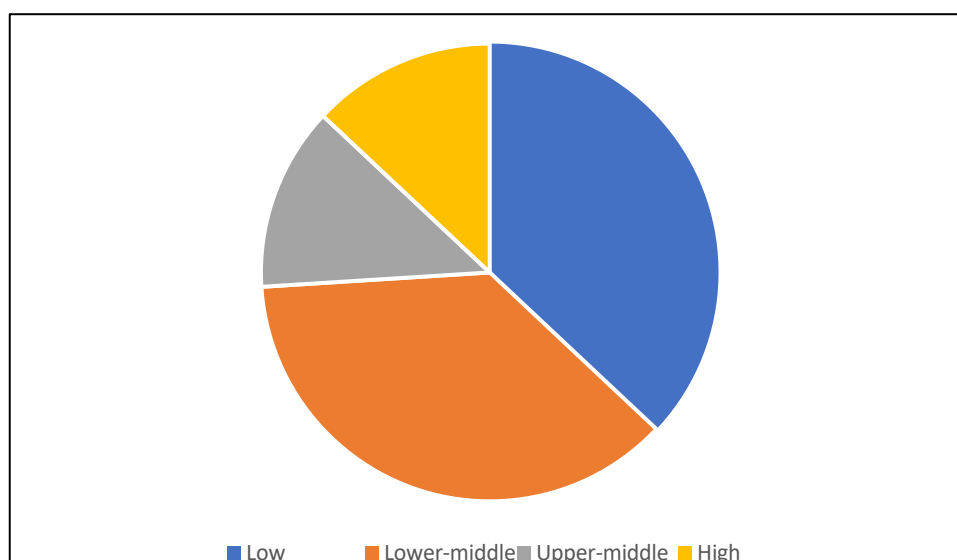
⁶¹ Geometric growth rate – growth rate r over n periods: $r = \exp[\ln(pn/p0)/n] - 1$.

⁶² Method for calculating the *Törnquist index*: (Feenstra et al., 2015).

NAJCS – Proportion of unsustainable countries within the income country group

Of the 38 unsustainable countries, 37% belong to the Low-Income group and another 37% to the Lower-Middle-Income group; 13% belong to the Upper-Middle-Income and High-Income groups, respectively.

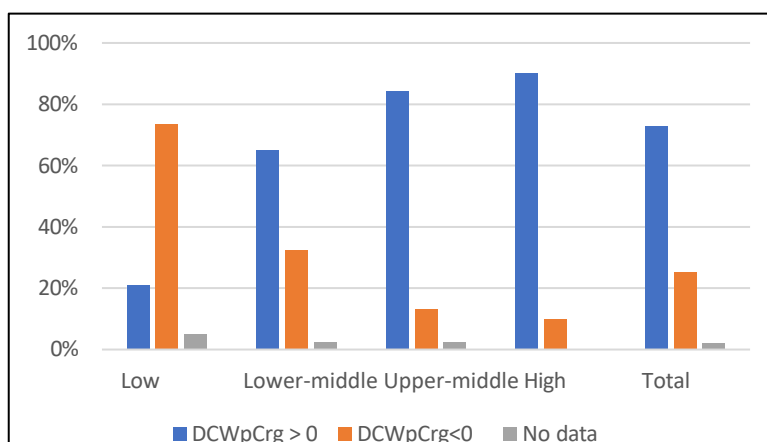
5- Figure 10: Proportion of income country groups, global sustainability, weak criterion, 1995–2020



Source: Author's analysis based on CWON

Figures 5–11 show the proportion of unsustainable countries by income group (Table 5-2, NAJCS).

Figures 5– 11: Proportion of unsustainable countries by income group, weak criterion, 1995–2020



Source: Author's analysis based on CWON

Strict sustainability

According to *the strict criterion*, a socio-economic system operated sustainably during a given period if the renewable component of natural capital did not decline during that same period. Similar to the weak sustainability criterion, the sustainability of nations under the strict criterion can be analyzed using the CWON database. According to Table 5-3, the indicator of strict sustainability is the Törnquist index of Renewable Natural Capital per capita based on 2019 data (RNCpCrg) ⁶³. The strict sustainability criterion is: $RNCpCrg > 0$ s. (Similar to the assessment of the weak sustainability criterion, the geometric growth rate is used to assess the strict sustainability criterion) (ANNEX D).

According to Table 5-3, no country in the Low- and Lower-Middle-Income groups met the strict sustainability criterion. In the Upper-Middle- and High-Income groups, the proportion of unsustainable countries was 78% and 82%, respectively (Figure 5-12).

Globally, 88% of countries (130 out of 148) did not meet the strict sustainability criteria.

Error! The reference source cannot be found. shows the global share of income groups regarding non-sustainable countries. (**Error! The reference source cannot be found.**, **Error! The reference source cannot be found.**, Share, income group, global) Most non-sustainable countries belong to the low-income and lower-middle-income groups.

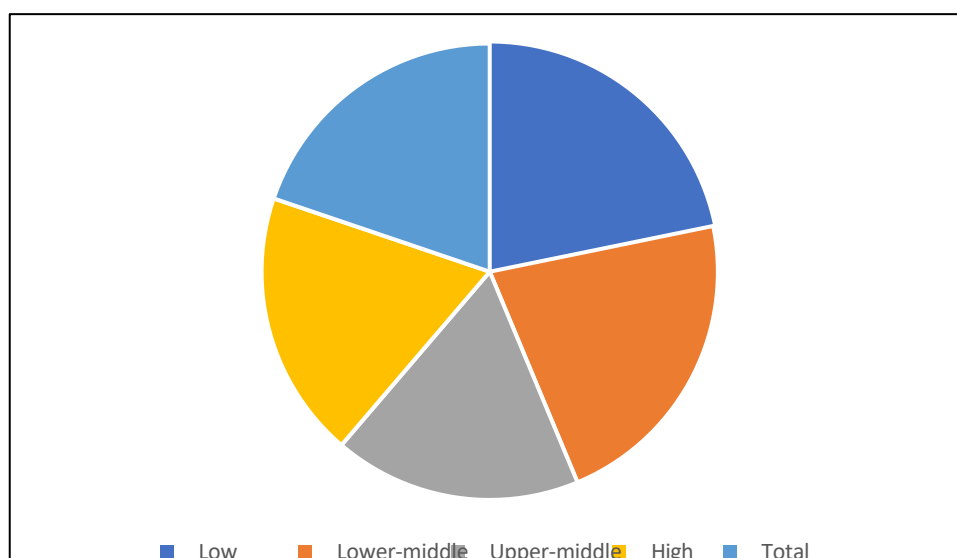
5- Table 3: Global Sustainability, Income Country Groups, Strict Criteria, 1995–2020

Indicator / Income Group	Low	Lower-middle	Upper-middle	High	Total
RNCpCrg>0	0	1	8	9	18
RNCpCrg<0	18	41	29	42	130
No data	1	1	1	0	3
JAG	14%	32%	22%	32%	100%
NAJCS	95%	95%	76%	82%	86%
Total	19	43	38	51	151

Source: Author's analysis based on CWON

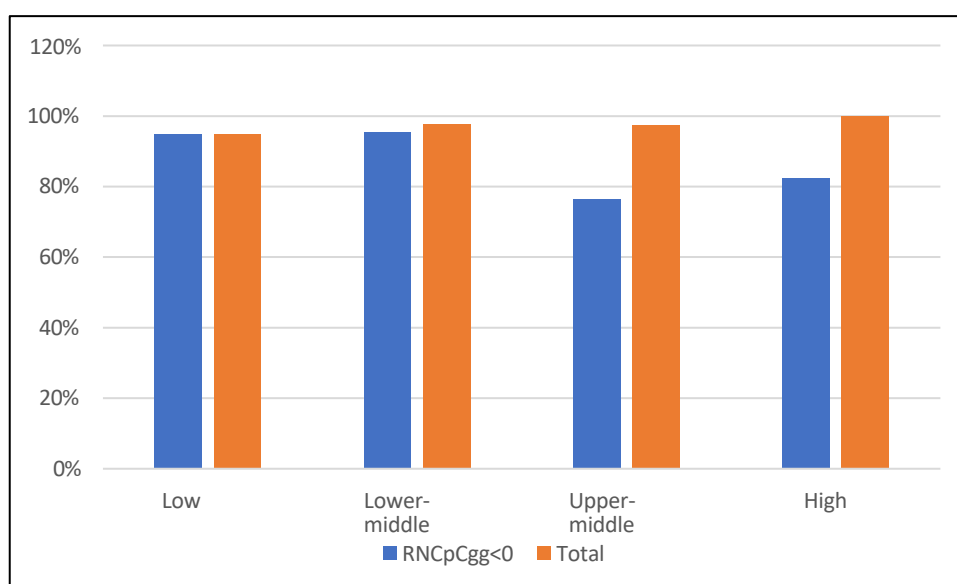
⁶³ RNCpCrg: Renewable Natural Capital per Capita real growth (Törnquist index)

5– Figure 12: Proportion of income country groups, unsustainable countries, 1995–2020



Source: Author’s analysis based on CWON

5– Table 4: Proportion of unsustainable countries, income country groups, strict criteria, 1995–2020



Source: Author’s analysis based on CWON

The Actual Savings Indicator

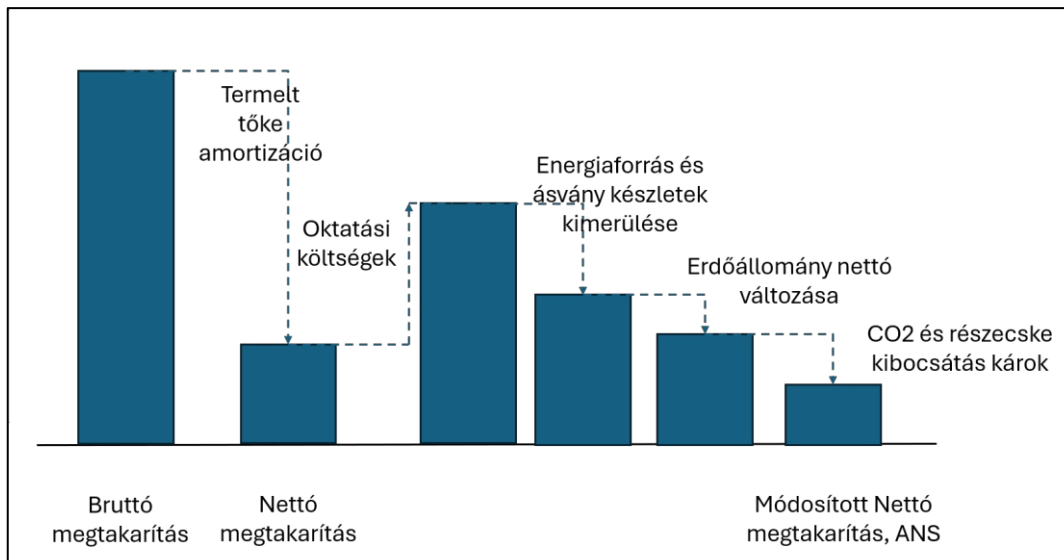
The indicator for assessing sustainability based on the “weak” criterion is the change in total assets, i.e., total wealth. As described in the previous chapters, the World Bank’s CWON database contains annual

data on the wealth of nations and their asset components. The IWI index is also based on the annual values of a nation's wealth; however, its calculation includes institutions, knowledge, social capital, and other factors influencing productivity and the shadow price of capital assets. According to macroeconomic theory, changes in total wealth can be approached from the perspective of savings—that is, the proportion of a nation's income that is allocated to accumulation (and consumption), meaning the increase in wealth that serves as a source of future income. In the traditional macroeconomic framework, this measure is gross savings, which can be expressed either in terms of the money supply or as a percentage of income⁶⁴.

In the system of financial accounting, savings take on a new meaning: unlike the traditional concept of gross savings, “*genuine savings*” refer to the depreciation and amortization of fixed capital assets (machinery, equipment, infrastructure, buildings) used in the production of income, as well as changes in the natural environment and the “cost” of the depletion of natural resources (Kovács A. F. 2021). The latter consists of two elements: (1) the decline in the value of non-renewable natural capital stocks (minerals, energy sources) and (2) changes in the monetary value of renewable natural resources. The former data are included in traditional statistics, while the latter—the monetary quantification of changes in natural capital—poses a significant challenge for both ecology and economics. The World Bank's Adjusted Net Savings (ANS) database serves as a practical approximation for estimating theoretical real savings. Figures 5–13 illustrate the calculation principle of the ANS indicator: Net savings are calculated as gross savings minus the depreciation of produced (man-made, fixed) capital assets. Education costs increase the value of human capital; the depletion of mineral and energy reserves reduces the value of non-renewable natural capital; the net change in forest stock is a factor that either reduces or increases the value of renewable natural capital; the negative economic impact of CO₂ and particulate matter emissions constitutes economic damage, which also represents a cost—that is, a factor that reduces actual savings.

⁶⁴ In the World Bank's World Development Indicators database, data on gross savings and gross domestic savings are available in the given country's currency, in current U.S. dollars, and as a percentage of GDP (Gross Domestic Product) and GNI (Gross National Income).

Figure 5-13: Calculation Method for the Adjusted Net Savings Indicator



Source: Compiled by the author based on World Bank Open Data metadata

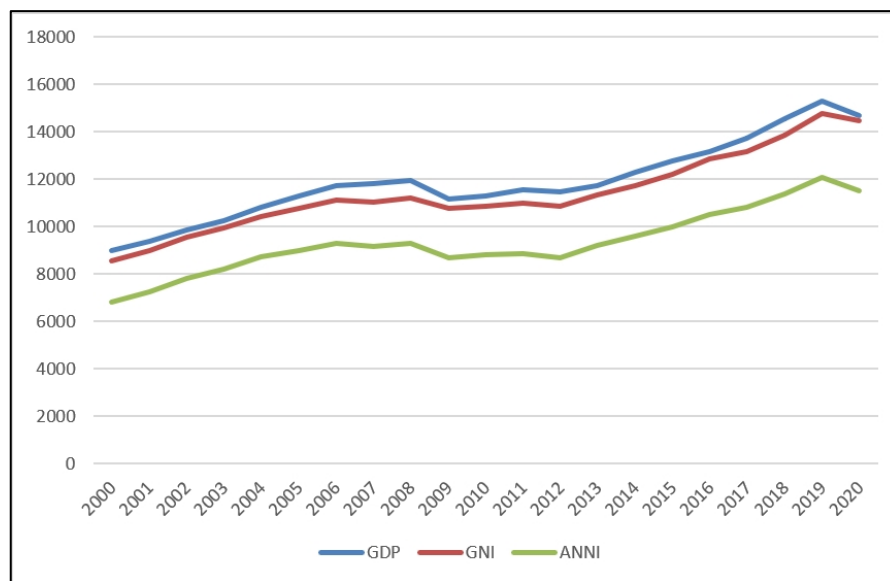
Hungary's Sustainability

The application of wealth accounting offers extensive opportunities for analyzing the sustainability of a national economy by examining changes in both income and savings flows and in the stocks of wealth assets. It also enables a comparative analysis of traditional GDP-based growth and the development of the socioeconomic system from a sustainability perspective. We illustrate the possibilities of this analysis using Hungary as an example—without claiming to be exhaustive.

Figure 5-14 shows data on Hungary's national income measured by GDP, GNI, and ANNI indicators over the two decades from 2000 to 2020. GDP and GNI data are calculated in the traditional manner, based on production and consumption data; the slightly lower GNI values do not differ significantly from the GDP data. By definition, ANNI is calculated from GNI by taking into account the costs of depreciation and environmental damage: it follows essentially the same trend as the first two indicators, but at a significantly lower level. For methodological reasons, ANNI does not fully incorporate the costs of depreciation and environmental damage; thus, it can be said that, for methodological reasons, it can be regarded only as a rough estimate of the theoretical real income that takes into account all economic, social, and environmental costs. That said, it can be observed that the per capita ANNI figures are approximately 20% lower than the GDP and GNI figures throughout the

entire period (ANNEX E).

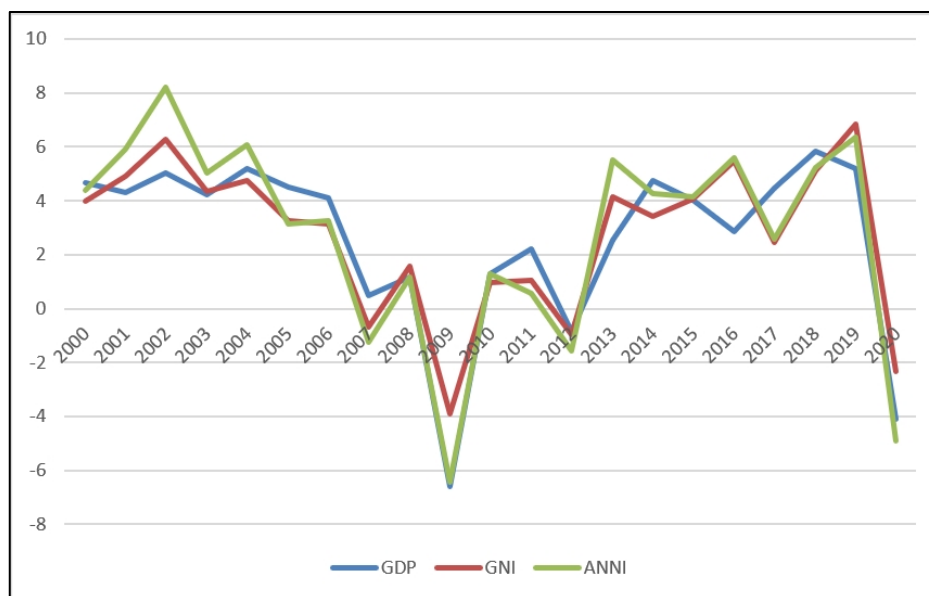
Figure 5-14: Hungary's National Income, GDP, GNI, and ANNI, 2000–2020, in constant 2015 US\$



Source: Compiled by the author using World Bank Open Data

Figure 5-15 shows the changes in the GDP, GNI, and ANNI indicators. The trends of the three indicators largely coincide, but their standard deviations differ: the standard deviation is highest for ANNI ⁶⁵.

Figure 5-15: Changes in Hungary's national income, 2000–2020, %

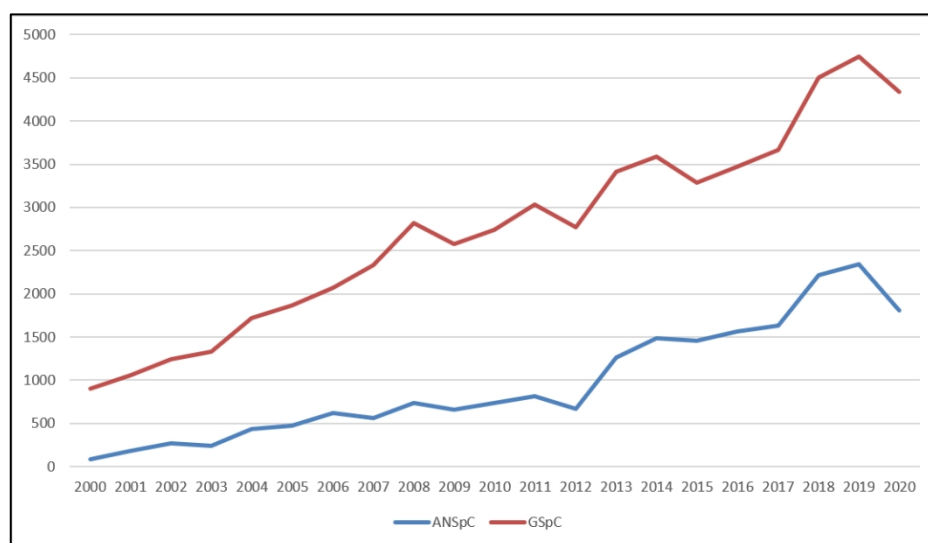


Source: Compiled by the author using World Bank Open Data

⁶⁵ Standard deviation of the indicator values: GDP – 3.13; GNI – 2.78; ANNI – 3.69

Figure 5-16 shows data on Hungary's gross savings per capita (GSpC) and adjusted net savings per capita (ANSpC). It can be observed that when environmental and social costs are taken into account (ANSpC), the actual savings figures are, on the one hand, significantly lower than the gross savings figures; furthermore, this difference increases over time, meaning that savings are increasingly failing to cover the environmental and social damages caused by economic activity (ANNEX E).

Figure 5-16: Hungary's Gross and Adjusted Savings, 2000–2020, in current US\$



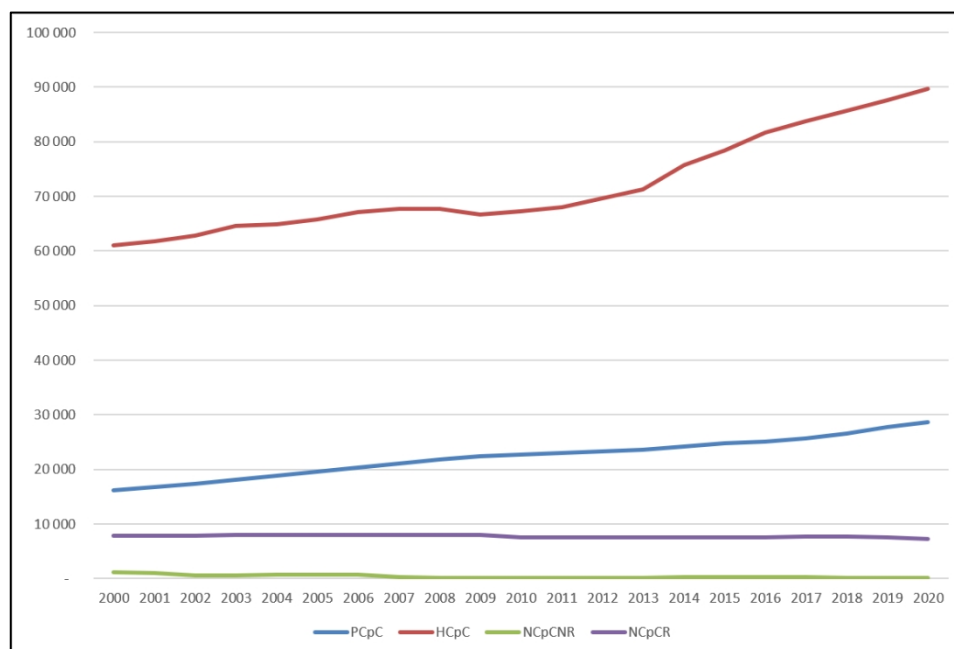
Source: Compiled by the author using World Bank Open Data

Figure 5-17 shows data on the components of Hungary's capital stock for the period 2000–2020, in chained real US\$ values based on a 2019 base ⁶⁶. The most significant component is human capital (human capital per capita, HCpC), which increased by approximately 50% over the two decades. In terms of significance, human capital is followed by produced capital (produced capital per capita, PCpC), which doubled during the period in question. The value of non-renewable and renewable natural capital (non-renewable natural capital per capita, NCpCNR, and renewable natural capital per capita, NCpCR) lags behind in terms of significance. The value of the former decreased significantly, while the value of the latter stagnated over the two decades (ANNEX E). It should be noted that, for methodological reasons, the sum of the chained real data for the individual types of capital is not equal to the value of total wealth. Hungary's total wealth (national comprehensive wealth per capita, NCWpC)

⁶⁶ As previously explained, chained real data—the Törnquist index—unlike current data, do not include the effect of price changes.

(chained real US\$ per capita, 2019 base). Figure 5-18 shows this in an international comparison.

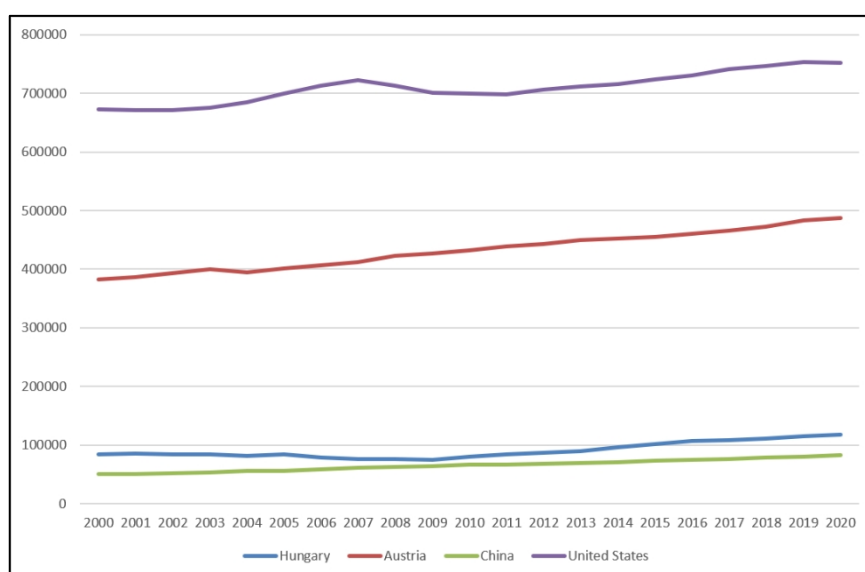
Figure 5-17 Asset Indexes, Hungary, 2000–2020, chained 2019 real US\$ per capita



Source: Compiled by the author using World Bank Open Data

Hungary's total wealth per capita is roughly equal to that of China; Austria's wealth per capita is approximately four times that of Hungary, while that of the U.S. is approximately seven times as much. During the period under review, the total wealth of all four countries increased (ANNEX E), meaning that the functioning of these countries' socioeconomic systems met the weak criterion of sustainability.

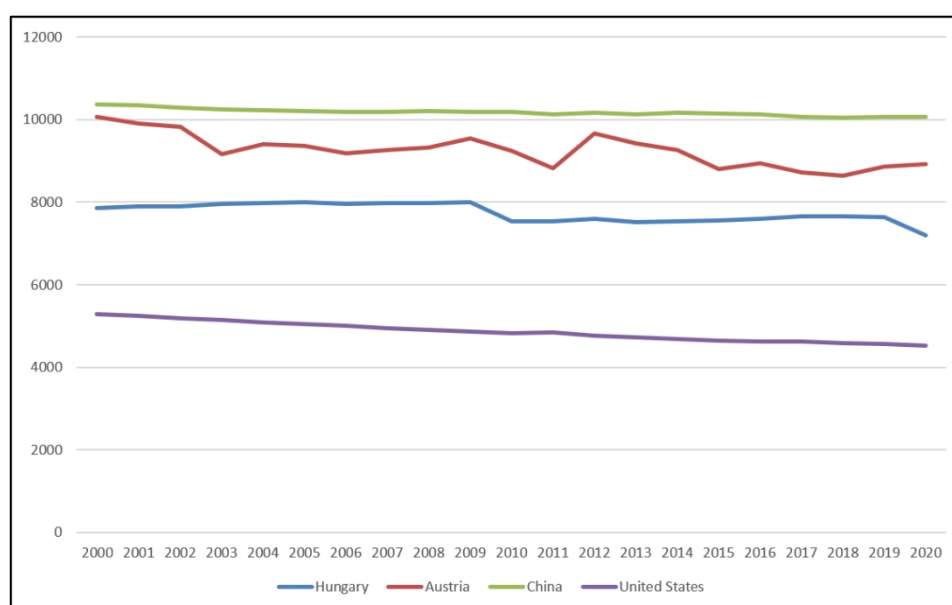
Figure 5-18: National Wealth Index, 2000–2020, chained to 2019 in real U.S. dollars per capita



Source: Compiled by the author using World Bank Open Data

According to Figure 5-19, per capita renewable natural capital was highest in China, followed by Austria, then Hungary, and the United States. It is striking that the value of natural capital per capita declined in all four countries: least of all in Austria, followed by China, then Hungary, and finally the United States (ANNEX E).

Figure 5-19 Renewable Natural Capital Wealth Index, Selected Countries, Chain-linked 2019 Real US\$/capita



Source: Compiled by the author using World Bank Open Data

The examples of Hungary and the selected countries demonstrate how the asset-based approach enables the examination of a country's sustainability over time, as well as the comparative analysis of different countries. Within a wealth- or capital-based framework for sustainability, the sustainability of a country's performance over a given period—whether assessed using lenient or strict criteria—can thus be characterized by a single number: the change in capital value. However, as discussed in the book, changes in capital value depend on a wide range of economic, social, and environmental factors. The asset-based framework for sustainability thus synthesizes the sustainability perspectives of the relevant disciplines.

Topics for Discussion

What is asset-based accounting, and how does it differ from traditional

statistics? What is the central concept of environmental accounting?

How are the elements of natural capital represented in the environmental

accounting system? What is the structure of the World Bank's CWON database?

How can global sustainability be analyzed in practice using weak and strict criteria?

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Afterword

One of the fundamental questions shaping humanity's fate in the 21st century is how we define our relationship with the natural environment. Environmental destruction caused by human activity is part of everyday life, and its effects are felt by everyone, regardless of whether they live in the developed world or in the world's poorer countries. Science has long been preoccupied with the issue of sustainability: what kind of system would allow the current generation to leave behind a world capable of meeting the needs of future generations? The goal is therefore clear, but defining the problem is highly complex.

What exactly do we mean by sustainability, and how do we measure it?

The wealth-based approach to sustainability provides an answer to both questions: a socio-economic system is sustainable if, in the course of its operation, the stock of resources at its disposal—that is, the totality of its wealth—remains unchanged. Measuring sustainability, in turn, involves tracking changes in the components of that wealth.

There has long been a general consensus in the scientific community that GDP, which measures an economy's annual performance, is not suitable for assessing the economy's future performance; in other words, other indicators are needed to evaluate sustainability. Research aimed at developing appropriate indicators has been ongoing for decades. The new indicators and measurement methods provide very important information on various aspects of sustainability, but none of them has become universally accepted in economic and political practice. Given the importance and urgency of the issue, a UN expert group⁶⁷ recommends in its summary report published in May 2026 a new framework consisting of numerous indicators, which individual countries could use to develop their own sustainability indicator systems. It remains to be seen how the scientific and political communities will receive the idea of this new system and to what extent it will prove suitable in practice. This dilemma is well illustrated by P. Kumar's article published in the scientific journal **Nature** (Kumar, 2026) and by the article by the same author cited in the text box.

⁶⁷ High-level Expert Group on Beyond GDP, HLEG

What Should Come After GDP?

A letter from 58 leading economists to the UN Secretary-General

In November 2025, the UN's high-level expert group on "Beyond GDP" published its first progress report, to which some members of the international scientific community responded with a strongly worded letter. According to the signatories—including many of the world's leading economists, statisticians, and sustainability experts—there is no need to develop new sustainability indicators or frameworks, because national accounts supplemented with natural capital components, a suitably adjusted GDP, and a few global biophysical indicators can adequately serve as a basic set of "beyond GDP" indicators.

In May 2025, António Guterres, Secretary-General of the United Nations, tasked a high-level expert group (HLEG) with developing a new indicator system to measure the sustainability of development. This system must build on the experience of the international statistical community, such as progress measured against the UN's Sustainable Development Goals (SDGs) or the application of existing indicator frameworks that measure national well-being. The mandate has attracted significant interest because, on the one hand, it aligns closely with international efforts aimed at developing potential new indicators of sustainability to complement GDP, and on the other hand, it highlights the lack of consensus regarding the scientific foundations on which the new indicator or indicator system should be based.

The expert group published its first interim progress report (IPR) in November 2025... which summarizes the group's mandate in four points:

- 1. The mandate reflects the consensus of UN member states as set forth in the document titled "Pact for the Future," which acknowledges that the international community relies too heavily on GDP as a universal indicator, even though it recognizes its limitations.*
- 2. The group's task is to create a universal, non-country-specific system of indicators to complement GDP.*
- 3. The new system of indicators must build on existing knowledge; it is intended to consolidate and strengthen that knowledge and to facilitate its international and widespread national application.*

4. This ambitious task requires a shift in traditional perspectives, measurement methods, applied policies, and decision-making mechanisms.

The IPR emphasizes that factors underpinning well-being—such as health, social capital, and the quality of the natural environment—are not only beneficial for social well-being but also contribute to economic prosperity. The report then summarizes the well-known arguments in favor of why new indicators or an indicator system to complement GDP are needed, and outlines the framework of the proposed new indicator system. This new framework is structured along two lines: on the one hand, it offers an alternative to the overreliance on GDP in areas where it is not the most appropriate indicator; on the other hand—in response to the known limitations of GDP—it aims to modify it in a practical way. Finally, the IPR analyzes why previous

“beyond GDP” initiatives failed to garner sustained political support, and promises that these lessons will be taken into account when developing the new indicator system. The proposal envisions an integrated, universal framework built on three conceptual pillars: well-being, inclusion and equity, and sustainability. The group’s goal is for the framework to be able to articulate the interconnections among the three pillars at the individual, community, national, and planetary levels. This means that a framework consisting of a complex set of multidimensional indicators would complement GDP, which currently serves as the sole indicator.

In connection with the group’s mandate, in March 2026, 58 leading economists, statisticians, and sustainability experts from around the world addressed the UN Secretary-General in an open letter. In the letter titled “An Alternative to the HLEG Proposal for Moving Beyond GDP,” these renowned experts express their doubts as to whether the commissioned expert group can offer an adequate solution to the need to measure the sustainability of the socio-economic system beyond GDP^{xiii}. Although they acknowledge the work of the group’s members, they believe the draft proposal fails to fulfill the mandate: on the one hand, the proposed system of indicators far exceeds the mandate’s call for a small number of indicators; on the other hand, it lacks sufficient theoretical grounding. Based on a detailed analysis of the problem, the economists do not believe that such a new indicator system would be capable of capturing policymakers’ attention, in contrast to GDP’s well-established “conciseness and robustness” of GDP. They urge an approach to the problem from a different angle, which, according to their proposal, essentially focuses on expanding existing

wealth statistics, modifying GDP, and incorporating a few biophysical indicators.

The starting point for the letter writers' approach to the problem is the question of what—in theory—best serves to supplement the information provided by GDP. The answer is that the most appropriate measure for this purpose is wealth—as the source of current income—and changes in wealth. Together, wealth and income provide the best foundation, spanning generations, for assessing well-being and sustainability. As basic indicators, these two measures do not, of course, provide answers to every question, but they shed light on development trends and, when corrective action is needed, generally indicate where intervention is required in the wealth structure. Naturally, developing solutions (policies) requires detailed analyses and the use of specific indicators.

Wealth Accounts

The topic of wealth accounts, as proposed by economists, has been a part of economic thought for many decades. Although the widely accepted definition of sustainability was formulated by the Brundtland Commission four decades ago (Brundtland, 1987), examination of the issue—particularly in the context of economic growth—appears as early as the beginning of the 20th century, for example in the work of Irving Fisher (Fisher, 1906), and indeed, in a certain sense, much earlier, during the classical era of economics.⁶⁸ According to the theory, human-generated capital (produced capital), human capital, and natural capital together constitute the totality of the wealth components of the socio-economic system, and these form the basis of current incomes, which the literature refers to as “comprehensive wealth” or “inclusive wealth.” According to a “weak” definition of sustainability, the economy (or, in a broader sense, the socioeconomic system) operated sustainably during a given period if the totality of its wealth components—that is, comprehensive wealth—did not decrease.

The total wealth of nations, its capital components, their per capita values, and changes in these figures are available for 196 countries for the period 1995–2020, based on data from the World Bank's database of national wealth accounts. The data are sourced from national statistics, which for most countries have been supplemented by the System of Environmental Economic Accounting (SEEA), and the expansion of statistical systems to include ecosystem accounts measuring natural capital has begun in numerous countries. In addition to the data from the balance sheets, also from the World Bank

⁶⁸ T. R. Malthus, J. S. Mill, D. Ricardo.

database, data on Adjusted Net Savings (ANS) and Adjusted Net National Income (ANNI) for 2017 are publicly available, dating back to the 1970s for many countries. ANS is essentially an alternative measure of changes in wealth, while ANNI is an alternative measure derived from GDP that takes social and environmental damages into account. The most recent report analyzing these data from the World Bank's Changing Wealth of Nations (CWON) program was published in 2024 (World Bank, 2024).

The Inclusive Wealth Index (IWI), developed in connection with the United Nations Environment Programme (UNEP), is also based on the theory of a wealth-based approach to sustainability. The UNEP Inclusive Wealth Report has been published four times, most recently in 2023 (UNEP, 2023), which details the methodological developments of the IWI and presents wealth-based global sustainability trends for 163 countries over the 1990–2019 period. The theory underlying the IWI is consistent with the theoretical framework of indicators based on the World Bank database, whose milestones include the 1993 paper by David Pearce and Giles Atkinson (Pearce & Atkinson, 1993), the NBER study by Kenneth Arrow and colleagues (Arrow et al., 2010), and the volume **The Economics of Biodiversity: The Dasgupta Report** (Dasgupta, 2021, 2025; Kovács, 2022), which was recently published in Hungarian as well ^{xiv}.

The Proposal by Leading Economists

Given all this, it is puzzling that the expert group's interim report made no reference to either the World Bank's CWON or the UNEP's IWI reports, nor does it mention the long-established, theoretically well-supported, asset-based sustainability indicators, which, incidentally, fully satisfy the objectives set out in the expert group's mandate. Leading economists therefore recommend the following three core indicators to complement GDP in measuring sustainability:

1. Total wealth per capita, which extends beyond traditional produced capital to include wealth embodied in human and natural capital. The value of these assets is calculated by estimating their theoretical shadow price, which depends on social inequality (as measured by the Gini index) and environmental quality.
2. Per capita GDP with an expanded definition (adjusted for social and environmental costs), and changes in this figure.

3. The global concentration of greenhouse gases in the atmosphere.

In the closing remarks of their letter addressed to the UN Secretary-General, the leading economists urge a rethinking of the expert group's mandate and, as an alternative, recommend the possibilities offered by the extended national accounts outlined in their letter. In their view, opportunities for nations to redefine the fundamental concepts of development and progress are rare, and they therefore consider the achievement of the goals set forth in the expert group's mandate to be of epochal significance.

Source: (Kovács,
2026)

ANNEX A. Global Sustainability, High-Income Country Group

Criterion for weak sustainability:

DCWpCr > 0, meaning that the estimated total wealth did not decrease during the examined period of 1995–2020.

DCWpCr – Domestic Comprehensive Wealth per Capita, real chained, 2019 US\$ – total domestic wealth per capita (real value)

DCWpCrg – Domestic Comprehensive Wealth per Capita geometric growth rate* – growth rate of domestic total wealth per capita (real value)

The sustainability
criterion is not met

* Geometric growth rate - over n periods, the geometric growth rate is $r = \exp[\ln(pn/p0)/n]$ -

1.

High-income country group – low sustainability

Country	DCWpCr 1995	DCWpCr 2020	DCWpCrg
Republic of Korea	143,375	262,484	2.42
Bulgaria	33,691	55,724	2.01
Poland	72,322	117,418	1.94
Lithuania	94,011	150,591	1.88
Estonia	131,905	210,934	1.88
Hungary	82,248	125,072	1.68
Panama	71,400	108,105	1.66
Spain	159,714	241,484	1.65
Chile	100,959	150,110	1.59
Slovak Republic	101,137	148,116	1.53
Latvia	116,112	168,250	1.48
Costa Rica	94,572	135,403	1.44
Croatia	74,594	106,383	1.42
Uruguay	125,651	178,812	1.41
Slovenia	177,431	247,037	1.32
Portugal	136,613	188,960	1.30
Finland	377,117	513,666	1.24

Canada	419,309	564,845	1.19
Israel	340,057	446,573	1.09
Romania	62,332	81,649	1.08
Italy	199,078	258,985	1.05
Australia	678,137	879,808	1.04
Iceland	799,671	1,009,702	0.93
Austria	383,387	481,838	0.91
Trinidad and Tobago	74,237	93,292	0.91
Singapore	414,013	518,759	0.90
Germany	452,268	566,363	0.90
Norway	756,859	938,198	0.86
New Zealand	503,660	622,235	0.85
France	393,117	482,357	0.82
United States of America	651,326	795,287	0.80
Saudi Arabia	69,646	84,968	0.80
Belgium	364,139	438,105	0.74
Denmark	613,926	724,366	0.66
Netherlands	503,438	592,011	0.65
Greece	116,815	136,499	0.62
Ireland	445,947	515,516	0.58
United Kingdom	352,997	407,567	0.57
Czech Republic	181,728	206,493	0.51
Guyana	103,167	115,840	0.46
Japan	439,082	490,450	0.44
Sweden	595,403	662,019	0.42
Switzerland	1,053,549	1,144,246	0.33
Malta	225,556	243,756	0.31
Oman	143,225	154,407	0.30
Russian Federation	105,518	113,326	0.29
Kuwait	152,624	117,465	-1.05
Qatar	998,771	741,499	-1.19
Luxembourg	1,252,130	871,124	-1.45
Bahrain	196,181	128,707	-1.69
United Arab Emirates	798,080	466,691	-2.15

Source: Author's analysis based on CWON

The strict sustainability criterion:

$RNCpCr_g > 0$, meaning that the estimated value of renewable natural capital did not decrease during the 1995–2020 period under review.

$RNCpCr$ – Renewable Natural Capital per Capita – renewable natural capital per capita (real value), in 2019 US\$

$RNCpCr_g$ – Renewable Natural Capital per Capita geometric growth rate – the growth rate of renewable natural capital per capita (real value)

The sustainability
criterion is not met

High-income country group – strict sustainability

Country Name	RNCpCr 1995	RNCpCr 2020	RNCpCr _g
Latvia	11,395	15,437	1,222
Lithuania	9,516	11,747	0.846
Estonia	10,804	12,878	0.705
Slovenia	9,453	10,944	0.587
Romania	8,062	8,840	0.370
Bulgaria	6,922	7,441	0.290
Iceland	29,053	30,751	0.228
Uruguay	14,264	14,903	0.175
Russian Federation	4,685	4,685	0.000
Portugal	5,981	5,829	-0.103
Finland	18,308	17,641	-0.148
Guyana	22,559	21,572	-0.179
Germany	3,249	3,077	-0.217
Italy	5,026	4,717	-0.254
Austria	9,585	8,923	-0.286
Hungary	8,039	7,202	-0.439
France	5,585	4,993	-0.447
Denmark	5,509	4,921	-0.451
United Kingdom	1,614	1,431	-0.481
Japan	4,623	4,064	-0.515
Croatia	8,479	7,358	-0.566
Sweden	22,334	19,367	-0.568
Czech Republic	6,833	5,891	-0.591

Switzerland	10,305	8,731	-0.661
Spain	7,794	6,591	-0.669
Slovak Republic	6,574	5,549	-0.676
Poland	6,549	5,487	-0.705
Netherlands	3,637	3,030	-0.727
Canada	26,772	22,276	-0.733
Norway	27,036	22,113	-0.801
Belgium	3,527	2,853	-0.845
Panama	7,057	5,703	-0.849
United States	5,605	4,519	-0.858
Ireland	4,845	3,898	-0.867
Chile	11,492	9,160	-0.903
Greece	9,396	6,861	-1.250
Republic of Korea	4,182	3,001	-1.319
Costa Rica	19,215	13,510	-1.399
Malta	1,296	890	-1.490
Trinidad and Tobago	2,301	1,566	-1.528
Luxembourg	4,260	2,845	-1.601
Israel	8,393	5,561	-1.633
Saudi Arabia	3,999	2,452	-1.937
Australia	69,506	42,088	-1.987
Oman	6,449	3,788	-2.107
New Zealand	132,847	75,541	-2.233
Singapore	496	200	-3.562
Kuwait	2,327	903	-3.717
Bahrain	1,685	529	-4.525
United Arab Emirates	9,875	2,621	-5.167
Qatar	6,006	1,153	-6.387

Source: Author's analysis based on CWON

ANNEX B. Global Sustainability, Upper-Middle-Income Countries

Weak sustainability

DCWpCr – Domestic Comprehensive Wealth per Capita

DCWPCrg – Geometric growth rate of Domestic Comprehensive Wealth per Capita*

The sustainability
criterion is not met

* Geometric growth rate – over n periods, the geometric growth rate is $r = \exp[\ln(pn/p0)/n] - 1$.

Upper-middle-income country group – weak sustainability

Country Name	DCWpCr 1995	DCWpCr 2020	DCWpCrg
Azerbaijan	9,275	33,083	5.09
Maldives	25,684	90,707	5.05
St. Lucia	44,443	100,235	3.25
Bosnia and Herzegovina	22,492	42,899	2.58
Dominican Republic	35,434	62,684	2.28
Peru	37,502	64,050	2.14
El Salvador	17,269	28,885	2.06
Albania	21,666	36,203	2.05
Turkey	33,866	55,860	2.00
China	49,309	81,065	1.99
Brazil	53,803	88,257	1.98
North Macedonia	26,700	43,307	1.93
Kazakhstan	39,902	62,708	1.81
Belarus	35,584	54,137	1.68
Iran, Islamic Republic of	30,163	45,582	1.65
Indonesia	18,748	28,164	1.63
Armenia	24,563	36,700	1.61
Colombia	45,118	64,399	1.42
Botswana	30,453	43,384	1.42
Mexico	52,085	72,107	1.30
Jamaica	47,644	61,273	1.01

Paraguay	48,908	61,755	0.93
Guatemala	29,824	36,672	0.83
Ecuador	58,434	71,400	0.80
Argentina	67,464	81,735	0.77
Georgia	19,942	23,723	0.69
Thailand	57,109	67,745	0.68
Malaysia	76,473	89,848	0.64
Mauritius	53,137	62,029	0.62
South Africa	42,566	48,735	0.54
Belize	37,512	41,451	0.40
Suriname	74,384	78,496	0.22
Mongolia	60,681	59,218	-0.10
Moldova	19,553	18,305	-0.26
Ukraine	31,923	28,603	-0.44
Iraq	88,629	76,598	-0.58
Gabon	74,829	52,538	-1.41

Source: Author's analysis based on CWON

Strict sustainability

RNCpCr – Renewable Natural Capital per Capita

RNCpCrg – Renewable Natural Capital per Capita geometric growth rate

The sustainability
criterion is not met

Upper-middle-income country group – strict sustainability

Country	RNCpCr 1995	RNCpCr 2020	RNCpCrg
Armenia	2,336	3,799	1,964
Bosnia and Herzegovina	6,136	7,893	1,012
Albania	7,587	9,641	0.963
Georgia	3,598	4,271	0.689
Ukraine	2,647	3,019	0.527
North Macedonia	6,122	6,669	0.343
Belarus	4,385	4,478	0.084
Moldova	2,341	2,391	0.084
Indonesia	6,274	5,866	-0.268

China	10,817	10,072	-0.285
Brazil	10,194	9,247	-0.389
Thailand	11,252	9,686	-0.598
Kazakhstan	2,607	2,224	-0.633
Jamaica	7,144	6,039	-0.670
Azerbaijan	3,862	3,087	-0.892
El Salvador	3,804	2,993	-0.954
Colombia	4,762	3,687	-1.018
Paraguay	18,429	13,969	-1,102
Mauritius	4,476	3,346	-1,157
Turkey	10,036	7,490	-1,163
Suriname	44,538	32,636	-1,236
Ecuador	6,087	4,436	-1,258
South Africa	6,793	4,925	-1,278
Dominican Republic	8,767	6,250	-1,344
Mongolia	4,954	3,490	-1,391
Peru	7,010	4,816	-1,491
Argentina	9,367	6,304	-1,572
Mexico	6,989	4,594	-1,664
Malaysia	19,749	12,967	-1,669
Iraq	2,659	1,472	-2,338
Botswana	9,790	5,283	-2,438
Iran, Islamic Republic of	10,611	5,713	-2,446
St. Lucia	13,270	7,049	-2,499
Guatemala	9,448	4,846	-2,635
Gabon	25,291	12,568	-2,758
Belize	24,581	11,827	-2,884
Maldives	1,868	652	-4,124

Source: Author's analysis based on CWON

ANNEX C. Global Sustainability, Lower-Middle- Income Countries

Weak sustainability

DCWpCr – Domestic Comprehensive Wealth per Capita

DCWPCrg – Geometric growth rate of Domestic Comprehensive Wealth per Capita*

The sustainability
criterion is not met

* Geometric growth rate – over n periods, the geometric growth rate is $r = \exp[\ln(pn/p0)/n] - 1$.

Lower-middle-income country group – weak sustainability

Country	DCWpCr 1995	DCWpCr 2020	DCWpCrg
Vietnam	17,540	34,445	2.70
Bangladesh	8,894	13,948	1.80
Djibouti	9,274	14,162	1.69
Morocco	14,913	22,730	1.69
Nicaragua	13,750	19,403	1.38
Sri Lanka	14,117	19,773	1.35
Honduras	17,434	23,985	1.28
Tunisia	19,514	26,699	1.25
Lebanon	36,618	48,186	1.10
Haiti	7,675	9,801	0.98
India	13,291	16,401	0.84
Bolivia	24,637	30,292	0.83
Eswatini	28,932	35,306	0.80
Nepal	10,674	12,709	0.70
Jordan	16,671	19,322	0.59
Zimbabwe	14,256	16,396	0.56
Comoros	13,363	14,997	0.46
Namibia	42,270	47,344	0.45
Cambodia	14,755	16,456	0.44
Egypt, Arab Republic	18,188	19,828	0.35

São Tomé and Príncipe	20,644	22,262	0.30
Philippines	23,812	25,433	0.26
Angola	26,409	27,841	0.21
Lesotho	9,376	9,838	0.19
Pakistan	10,818	11,254	0.16
Solomon Islands	38,070	39,498	0.15
Kenya	21,901	22,537	0.11
Lao PDR	31,464	31,377	-0.01
Benin	19,450	18,793	-0.14
Kyrgyz Republic	11,729	11,027	-0.25
Tanzania	13,485	12,368	-0.35
Congo, Rep.	46,822	42,727	-0.37
Côte d'Ivoire	30,639	27,388	-0.45
Nigeria	24,146	21,575	-0.45
Senegal	16,757	14,818	-0.49
Mauritania	19,393	17,083	-0.51
Ghana	31,045	27,186	-0.53
Cameroon	25,066	21,319	-0.65
Zambia	24,565	19,947	-0.83
Guinea	15,356	12,140	-0.94
Papua New Guinea	54,028	34,615	-1.78
Tajikistan	24,854	12,844	-2.64

Source: Author's analysis based on CWON

Strict sustainability

RNCpCr – Renewable Natural Capital per Capita

RNCpCrg – Renewable Natural Capital per Capita geometric growth rate

The sustainability
criterion is not met

Lower-middle-income country group – strict sustainability

Country Name	RNCpCr 1995	RNCpCr 2020	RNCpCrg
Vietnam	9,089	12,261	1,204
Lesotho	1,901	1,841	-0.129
Sri Lanka	3,865	3,739	-0.133

Eswatini	8,964	7,669	-0.622
Zimbabwe	4,609	3,818	-0.751
Lao PDR	26,204	21,617	-0.767
Nepal	8,393	6,810	-0.833
Tunisia	8,961	7,128	-0.911
Cambodia	10,650	8,033	-1.122
Haiti	2,304	1,729	-1,141
Lebanon	7,374	5,510	-1,159
Bangladesh	3,899	2,889	-1,192
Egypt, Arab Republic	10,158	7,337	-1,293
Tajikistan	4,729	3,403	-1,307
Morocco	8,185	5,884	-1,312
Philippines	6,255	4,328	-1,463
India	6,650	4,586	-1,476
Kyrgyz Republic	4,372	3,004	-1,490
Solomon Islands	33,451	22,816	-1,519
Djibouti	922	621	-1,570
Benin	11,492	7,394	-1,748
Bolivia	4,852	3,095	-1,783
Comoros	6,286	3,838	-1,954
Pakistan	5,651	3,440	-1,966
Nicaragua	7,315	4,393	-2,019
São Tomé and Príncipe	6,613	3,839	-2,152
Namibia	12,789	7,379	-2,176
Honduras	6,845	3,902	-2,223
Angola	8,694	4,954	-2,225
Papua New Guinea	28,861	16,276	-2,265
Guinea	10,599	5,973	-2,268
Tanzania	8,239	4,533	-2,361
Cameroon	14,783	8,108	-2,374
Nigeria	10,287	5,598	-2,405
Côte d'Ivoire	17,618	9,411	-2,477
Ghana	15,907	8,306	-2,566
Congo, Rep.	13,530	7,045	-2,576
Kenya	7,443	3,869	-2,584
Zambia	14,123	7,278	-2,617
Senegal	10,375	5,122	-2,784

Mauritania	3,742	1,716	-3,070
Jordan	3,860	1,460	-3,815

Source: Author's analysis based on CWON

ANNEX D. Global Sustainability, Low-Income Country Group

Weak sustainability

DCWpCr – Domestic Comprehensive Wealth per Capita, real chained 2019 US\$

DCWPCrg – Domestic Comprehensive Wealth per Capita geometric growth rate*

The sustainability
criterion is not met

* Geometric growth rate – over n periods, the geometric growth rate is $r = \exp[\ln(pn/p0)/n] - 1$.

Low-income country group – weak sustainability

Country Name	DCWpCr 1995	DCWpCr 2020	DCWpCrg
The Gambia	4,324	4,821	0.44
Mozambique	8,186	8,573	0.18
Uganda	10,471	10,914	0.17
Rwanda	11,690	11,383	-0.11
Ethiopia	13,179	12,766	-0.13
Togo	19,291	17,030	-0.50
Madagascar	8,421	7,127	-0.67
Chad	9,495	7,969	-0.70
Guinea-Bissau	14,128	11,359	-0.87
Malawi	14,484	11,420	-0.95
Mali	17,895	13,655	-1.08
Sierra Leone	10,925	8,193	-1.15
Burkina Faso	12,522	9,156	-1.25
Niger	10,461	7,372	-1.40
Central African Republic	7,957	5,569	-1.43
Burundi	8,187	5,616	-1.51
Democratic Republic of the Congo	14,410	9,440	-1.69
Liberia	19,514	11,943	-1.96

Source: Author's analysis based on CWON

Strict sustainability

RNCpCr – Renewable Natural Capital per Capita

RNCpCrg – Renewable Natural Capital per Capita geometric growth rate

The sustainability
criterion is not met

Low-income country group – strict sustainability

Country Name	RNCpCr 1995	RNCpCr 2020	RNCpCrg
Mozambique	6,256	4,715	-1,125
Malawi	11,253	7,019	-1,870
Central African Republic	6,176	3,807	-1,916
Sierra Leone	5,879	3,592	-1,951
Guinea-Bissau	10,092	5,941	-2,097
Ethiopia	6,289	3,546	-2,266
Uganda	5,378	2,990	-2,321
Togo	6,946	3,827	-2,356
Burkina Faso	8,782	4,727	-2,447
Mali	11,212	6,023	-2,455
Madagascar	5,292	2,812	-2,497
Rwanda	8,041	4,176	-2,586
Democratic Republic of the Congo	8,532	4,424	-2,593
Niger	8,001	4,065	-2,672
Burundi	6,218	3,073	-2,779
Liberia	12,684	5,868	-3,037
Chad	6,407	2,855	-3,181
The Gambia	2,657	1,124	-3,382

Source: Author's analysis based on CWON

ANNEX E. Hungary's Sustainability Data

Source: Data from Figures 5–

14 in World Bank Open Data

Constant 2015 US\$/capita	2000	2005	2010	2015	2020
GDP	8,980	11,273	11,287	12,783	14,664
GNI	8,551	10,757	10,859	12,183	14,439
ANNI	6,824	8,989	8,788	9,968	11,491

Data from Figures 5–16

Constant 2015 US\$ per capita	2000	2005	2010	2015	2020
ANSpC	82	475	740	1,456	1,804
GSpC	900	1,866	2,746	3,282	4,339

Data from Figures 5–17

constant 2015 US\$/capita	2000	2005	2010	2015	2020
PCpC	16,219	19,574	22,698	24,780	28,599
HCpC	61,010	65,822	67,250	78,422	89,730
NCpCNR	1,172	763	192	214	192
NCpCR	7,849	8,004	7,530	7,564	7,202

Data from Figures 5–18, constant 2015 US\$ per capita

	2000	2005	2010	2015	2020	GGr
Hungary	83,940	83,886	79,836	101,706	117,713	1.94
Austria	382,241	400,765	432,388	455,312	487,657	1.27
China	50,415	56,702	66,425	73,359	82,712	2.50
United States	672,533	699,853	699,985	723,580	751,632	0.70

Data from Figures 5–19, constant 2015 US\$ per capita

	2000	2005	2010	2015	2020	GGr
Hungary	7,849	8,004	7,530	7,564	7,202	- 0.47
Austria	10,070	9,367	9,254	8,805	8,923	- 0.18
China	10,362	10,213	10,190	10,148	10,072	- 0.26
United States	5,285	5,048	4,825	4,645	4,519	- 0.86

Endnotes

ⁱ László Krasznahorkai (2008): *Seiobo Was Down There. Magvető, Budapest.* — in particular: p. 987.

Chapter: The Reconstruction of the Ise Shrine.

In one chapter of his novella, László Krasznahorkai describes the ritual reconstruction of the Grand Shrine of Ise (Ise Jingū) every twenty-seven years, known as *shikinen sengu*. For 1,300 years, the shrine has been completely dismantled every twenty years and then rebuilt immediately next to it in the same form using wood from the shrine's own forest. Through the meticulous precision of the wood selection and craftsmanship, Krasznahorkai demonstrates that it is not the material but the continuity of form, knowledge, and spirituality that is preserved here. The building's material is transient; the knowledge of how to rebuild it is permanent.

- ⁱⁱ GDP is the most fundamental concept in macroeconomics, and its use—particularly in communications directed at the general public—is typically accompanied by misinterpretations. The limitations of applying GDP have been known since its inception, a topic that has been the subject of numerous scholarly works as well as less scholarly writings. Diane Coyle discusses the role of GDP in a historical context and on a historical scale, which serves as a useful reference point and a basis for debate in the academic discourse on the criteria by which economic performance should be measured from a sustainability perspective: Coyle, D. (2016). *GDP: A Brief But Affectionate History*. Princeton University Press; Syrquin, M. (2016). A Review Essay on “GDP: A Brief but Affectionate History” by Diane Coyle. *Journal of Economic Literature*, 54(2), Article 2. JSTOR.
- ⁱⁱⁱ In a lecture delivered on May 8, 2025, at the Center for Economic Geography and Urban Marketing at János Neumann University, Sir Partha Dasgupta summarized the key messages of the Dasgupta Report and their place in economic thought and environmental economics curricula. <https://geo.nje.hu/en/videos/2025/environmental-economics-workshop-budapest-hungary-infopark-8th-of-may-2025>
- ^{iv} Since the publication of **Laudato si’** in 2015, Pope Francis has emphasized the key role of ecological education in achieving an authentic “ecological conversion,” defined as “a transformation of hearts and minds toward a greater love for God, for one another, and for

creation.” As a concrete expression of this commitment, Pope Francis

launched the “Borgo Laudato Si” project, an educational center dedicated to integrated ecology, located at the papal residence in Castel Gandolfo, 24 kilometers south of Rome.

- v One of Rawls’s fundamental concepts of justice-as-equity rests on two main principles. The first principle is respect for basic freedoms, such as freedom of religion, freedom of thought, and freedom of speech. The second principle essentially addresses the issue of economic equality, within which Rawls establishes two important rules: first, that a just distribution is one that serves the interests of all members of society, while at the same time being linked to positions that are open to everyone. Justice, as fairness, can essentially be summarized as the equal distribution of all values in society (such as freedom, income, and the basis of self-respect), unless inequality serves the interests of everyone.

A Critical Analysis of John Rawls’s Work:

Zoltán Pogátsa (December 5, 2016). *John Rawls’s “A Theory of Justice”—Liberal or Social Democratic? Új Egyenlőség*. <https://ujegyenloseg.hu/john-rawls-az-igazsagossag-elmelete-liberalis-vagy-szocialdemokrata/>

- vi Another interesting aspect of the bibliography of Green Philosophy is that it includes virtually all the authors and documents that, by the beginning of the 21st century, had essentially laid the foundation for the scientific, political, and public understanding of the environment and sustainability.
- vii Harold Hotelling, an American economist (1895–1973), in his 1931 article titled “The Economics of Exhaustible Resources,” defines the optimal schedule for the extraction of minerals and energy resources, on the one hand, and introduces the concept of user cost, which is crucial for understanding mining royalties, on the other. Source: Ferenc Mádai, *Mineral Resource Management*, 2009.
- viii David Pearce died tragically and suddenly in 2005, just hours after being . The UCL published a obituary honored his work (<https://www.ucl.ac.uk/news/2005/sep/obituary-professor-david-pearce-economist-who-priced-environment>). According to an article in *The Guardian*, Pearce influenced numerous areas of economics: he changed scholarly thinking on economic growth,

pollution and and well-being

(<https://www.theguardian.com/science/2005/sep/22/highereducation.guardianobituaries>)

- ix Kenneth Boulding used the metaphor of “Spaceship Earth” to highlight the finite nature of the Earth’s resources and the need to strive for sustainability. The “Cowboy economy” views the Earth as an infinite resource, whereas the “astronaut economy” regards the Earth as a closed system.
- x According to the capital approach to sustainability—that is, the asset-based perspective—natural capital is a factor of production that contributes to the generation of economic output (income). Natural capital consists of renewable and non-renewable components. Non-renewable natural capital—minerals and energy resources—can be substituted with other factors of production, such as man-made (productive) capital (equipment and machinery) or human capital, that is, knowledge.
- xi His textbook, **Economics**, co-authored with Paul Samuelson and translated into Hungarian, is a synthesis of neoclassical economics. The Dynamic Integrated Climate Economy (DICE) model, developed by Nordhaus (supplemented by RICE—Regional Integrated Climate Economy), is an integrated assessment model (IAM) that enables the quantification of the long-term economic costs and benefits of global climate policy scenarios. Essentially, the model suggests that humanity is gambling with the future of the Earth.
- xii Ramsey’s work far surpassed the economic thinking of his time, and his groundbreaking results were largely recognized only later. A later, refined version of Ramsey’s model is the Ramsey-Cass-Koopmans model. His articles and writings continue to influence theoretical economic research to this day.

Additional sources:

The Wall Street Journal. Frank Ramsey Review - The Most Genial Genius. URL: <https://www.wsj.com/articles/frank-ramsey-review-the-mostgenial-genius-11585322801>

The Wall Street Journal. Frank Ramsey Review - The Most Brilliant Genius. url: <https://www.wsj.com/articles/frank-ramsey-review-the-mostgenial-genius-11585322801>

^{xiii} Source: <https://www.linkedin.com/in/robert-smith-3441581a/recent-activity/all/>

^{xiv} In 2026, Pázmány Péter Catholic University awarded Sir Partha Dasgupta an honorary doctorate in recognition of his work and his support for environmental economics education in Hungary.