#ENVECON10


# 10th Anniversary ENVECON Conference
# 6 – 7 December 2024 | HYBRID

## SCOPE

Main issues that concern the Economics of Natural Resources and the Environment with emphasis on the various environmental problems and their management and solution policies.

## AIM

Highlight the interdisciplinary nature of environmental research through the exchange of views and experiences of researchers from different scientific fields and the finding of common components of research approaches.

**Organized by Laboratory of Operations Research**
**Hosted at Department of Economics, University of Thessaly**

# Conference Organization



Laboratory of Operations Research
Department of Economics
School of Economics and Business
University of Thessaly

Book of Proceedings 10th Anniversary Conference
ENVECON 2014 – 2024

# Opening Speech for the 10th Anniversary Conference

Dear,
Distinguished guests, esteemed colleagues, and students,

On behalf of the Scientific and Organizing Committee I welcome you at the:

10th Anniversary Conference on "**Economics of Natural Resources and the Environment**".



It is with immense pride and heartfelt gratitude that I welcome you all to our 10th Anniversary ENVECON Conference. Today, we stand together to celebrate a milestone that marks a decade of growth, achievements, and shared success. This occasion is not just about celebrating the passage of time. It is about honoring the people who have been the heart and soul of this journey.

To our hardworking team members, loyal partners, and supportive community—this celebration is a tribute to each of you. Your passion, perseverance, and dedication have made this organization what it is today for completing 10 years of robust scientific work with practical results and policy implications.

When we began this journey ten years ago, we had a dream – a dream to disseminate the pivotal goals of environmental science and all of its sub-categories from environmental or ecological economics to marine and water-related studies, psychology, circular economy, transportation, tourism to name but a few. We started with a handful of determined individuals, bold ideas, and an unwavering belief in the possibilities ahead. Over the years, we have faced challenges, embraced opportunities, and achieved milestones we could only imagine. Looking back, it is not just the successes that define us, but the resilience and innovation that carried us through the most difficult times. These qualities are what inspire us to aim higher and dream bigger as we look to the future.

As a first Milestone, it was the organization of the initial four national conferences. The first four conferences were exclusively on a national scale and took place at the Department of Economics. The Laboratory of Operations Research in the Department of Economics of the School of Economics and Business at the University of Thessaly organized successfully under the research project COOPERATION 2011 and the project entitled "Greenhouse Gas Emission Scenarios and Policies to Combat them by the year 2030, of Energy, Transport and Industry in Greece". More specifically, the first two were on Climate Change on March 2014 and October 2014, whereas the 3rd and 4th were on Environmental Economics and took place on 2015 and 2016 on the former premises of our Department in the formerly French Institute.

Regarding the second Milestone, it was the international phase of the conference. Beginning with the 5th ENVECON Conference which was organized in 2018 in the Department of Economics of the University of Thessaly at Volos Greece.

The third Milestone focused on cooperation with other departments in order to boost scientific excellence and openness. For example, the 6th ENVECON Conference was jointly organized by the Department of Economy and Sustainable Development of the Harokopio University and our Laboratory online on June 2021 due to COVID-19 restrictions. Additionally, the 7th ENVECON Conference was jointly organized by the Laboratory of Operations Research of the Department of Economics and the Interdepartmental Postgraduate Studies Program Education for Sustainability and the Environment of the University of Thessaly with emphasis to "Environmental awareness and education". The Conference took place online in November 2021. Furthermore, the 8th ENVECON Conference was jointly organized by the Research Unit of Environmental Communication and Education, Department of Public and Community Health, University of West Attica and our Laboratory. The Conference took place in December 2022 with emphasis to "Environmental Research Activities: Progress and Trends". The 9th ENVECON Conference was jointly organized by the Laboratory of Forest Economics of the Aristotle University of Thessaloniki (AUTh) of the School of Forestry and Natural Environment of AUTh and our Laboratory. The Conference took place on December 2023 with physical presence in Thessaloniki at the premises of the School at Finikas region in Thessaloniki, Greece and Online.

Today we celebrate the fourth Milestone: The 10th ENVECON. Now, the 10th Anniversary ENVECON Conference is organized by our Laboratory in the Department of Economics at the University of Thessaly. The scope of the conference is to present the main issues that concern the Economics of Natural Resources and the Environment with emphasis on the various environmental problems and their management and solution policies. Its aim is to highlight the interdisciplinary nature of environmental research through the exchange of views and experiences of researchers from different scientific fields and the finding of common components of research approaches.

In this anniversary conference emphasis will be given to the findings of 10 years of experience of interdisciplinary meetings and constructive discussions in the many and important sessions of ENVECON. Today's conference is not just a celebration, but a platform to reflect, learn, and ignite new ideas. The sessions we have planned are designed to inspire thought-provoking discussions and spark collaborations that will shape our next decade. As we celebrate this milestone, let us also remember that anniversaries are not just a time to look back, but a moment to look forward. The next chapter is waiting to be written, and we have the tools, the talent, and the determination to make it even more impactful.

I would also like to wholeheartedly thank the keynote speakers of the 10$^{th}$ anniversary ENVECON Conference: Prof. Efthymios Lekkas, Prof. Anil Markandya, Director Jaime Moll de Alba, and Prof. Thanasis Stengos who accepted the invitation to present their long-term remarkable research experience on topics relevant to the conference.

Thank you once again for being here to celebrate this special moment with us, as we are here ***188 participants*** from ***102 institutions***. Whether you have been with us since the beginning or joined us along the way, you are part of our story. Together, let us make this conference a memorable one, filled with insight, connection, and inspiration.

Here's to ten remarkable years—and to an even brighter future ahead!

Thank you very much for being here and we hope that we'll meet again each and every year till the 20th ENVECON.



**ENVECON Conference Scientific Coordinator**
**Professor George E. Halkos**
Laboratory of Operations Research
Department of Economics
School of Economics and Business
University of Thessaly, Volos, Greece

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# Scientific & Organizing Committees

**Scientific Coordinator of ENVECON Conference**

George Halkos, Professor, University of Thessaly

**Scientific Committee**

- Amman Hans, Professor University of Amsterdam
- Andreopoulou Zacharoula, Professor, Aristotle University of Thessaloniki
- Apergis Nicholas, Professor, University of Piraeus
- Arabatzis Garyfallos, Professor, Democritus University of Thrace
- Barbier Edward, Professor, Colorado State University
- Coccossis Harry, Professor, University of Thessaly
- Dasgupta Partha, Sir Professor University of Cambridge
- Diakoulaki Danae, Professor, National Technical University of Athens
- Evangelinos Konstantinos, Professor, University of the Aegean
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- Filho Leal, Professor, Manchester Metropolitan University
- Georgantzis Nikos, Professor, University of Reading
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- Hristopoulos Dimitris, Professor, Athens University of Economics
- Kagawa Shigemi, Professor Kyushu University
- Karakasidis Theodore, Professor University of Thessaly
- Kinzig Ann, Professor, Arizona State University
- Kitsos Christos, Professor, University of West Attica
- Kollias Christos, Professor, University of Thessaly
- Kougolos Athanasios, Professor, Aristotle University of Thessaloniki
- Koundouri Phoebe, Professor, Athens University of Economics and Business
- Kounetas Kostas, Professor, University of Patras
- Laspidou Chrysi, Professor University of Thessaly
- Leitão Nuno Carlos, Professor, Polytechnic Institute of Santarém
- Löschel Andreas, Professor University of Münster
- Markandya Anil, Distinguished Ikerbasque Professor & Former Scientific Director, Basque Centre for Climate Change
- Managi Shunsuke, Professor, Kyushu University
- Matsiori Steriani, Professor Unoversity of Thessaly
- Mattas Konstantinos, Professor, Aristotle University of Thessaloniki
- Mazzanti Massimiliano, Professor Università di Ferrara
- Michalakakou Panagiota, Professor, University of Patras
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- Moll de Alba, Jaime, Dr Director UNIDO
- Mpithas Konstantinos, Professor, Panteion University

## Scientific Committee

- Nikolaou Ioannis, Professor, Democritus University of Thrace
- Oueslati Walid, Professor, Organisation of Economic Cooperation and Development (OECD)
- Papandreou Andreas, Professor, National and Kapodistrian University of Athens
- Perrings Charles, Professor, Arizona State University
- Profillidis Vasilios, Professor, Democritus University of Thrace
- Protopapas Angelos, Professor, Democritus University of Thrace
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- Zerefos Christos, Professor, President elect of the International Ozone Commission (IO3C) of IAMAS of ICSU
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- Bampatsou Christina, Associate Professor, Ionian University
- Economou Athina, Associate Professor, University of Thessaly
- Kontogianni Areti, Associate Professor, University of Western Macedonia
- Månsson Jonas Associate Professor, Linnaeus University, Sweden
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- Hatzistamoulou Nikolaos, Assistant Professor University of Ioannina
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- Ren Jingzheng, Assistant Professor Hong Kong Polytechnic University

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- Topalidis Michail
- Tsiachtanis Dimitrios
- Tzakou Sevasti
- Vouklis Christos

### Technical Support

- Iatridis Alexandros, University of Thessaly

# Keynote Speakers

*"Natural Hazards Management in an Era of Escalating Climate Crisis"*

**Prof. Efthymios Lekkas**

Professor of Dynamic, Tectonic, Applied Geology and Natural Disaster Management
National and Kapodistrian University of Athens
President of the Earthquake Planning and Protection Organization of Greece (EPPO)

*"The Triple Planetary Crises: Linkages Between Policies"*

**Prof. Anil Markandya**

Distinguished Ikerbasque Professor

Basque Centre for Climate Change – BC3
Honorary Professor at University of Bath

*"Sustainable Industrial Development and SDG 9: A Global Overview"*

**Director Dr. Jaime Moll de Alba**

Director of the Division of Strategic Programming, Results Monitoring and Quality Assurance

United Nations Industrial Development Organization (UNIDO)

*"Revisiting the specification of the relationship between $CO_2$ per capital emissions and income per capita"*

**Professor Thanasis Stengos**

Professor of Economics with specialization on Econometrics

University of Guelph

# Honorary Greetings

**Prof. Shunshuke Managi**
**Kyushu University, Japan**

Professor Shunsuke Managi, a Distinguished Professor of Technology and Policy & Director of Urban Institute at the Kyushu University, Japan will give an honorary speech at the 10th Anniversary ENVECON Conference as Director of the of Urban Institute.

**Prof. Charles Perrings**
**Arizona State University, USA**

Professor Charles Perrings, an Emeritus professor at the Arizona State University in the USA, on the field of environmental economics and environmental management will give an honorary speech at the 10th Anniversary ENVECON Conference

**Prof. Ann Kinzig**
**Arizona State University, USA**

Professor Ann Kinzig, a professor at the Arizona State University in the USA, on the field of Ecology, Economics, and Ethics of the Environment will give an honorary speech at the 10th Anniversary ENVECON Conference.

**Prof. Clevo Wilson**
**Queensland University of Technology, Australia**

Professor Clevo Wilson, a professor at Queensland University of Technology, in the field of Applied Economics and Tourism, will give an honorary speech at the 10th Anniversary ENVECON Conference.

# Honorary Greetings

**Prof. Charalambos Billinis**
**University of Thessaly**

Professor Charalambos Billinis, a professor at the University of Thessaly (UTH), on the field of Zoonoses, Wildlife diseases transmitted to domestic animals and humans will give an honorary speech at the 10th Anniversary ENVECON Conference as the Rector of UTH.

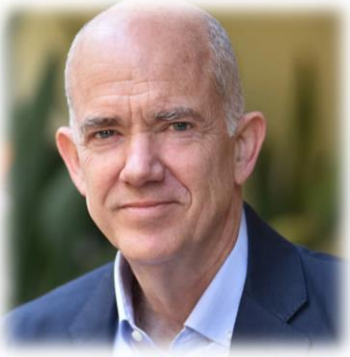


**Prof. Chrysi Laspidou**
**University of Thessaly**

Professor Chrysi Laspidou, a professor at the University of Thessaly (UTH), on the field of resource Nexus and water informatics will give an honorary speech at the 10th Anniversary ENVECON Conference as the Vice-Rector of Innovation, Internationalization, Collaborations and Digital Governance at UTH.

**Assoc. Prof. Loukas Zachilas**
**University of Thessaly**

Professor Loukas Zachilas, an associate professor at the University of Thessaly (UTH), on the field of numerical and analytical study of non-linear dynamical models and stability of economic systems will give an honorary speech at the 10th Anniversary ENVECON Conference as the Head of the Department of Economics at UTH.



**Prof. Andreas Papandreou**
**National and Kapodistrian University of Athens**

Professor Andreas A. Papandreou, a professor at the National and Kapodistrian University of Athens (NKUA), on the field of environmental economics will give an honorary speech at the 10th Anniversary ENVECON Conference as co-president of the United Nations Sustainable Development Solutions Network in Greece.

# Honorary Greetings

**Assoc. Prof. Athanasios Dagoumas**
**University of Piraeus**

Professor Athanassios Dagoumas, an associate professor at the University of Piraeus (UNIPI), on the field of Energy and Resource Economics will give an honorary speech at the 10th Anniversary ENVECON Conference as the President of the Regulatory Authority for Energy, Waste and Water in Greece and the founding Director of the Energy & Environmental Policy laboratory at UNIPI.

**Apostolos Siskos**
**Co-Founder & Chairman | ENVIROMETRICS**

Apostolos Siskos, the co-founder and chairman in Envirometrics, on the field of air pollution and environmental project management will give an honorary speech at the 10th Anniversary ENVECON Conference.

**Theodora Antonakaki**
**Bank of Greece**

Theodora Antonakaki, a Director at the Bank of Greece, on the field of climate change will give an honorary speech at the 10th Anniversary ENVECON Conference as the Director of Climate Change and Sustainability and as the representative of BoG on a network of 114 central banks and financial supervisors on the Network for Greening the Financial System.

**Prof. Dimitrios Komilis**
**Democritus University of Thrace**

Professor Dimitrios Komilis, a professor at Democritus University of Thrace, on the field of solid waste management will give an honorary speech at the 10th Anniversary ENVECON Conference.

# Concise Conference Programme

| Greek Time | Sessions-Topics<br>Day 1 – Friday 06/12/2024 |
|---|---|
| **10:00-11:30** | OPENING – WELCOME |
| **11:30-12:00** | Keynote Speaker: Professor Anil Markandya |
| **12:00-12:15** | Coffee Break |
| **12:15-14:00** | Session 1: Circular Economy and Bioeconomy<br>*Chairperson: Dr. Jaime Moll de Alba.* |
| **12:15-14:00** | Session 2: Smart Technologies and Sustainable Development<br>*Chairperson:Prof. Zacharoula Andreopoulou* |
| **14:00-14:45** | Lunch Break |
| **14:45-16:15** | Session 3: Climate Change Adaptation<br>*Chairperson: Prof. George Halkos* |
| **14:45-16:15** | Session 4: Sustainable Tourism and Transportation<br>*Chairperson: Prof. Vassilios Profillidis* |
| **16:15-16:30** | Coffee Break |
| **16:30-17:00** | Keynote Speaker: Professor Thanasis Stengos |
| **17:00-19:00** | Session 5: Energy Poverty and Inequality<br>*Chairperson: Prof. George Halkos.* |
| **17:00-19:00** | Session 6: Forest Economics<br>*Chairperson: Assoc. Prof. Konstantinos G. Papaspyropoulos* |
| **19:00-20:00** | Dinner |
| | **Day 2 - Saturday 07/12/2024** |
| **10:00-11:30** | Session 7: Novel Research Activities<br>*Chairperson: Asst. Prof. Giannis Adamos.* |
| **10:00-11:30** | Session 8: Quantitative Methods in Environmental Economics & Management<br>*Chairperson: Prof. Christos Kitsos* |
| **11:30-12:00** | Keynote Speaker: Professor Efthymios Lekkas |
| **12:00-12:15** | Coffee Break |
| **12:15-14:00** | Session 9: Health and Unexpected Events<br>*Chairperson: Assoc. Prof. Athina Economou* |
| **12:15-14:00** | Session 10: Growth, Institutions & Policies<br>*Chairperson: Prof. Michel Zouboulakis* |
| **14:00-14:45** | Lunch Break |
| **14:45-15:15** | Keynote Speaker: Director Dr. Jaime Moll de Alba |
| **15:15-16:45** | Session 11: Environmental Innovative Policies and Applications<br>*Chairperson: Prof. George Halkos* |
| **15:15-16:45** | Session 12: Corporate Social Responsibility & Environmental Social Governance<br>*Chairperson: Prof. Konstantinos Evangelinos* |
| **16:45-17:00** | Coffee Break |
| **17:00-17:30** | Honorary Greetings |
| **17:30-18:00** | Closing of the 10th Anniversary ENVECON Conference |
| **18:00-19:00** | Dinner |

# Conference Schedule

# Friday 06 December

**Opening – Welcome** **10:00-11:30**

**Keynote Speaker – Room B1** **11:30-12:00**

*Topic: "The Triple Planetary Crises: Linkages Between Policies"*

**Professor Anil Markandya**

*Distinguished Ikerbasque Professor*
*Basque Centre for Climate Change – BC3*
*Honorary Professor at University of Bath*

**Coffee Break** **12:00-12:15**

**1st Session – Room B1** **12:15-14:00**

| **Topic** | **Circular Economy and Bioeconomy** |
|---|---|
| **Chairperson** | **Dr. Jaime Moll de Alba** |
| **12:15-12:30** | *The role of consumers and producers in implementing a circular bioeconomy: an Australian case study*<br>Alice Payne, Clevo Wilson, Jeremy Webb, Uttam Khanal &Anushiya Thanapalan |
| **12:30-12:45** | *Circular Economy in the European Rubber and Plastics Industry*<br>George E. Halkos, Jaime Moll de Alba, Panagiotis – Stavros C. Aslanidis & Christina Bampatsou |
| **12:45-13:00** | *Sustainable Management of Recyclable Waste in Educational Institutions: The Case of Aristotle University of Thessaloniki*<br>Sofia Gerochristou & Maria Samolada |
| **13:00-13:15** | *Best Environmental Practices for the reduction and management of solid waste, energy and the promotion of circular economy: The case of Mediterranean spa hotel in Katerini*<br>Panagiotis Vouros, Peni Lamprou, Christos Mitsokapas, Petros Dallas, Akrivi Vagena, Panagiotis Tridimas, Konstantinos Evangelinos & Panagiotis Grammelis |
| **13:15-13:30** | *Sustainability in municipal waste recycling: an empirical investigation of economic and institutional determinants*<br>Ioannis Kostakis, George Halkos & Eleni Sardianou |
| **13:30-13:45** | *Global Bioeconomy: History, Visions and Limitations*<br>Panagiotis Koronaios, Panagiotis Kalimeris & Georgios Maroulis |

**2nd Session – Room B20** **12:15-14:00**

| | |
|---|---|
| **Topic** | **Smart Technologies and Sustainable Development** |
| **Chairperson** | **Prof. Zacharoula Andreopoulou** |
| **12:15-12:30** | *Green IT and smart technologies for optimal economic efficiency of mineral resources and energy*<br>Chatzipanagiotou, A., Andreopoulou, Z. & Koliouska, C. |
| **12:30-12:45** | *Green certification in coastal areas of Greece as a significant factor for local development*<br>Delarda, E., Andreopoulou, Z. & Koliouska, C. |
| **12:45-13:00** | *Virtual Reality: A tool to promote tourism in the rehabilitated mines of Western Macedonia*<br>Koliouska, C. |
| **13:00-13:15** | *Climate change and the environment in apps for disabled people: The use of digital media*<br>Terzi, E. & Andreopoulou, Z. |
| **13:15-13:30** | *Natural History Museums and Protected Areas Information Centres: Characteristics of video presentations and regional development*<br>Andreopoulou Zacharoula, Georgilas Argyrios & Christos Liotiris |
| **13:30-13:45** | *Fermentation technologies for bioethanol production: Prospects and challenges*<br>Morfopoulos Nikolaos & Kamperidou Vasiliki |

**Lunch Break** **14:00-14:45**

**3rd Session – Room B1** **14:45-16:15**

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|---|---|
| **Topic** | **Climate Change Adaptation** |
| **Chairperson** | **Prof. George Halkos** |
| **14:45-15:00** | *Development and application of a methodological framework for assessing the resilience of military infrastructure against climate change impacts*<br><br>Ilias Manolis, Christos Makropoulos, Athanasios Sfetsos & Antonios Skouloudis |
| **15:00-15:15** | *Climate risk assessment on Fisheries and Aquaculture in Greece*<br><br>Vasileia Pentsiou, Charis Benetatos & Christina Papadaskalopoulou |
| **15:15-15:30** | *Deciphering the footprint of climate risks on shaping inflationary devaluation pressures in developed economies*<br><br>Nikolaos A. Kyriazis, Konstantinos A. Dimitriadis, Emmanouil-Marios Economou &Sevasti-Maria Karakosta |
| **15:30-15:45** | *An adapted model of climate change adaptation behavior*<br><br>Anastasia Gkargkavouzi & George E. Halkos |
| **15:45-16:00** | *Value chain analysis and market analysis on advanced biofuels and RFNBOs of the FUELPHORIA Horizon Europe project*<br><br>Katakalos Stroikos, Ioannis Konstas, Aristotelis Folas, Stamatia Antonakoudi, Katerina Valta & Xaido Anthouli |

**4th Session – Room B20** **14:45-16:15**

| | |
|---|---|
| **Topic** | **Sustainable Tourism and Transportation** |
| **Chairperson** | **Prof. Vassilios Profillidis** |
| **14:45-15:00** | *Drivers of air pollution in the Eurozone countries: An empirical analysis of the Environmental Kuznets Curve hypothesis*<br>George Ekonomou & George Halkos |
| **15:00-15:15** | *Payments for Ecosystem Services in the Tourism sector*<br>Alexandra Skouteli & Antonios Skouloudis |
| **15:15-15:30** | *Electric Vehicle Purchase Subsidization versus Public Transit Expansion – A Comparison for the Case of Greece*<br>Konstantinos Christidis, Vassilios Profillidis & George Botzoris |
| **15:30-15:45** | *Investigating the environmental footprint of university students' mobility*<br>Foteini Mikiki, Ermioni Katartzi, Georgia Avrami, Aikaterini Tzampazi & Athanasios Galanis |
| **15:45-16:00** | *Case study: Research on sustainable tourism in Thassos*<br>Christos Damaskos |



**Coffee Break** **16:15-16:30**

**Keynote Speaker – Room B1** **16:30-17:00**

*Topic: "Revisiting the specification of the relationship between $CO_2$ per capital emissions and income per capita."*

**Professor Thanasis Stengos**

*Professor in Econometrics*
*University of Guelph*

**5th Session – Room B1** **17:00-19:00**

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|---|---|
| **Topic** | **Energy Poverty and Inequality** |
| **Chairperson** | **Prof. George Halkos.** |
| **17:00-17:15** | *Socioeconomic inequalities persistence and their mediating effect upon pro-environmentalism stances*<br><br>Athina Economou & George Halkos |
| **17:15-17:30** | *Powering progress: Bridging energy inequality and energy poverty in Sub-Saharan Africa*<br><br>Nguyet T.M. Tran & Trung Thanh Nguyen |
| **17:30-17:45** | *Enhancing Energy Literacy to Alleviate Energy Poverty in Greece: Identifying Energy Consumption Knowledge and Behavioural Patterns*<br><br>Stefania Zourka, Paraskevi Alexiou, Sofia-Natalia Boemi, Nikolaos Ntavos & Ioannis Fallas |
| **17 :45-18:00** | *Economic and environmental impacts of sustainable wheat intensification: Insights from the eastern Indo-Gangetic Plain*<br><br>Gokul P. Paudel, Trung Thanh Nguyen & Jordan Chamberlin |
| **18:00-18:15** | *The new energy and climate architecture of the Eastern Mediterranean*<br><br>Andreas Stergiou |
| **18:15-18:30** | *Measuring Energy Poverty in Greece: Case Study of an Athenian Household*<br><br>Athanasios Atsalis |

**6th Session – Room B20** **17:00-19:00**

| **Topic** | **Forest Economics** |
|---|---|
| **Chairperson** | **Assoc. Prof. Konstantinos Papaspyropoulos** |
| **17:00-17:15** | *A text analytics literature review of the Faustmann natural resource economic model*<br><br>Sofia Mpekiri & Konstantinos G. Papaspyropoulos |
| **17:15-17:30** | *Environmental NGOs as a key determinant in the implementation of eco-innovation by businesses*<br><br>Theodora Vlamidou & Konstantinos G. Papaspyropoulos |
| **17:30-17:45** | *On the environmental accountability of blockchain systems*<br><br>Lydia Negka & Konstantinos G. Papaspyropoulos |
| **17 :45-18:00** | *Development of an Interactive Forest Fire Mapping Tool*<br>Morfopoulou, I. & Mallinis, G. |
| **18:00-18:15** | *Expectational and legitimation gaps in an experiment of SDG reporting in a public forestry organization*<br><br>Konstantinos G. Papaspyropoulos, Dimitra Panori & Christina Lamprou |
| **18:15-18:30** | *Evaluation of the available indicators for Bioeconomy measurement within non-financial reporting frameworks*<br>Marina-Vassiliki Andreadou, Ioannis E. Nikolaou & Konstantinos G. Papaspyropoulos |
| **18:30-18:45** | *Forest Management Public Organizations and the adoption of ESG reporting: challenges and barriers*<br><br>Victoria Datsi & Konstantinos G. Papaspyropoulos |

**Dinner** **19:00-20:00**

# Saturday 07 December

**7th Session – Room B1** **10:00-11:30**

| | |
|---|---|
| **Topic** | **Novel Research Activities** |
| **Chairperson** | **Asst. Prof. Giannis Adamos** |
| **10:00-10:15** | *Investigating How Extreme Events Trigger Nexus Effects and Developing a Nexus Methodological Framework to Increase Resilience*<br><br>Dimitris Kofinas, Cevza Melek Kazezyılmaz-Alhan, Giannis Adamos, Serena Caucci, Tamara Radjenovic, Dejana Đorđević, Tina Dasic, Cristina Calheiros, Nina Nikolova, Dejan Vasovic, Dijana Likar, Messaoud Lazreg, Edyta Hewelke, Jairo Guzman, Michael Nones, Sarah Milliken, Milena Rajic, Alexandra Spyropoulou, Müge Akın, Kemal Koca, Mirela Sertić Perić, Kaan Ilker Demirezen, Georgios Alexandros Chatzistefanou, Marco Falda, Sofia Almeida Pereira, Hai-Ying Liu, Carlos Felipe Marin Rivera, Argyrios Balatsoukas, Monika Suskevics, Julieta Domínguez-Soberanes, Bamgboye Taiwo, Violeta Vasilić, Rocío Pineda-Martos, Ivar Zekker, Stefania Munaretto, Floor Brouwer & Chrysi Laspidou |
| **10:15-10:30** | *Educational Activity to create a Digital Biodiversity Observatory through the Citizen Science Approach*<br><br>Alexandra E. Ioannou & Chrysi S. Laspidou |
| **10:30-10:45** | *The role of citizen science in improving the quality of life in cities: an innovative approach established in the MI-TRAP project*<br><br>Georgia Tseva, Giorgos Chatzinakos, Argyrios Balatsoukas, Ioanna Tyligada, Amaryllis Zachariadou, Stylianos Mimis, Giannis Adamos & Chrysi Laspidou |
| **10:45-11:00** | *Tackling Environmental Risks with Nature-Based Solutions in EU Policies: Insights from Case Studies across Europe*<br><br>Alexandra Spyropoulou, Georgia Tseva & Chrysi Laspidou |
| **11:00-11:15** | *Perspectives on Sustainability for Small-and-Medium-Sized Enterprises in Greece: A Quantitative and Qualitative Analysis*<br><br>Andreas Moursellas & Konstantinos Evangelinos & Antonios Skouloudis |

**8th Session – Room B20** **10:00-11:30**

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|---|---|
| **Topic** | **Quantitative Methods in Environmental Economics & Management** |
| **Chairperson** | **Prof. Christos P. Kitsos** |
| **10:00-10:15** | *Natural resource management under deep uncertainty and congestion costs: Simultaneous versus serial dictatorship management*<br>Petros Xepapadeas & Anastasios Xepapadeas |
| **10:15-10:30** | *The Influence of European Environmental Policies towards Carbon Neutrality: A Quantile Analysis of Green Technologies and Policy Effectiveness*<br>Nikos Chatzistamoulou & Andriana G. Dimakopoulou |
| **10:30-10:45** | *Probability Oriented Environmental Data Analysis: Comparing Athens and Thessaloniki*<br>Christos P. Kitsos & C-S Nisiotis |
| **10:45-11:00** | *A configurational approach to eco-innovation and innovation performance relationship: Does size matter?*<br>George Koutsouradis, Kostas Kounetas & Kostas Tsekouras |
| **11:00-11:15** | *Ecologically Optimal Quantities Extraction. Conflicting cases.*<br>George Emm. Halkos, George J. Papageorgiou, Emm. G. Halkos & John G. Papageorgiou |

**Keynote Speaker – Room B1** **11:30-12:00**

*Topic: "Natural Hazards Management in an Era of Escalating Climate Crisis"*

**Professor Efthymios Lekkas**

Professor of Dynamic, Tectonic, Applied Geology and Natural Disaster Management at National and Kapodistrian University of Athens.
President of the Earthquake Planning and Protection Organization of Greece (EPPO)

**Coffee Break** **12:00-12:15**

**9th Session – Room B1** **12:15-14:00**

| | |
|---|---|
| **Topic** | **Health and Unexpected Events** |
| **Chairperson** | **Assoc. Prof. Dr. Athina Economou** |
| **12:15-12:30** | *Unraveling the Future: Forecasting Unexpected Natural Disasters in the Mediterranean and Balkan Region Amid Climate Change*<br><br>George Halkos & Argyro Zisiadou |
| **12:30-12:45** | *Leadership as a Pillar of Change: Pioneering Sustainability Reporting in Healthcare Systems*<br><br>Anastasios Sepetis & Ioannis Parlavantzas |
| **12:45-13:00** | *Virtual Reality Training in Occupational Health and Safety in High-Risk Industries: An Overview of Trends in the Mining and Petroleum Industries*<br><br>Stefanos Fotiadis, Vlasis Kasapakis & Konstantinos Evangelinos |
| **13:00-13:15** | *Enhancing Mental Resilience of Employees in Supportive Frameworks for Vulnerable Populations*<br><br>Eleni Georganta & Kristina Kucheruk & Konstantinos Evangelinos |
| **13:15-13:30** | *Quantile connectedness in renewable energy companies and related commodities during Covid-19 outbreak*<br><br>Bikramaditya Ghosh, Hayfa Kazouz & Dimıtrios Papadas |
| **13:30-13:45** | *Organizational changes as a condition for sustainable development*<br><br>Bousinakis Dimitrios |

**10th Session – Room B20** **12:15-14:00**

| | |
|---|---|
| **Topic** | **Growth, Institutions and Policies** |
| **Chairperson** | **Prof. Michel Zouboulakis** |
| **12:15-12:30** | *From stationarity to sustainability. Lessons from the Classics*<br>Michel S. Zouboulakis |
| **12:30-12:45** | *Tracing the key determinants for a successful water management policy: Evidence from Classical Athens*<br>George E. Halkos & Emmanouil M.L. Economou |
| **12:45-13:00** | *Beyond GDP: A Proposal for Estimating the Genuine Progress Indicator (GPI) for the Greek Economy*<br>Georgios Maroulis Christos Tsirimokos & Panagiotis Kalimeris |
| **13:00-13:15** | *Water commons. The case of Stagiates*<br>Paschalis Arvanitidis & George Papagiannitsis |
| **13:15-13:30** | *Exploring farmers' intentions towards adoption of environmentally friendly pest management practices*<br>Giorgos N. Diakoulakis & Irene Tzouramani |
| **13:30-13:45** | *Constructing environmental subsidy rules. The feedback case.*<br>George Emm. Halkos, George J. Papageorgiou, Emm. G. Halkos, & John G. Papageorgiou |

**Lunch Break** **14:00-14:45**

**Keynote Speaker – Room B1** **14:45-15:15**

*Topic: "Sustainable Industrial Development and SDG 9: A Global Overview"*

**Dr. Jaime Moll de Alba**

Director of the Division of Strategic Programming,
Results Monitoring and Quality Assurance
United Nations Industrial Development Organization (UNIDO)

**11th Session – Room B1** **15:15-16:45**

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|---|---|
| **Topic** | **Environmental Innovative Policies & Applications** |
| **Chairpersons** | **Prof. George Halkos** |
| **15:15-15:30** | *Revisiting the determinants of environmental policy stringency: Findings from a panel data for 33 countries, 1995-2020*<br><br>George Halkos & Antonios Skouloudis |
| **15:30-15:45** | *Empirical Evidence on Non-linear Relationships between Bitcoin Mining and Carbon Emissions*<br><br>Andreas Retouniotis, Eirini Stergiou, Manolis Tzagkarakis, & Kostantinos Kounetas |
| **15:45-16:00** | *From Data to Insight: Using Unsupervised Learning to Explore Financial and Sustainability Patterns in S&P 500 Firms*<br><br>Emmanouil Zaganidis, Periklis Gogas & Theophilos Papadimitriou |
| **16:00-16:15** | *Enhancing environmental-forestry education through Big Data and Analytical Tools for Sustainable Development*<br><br>Konstantinidis, L. &Andreopoulou, Z. |
| **16:15-16:30** | *Optimizing Renewable Energy Systems Placement Through Advanced Deep Learning and Evolutionary Algorithms*<br><br>Konstantinos Stergiou and Theodoros Karakasidis |
| **16:35-16:45** | *New paradigms in the role of ICT over environmental degradation*<br><br>Daniel Balsalobre-Lorente |

**12th Session – Room B20** **15:15-16:45**

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|---|---|
| **Topic** | **Corporate Social Responsibility & Environmental Social Governance** |
| **Chairperson** | **Prof. Konstantinos Evangelinos** |
| **15:15-15:30** | *Approaches to Integrating ESG Principles & Processes into Local Governments*<br><br>Panagiotis Vouros & Konstantinos Evangelinos |
| **15:30-15:45** | *Exploring the Impact of Corporate Social Responsibility on Employee Mental Health, Resilience, and Job Satisfaction*<br><br>Kristina Kucheruk & Konstantinos Evangelinos |
| **15:45-16:00** | *The impact of sustainable development goals at the national level*<br><br>Vasilis Menexes-Emvraizoglou & Pr. Dorothea Kasiteropoulou |
| **16:00-16:15** | *Incorporating the TCFD Recommendations in corporate reporting: A study on the large-cap companies listed in the Athens Stock Exchange*<br><br>Polyxeni-Panagiota Nana & Antonios Skouloudis |
| **16:15-16:30** | *Collaboration Between Companies and NGOs: Creating Inclusion and Mutual Benefits*<br><br>Kristina Kucheruk, Pavlina Papilia & Konstantinos Evangelinos |

**Coffee Break** **16:45-17:00**

**Keynote Speaker – Room B1** **17:00-17:30**

**Honorary Greetings**

**Closing** **17:30-18:00**

# Proceedings Summary

The **10th ENVECON Anniversary Conference** program consisted of ***12*** *sessions* that included ***68*** *presentations* by ***188*** *participants* from ***101*** *institutions*. The 10th ENVECON was announced and greeted by ***12*** *Honorary Speakers* and ***4*** *Keynote speakers*. The 12 thematic sessions presented concerned agricultural production and food consumption, forest economics, environmental risks, climate change and urban environment, social and natural capital, sustainable tourism, welfare and regional development, circular economy, sustainable water management, sustainable transport, corporate social responsibility, environmental psychology, big data in environmental risk analysis, quantitative methods, and environmental efficiency, data science and artificial intelligence on improving health equity and urban environments. In total, ***15*** studies were included in the conference proceedings, however, several papers have not been included in the book of proceedings as they have already been submitted to the conference special issues or in international respected journals.

The 1st paper, authored by *G.E. Halkos, J. Moll de Alba, P.S.C. Aslanidis and C. Bampatsou*, is titled "*Circular Economy in the European Rubber and Plastics Industry*". This study assesses eco-efficiency in the European rubber and plastics industry using a hybrid WDEA method across 27 countries (2014–2022). Moreover, the empirical findings reveal regional disparities, a 70.33% average efficiency, and shifts in country rankings. Club clustering analysis shows three convergence groups, indicating varied progress toward sustainable, cost-effective industrial performance.

The 2nd paper, authored by *P. Vouros, P. Lamprou, C. Mitsokapas, P. Dallas, A. Vagena, P. Tridimas, K. Evangelinos & P. Grammelis*, is titled "*Best Environmental Practices for the reduction and management of solid waste, energy and the promotion of circular economy: The case of Mediterranean spa hotel in Katerini*." This study examines the adoption of circular economy practices in tourism, focusing on solid waste, energy, and water management. Using the Mediterranean SPA Hotel in Katerini as a case study, it evaluates the implementation of a certified Circular Economy Management System, revealing key benefits, challenges, and opportunities for sustainable innovation.

The 3rd paper, authored by *E. Delarda, Z. Andreopoulou & C. Koliouka*, is titled "*Green Certification in Coastal Areas of Greece as a Lever for Local Development.*" This study focuses on green certification in Greece's coastal regions that supports sustainable development by promoting responsible resource management and environmental protection. Programs like Ecolabel, Green Key, and Blue Flag guide improvements in tourism, agriculture, and fisheries. These certifications boost local economies, raise environmental awareness, and help preserve marine ecosystems and cultural heritage.

The 4th paper, authored by *Z. Andreopoulou, A. Georgilas & C. Liotiris*, is titled "*Natural History Museums and Protected Areas Information Centres: Characteristics of video presentations and regional development.*" This study monitors how Natural History Museums and Protected Areas Information Centres promote conservation and public engagement. Since the 19th century, they've integrated photography and video, now widely used on websites and

social media. Short, structured video content can boost visitor numbers and support local development, with potential funding from EU digital and green initiatives.

The 5th paper, authored by *N. Morfopoulos, V. Kamperidou*, is titled "*Fermentation technologies for bioethanol production: Prospects and challenges."* This study reveals how Bioethanol, a renewable biofuel, offers environmental benefits by reducing greenhouse gases and reliance on fossil fuels. Produced from plant-based materials via fermentation, especially lignocellulosic biomass, it supports sustainability without affecting the food chain. Despite challenges, advancements in production, separation, and purification processes enhance its efficiency and overall impact.



The 6th paper, authored by *K. Christidis, V. Profillidis & G. Botzoris*, is titled "*Electric Vehicle Purchase Subsidization versus Public Transit Expansion – A Comparison for the Case of Greece*." This study evaluates Greece's electric vehicle (EV) subsidies using Machine Learning to estimate EV sales without incentives and their environmental impact. Comparing this to investing the same funds in expanding Athens' Metro system, findings show public transport infrastructure yields greater environmental and economic returns than current EV subsidization schemes.

The 7th paper, authored by *L.P. Konstantinidis & Z. Andreopoulou*, is titled "*Enhancing environmental-forest education through Big Data and Analytics: Analytics Tools for Sustainable Development*." This study explores the relationship between precipitation patterns and changes in the size of Lake Koronia in Central Macedonia. Using climate data and satellite imagery, the analysis indicates a link between rainfall and lake extent. The findings underscore rainfall's role in wetland stability, while highlighting the need for deeper investigation.

The 8th paper, authored by *I. Morfopoulou & C. Mallinis*, is titled "*Development of an Interactive Forest Fire Mapping Tool*." This study presents a cloud-based mapping tool for assessing burn severity using Landsat satellite data and fire perimeters from EFFIS. By calculating the Normalized Burn Ratio (NBR) and applying USDA thresholds, it produces accurate, low-cost maps. The approach highlights remote sensing's value in addressing environmental challenges like disaster management.

The 9th paper, authored by *M.-V. Andreadou, I.E. Nikolaou & K.G. Papaspyropoulos*, is titled "*Evaluation of the available indicators for Bioeconomy measurement within non-financial reporting frameworks.*" This study explores the role of non-financial reporting frameworks, such as GRI and SASB, in supporting the bioeconomy transition. It evaluates how existing indicators align with bioeconomy goals, particularly in the use of renewable resources. The research suggests developing a dedicated Bioeconomy Reporting Standard to enhance transparency and accountability.

The 10th paper, authored by *A. Moursellas, K. Evangelinos & A. Skouloudis*, is titled "*Perspectives on Sustainability for Small-and-Medium-Sized Enterprises in Greece: A Quantitative and Qualitative Analysis*." This study examines sustainability practices in Greek SMEs, focusing on enablers and barriers. Using quantitative and qualitative methods, including SEM and case studies, it analyzes the economic, environmental, and social impacts of

sustainability efforts. The findings highlight key factors influencing sustainability and offer insights for policymakers and business leaders to improve performance.

The 11th paper, authored by *E. Georganta, K. Kucheruk & K. Evangelinos*, is titled "*Enhancing mental resilience of employees in supportive frameworks for vulnerable populations.*" This study explores strategies to strengthen the mental resilience of employees supporting vulnerable populations. Through interviews and analysis, it examines internal support, coping mechanisms, and collaboration with external services. Findings aim to inform frameworks that enhance employee well-being, reduce stress, and improve the quality of care provided to vulnerable groups.



The 12th paper, authored by *G. Maroulis, C. Tsirimokos & P. Kalimeris*, is titled "*Beyond GDP: A Proposal for Estimating the Genuine Progress Indicator (GPI) for the Greek Economy*." This study reviews the "Beyond GDP" movement and proposes a framework for estimating the Genuine Progress Indicator (GPI) for Greece. By incorporating environmental, social, and inequality factors, GPI offers a more holistic measure of prosperity. The proposed approach supports future research on sustainable development and well-being in the Greek economy.

The 13th paper, authored by *I. Manolis, C. Makropoulos, A. Sfetsos & A. Skouloudis*, is titled "*Development and application of a methodological framework for assessing the resilience of military infrastructure against climate change impacts*." This study addresses the need for resilient military infrastructure amid climate change, focusing on airports as highly vulnerable assets. It introduces a practical, test-based methodology adapted from civilian airport assessments, tailored to defense-specific needs. Applied at Araxos Airport, the approach identifies urgent climate risks and guides targeted cost-effective resilience investments.

The 14th paper, authored by *K. Kucheruk & K. Evangelinos*, is titled "*Exploring the Impact of Corporate Social Responsibility on Employee Mental Health, Resilience, and Job Satisfaction*." This study investigates the impact of Corporate Social Responsibility (CSR) on employee mental resilience, job satisfaction, adaptability, and turnover intentions, focusing on NGOs. Using questionnaire data, it explores links between CSR practices and employee well-being. Findings aim to guide HR strategies that integrate CSR to promote a healthier, more engaged workforce.

The 15th paper, authored by *K. Kucheruk, P. Papilia & K. Evangelinos*, is titled "*Collaboration Between Companies and Non-Governmental Organizations: Fostering Inclusion and Mutual Benefit.*" This presentation highlights the importance of strategic partnerships between companies and NGOs to promote workforce inclusion of vulnerable social groups. Focusing on awareness and education, it outlines how businesses can adapt to support diversity, enhancing corporate social responsibility, fostering innovation, and contributing to social cohesion through inclusive employment practices.

# Conference Papers

# Session 1
# Circular Economy & Bioeconomy

# The role of consumers and producers in implementing a circular bioeconomy: an Australian case study

**Alice Payne[1], Clevo Wilson[2], Jeremy Webb[3], Uttam Khanal[4] &Anushiya Thanapalan [2,4]**

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**Abstract**

Estimates are that globally, the manufacturing of clothing and textiles accounts for 2-8% of global emissions. A substantial proportion – some 50% - of this output is derived from agricultural sources and therefore has an important effect on the world's biodiversity. Estimates are that some 75% of this output is wholly or partially composed of cotton fabrics and that 6-8% are made from viscous materials. According to the Ellen MacArthur Foundation (2024), textile production accounts for 1.2 billion tonnes of greenhouse gas emissions annually, of which less than 1% is being reused to create new clothing. Globally, Australia's yearly consumption of textiles is second only to that of the US. In 2018/19, Australia's annual total importation & production of new clothing was 380,000 tonnes, or 56 items per capita, with an estimated 227,000 tonnes going to landfill in Australia. However, Australia has historically lagged behind some other countries particularly those within the EU in both recognising and dealing with the textile waste problem. In total, more than 800,000 tonnes of textiles, leather and rubber are discarded annually by Australians with a textile recycling rate of 5%, most of which is carpet recycling, according to the 2022 National Waste Report. Extended Producer Responsibility (EPR) policies often place levies or fees on products, paid by producers, to fund addressing the end-of-life impacts of the product. Australia's approach to EPR, known as product stewardship, has established a voluntary scheme, Seamless, that proposes a 4c levy on each new item of clothing. This study examines the role of consumers' willingness to pay for a recycling levy on clothing sales as a key element in generating a circular bioeconomy. A choice experiment is employed to gauge the willingness of residents of Brisbane, Australia, to accept a levy on the sale of clothing garments to promote a circular economy in their production, sales, and reuse. Explored is the size of the levy, who should pay the levy – consumers or producers - whether it should be mandatory and what garment value the levy should be applied to. The findings indicate that preferences are for both producers and consumers to share the cost jointly.

***Keywords***: *Clothing circularity, Consumer preferences, discrete choice experiment, bio-circular economy*

**JEL Codes:** Q5

# Circular Economy in the European Rubber and Plastics Industry

**George E. Halkos[1], Jaime Moll de Alba[2], Panagiotis – Stavros C. Aslanidis[1] & Christina Bampatsou[1,3]**

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## Abstract

Efficient energy use is crucial for the European rubber and plastics industry to minimize production costs and reduce environmental impact. Moreover, circular economy solutions can support the industry's competitiveness while aligning with sustainability goals and regulatory requirements. In the present research, we employ a hybrid window data envelopment analysis (WDEA) methodology in order to measure panel data eco-efficiency via the application of moving average principle. The examination of 27 European countries as decision making units (DMUs), in the period 2014 – 2022 led to the conclusion that the average eco-efficiency is 70.33%, showing that most of the DMUs can ameliorate their performance. The highest eco-efficiency in 2014 can be monitored in Ireland, Switzerland, Norway, and Poland, but in 2022 only Ireland and Switzerland kept their positions whereas Norway dropped to the 16th position and Poland plummeted to 24th hierarchical position. Geographical disparities can be spotted also, as Northern and Western Europe has greater eco-efficiency than Eastern and Southern Europe. At a second level of analysis, the possibility of convergence between the 27 European countries in the period under consideration is examined using the log t regression test and club clustering. The analysis leads to three final clubs in which conditional convergence dominates.

***Keywords:*** *Plastic pollution, Circular Economy, eco-efficiency, DEA, club convergence*

**JEL Codes:** Q53; Q56; Q57.

## 1. Introduction

Geyer et al. (2017) highlighted that "*a world without plastics… seems unimaginable today*" revealing the multitude of plastics' purposes due to being economical and useful; nevertheless, the majority of plastics derive from fossil fuels, whereas only a minority (about 10%) comes from recycled and biobased plastics. The Organization for Economic Co-operation and Development (OECD) projected that plastic use will be doubled by 2060; additionally, plastic leakage will be doubled in the developing countries and will be tripled in terms of stocks disposed on marine ecosystems (OECD, 2022a, 2022b).

The reliance on fossil fuels for raw materials and energy has led to significant environmental and health issues (Geyer et al., 2017; Woodruff, 2024). While biobased plastics can reduce greenhouse gas (GHG) emissions, their production contributes to deforestation and further emissions (OECD, 2022a, 2022b). Plastic prices are closely tied to fossil fuel markets, creating policy challenges in Europe, where governments subsidize fossil fuel consumption.

Watkins and Schweitzer (2018) estimate these subsidies at EUR 112 billion annually, with EU member states struggling to phase them out.

This study explores factors influencing eco-efficiency in the European rubber and plastics industry (E-RPI) and examines its convergence toward sustainability. Additionally, Andersen (2024) stresses the need for a circular economy to address the triple planetary crisis: climate change, biodiversity loss, and pollution. Plastic pollution exacerbates these crises, as the OECD (2022a, 2022b) highlights its role in GHG emissions, waste generation, and environmental contamination, leading to biodiversity loss, particularly affecting marine life like turtles.



The circular economy (CE) offers an alternative to the traditional linear model by promoting the continuous use of resources and minimizing material losses through preventive measures (Bucknall, 2020; Halkos and Aslanidis, 2024a, 2024b). It underscores the economic and environmental drawbacks of plastic production, use, and disposal, as the current linear approach not only captures economic value but also depletes resources and harms the environment (Hsu et al., 2021; Robaina et al., 2020). The United Nations introduced the Sustainable Development Goals (SDGs) (UN, 2016) to address various global challenges, including environmental sustainability. The European rubber and plastics industry plays a role in achieving several SDGs, such as economic growth (SDG8), sustainable industrialization and cleaner production (SDGs 9 & 12), climate change mitigation (SDG13), and the reduction of plastic pollution in land and water ecosystems (SDGs 14 & 15). To effectively tackle the interconnected issues of climate change and plastic pollution, fostering synergies is essential, as emphasized by Karali et al. (2024). A significant step in this direction occurred in March 2022, when all United Nations Member States agreed to negotiate an internationally legally binding instrument (ILBI) on plastic pollution, incorporating its impact into climate change discussions under the UNFCCC framework (Karali et al., 2024).

Regarding the present paper, theconomic performance that considers also the environmental parameters, is called eco-performance and more specifically there are two well-known categories of eco-efficiency and eco-productivity. The data envelopment analysis (DEA) multidisciplinary application enables the valuation of efficiency in different sectors and activities. For example, the DEA methodologies have been adopted in plenty industrial sectors (Hahn et al., 2021; Halkos et al., 2024a; Hemmasi et al., 2011; Kang et al., 2018; Lo et al., 2012; Veiga et al., 2021; Wang et al., 2019), and the economy-environment interrelations (Giannakitsidou et al., 2020; Halkos et al., 2024b; Halkos and Aslanidis, 2024b, 2023a, 2023b; Pérez et al., 2017; Taleb et al., 2023; Zhou et al., 2007). In the following text, the plastic and rubber industries exhibit different performance in the literature; however, the environmental impacts of these industries have attracted the attention of academicians and policymakers in the recent decades.

This present research refers to two research questions (RQs) regarding the eco-efficiency of the E-RPI and potential club convergence among the decision making units (DMUs):

***RQ1:*** *What is the current eco-efficiency in the E-RPI and how can be strengthened by circular strategies?*
***RQ2:*** *Is there convergence among the DMUs?*

This study aims to assess the eco-efficiency of the European rubber and plastics industry (E-RPI) across 27 European countries and examine whether convergence exists among them. To achieve this, a two-stage analysis is employed. The first stage utilizes a Hybrid Window Data Envelopment Analysis (WDEA), which incorporates both radial and non-radial parameters and addresses undesirable outputs through a weak disposability approach. In the second stage, a club convergence methodology is applied to determine whether European rubber and plastics industries are moving toward a common performance level. The study's novelty lies in its two-stage methodological approach, which has not previously been applied to this industry. By doing so, it provides fresh insights into circular economy (CE) solutions within the E-RPI. Additionally, it fills a research gap by exploring how CE can enhance eco-efficiency in the sector while considering the ongoing negotiations for a global plastics treaty. The paper is structured as follows:

## 2. Materials and Methods

This study collected data on labor, Gross Fixed Capital Formation (GFCF), and Value Added from the INDSTAT 2 (2023 edition) database, using ISIC revision 3 at the 2-digit level from the United Nations Industrial Development Organization (UNIDO, 2024). Additionally, information on energy consumption and greenhouse gas (GHG) emissions was sourced from EUROSTAT (EUROSTAT, 2024a, 2024b).

**Table 1.** Descriptive Statistics

| | **INPUTS** | | | **OUTPUTS** | |
|---|---|---|---|---|---|
| | **GFCF** (Current USD) | **Energy Use** (Terajoule) | **Labor** (Number of Employees) | **Value Added** (Current USD) | **GHGs/$CO_2$** (Tonnes) |
| **Mean** | 690,700,815.65 | 14,153.70 | 65,674.00 | 4,150,932,116.64 | 316,791.42 |
| **Min** | 2,077,775.77 | 61.60 | 840.00 | 27,734,506.75 | 3,632.44 |
| **Max** | 4,897,864,010.77 | 99,336.50 | 471,527.00 | 41,925,714,434.40 | 3,142,295.41 |
| **STDEV** | 948,814,254.64 | 21,727.37 | 97,433.00 | 6,992,657,417.51 | 532,583.64 |

**Table 2.** Correlation Matrix

| | **GFCF** | **LABOR** | **Value Added** | **GHGs/$CO_2$** | **Energy Use** |
|---|---|---|---|---|---|
| **GFCF** | 1 | | | | |
| **LABOR** | 0.971** | 1 | | | |
| **Value Added** | 0.957** | 0.924** | 1 | | |
| **GHGs/$CO_2$** | 0.862** | 0.863** | 0.893** | 1 | |
| **Energy Use** | 0.952** | 0.932** | 0.928** | 0.838** | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).

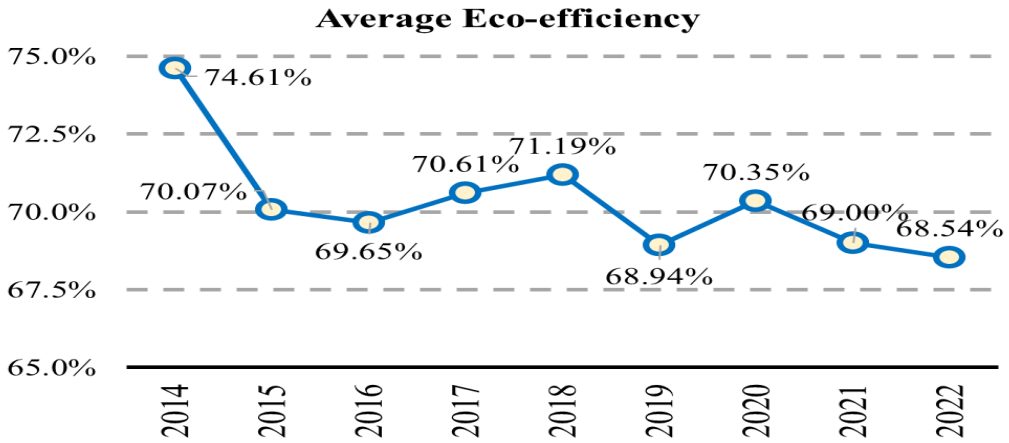
Covering the period from 2014 to 2022, the study selected countries based on data availability for the plastics and rubber industry and employed a two-stage analysis. The hybrid WDEA model incorporates the following inputs: (i) labor measured by the number of

employees, (ii) GFCF in USD, and (iii) energy consumption in terajoules. The desirable output is Value Added in current USD, while the undesirable output is GHG emissions in tonnes. The desirable output is treated separately, while the undesirable output is non-separable, as its generation negatively impacts overall eco-efficiency. The descriptive statistics are provided in Table 1, and Table 2 presents the correlation matrix, which shows a strong, statistically significant positive correlation among the variables.

## 3. Results

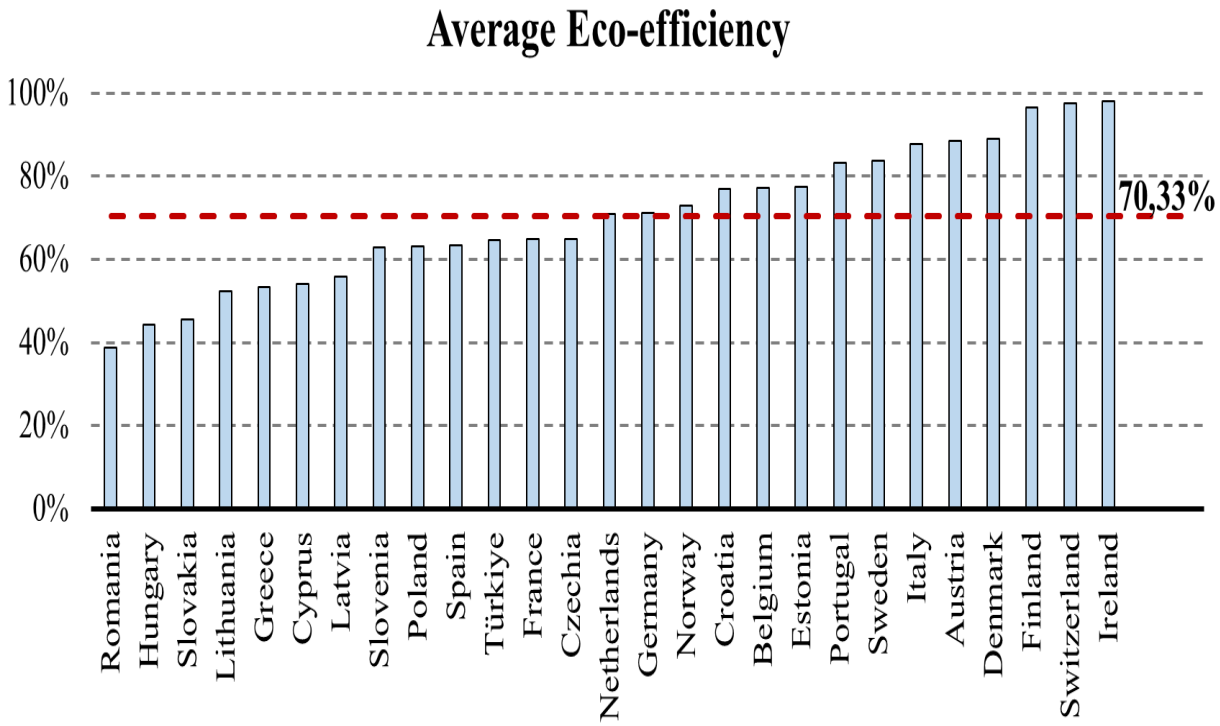
In response to RQ1, the assessment of eco-efficiency in the European rubber and plastics industry (E-RPI) using the hybrid WDEA technique reveals a notable decline in average eco-efficiency, as shown in Figure 1. Specifically, from 2014 to 2022, eco-efficiency decreased by 6%. This decline can be attributed to two key factors. While many countries have successfully reduced GHG emissions in the E-RPI, the industry's overall energy consumption has increased. This rise in energy use is largely driven by the need to meet growing global demand.

**Figure 1.** Average Eco-efficiency focusing on the period 2014 – 2022.

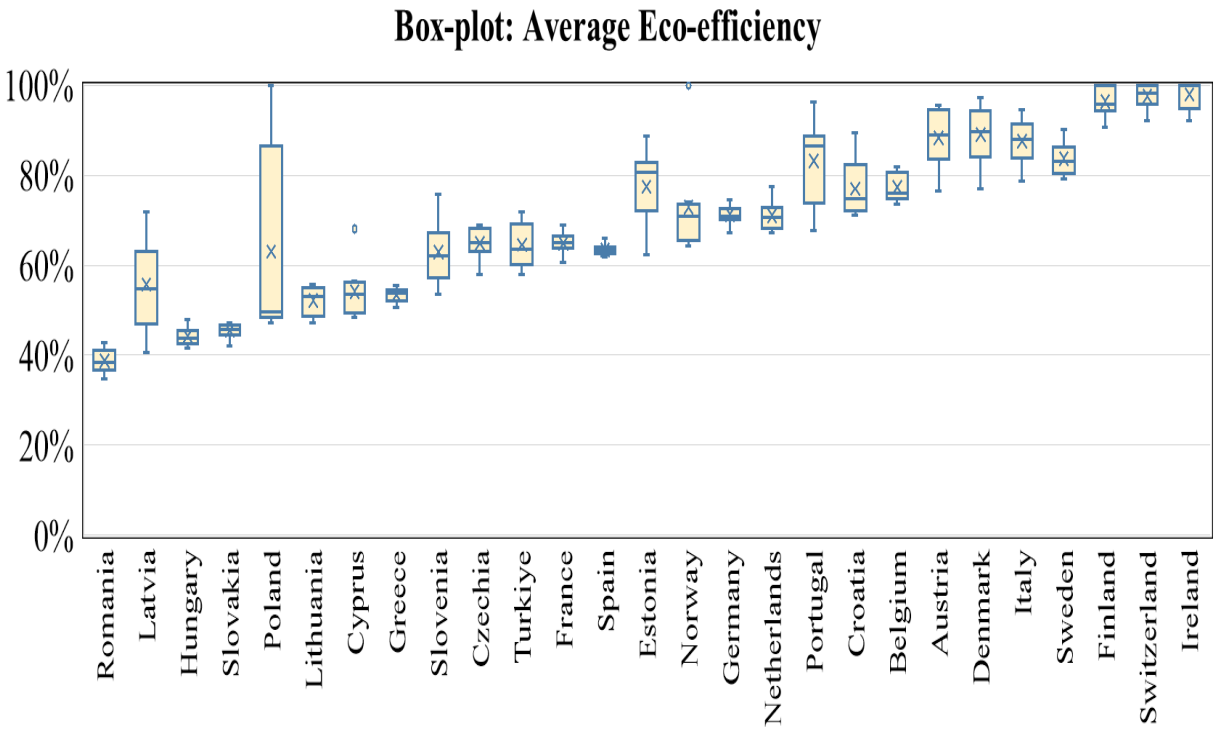



Throughout the entire study period, the average eco-efficiency of the European rubber and plastics industry was 70.33%, as illustrated in Figure 2a. Figure 1 further highlights a downward trend in eco-efficiency between 2014 and 2022. The highest-performing countries, based on average eco-efficiency, are primarily located in Northern and Western Europe, including Ireland, Switzerland, Finland, and Denmark. Conversely, lower-performing countries are mostly in Eastern and Southern Europe, such as Romania, Hungary, Slovakia, Lithuania, and Greece. The average eco-efficiency indicates that many Balkan countries exhibit weak performance. Additionally, France, Spain, Portugal, and Norway experienced a decline in eco-efficiency from 2014 to 2022. To gain a deeper understanding of eco-efficiency trends, examining fluctuations over this period reveals that the most significant variations occurred in Poland, Latvia, Estonia, and Portugal, as illustrated in Figure 2b.

**Figure 2. (a)** Average Eco-efficiency focusing on DMUs performance, and **(b)** fluctuations in DMUs during the whole period.




**(a)**




**(b)**

DEA is a benchmarking method; therefore, the hierarchy plays a pivotal role as can be seen in **Table 3**. The DMUs that expose the most significant positive changes are Latvia (+16 places), Croatia (+10 places), and Finland (+7 places). Oppositely, the DMUs with the most significant negative changes are Portugal and Türkiye (–5 places), Norway (– 15 places), and Poland which downgraded 23 places.



**Table 3.** Change in Hierarchy based on eco-efficiency from 2014 to 2022.

| Country | 2014 | 2022 | Change in Hierarchy | Trend |
|---|---|---|---|---|
| Austria | 6 | 9 | -3 | ↓ |
| Belgium | 11 | 6 | 5 | ↑ |
| Croatia | 15 | 5 | 10 | ↑ |
| Cyprus | 17 | 21 | -4 | ↓ |
| Czechia | 18 | 15 | 3 | → |
| Denmark | 5 | 8 | -3 | ↓ |
| Estonia | 16 | 10 | 6 | ↑ |
| Finland | 8 | 1 | 7 | ↑ |
| France | 20 | 17 | 3 | ↑ |
| Germany | 13 | 12 | 1 | ↑ |
| Greece | 23 | 20 | 3 | ↑ |
| Hungary | 25 | 25 | 0 | → |
| Ireland | 1 | 1 | 0 | → |
| Italy | 7 | 7 | 0 | → |
| Latvia | 27 | 11 | 16 | ↑ |
| Lithuania | 22 | 23 | -1 | ↓ |
| Netherlands | 12 | 13 | -1 | ↓ |
| Norway | 1 | 16 | -15 | ↓ |
| Poland | 1 | 24 | -23 | ↓ |
| Portugal | 9 | 14 | -5 | ↓ |
| Romania | 26 | 27 | -1 | ↓ |
| Slovakia | 24 | 26 | -2 | ↓ |
| Slovenia | 19 | 22 | -3 | ↓ |
| Spain | 21 | 18 | 3 | ↑ |
| Sweden | 10 | 4 | 6 | ↑ |
| Switzerland | 1 | 1 | 0 | → |
| Türkiye | 14 | 19 | -5 | ↓ |

Next in order, regarding ***RQ2***, there is the observation of the convergence hypothesis in which firstly there is the examination of whether the convergence hypothesis holds for the entire sample. Then there is the investigation of the possibility of convergence of the clubs using the clustering algorithm proposed by Phillips and Sul. After these steps, the application of the log t regression takes place in order to test for convergence and the test's output gives the coefficient,

standard error, and t-statistic for log(t). Lastly, since the value of the t-statistic calculated as –108.851 is less than −1.65, the null hypothesis of convergence is rejected at the 5% level. Now we have to identify subgroups converging their steady states in eco-efficiency since the whole sample convergence is rejected.

Consequently, the final club classification is presented in **Table 4**, where from the initial five groups, now the final clubs are three from which the first club contains the first three initial clubs containing 12 countries. The t-stat is above the value –1.65 in all cases, thus there is no further merging, and the three clubs are the final possible classification of the countries based on their eco-efficiency.

**Table 4.** Final club classifications

| **Final Classification (No. of countries)** | **Club members** | **b** | **t-statistic** |
|---|---|---|---|
| Club 1 (**12**) | Austria, Belgium, Croatia, Denmark, Estonia, Finland, Germany, Ireland, Italy, Latvia, Sweden, Switzerland | 0.190 | 2.139 |
| Club 2 (**9**) | Czechia, France, Greece, Lithuania, Netherlands, Norway, Portugal, Spain, Türkiye. | 0.057 | 0.471 |
| Club 3 (**6**) | Cyprus, Hungary, Poland, Romania, Slovakia, Slovenia | 0.060 | 0.611 |

The final club classification reveals three distinct groupings among the 27 European countries. The first group spans from Sweden to Italy, encompassing all Central European nations from north to south. The second includes Western European countries along with the Czech Republic, Lithuania, Greece, and Türkiye, while the third mainly consists of Eastern European countries and Cyprus. The findings indicate that these nations have yet to fully align their regulatory measures for a unified circular economy (CE) strategy. Instead, the existence of three separate groups highlights the need for tailored, country-specific action plans that could gradually lead to long-term convergence and the development of a cohesive policy. Given the lack of absolute convergence in the European rubber and plastics industry (E-RPI), the key challenge lies in establishing the necessary conditions for such alignment. Karali et al. (2024) emphasize the importance of a global plastics treaty, currently under negotiation in international forums. A legally binding international agreement on plastics could serve as a foundation for integrating climate and plastic-related policies, fostering sustainability. If European countries move toward a shared institutional framework, greater convergence in eco-efficiency may become achievable.

## 4. Conclusions and Policy Implications

The study employs a consecutive analysis to assess eco-efficiency in the European rubber and plastics industry. In the first stage, related to RQ1, the study measures eco-efficiency across 27 European countries, revealing variations in performance. While some countries maintain

stable eco-efficiency levels, others, such as Poland and Norway, experience significant fluctuations. This disparity highlights the need to categorize countries into groups with similar industrial eco-efficiency performance. Moreover, addressing RQ2, the study examines whether eco-efficiency convergence occurs. The findings reveal three distinct convergence clubs: (1) Central and Northern European countries (from Sweden to Italy), (2) Western European countries along with the Czech Republic, Lithuania, Greece, and Türkiye, and (3) Eastern European countries and Cyprus. The results indicate conditional convergence, meaning countries with similar eco-efficiency levels tend to align, yet they do not reach a shared steady state due to differences in institutional frameworks and macroeconomic policies.

Given these findings, policy recommendations should aim for a dual transformation: (i) promoting cleaner production in line with circular economy (CE) principles and (ii) enhancing production efficiency for better eco-efficiency outcomes. While carbon intensity in the industry has declined, energy intensity has surged in recent years, necessitating policies that prioritize energy efficiency improvements. Increased investment in research and development (R&D) is essential to address this challenge. To improve eco-efficiency, policymakers should also focus on capital and labor inputs. Central and Western European nations have heavily invested in advanced technologies, whereas Eastern and Southern European countries lag behind, partly due to past financial instability. Enhancing labor productivity through vocational training is crucial. Public and private sectors must collaborate to educate workers on cleaner production practices (e.g., new recycling standards) and emerging technologies (e.g., robotics) to boost productivity.

A key limitation of the study is the lack of sector-specific waste-related data for rubber and plastic industries. Since plastic pollution is largely driven by waste generation, the absence of disaggregated data limits the analysis. However, the study does incorporate broader air pollution data, including multiple greenhouse gases beyond $CO_2$. Future research could extend this methodology to other industries and regions, especially if sectoral waste data become available at the ISIC level, enabling a more comprehensive model for plastic waste management.

In conclusion, the European rubber and plastics industry is vital for economic growth and job security. As discussions on a global plastics treaty progress, Europe has taken the lead in cleaner production through CE policies to combat plastic pollution. The industry has the potential to not only produce high-quality goods but also deliver environmentally sustainable solutions. Furthermore, by focusing on labor-driven productivity and cleaner production, the sector can contribute to achieving multiple Sustainable Development Goals (SDGs), including SDG8 (decent work and economic growth), SDG9 (industry, innovation, and infrastructure), SDG12 (responsible consumption and production), SDG13 (climate action), SDG14 (life below water), and SDG15 (life on land).

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# Sustainable Management of Recyclable Waste in Educational Institutions: The Case of Aristotle University of Thessaloniki

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**Abstract**

The rapid increase in global waste production poses a significant threat to the environment and public health, making organized waste management essential for sustainable development, especially in public bodies. This study examines the implementation of a system for the collection of recyclable materials produced at the Aristotle University of Thessaloniki (AUTH), focusing on the effective role of Mobile Green Points (MGPs). It aims to examine how MGPs can contribute to wastes' reduction and enhance citizens' attitudes and behaviors towards recycling and reuse. The study includes an analysis of the proposed recycling scheme based on MGPs, including the economic analysis and feasibility assessment for its establishment and operation. Potential revenues from the effective collection of the recyclable materials were considered and compared to the existing waste management system. The results of the study are particularly encouraging and could be a good basis for an even more detailed study. The incorporation of MGPs in Educational Institutions proved to be a promising solution for the effective collection of RMs by realizing the increased active participation of the whole Academic Community in recycling leading to the goal for sustainable operation.

***Keywords:*** *Municipal Solid Wastes, Source Separation, recycling, Circular Economy, Mobile Green Points.*

**JEL Codes**: Q53; Q56; Q58.

# Best Environmental Practices for the reduction and management of solid waste, energy and the promotion of circular economy: The case of Mediterranean spa hotel in Katerini

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**Abstract**
Several policies have been developed at the national and European level to reduce the environmental footprint of tourism businesses but also to promote innovative products and services. This research focuses on the implementation of best environmental practices in the tourism industry with particular emphasis on solid waste management, energy, water saving and in general the application of circular economy principles. The research examines a case study concerning the Mediterranean SPA Hotel in Katerini. The opportunities and challenges highlighted by the implementation of innovative strategies to reduce the environmental footprint are presented. Furthermore, the development and pilot implementation of a certified Circular Economy Management System at Mediterranean SPA Hotel is presented and evaluated. The results of the research highlight significant benefits and opportunities of strategies in the tourism sector. In addition, the certification system for the circular economy in the industry also offers a comprehensive management system for Circular Economy strategies.

***Keywords:*** *Corporate Social Responsibility, Circular Economy, Certified Management System, Hotel industry*

**JEL Codes**: Q52; Q53, Q56

## 1. Introduction

In recent years, the importance of sustainability in the tourism industry has become a global business and social trend - one with a specific positive impact on attracting customers, protecting the tourism product, society and promoting sustainable business (Bux & Amicarelli, 2023). As a sound business approach, sustainability contributes to the operation of a business under specific terms, conditions and controlled costs, limiting environmental, economic and social risks. As sustainable practices emerge as a tourism megatrend of our times, destinations

and in particular businesses that will be transformed by adopting smart and sustainable overall management, (intelligent green travel, natural resource and waste management, energy footprint reduction, crisis management, smart attractions and environmentally friendly experiences) will be able to provide a more integrated travel experience and socially responsible behaviour and operations in line with new requirements (Sorin & Sivarajah, 2021).



Previous research (eg. Dodds & Holmes, 2020) has highlighted the positive and negative effects of tourism on the environment as well as the significant contribution of hotels to the production of waste (especially food), greenhouse gases, biodiversity and, in general, to wider environmental impacts in various ways. This research offers concrete and tested solutions that can be applied to any hotel establishment that wishes to adopt them in the context of sustainable tourism development. The aim of this paper is to highlight and present how a hotel, can act as a model of sustainability in practice. As a case study in this research, the Mediterranean Hotel & Spa of the Mediterranean Hotels Group is presented and analysed.

## 2. Literature review

The hospitality sector is an important source of income in Europe, but it has a significant impact on the environment, due to high water and energy consumption and food waste. This has led to the implementation of various initiatives to promote sustainability in hotels, restaurants and resorts, such as farm to fork practices and towel reuse (Bux & Amicarelli, 2023). Another approach that hospitality businesses can take to achieve sustainability goals is to adopt circular economy strategies which are based on creating small regenerative cycles that require the collaboration of multiple stakeholders (Tomassini & Cavagnaro, 2022). Moreover, one quarter of the Greek Gross Domestic Product (GDP) is generated by tourism. This highlights its crucial importance for the national and global economy and employment (INSETE, 2022).

The hotel sector is one of the most important sectors of the Greek tourism industry but at the same time it imposes a significant burden on the environment (Gössling, & Higham, 2020). A lack of proper planning and infrastructure have led to the inability to sustainably serve an increasing number of arrivals. What is certain is that when the natural environment is degraded the tourism product of both the individual tourist destination and the entire country suffers (Stankov, et al, 2021).

Environmental issues have been at the centre of global debates since the second half of the 20th century (Leiper, 1990), and especially in the last decade, as they affect all sectors of the economy. According to the Cambridge Institute for Sustainability Leadership, tourism contributes around 5% of global greenhouse gas emissions - a figure that is expected to increase by 130% by 2035. In doing so, it is ranked as one of the most vulnerable industries to environmental degradation and climate change.

The circular economy is gaining momentum in business cycles and economic policies. However, its relevance and applicability to service-dominated industries such as tourism and

hospitality have not been widely researched (Sorin & Sivarajah 2021). The circular economy as a "green growth model" aims to produce products and services with fewer and greener resources (Rodríguez et al., 2020; Bocken et al, 2016). That is, by minimizing or even eliminating waste at all stages of production and also after the end of the product life cycle (Di Maio et al, 2017). It seeks and encourages the use of secondary materials and waste as productive resources and useful materials, adding the dimension of sustainability to the production model (Kjaer et al., 2019).



The adoption of initiatives with a positive social and environmental footprint by hotels is high on the political agenda worldwide (EC, 2014a,b, 2015a). The need for the adoption of such initiatives by the entire industry (Bocken et al., 2016; World Travel & Tourism Council, 2021), especially in the current context of the energy crisis is significant and therefore there is no room for delay in achieving the goal of Sustainable Tourism Development taking also into account the devastating experience of the pandemic crisis and the present one of the corresponding energy crisis that has created many problems in the survival of hotel units (Bocken et al, 2016; EMF, 2012; Kok et al., 2013). As it seems, the specific direction of adopting the principles and practices of Sustainable Development can decisively contribute to the effective response to these and other future crises, while meeting the institutional requirements of the EU and the country for the operations of the hotel sector, achieving at the same time economic benefits (Sariatli, 2017).

The economic, social and environmental impacts of tourism on the regions where it is in operation are the reasons why sustainability is so important to the tourism industry (WTTC, 2018). The economic impacts relate to the monoculture of tourism activity in many regions with a simultaneous focus of markets, investors and workers towards it, the rising cost of living, seasonality and low wages for workers.

As social impacts, it is worth mentioning the impacts on the man-made environment of the tourism development area with emphasis on cultural heritage, the standardization of services and facilities, cultural contrasts and social pressures brought by visitors due to different cultures, nuisance, crime, working conditions and cases of child labour and sexual harassment (Di Maio et al, 2017). Finally, environmental impacts include anything related to natural resource management, pollution, other environmental pressures (e.g. coastal zone), biodiversity and the man-made environment (land use, infrastructure, urban environment), (Manniche et al., 2017).

With a circular economy, resource productivity is enhanced, (Gössling et al, 2020), dependence on non-renewable resources and critical raw materials is reduced, costs are saved and jobs are created. For example, based on statistics, the expected benefits of the Circular Economy for the European Union are (Sgambati et al., 2021):

- Reduction of greenhouse gas emissions from 2% to 4%

- 600 billion euro savings for businesses (equivalent to 6%-8% of their turnover)

- over 2 million jobs created
- growth of up to 6% while saving resources. Today, for example, 80% of products are turned into waste within the first 6 months of being placed on the market.

The hospitality sector's cyclical transformation roadmap consists of four steps (Bocken, et al. 2016; Ghisellini et al, 2016; Lew, et al 2018; Jones et al, 2017):

**Step 1** of the Cyclicality Exploration which involves presenting the framework, its rationale, potential impacts on the organization and the value chain to key stakeholders.

**Step 2** of the Cyclicality Assessment which involves the analysis of the organizational context, drivers and barriers to cyclicality, material flows, strengths, weaknesses, opportunities and threats in the context of cyclical value creation, capture and distribution

**Step 3** of the Action Plan roadmap for circular transformation. This step further analyses the options of circular value creation, capture, distribution and business models to propose a circular strategic roadmap and highlight the key stakeholders to engage.

**Step 4** concerns the implementation of the Cyclical Strategy and in particular the definition of an action plan across all business activities, supported by key cyclical performance indicators tailored to the organisation.

At this point, key questions should be raised for the tourism industry and the respective stakeholder groups regarding the existence and creation of incentives for them in terms of choosing sustainable tourism destinations and services (Jones et al, 2017). Incentives linked to the provision of information and knowledge, related to the full costs of travel expenditure, social and ecosystem costs, climate change impacts and finally the supply of travel services based on a holistic approach

## 3. Design and methodological approach

This paper presents a review of the scientific research related to the implementation of the circular economy in tourism and hotels and the conditions and needs that led to this discussion. The literature review is followed by the presentation of a case study, which illustrates the implementation of the pilot project "Value Added Services in the Hospitality Sector" in a specific hotel. Actions, findings and concerns that emerged in practice during the implementation of the circular economy in the Mediterranean Hotel & Spa unit are presented in detail. It is a 5-star, classic-type tourism business with 176 rooms and 404 beds. It has additional facilities such as swimming pools, restaurants and bars, multi-purpose rooms, shops and supporting facilities for water supply and energy use.
The case study approach as a research method for data collection (Stoecker, 1991) is widely used as a "common research strategy in psychology, sociology, political science, business,

social work and programming" as it has the potential to offer unique contributions "to the knowledge of individual, organizational, social and political phenomena" (Yin, 1994). The unique feature of the case study approach is its ability to acquire and "retain the holistic and substantive characteristics of real-life events" (Yin, 1994), which can be of immense importance in any sociological research study. Furthermore, Stoecker (1991) concluded, "the case study approach is the best way in which we can improve general theory and apply effective interventions to complex situations.



The choice of Mediterranean Village Hotel & Spa for this project was appropriate for the following reasons:

1. Location and accessibility

Mediterranean Village Hotel & Spa is located in a popular tourist area, making it a representative example of the implementation and study of sustainable practices in the tourism sector. Its location offers easy access for both visitors and researchers, facilitating data collection and monitoring changes in environmental performance.

2. Infrastructure and size of the hotel

The Mediterranean Village Hotel & Spa has extensive infrastructure, including a variety of hospitality venues, restaurants, leisure centres and conference facilities. The size and variety of services offered by the hotel make it ideal for testing and implementing circular economy practices, as changes can be studied in different environments within the same facility.

3. Commitment to sustainability

The hotel has already shown interest in adopting sustainability practices, which makes it open to participating in projects aimed at improving its environmental performance. This predisposition enhances the likelihood of successful implementation of the proposed practices and their maintenance in the long term.

4. Ability to collect a variety of data

Due to the wide range of services offered by the Mediterranean Village Hotel & Spa, data collection on energy consumption, waste management, water use and other environmental indicators can be carried out in different environments (e.g. rooms, restaurants, leisure facilities). This possibility allows for a more comprehensive and reliable evaluation of the results.

5. Economic impact and performance

The Mediterranean Village Hotel & Spa, as a major hotel in the region, has the financial capacity to support the necessary investments to implement innovative circular economy practices. Furthermore, this facility is able to evaluate and demonstrate the economic impact of these practices, which is crucial for assessing the sustainability and efficiency of the overall research project.

6. Possibility of setting an example

As one of the largest and most recognizable hotels in the region, the Mediterranean Village Hotel & Spa can serve as a model for other hotels and tourism businesses. The success of the project at this hotel can encourage other businesses to follow similar paths, contributing to the wider adoption of circular economy practices in the hospitality industry.

7. Previous partnerships and experience

The hotel has been involved in previous projects and partnerships aimed at sustainability, which indicates its experience and willingness to actively engage in similar projects. Previous experience and positive attitude of managers and staff towards sustainability projects are key factors for the success of the project.

These reasons make Mediterranean Village Hotel & Spa suitable for this project, as it combines the characteristics required for the successful implementation and evaluation of the proposed circular economy practices.

**3.1 The conceptual framework and philosophy of the project**

This research was based on a funded project aiming to highlight and demonstrate in practice how a hotel can function as a sustainability model. Entitled "Value added services in the hospitality sector - P.R.A.X.E.I.S." the project was co-funded by the Region of Central Macedonia following its inclusion in the Action "Innovation Investment Projects" under the Operational Programme "Central Macedonia 2014-2020". Implementing bodies are the company VASILEOS LAMBROU HOTELS S.A. in cooperation with the National Centre for Research and Technological Development - Institute of Chemical Processes and Energy Resources (EKETA-IDEP).

The main points of the "P.R.A.X.E.I.S." project, the initial objectives, the areas of focus in terms of sustainable operation intervention actions of the Mediterranean Village Hotel & Spa and the expected results upon its completion will be presented below.

Initially three key questions were asked:

1. How can a hotel serve as a model of sustainability?
2. What are the steps required to reduce its environmental footprint?
3. How can it become a "green" hotel by following the Circular Economy and resource saving model?

The project aimed to strengthen the hotel business from a modern perspective, that of sustainable tourism development.

To this end, the following actions were implemented:

- ✓ Adoption of the principles of the Circular Economy with the aim of moving to a model as close as possible to that of zero environmental footprint (zero waste-zero emissions)

with a positive impact on operating costs, customer attraction and the local community (CYCLIC HOTEL).

- ✓ Development, Implementation and Certification of a Quality System for the Circular Economy in the hotel sector. (CERTIFICATION OF A CYCLICAL HOTEL)
- ✓ Crisis & risk management through the development and use of a digital application (GIVS-Mediterranean Village for Android & Ios). (CRISIS & RISK MANAGEMENT)
- ✓ Preparation & publication of Sustainability Report (CSR).

In order for the hotel to reach its green target, it needs motivation and clear commitment from the hotel management and staff, but also a process with several stages, starting with the energy audit. Actions are needed that aim at better energy management, reducing heating and cooling needs, improving the efficiency of existing equipment and energy systems, equipment/appliance efficiency, system performance, staff training and customer awareness.

The project "P.R.AX.EIS." presented, highlights the benefits that the adoption of sustainable development brings to the hotel sector and especially to the Mediterranean Village Hotel & Spa. Through its interventions, it seeks to provide sustainable solutions for hotel units and in particular for the above mentioned unit as a case study, such as:

- the introduction of new recycling policies.
- waste reduction, recovery and reuse.
- reduction of food waste and management of organics (new national legislation).
- minimising the energy footprint of the establishment.
- reducing atmospheric emissions such as the amount of carbon dioxide (CO2) released into the atmosphere from daily activities (those related to energy consumption).
- the promotion and use of Renewable Energy Sources (RES) to meet its energy needs.
- the drafting of a new environmental/sustainability policy and its promotion to employees, hotel guests, the local community and other stakeholders.
- the promotion of the local community
- the ongoing effort to improve the environmental performance of the facility through a new certification for the Circular Economy
- the transition to the Circular Economy (CE) system.

For the needs of the project, the utilization of energy outputs, solid waste streams and water management as a valuable natural resource was investigated. The research considered the advisory report of the Hellenic Society for the Protection of Nature entitled "Provision of proposed solutions and recommendation of best practices of the Circular Economy for the hotel industry". In addition, it took into account the new NAP and the NECC including the specific references for tourism units, as well as the WWF's "Guide for the reduction of food waste in hotels-HOTEL KITCHEN", in order to contribute to the rapid adoption of the above sustainable solutions.

Finally, taking into account that the project has the ultimate objective of developing a pilot regulation for the certification of Good Cycle Economy Practices for the hotel sector and pilot certification of the Mediterranean Village Hotel & Spa as a case study, the need to identify the stages of implementation of Good Cycle Economy Practices per category of sectors of interest was assessed, as listed below:

**PROPOSED GOOD PRACTICES**

**A. GOOD PRACTICES OF THE CIRCULAR ECONOMY - WASTE**

**Implementation stages**

Definition of waste categories
Definition of waste production stages by section & category
Define good prevention, reduction, collection, measurement, storage and disposal practices by category, section & stage of waste production
Definition of Key Performance Indicators (KPIs) for the implementation of good practices.
Definition of performance targets for waste prevention, reduction, management - disposal in relation to the existing situation records
Definition of procedures for monitoring, evaluation and redefinition of previous stages

**B. GOOD PRACTICES OF THE CIRCULAR ECONOMY - WATER**

**Stages of implementation**

Inventory of sources of origin
Determining uses and post-use disposal
Determination of good saving and reuse practices.
Definition of Key Performance Indicators (KPIs) for the implementation of good practices.
Definition of performance targets for water prevention, reduction, management - disposal in relation to the existing situation records
Definition of procedures for monitoring, evaluation and redefinition of previous stages

**C. GOOD PRACTICES OF THE CIRCULAR ECONOMY - ENERGY**

**Stages of implementation**

Inventory of supply sources
Determination of the amount of electricity and fuel consumption by department and activity
Determination of good practices for saving and alternative sources of energy and fuel supply.
Definition of Key Performance Indicators (KPIs) for the implementation of good practices.
Definition of energy efficiency, savings, production (e.g. mix) targets in relation to existing situation records
Definition of procedures for monitoring, evaluation and redefinition of previous stages
The proposed good practices of circular economy aim to achieve sustainable operations in the hotel sector, while reducing operating costs, effective crisis management, improving services, customer and employee satisfaction, as well as institutional compliance and social acceptance. In particular, it concerns good practices in energy saving and autonomy, water management and use, optimal management and utilisation of waste and liquid waste, as well as guidelines for green procurement.

## 4. Results and Discussion

The waste streams of the Mediterranean Village Hotel & Spa include mainly organic waste and recyclable materials, with organics comprising approximately 50% of the total waste. Recyclable materials, such as paper, plastic, metal and glass, account for approximately 30%, while the remaining 20% consists of mixed waste that cannot be recycled. From April to October, almost 13 tons of organic waste from the hotel gardens were recorded. These quantities vary depending on the time period and the hotel's operating conditions, with July showing the highest waste burden (1,3384 kgs), while May (1,1228 kgs), June (1,0852 kgs) and August (1,0812 kgs) give almost the same weight of waste per person per night.



In order to better reflect the current situation for future management, the waste streams were grouped according to the criteria of the obligations of the existing legislation and the possibilities of their disposal: organic, fully recyclable and mixed. During the months of April to October, waste was categorised into organic, fully recyclable and mixed waste. The percentage distribution of this waste was approximately 50% organic, 30% recyclable and 20% mixed, with quantities varying according to the type of waste (1. meat, vegetables, organic in general, 2. plastic, paper, metal, glass, 3. mixed).

As part of the implementation of actions and good practices to reduce the production of organic kitchen waste at source (premises, preparation and consumption), information, awareness raising and training actions have been initiated for staff in all departments, as well as for customers. A special information sign that has been placed in the catering areas for customers to raise awareness. Regarding the disposal of waste from the catering premises, 30.73% is sent to one of the largest collection and management companies of recyclable waste in Thessaly (Saitis Eco-Line) and the rest although separated into 18.73% mixed and 50.54% organic in the municipality as well.

Although alternatives for the disposal of organic waste were examined and some of them were implemented for some time (and for some quantities), such as the disposal of part of it to pig farms or other livestock units, they were unfortunately discontinued due to the reluctance of farmers to cover the cost of transport and absorption of large quantities of organic waste during the summer period.

For the project team, the search for good practices to reduce the production of waste of all categories and the disposal of the above mentioned organic kitchen waste as well as the organic green waste from the gardens of the company has been a key objective in order to achieve the main goal of reducing the waste to be disposed of in landfills and the certification of the hotel unit as a "Circular Hotel" in connection with the corresponding actions for energy saving and self-sufficiency.

According to the data presented, if a solution for the disposal of all organic waste is found, the municipality will only receive a percentage close to 18% of the waste produced (mixed), without taking into account the possibility of further reduction through the implementation of good practices. This reduction will have significant economic benefit for municipalities due first of all to a reduction in the required routes, personnel and disposal costs at the landfill site, which are expected to be adjusted by an increase in costs. The reduction of waste for disposal will also contribute to a longer lifetime of the existing landfills as it is not foreseen to finance such projects in the future as the European and national waste management policy now focuses on reducing waste production and moving to a circular model.

The mapping of the existing energy situation of the Mediterranean Village Hotel & Spa was an additional objective of the project and involved (a) the inventory of the existing equipment and (b) the inventory of the existing technological applications in use to meet the energy needs of the hotel unit.

Additional objectives towards the transition and certification as a "Circular Hotel" model were:

1. the recording of energy flows and energy quantities
2. the identification of vulnerabilities
3. identification and implementation of good practices of the Sustainable Development Strategy to meet the energy needs of the hotel unit

Initially, the inventory concerned the composition of the hotel's buildings in terms of:

- the spaces
- the structural elements and use
- elements of its licensing

The Mediterranean Village Hotel & Spa hotel unit consists of various spaces such as hospitality rooms, restaurants, leisure areas and administrative offices. Each of these areas is structured in such a way that it serves the needs of the guests and staff, ensuring comfort and efficiency in operations. The control of the above systems is achieved centrally through a BMS system, the distribution network is located inside the walls and the temperature control of each space is achieved with a thermostat.
The heating and cooling system of Mediterranean Village Hotel & Spa is based on advanced technologies, such as VRV devices and heat pumps, which allow efficient temperature management throughout the building, reducing energy consumption and improving guest comfort.

A series of measurements were then carried out involving:

- indoor air quality,
- the heat levels in them (thermography)
- the levels of light

The air quality indoors is regularly monitored to ensure guest comfort and compliance with environmental standards. Air temperature, humidity and cleanliness levels have been found to be within acceptable limits, contributing to the overall guest experience. The lighting in the interiors of Mediterranean Village Hotel & Spa can be adapted to provide sufficient and comfortable lighting for all activities. Measurements have shown that lighting levels are sufficient for both public areas and rooms, ensuring the comfort of guests during their stay.
Electricity consumption at Mediterranean Village Hotel & Spa during 2012-2021 showed fluctuations, with the highest values recorded during the summer months due to increased demand for air conditioning and water heating. Overall electricity consumption shows a gradual increase over time, suggesting the need for further improvements in energy efficiency.
The hotel's energy consumption fluctuates throughout the year, with increased needs during the summer months due to the use of air conditioning units. These fluctuations are recorded and analysed to adjust the hotel's energy saving strategies. According to the findings of the survey, the hotel has a high level of thermal comfort - accommodation conditions, uses solar energy (RES) to heat the water for use, has an intelligent central control-measurement system for energy parameters, with its structural elements meeting the prescribed quality requirements. Nevertheless, further improvements to the existing energy management and saving systems are needed, as well as extensions to monitoring and measurement and other functions. This is because, according to the electricity consumption data presented above, the building consumes high amounts of energy resulting in increased operating costs.

The suggestions for improving energy management and savings were:

1. Installation of an advanced KNX system for higher level control of the hotel's energy parameters and not only of the lighting.

2. Investigation of the use of heat pumps with seawater utilization for the swimming pools' DHW

3. Investigation of the possibility of meeting energy needs through renewable energy sources to reduce operating costs

An additional action of the pilot project was the development of a multi-topic digital application that will contribute to the management of either risks/crisis and issues of daily life that arise or require information, facilitating customers and employees. This particular application exclusively concerns the hotel business Mediterranean Village Hotel & Spa but with the appropriate adjustments, it can be good practice for any hotel business.
This digital multidisciplinary application aims to contribute through direct communication between customers and responsible executives or employees per department of the hotel unit to the management of risks/crises (safety issues from health, environmental and other crises, natural disasters, etc.) or potential risks/crises of any kind through continuous information with a two-way relationship in some cases.
It is also intended to help address and manage issues relating to the daily lives of customers and employees (restaurant and beach occupancy, weather forecast, parking availability, specific

customer interests, preferences or health issues). Accessibility for people with disabilities, etc. Finally, it will provide additional support services, mainly in the field of 'green' or 'sustainable' tourism. The Mediterranean Hotel mobile application aims to ensure the immediacy of communication between the guests staying at the hotel and the relevant hotel department.

In summary, the procedures that can be implemented are the following:



- **Information on services provided**
  The user can be informed about the hotel and the services provided by the hotel.
- **Information about the status of the hotel and the services provided by the hotel**
  The user has access to a map with a floor plan of the hotel and can be informed about mobility on the premises.
- **View Menu**
  The user can find the hotel menu by sector.
- **Questionnaire**
  The customer-user has access to a questionnaire regarding the hotel which can be answered within the application.
- **Customer - department contact**
  The customer-user can send contact messages to the respective hotel department. Also, the respective user - employee the respective department can reply to the messages sent from the side of
- **Notifications**
  The user has access to notifications about events in the hotel facilities

As far as the administrative part of the Mediterranean Hotel application is concerned, it aims to manage hotel sectors, supervise staff and guests' conversations and modify content displayed in the application (e.g. presentation of services provided).
In summary, the procedures that can be implemented are the following:

- **User Management**
  The administrator can access the user data of the application. The administrator can control customer details (name, room number, check-in date, check-out date) and delete customers. S/he also has the ability to add employees, edit their details and delete them from the system.
- **Domain Management**
  The administrator can edit the domains with which the customer can communicate through the mobile application. He has the ability to add, edit and delete domains of the hotel unit.
- **Send notifications**
  The manager can create notifications which are sent to the customers to inform them about what's happening in the hotel.
- **Management of promoted services and questionnaire**
  The administrator can edit the services displayed in the application as well as modify the questionnaire that customers are invited to answer through the application.

The above application can increase service time speed by 50%, staff efficiency by 15% and customer satisfaction by 100%.

The issues of corporate social responsibility were also important for this project as well as for sustainability in general as the necessity of implementing CSR practices and their publicity in the tourism sector and especially in the hospitality sector is emphasized every day.



**The positive results of corporate social responsibility are:**

- quality of tourism products
- a positive image of business vis-à-vis society and its social partners
- positive environmental and social impacts of tourism activity
- differentiation of businesses from their competitors, creating more 'loyal customers'.

**According to international research, the issues usually included in the E.C.E. reports as most essential for hotels are:**

1. environment
2. health and safety
3. human resources
4. supply chain management
5. customers and communities
6. corporate policy and ethics

while after the pandemic they have also included crisis management as an important issue Filimonau et al. (2020).

**Major CSR actions in the hotel industry:**

- energy saving
- use of environmentally friendly products
- donations to charities
- principles of the circular economy
- organising charity events
- staff development and training
- compliance with health and safety rules and others
- working with small businesses in the local market

**For this pilot project, the objectives were:**

- The development of the necessary skills and infrastructure in the company in order to be able to implement in the long term the Sustainable Tourism Development strategies

that will have been designed and developed in the framework of this Corporate Responsibility and the programme in general

- The possibility through the preparation of the Sustainability Report to make the hotel in question a model example (on the basis of the other actions provided for by the programme and presented above) as there are very few companies in Greece, especially in this sector, that proceed with similar publications.

**<u>As individual advantages from the implementation of actions and the issuing of a CSR Report for the company, the following were mentioned as they were set out from the beginning:</u>**

- monitoring the performance of the facility in terms of sustainability (waste reduction, cost savings, etc.)
- increasing the confidence of stakeholders in the business
- effective management of business risk cases
- training and continuous learning from the reporting process
- continuous improvement of the company's environmental and social footprint
- promoting business integrity
- improving the image and corporate reputation (brand timelessness)
- better credit rating

Sustainable tourism has become an increasingly popular field of research since recent years

- Most of the waste in a hotel is composed of organics at around 50%, with that for recycling, recovery, and perhaps reuse being around 30%. The remainder is related to mixed waste.

- Although good practices to reduce waste at source (with the involvement and cooperation of management, employees and customers) are gradually feasible over time, as provided for by the national legislation in force, which incorporates European legislation, there is a significant problem with regard to its disposal.

- There is a significant shortfall of the first-tier local authorities in terms of organisation, human resources and infrastructure in terms of the reception of recyclable and organic waste, with the result that, although important economic sectors such as the hotel industry are either ready or able to immediately complete the required actions in the collection and management of waste towards the transition to a circular operating model, this is not feasible.

- Similarly in the private sector there is either a significant gap in waste reception and management companies for recycling, recovery, reuse and even more so for organic kitchen waste or green waste. This is either due to a lack of policy direction, financial

incentives, or reluctance of private business for various reasons (e.g. bureaucracy, or market incentives, etc.)

- Under the above circumstances, compliance with the relevant legislation on waste management, waste reduction and the transition to a circular model, especially for the important hotel sector, will either be long overdue or will be a dead letter.

- In order to achieve sustainable tourism entrepreneurship, hotel businesses need the help of the state, as it turns out that it is insufficient to have the willingness at the level of the respective corporate management or even to take relevant initiatives and actions. The absence of specialised financial instruments to subsidise the necessary equipment and corresponding actions, as well as the lack of preparation on the part of local authorities in terms of human resources, proper planning and infrastructure, distances hotel businesses from achieving the goal of sustainable tourism operation.



## 5. Conclusions

The aim of this paper is to highlight and present how a hotel, can act as a model of sustainability in practice. As a case study in this paper, the Mediterranean Hotel & Spa of the Mediterranean Hotels Group is discussed and analysed. This research highlights a very significant improvement of the sustainability performance of Mediterranean Hotel & Spa. Specifically, it has achieve significant reduction of the environmental footprint as a result of the implementation of the circular economy management system with significant saving on resource utilization. Furthermore, it is highlighted that a comprehensive Corporate Social Responsibility and Crisis Management has been developed and implemented. These case study results highlight that the whole sector following good practices of the study can be a vehicle to enhancing sustainable operations, while reducing operating costs, improving crisis management, enhancing safety, corporate social responsibility, improving services and customer and employee satisfaction. The good practices of energy autonomy, water management, optimal management and utilization of waste, development of a mobile phone application to manage customer needs and emergency incidents, in an innovative approaches to corporate social responsibility and sustainable tourism operation which can be adapted by any hotel business. A further conclusion of this research is that certification ensures the transparency and reliability of circular management system and sustainability strategies developed and implemented. Finally, the limitations of the project and for a wide implementation of these findings in the hotel industry are related to various weaknesses and shortcomings such as, for example, the lack of resources of local authorities in material, human resources and infrastructure, as well as the central administration itself in terms of understanding the opportunities of circular management systems and sustainability strategies.

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# Sustainability in municipal waste recycling: an empirical investigation of economic and institutional determinants

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**Abstract**

The present paper addresses the global challenge faced by the European Union (EU) to achieve sustainable waste management by estimating the factors that drive municipal waste recycling rates across countries. This analysis adopts the recycling rate of municipal waste as the dependent variable and evaluates GDP per capita, expenditures on waste management, government debt, level of tertiary education status among adults in a society or human capital quality), governance effectiveness (Government Effectiveness & Regulatory Quality) as explanatory variables, during the period 2000-2021 to detect major drivers and common trends. Findings suggest wealth (GDP per capita) is a key driver of increased recycling rates. They can invest in better systems and infrastructure for recycling, which ultimately results in higher recycling rates. The dividend in waste management spending further translates into higher recycling rates, showing that countries need to put more of their GDP aside for waste management to achieve good environmental value through practice. Because of the flow-on environmental benefit through improved waste management facilities, this result indicates that funding for environmentally friendly onshore recycling and disposal may also spontaneously achieve sustainability. Furthermore, the analysis finds an intricate relationship between public debt and recycling rates. Although some level of debt may facilitate public expenditure in waste diversion beyond a certain point, it appears to impair the viability of recycling investments by reducing the marginal effectiveness of additional units purchased with external credit. Thus, research offers a robust empirical basis for the importance of budgeting and implies that governments should be cautious about getting too far in debt, as this would indeed fly against their long-term ability to meet their sustainability goals.

***Keywords:*** *Recycling Municipal Rate, Panel Data Analysis, European Union, Sustainability Policy.*

**JEL Codes**: Q01; C33; Q53 Q56; Q58.

# Global Bioeconomy: History, Visions and Limitations

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**Abstract**

The present paper aims to shed light in the interdisciplinary field of bioeconomy. Bioeconomy is represented by key stakeholders as a prominent alternative paradigm of socioeconomic organization. However, bioeconomy is still a work in progress. As a result, there are diversified perceptions about the definition, the visions, and the goals which the proposed bioeconomy strategies aim to address. A detailed literature review was conducted in order to depict the evolution of bioeconomy, as a concept. The evolutionary process of the definition led to the creation of the three main visions, namely: biotechnology, bioresource and bioecology. Furthermore, the paper aims to identify the major constraints to the implementation of bioeconomy in practice, emerging as obstacles in the acceleration of the transformational process towards forming bio-economies worldwide.

***Keywords:*** *Bioeconomy; bioeconomy visions; bioeconomy strategies; sustainable development*

**JEL Codes:** Q57; Q56; Q43; Q2

# Session 2
# Smart Technologies
# & Sustainable Development

# Green IT and smart technologies for optimal economic efficiency of mineral resources and energy

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**Abstract**

Green IT technologies contribute to increasing energy efficiency and reducing environmental footprint, while also being linked to the economic efficiency of mineral resources and energy. The depletion of mineral resources and their environmental impacts make the transition to more sustainable practices essential. In this context, Green IT offers innovative solutions for energy sustainability in areas such as smart homes, smart grids, and smart cities. It also contributes to effective resource management through mobile phone applications, enhancing sustainability on both individual and collective levels. The aim of this study is to highlight applications that provide tools for measuring and monitoring energy consumption, carbon footprint, promoting sustainable practices in housing and transportation, as well as tools for developing environmental awareness and sustainability. The methodology involves the search for applications that support the reduction of emissions and the enhancement of energy and economic efficiency through mobile platforms. In conclusion, the study emphasizes the importance of spreading these applications and developing more affordable technologies for wider accessibility.

***Keywords:*** *Green IT, Smart technologies, Energy efficiency, Resource management, Environmental footprint.*

**JEL Codes:** Q000, Q020, Q200, Q290, Q320, Q400, O310

# Green certification in coastal areas of Greece as a significant factor for local development

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**Abstract**

Green certifications in coastal areas of Greece participate in a significant way in local development. Those certifications encourage the sustainable management of natural resources, protect the environment, promote sustainability and combat climate change. European Union schemes, such as Ecolabel and Green Key, provide frameworks and guidelines for improving environmental performance across different sectors. By implementing standardized practices in areas such as tourism, fishing, and agriculture, local communities can enhance the quality of their products and attract visitors seeking eco-friendly options. Additionally, green certifications raise public awareness about the protection of marine ecosystems and the impacts of climate change. Therefore, green certifications can serve not only as a tool of tourism promotion but also as a main lever for preserving cultural heritage and ensuring the economic prosperity of coastal areas.

***Keywords***: *green certificate, coastal areas, local development, sustainable management, climate change*

**JEL Codes**: Q010, Q260, Q540, Q560, Q570, Z320

## 1. Introduction

Green certifications are an essential tool for promoting sustainable development in the coastal areas of Greece. Certifications such as Ecolabel, Green Key, and Blue Flag provide frameworks and guidelines for improving environmental performance across various sectors, including tourism, fisheries, and agriculture. Their implementation contributes to the sustainable management of natural resources, environmental protection, and sustainability promotion.

Green certification is a vital instrument for sustainable development, particularly in Greece's coastal areas. Through natural resource management, reducing environmental impacts, and strengthening the local economy, green certifications support sustainability and environmental protection. These certifications serve not only as a means of preserving natural heritage but also as a crucial factor in promoting tourism and local products.


## 2. Environmental Certifications and Labels in the EU

With growing concerns about the adverse effects of climate change and environmental degradation, there is an increasing need for organizations and individuals to adopt sustainable practices. In the European Union (EU), an effective tool for promoting environmentally friendly actions is the use of environmental certifications. These certifications provide a standardized assessment of an entity's environmental performance, offering numerous benefits for businesses, consumers, and the environment (European Commission, 2021).

The Importance of Green Certifications

In Europe, various green certification programs, such as Ecolabel, Green Key, and Blue Flag, provide guidelines for improving environmental practices. These programs focus on reducing pollutant emissions, managing water resources, and minimizing energy consumption. In coastal areas, implementing these certifications is crucial, as it directly relates to preserving marine ecosystems.

Impact on Tourism

Today, tourists place significant emphasis on the sustainability of the destinations they visit. Green certification is a key factor in attracting travelers interested in eco-friendly vacations. Coastal areas that have adopted green practices become more attractive while maintaining their natural beauty and simultaneously enhancing economic growth.

Applications in Fisheries and Agriculture

Beyond tourism, green certification also affects other sectors such as fisheries and agriculture. Sustainable fishing ensures that marine resources are not depleted, while implementing environmentally friendly agricultural practices reduces the use of chemical fertilizers and pesticides, helping to preserve biodiversity.

Economic and Social Benefits

The adoption of green certifications leads to economic benefits for local communities. Businesses that follow sustainable practices gain a competitive advantage, while local communities benefit from new job opportunities in the green economy. Additionally, citizen awareness of environmental protection issues increases, fostering a culture of sustainable development.



## 3. Research Purpose

The purpose of this study is to investigate the role of green certifications as a lever for local development in the coastal areas of Greece. Specifically, it examines how these certifications can:

- Improve the quality of local products and services.
- Attract visitors seeking ecological options.
- Raise citizen awareness about marine ecosystem protection and the effects of climate change.

Eco Label

The EU Ecolabel is a globally recognized voluntary system that promotes products and services that demonstrate clear environmental excellence based on standardized procedures and scientific evidence. The operation of the EU Ecolabel is defined by the official regulation of the European Parliament and the Council. It is managed by the European Commission and member states according to the priorities set in the EU Ecolabel strategic work program (About the EU Ecolabel, 2023).

The Ecolabel is a voluntary environmental label for products and/or services (generally referred to as "products"). These products must meet specific criteria related to reducing overall environmental impact. The criteria depend on the product category. The EU Ecolabel is governed by Regulation (EC) No. 66/2010 and aligns with the International Organization for Standardization (ISO) definition for Type 1 ecolabels. This means that the EU Ecolabel is awarded on a voluntary basis, based on multiple criteria, by an independent third party to indicate overall environmental preference within a specific product category, based on a life cycle assessment. (About the EU Ecolabel, 2023).

Green Key

Green Key is the most internationally recognized eco-label supporting sustainable development in the tourism industry. It is awarded to tourist establishments with an environmental identity. It is an international certification that reliably confirms that the accommodation facility meets all international environmental management requirements set by the Foundation for Environmental Education (Green Key, n.d.).

A tourism business with the Green Key actively participates in sustainable development initiatives within the tourism industry by protecting the environment, reducing its energy footprint, minimizing the waste of natural resources, and improving environmental conditions both locally and globally.

The Green Key represents a business's commitment to its guests that by choosing to stay at such an establishment, they are contributing to positive change in terms of environmental responsibility and sustainability. (Green Key, n.d.).

The Blue Flag

The Blue Flag program began in France in 1985. Its criteria have been applied in Europe since 1987 and in non-European areas since South Africa joined the network in 1998. Today, the Blue Flag has become a truly global program with an increasing number of participating countries. The international coordinator of the Blue Flag program for beaches and marinas is the non-governmental, non-profit organization Foundation for Environmental Education (FEE) (Blue Flag, n.d.).

Today, the Blue Flag has become a truly global program, with a continuously increasing number of participating countries. The international coordinator of the Blue Flag program for beaches and marinas is the non-governmental, non-profit organization FEE (Foundation for Environmental Education). (General Information About the Blue Flag | BLUE FLAG, n.d.).

The Blue Flag program promotes sustainable development in aquatic ecosystems, whether they are inland or marine waters. It encourages local authorities and coastal managers to work toward achieving high standards in four categories of criteria: water quality, environmental management, environmental education, and safety. Over the years, the Blue Flag has evolved into a highly reliable and widely recognized eco-label, bringing together the

environmental and tourism sectors at local, regional, and national levels. (Explanations of the Blue Flag Program Criteria | BLUE FLAG, n.d.).



## 4. Methodology

The research is based on secondary data, including:

- European certification programs such as Ecolabel, Green Key, and Blue Flag.
- Case studies from coastal areas of Greece.

## 5. Results

The study's results indicate that green certifications significantly contribute to local development. Specifically:

- They encourage sustainable management of natural resources, promoting practices that reduce waste, protect biodiversity, and enhance recycling and material reuse.
- They improve the quality of products and services, increasing the reliability and competitiveness of local businesses that adopt more responsible and environmentally friendly practices.
- They attract visitors interested in ecological options, creating new opportunities for sustainable tourism and increasing the income of local communities by offering environmentally responsible experiences.
- They enhance citizen awareness of environmental issues, fostering an ecological mindset and encouraging greener habits in daily life.
- They contribute to preserving cultural heritage by protecting traditional production methods, local customs, and architectural characteristics linked to the natural environment.

Overall, green certifications benefit not only the environment but also the economy and society, creating a development model based on sustainability and long-term prosperity.

## 6. Conclusion

Green certification is not merely a promotional tool for Greece's coastal areas but a necessary strategy for maintaining environmental balance and sustainable development. By implementing these practices, local communities can ensure their long-term prosperity while protecting the natural environment. The state, in collaboration with stakeholders and businesses, must promote green certification as a fundamental tool for local development.

Green certifications are not just a means of promoting tourism but also an essential mechanism for preserving cultural heritage and ensuring the economic prosperity of coastal areas. Their implementation can lead to sustainable development while simultaneously protecting the environment and enhancing the economic and social well-being of local communities.

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# Virtual Reality: A tool to promote tourism in the rehabilitated mines of Western Macedonia

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**Abstract**

Virtual reality (VR) is an advanced technology that creates immersive, computer-based environments, allowing users to interact with and explore these virtual worlds as if they were real. When applied to promote rehabilitated areas, VR tools provide a smart way to highlight transformations and attract tourists. These tools can offer to the potential visitors an engaging preview of rehabilitated mines, especially when these areas are repurposed as historical, cultural or ecological destinations. This paper studies the attitudes and the awareness of Greek citizens toward the positive impact of VR tools in promoting the rehabilitated mines in Western Macedonia, Greece. The questionnaire method was used to collect al the necessary data, which was analyzed using SPSS. It is clear that, the mining region of Western Macedonia should adapt to the new digital era by integrating VR tools to boost tourism and operational efficiency in restored mines. Moreover, the widespread adoption of VR technology promises to accelerate progress toward the Sustainable Development Goals, while significantly enhancing overall quality of life.

***Keywords:*** *Virtual Reality (VR), tourism, Rehabilitated mines, Western Macedonia, Sustainable Development.*

**JEL Codes**: Q01; L83

# Climate change and the environment in apps for disabled people: The use of digital media

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**Abstract**

Nowadays, climate change and environmental protection are at the heart of European environmental policies. In the context of energy and environmental sustainability, various multimedia applications have been developed aiming to improve the quality of life of Persons with Disabilities. Multimedia applications usually include an electronic, interactive presentation that integrates multiple multimedia elements, such as text, images, sound, animations and video on an electronic device. This paper presents and assesses these applications. According to the results, applications that promote the well-being of disabled people in the context of climate change and environmental protection are few and this indicates that there is an urgent need for the design and implementation of more environmental applications.

***Keywords:*** *Climate change, Environmental protection, apps for disabled people, digital media, sustainable development*

**JEL Codes:** O30; O39; Q01

# Natural History Museums and Protected Areas Information Centres: Characteristics of video presentations and regional development

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**Abstract**

Natural history museums host collections that contribute to the preservation and interpretation of the natural world, and along with the Protected Areas Information Centres they serve as educational and conservational resources for raising awareness and engagement among the public. Since the 19th century they started to implement photography and later, video presentations at their premises. At the end of the 20th and the beginning of the 21st century, photo and video presentations were broadly incorporated in Natural History Museums websites and social media. There is a significant strong correlation between website and actual onsite visitors. The creation of short thematic video presentations up to 5 minutes long that follow a certain structure, for usage at the premises, websites and social media, may contribute to the increasement of the number of visitors and local develpomet. Such initiatives can be subsidised from regional development EU funds for digital transformation and green transition.

***Keywords:*** *Natural History Museum, Protected Area Information Centre, Video Presentation, Website Visitors, Local and Regional Development*

**JEL Codes:** Q20, Q26, O30

## 1. Introduction

Natural history museums are scientific institutions that host collections regarding nature, including plants, animal and fungi specimens and other exhibits related to ecosystems, climatology, palaeontology, and geology. Through these collections and exhibits, natural history museums contribute to the preservation and interpretation of the natural world (Johnson & Owens, 2023). Their origins are traced back to the “cabinets of curiosities”, private collections of natural objects that were displayed for enjoyment and study during the Renaissance (Chervonenko, 2021). Among the oldest natural history museums are the Ashmolean Museum that was founded in 1683 and is the first university museum, the Muséum National d’Histoire Naturelle in Paris that was founded in 1793 and the Natural History Museum in London that was part of the British Museum and in 1881 became an independent entity (Knell, 2000; MacGregor, 2001; Blanckaert, 2009).

Although Protected Areas Information Centres and Natural history museums do not share the exact same scope and focus, they both serve as educational and conservational resources for raising awareness and engagement among the public (Naro-Maciel et al., 2009; Pulido-Chadid et al., 2023).

Photography started being incorporated in Natural museums as early as the 19th century, first by the Australian Museum and the Smithsonian National Museum of Natural History, initially for documenting specimen and exhibits and share them with the public and academia (Rieppel, 2012; Edwards, 2020). During 1920s moving pictures were also used to documents exhibits and display natural phenomena by the American Museum of Natural History (Mandelli, 2019). More and more museums started utilising audio-visual content to enhance visitors experience throughout the 20th century (Hein, 2006).

During the mid-1990s, museums such as the Natural History Museum of Los Angeles County, started creating websites to provide online access to the public for information, access to collections and educational resources (Bowen et al., 2005). Digital interpretation and presentation immersive technologies such as sophisticated video clips and virtual reality applications can enhance visitor experience and satisfaction, leading to higher visitation rates in Museums (Li et al., 2024).

Video content provides interactive and dynamic experiences that increases visitors' engagement (Luck and Sayer, 2024), satisfaction and loyalty (Li et al., 2024). The length and number of such short video presentations that can also be utilized in websites and social media may vary, depending on the thematic and the museum size. A good practise applied by Harvard Museum of Natural History is the creation of a webpage containing short educational video presentations with a duration up to 5 minutes, aiming to quickly engage viewers and provide concise information. The structure of such a short video consists of (Harvard Museum of Natural History, 2024):

- Introduction (10-15 seconds)
- Background Information (30-45 seconds)
- Detailed Explanation (2-3 minutes)
- Conclusion (30-45 seconds)
- Credits and Additional Resources (10-15 seconds)

The aim of this research is to provide proof and examine the ways in which a set of video clips can be produced to promote visitation at a Natural History Museum (or a Protected Area Information Centre) situated in a rural area, such as the Natural History Museum of the University Forest of Taxiarchis at Chalkidiki, Greece. Rising touristic visitations in rural and protected areas can stimulate local development and mitigate population loss (Andreopoulou et al., 2015; Ivona, 2021).

## 2. Methods and Data

Literature review was conducted, and best practices were explored, examining the importance and the characteristics of thematic video presentations creation for Natural History

Museums and Protected Areas Information Centres. Secondary research is conducted to examine if there is a link between increased website traffic and actual visitors number at the National History Museums. Secondary research is a method in which the utilization of primary data form credible organisations or researchers is used for further research (Johnston, 2014). A table is created to compare the website traffic and actual visitor numbers of the most popular Natural history museums globally. The website visitors number is retrieved from Similarweb statistical data which is reliable and valid for secondary data research purposes (Jansen and Spink, 2019). Information about on-site actual visits were retrieved mostly from the museum's websites. Data from the table was inserted in SPSS and examined for possible corelation.



Table 1. Most Visited Natural History Museums. Source: SimilarWeb, 2024.

| List | Museum Name | 2023 On-Site | 2023 Website |
|---|---|---|---|
| 1 | Natural History Museum (London) | 5,846,680 | 12,000,000 |
| 2 | American Museum of Natural History (New York) | 5,000,000 | 10,500,000 |
| 3 | National Museum of Natural History (Washington D.C) | 4,400,000 | 9,800,000 |
| 4 | Field Museum (Chicago) | 2,000,000 | 4,500,000 |
| 5 | Natural History Museum (Vienna) | 1,500,000 | 3,200,000 |
| 6 | Canadian Museum of Nature (Ottawa) | 1,200,000 | 2,800,000 |
| 7 | Museum für Naturkunde (Berlin) | 882,388 | 2,500,000 |
| 8 | Royal Belgian Institute of Natural Sciences (Brussels) | 300,000 | 2,200,000 |
| 9 | Australian Museum (Sydney) | 1,000,000 | 2,000,000 |
| 10 | Shanghai Natural History Museum (Shanghai) | 2,180,000 | 1,900,000 |
| 11 | National Museum of Nature and Science (Tokyo) | 800,000 | 1,800,000 |
| 12 | Natural History Museum of Los Angeles County (L.A) | 750,000 | 1,700,000 |
| 13 | National Museum of Natural History (Paris) | 700,000 | 1,600,000 |
| 14 | Natural History Museum (Oslo) | 650,000 | 1,500,000 |
| 15 | Natural History Museum (Madrid) | 600,000 | 1,400,000 |
| 16 | Natural History Museum (Stockholm) | 550,000 | 1,300,000 |
| 17 | Natural History Museum (Copenhagen) | 500,000 | 1,200,000 |
| 18 | Natural History Museum (Helsinki) | 450,000 | 1,100,000 |
| 19 | Natural History Museum (Zurich) | 400,000 | 1,000,000 |
| 20 | Natural History Museum (Mexico City) | 350,000 | 900,000 |

Table 2. Pearson Correlation between On-Site guests and Website visitors of the 20 most visited Natural History Museums

| SPSS Pearson correlation | | | |
|---|---|---|---|
| | | 2023 On-Site | 2023 Website |
| 2023 On-Site | Pearson Correlation | 1 | .976** |
| | Sig. (2-tailed) | | <.001 |
| | N | 20 | 20 |
| 2023 Website | Pearson Correlation | .976** | 1 |
| | Sig. (2-tailed) | <.001 | |
| | N | 20 | 20 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | |

The Pearson correlation coefficient between "2023 On-Site" guests and "2023 Website" visitors is 0.976. This value is very close to +1, indicating a strong positive linear relationship between the two variables. The significance value (Sig. 2-tailed) is <.001. This p-value, indicating that the correlation is statistically significant.

The population at the rural, mountainous Municipal Communities of Taxiarchis and Vrastamon at Chalkidiki, Greece has decreased between 2011 and 2021 by a 17.83% (Table 3.) and 4.65% (Table 4.).

Table 3. Population of Taxiarchis, Chalkidiki between 2011 and 2021. Source: ELSTAT

| Taxiarchis Municipal Community | | | |
|---|---|---|---|
| Year | Population | Change | Percentage Change |
| 2011 | 903 | 0 | 0 |
| 2021 | 742 | -161 | -17.83% |

Table 4. Population of Vrastamon, Chalkidiki between 2011 and 2021. Source: ELSTAT

| Vrastamon Municipal Community | | | |
|---|---|---|---|
| Year | Population | Change | Percentage Change |
| 2011 | 990 | 0 | 0 |
| 2021 | 944 | -46 | -4.65% |

## 3. Conclusions

Video content incorporation in the largest Natural History Museum and Protected Areas Info Centres websites and premises can stimulate public interest, awareness (Koliouska & Andreopoulou, 2013) and improve visitors experience (Georgilas & Andreopoulou, 2023) There is a significant, positive correlation between the number of on-site guests and website visitors among the 20 most visited Natural History Museums in the world. Creating and displaying thematic short video presentations up to 5 minutes long in the museum's premises,

websites and social media can rise interest and lead to the increase of the number of on-site actual visitors, contributing to the local development and population loss.
In the case of the Natural History Museum of the University Forest of Taxiarchis at Chalkidiki, Greece, a set of 4 video presentations up to 5 minutes long, concerning the thematic of the museum, will be produced during 2024 and 2025 by the Laboratory of Forestry Informatics, of the Department of Forestry and Natural Environment, of Aristotle University of Thessaloniki.

The four thematic concerns:

- Presentation of the Natural History Museum of the University Forest
- Logging in the university forest
- The cycle of water
- Recreation and Education at the University Forest



This research is carried out by the Laboratory of Forestry Informatics of the Forestry Department of Aristotle University and is funded by the University Forest Administration and Management Fund of Aristotle University. Such initiatives that can also be applied in Protected Areas Info Centres, can be subsidised from regional development EU funds for digital transformation and green transition. Rising visitation patterns at the mountainous regional area of the Municipal Communities of Taxiarchis and Vrastamon can stimulate tourism development and may lead to population loss mitigation (Andreopoulou et al., 2017).

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# Fermentation technologies for bioethanol production: Prospects and challenges

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**Abstract**

The production of biofuels based on renewable biological raw materials attracts the interest of the global scientific community strongly, in the effort to address modern environmental issues, such as climate change and the reduction of available fossil resources. Bioethanol is one of the most interesting biofuels, due to its positive impact on the environment, as it is produced using mainly residual lignocellulosic biomass, through the process of alcoholic fermentation. Lignocellulosic biomass contains a complex mixture of carbohydrates and phenolic components, which need effective pre-treatment to ensure accessible pathways to enzymes for the production of fermentable sugars, which after hydrolysis are fermented into ethanol. The chemical composition and anatomical characteristics of the raw material seem to be critical factors. Despite technical and economic difficulties, renewable lignocellulosic feedstocks do not compete with the food and feed chain, thus contributing to achieving sustainability. Various bio-process methods have been developed for the production of bioethanol from plant feedstocks, while in addition, various separation and purification processes of bioethanol are proposed in order to increase its yield and quality.

***Keywords:*** *fermentation technologies, bioethanol, biofuels*

**JEL Codes:** Q01

## 1. Introduction

Nowadays, when environmental protection from issues such as the climate crisis and the greenhouse effect is an imperative need, while at the same time the issue of the rapid depletion of mineral resources is emerging (Aditiya et al., 2016), the global community is looking for energy sources that ensure sustainable development, while meeting the ever-increasing modern energy demands (Gray, Zhao and Emptage, 2006).

Renewable energy sources, such as biomass, are the main solution to the above issues, as their use is consistent with the development of low-cost, sustainable and renewable energy sources (Datar et al., 2004). Bioethanol is a typical example of a renewable energy source produced from plant residues, thus contributing both to the substitution of consumed mineral resources and to the prevention of waste disposal in landfills (Balat, Balat and Öz, 2008).

Bioethanol is a chemical substance widely used in the pharmaceutical, food, fuel and agricultural industries. It has been used to replace conventional fuels and reduce dependence on petroleum resources, while also indirectly contributing to the reduction of environmental pollution (Kumar, Ruplappara Sharath *et al.*, 2024). Sugar derived from biomass is a mixture of hexose (mainly glucose) and pentose (mainly xylose) (Gray, Zhao and Emptage, 2006).

Biomass used for energy purposes is categorized into generations, depending on the origin of the feedstock. Feedstocks containing sugar and starch (first generation) compete with their use as food, thus affecting their supply. In contrast, lignocellulosic biomass (second generation) represents an alternative feedstock for bioethanol production. Second generation biofuels are derived from crops that have been grown exclusively for energy use.



Lignocellulosic biomass is widely used due to its low cost and wide availability, while at the same time it has the advantage of not competing with food crops (Bušić et al., 2018). Bioethanol produced from lignocellulosic waste is referred to as second-generation ethanol (2G ethanol) (Kumar, Ruplappara Sharath et al., 2024).

## 2. Bioethanol characteristics

Bioethanol is produced through alcoholic fermentation using appropriate enzymes from a variety of feedstocks. It is a high-octane fuel and its physicochemical characteristics differ significantly from conventional fossil fuel sources, such as gasoline (Table ) (Bušić et al., 2018).

**Table 1**. Characteristics of gasoline and bioethanol (Bušić et al., 2018)

| Characteristic | Benzin | Bioethanol |
|---|---|---|
| Chemical formula | $C_nH_{2n+2}$ $(n = 4,5, \dots ,12)$ | $C_2H_5OH$ |
| Molecular weight (g/mol) | 100-105 | 46.07 |
| Octane number | 88-100 | 108 |
| Density (kg/dm3) | 0.69-0.79 | 0.79 |
| Lower calorific value (LHV) (*103 kJ/dm3) | 30-33 | 21.1 |

Ethanol has a higher octane number (108), which gives it a higher quality than a gasoline sample. It also has higher flammability limits, higher ignition speeds, and higher heat of vaporization. These properties give bioethanol properties such as a higher compression ratio and shorter burn time, which theoretically leads to performance advantages over conventional gasoline (Balat, Balat and Öz, 2008).

## 3. Raw materials

Different types of biomass have potential for use as raw materials for bioethanol production. Based on their chemical composition as carbohydrate sources, they are categorized

into three groups (Mussatto et al., 2010). Sugar raw materials (sugar beet, sugar cane, molasses, whey, sweet sorghum), starch-containing raw materials (grains such as corn, wheat, root crops such as cassava), lignocellulosic biomass (straw, agricultural waste, crop and wood residues).

Sugarcane and beets are the most important sugar-producing plants, as grain crops and root/tube crops contain large amounts of starch. The most commonly occurring renewable fuel is ethanol derived from corn kernels (starch) and sugarcane (sucrose). Furthermore, raw materials such as corn, wood and wheat bran can be used (Chen et al., 2024), however it is expected that there will be limitations in the effort to procure these raw materials in the future. Therefore, the alternative option of lignocellulosic biomass is considered an attractive feedstock for future bioethanol supplies (Gray, Zhao and Emptage, 2006).



In addition to agricultural waste, forest waste can also be used as raw materials, such as for example the production of second-generation ethanol from eucalyptus wood (Romaní et al., 2010), grass straw (Achinas et al., 2019) or pine shavings, which is a residual biomass obtained from the conservation of spruce trees (Cotana et al., 2014).

Wood samples pre-treated under certain conditions were successfully used as substrates for bioethanol by simultaneous saccharification and fermentation. Lignocellulosic waste contains on average 43% cellulose, 27% lignin, 20% hemicelluloses and 10% other components (Bušić et al., 2018). They are often considered, as mentioned above, a promising feedstock for bioethanol production, due to their abundance and availability (Kumar, Ruplappara Sharath et al., 2024). Sugarcane bagasse (Saccharum officinarum) (SCB) is a type of agricultural waste biomass obtained during sugarcane processing and is found in abundance (Ajala et al., 2021).

There are certain microorganisms that can accumulate high amounts of bioethanol. The most commonly used microorganism that is the most preferred for most ethanol fermentation processes is the species Saccharomyces cerevisiae, which can produce ethanol with a concentration of up to 18% of the output feed. This microorganism is a type of yeast, which can grow on both simple sugars, such as glucose, and more complex ones, such as the disaccharide sucrose (Lin and Tanaka, 2006).

## 4. Bioethanol production process

Fuel ethanol can be produced by direct fermentation of simple sugars or polysaccharides such as starch or cellulose that can be converted into sugars (Mussatto et al., 2010).

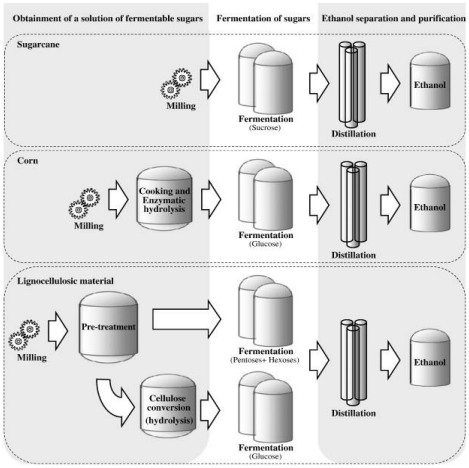


**Figure 1.** Bioethanol production process (Mussatto et al., 2010)

Before raw materials are used to produce biofuels and other biochemicals, delignification is the first step that must be performed, followed by pre-treatment and hydrolysis (Ajala et al., 2021). In brief, the process of producing ethanol from sugarcane consists of the steps of preparation, grinding of sugarcane, the fermentation process, and distillation-rectification-dehydration. Currently, ethanol fermentation is mainly carried out by fed-batch processes with cell recycling, and a small part is produced through continuous multi-stage fermentation with cell recycling (Mussatto *et al.*, 2010).

## 5. Lignin removal

The existence of lignin complicates the alcoholic fermentation process of cellulose for the production of biofuels. Therefore, it is important to remove a large amount of lignin at the beginning of the process, to make it easier to utilize the cellulose using enzymes (Ajala *et al.*, 2021). Lignin removal can be accomplished in two ways, with the use of enzymes and with the use of chemicals (such as alkaline chemicals or acids).

The above are used for the depolymerization of lignin, which will lead to the easier disposal of cellulose polymers for utilization. The first method involves the use of enzymes, such as lignin peroxidase (LiP), manganese peroxidase (MnP), laccase (laccase E.C. 1.10.3.2), cellulase, xylanase, etc., which are the main enzymes used for delignification (Malik, Khan and Javed, 2022). In the second method, the samples are treated with alkalis (such as, for example, 4% w/w NaOH) (Asgher, Ahmad and Iqbal, 2013) or with acids. For alkaline pretreatment of lignocellulosic raw materials, NaOH, KOH, Ca(OH)2 and NH4OH are most commonly used (Bušić et al., 2018), while for acidic pretreatment, hydrochloric acid, phosphoric acid, nitric acid and sulfuric acid are used (Aditiya et al., 2016). Alkaline pre-treatment can greatly improve the cellulose digestion process.

The degradation of sugars, as studied, was found to be lower during acid treatment (Talebnia, Karakashev and Angelidaki, 2010), compared to the use of alkali. Also, when comparing the two techniques, it was observed that the pre-treatment of sugarcane bagasse with

ligninolytic enzyme extract had a higher yield compared to the pre-treatment with NaOH. However, in the case of enzymatic treatment, cellulose hydrolysis was higher, compared to alkali pre-treatment, suggesting that the enzymatic extract caused cellulose breakdown simultaneously with lignin degradation. Therefore, although ligninolytic pretreatment contributed to a higher degree of lignin removal, alkali pretreatment gave higher ethanol production. However, the difference was not significant, so both methods are suitable for use (Asgher, Ahmad and Iqbal, 2013). Another important factor to consider when choosing a suitable method is the fact that the application of alkaline pre-treatment presents difficulties due to the high cost of alkalis (Talebnia, Karakashev and Angelidaki, 2010).

## 6. Pre-treatment

In pre-treatment, certain necessary processes should take place, such as reducing the degree of polymerization and crystallinity index, breaking lignin-carbohydrate bonds, removing lignin and hemicelluloses, and increasing the porosity of the material, in order to ensure effective enzymatic hydrolysis of lignocellulosic biomass. The choice of the appropriate pre-treatment method depends on the nature of the raw material and the formation of by-products during the selected pre-treatment. Its choice is of fundamental importance, as it has a great impact on all subsequent stages of bioethanol production (Bušić et al., 2018). The pre-treatment methods used are:

- Physical (mechanical) methods: grinding, irradiation, hydrothermal treatment, expansion, extrusion, pyrolysis
- Chemical methods: acid or gas treatment, addition of oxidizing agents, ionic liquids or organic solvent
- Physicochemical methods: liquid oxidation, explosion (steam explosion, ammonia fiber explosion, CO2 explosion, SO2 explosion), microwave, ultrasound or liquid hot water pre-treatment
- Biological methods: use of microorganisms (fungi)

Sugar crops only require a milling process to extract the sugars until fermentation (which does not require any hydrolysis step), which becomes a relatively simple process of converting sugar into ethanol. In processes using starch from grains such as corn, saccharification is necessary before fermentation. At this stage, the starch is gelatinized by cooking and undergoes enzymatic hydrolysis to form glucose monomers, which can be fermented by microorganisms. In the case of lignocellulosic materials, the technologies involved are more complex and the cost of ethanol production is higher compared to sugarcane, beets or corn.

The "harsh" conditions used during pre-treatments lead to the synthesis of toxic compounds, such as furans, carboxylic acids and phenolic compounds. In order to avoid the formation of the above by-products, it is necessary to apply techniques aimed at inactivating inhibitors, such as processes of inhibitor removal, use of yeast strains highly tolerant to inhibitors, selection of effective pre-treatment that causes minimal sugar degradation and inhibitor formation.

## 7. Hydrolysis

Hydrolysis of lignocellulosic biomass into monomeric sugars is necessary before their metabolism by microorganisms becomes possible (Bušić et al., 2018). The hydrolysis process separates the long chain of carbohydrates (from cellulose or starch) by adding a water molecule and is usually catalyzed by an enzyme or acid. This stage is critical for bioethanol production, as the subsequent fermentation process is linked to the quality of the ethanol as a final product. The hydrolysis process is necessary, as the microorganisms used in the fermentation process are only capable of digesting a simpler form of sugar derived from the complex carbohydrate of the biomass (Aditiya *et al.*, 2016).

## 8. Alcoholic Fermentation

In integrated bio-process systems, alcoholic fermentation is carried out by combining the hydrolysis and fermentation systems which operate in the following combinatorial ways (Bušić *et al.*, 2018).

- Separate Hydrolysis and Fermentation (SHF)
- Simultaneous Saccharification and Fermentation (SSF)
- Simultaneous Saccharification and Co-Fermentation (SSCF)
- Consolidated Bio-Processing (CBP)
- Simultaneous Saccharification, Filtration and Fermentation (SSFF)

In the SHF method, both hydrolysis and fermentation take place at their optimal temperatures (50 °C for hydrolysis and 28–32 °C for fermentation). Suitable microorganisms carry out the fermentation of hexoses and pentoses separately.

During the SSF process, hydrolysis and fermentation take place in a single bioreactor. Therefore, the sugars released from enzymatic hydrolysis are immediately utilized by the microorganism. Under these conditions, there are relatively low sugar concentrations in the extracted broth and, consequently, cellulase inhibition by the released sugars is reduced. The optimal temperature for the SSF technique (approximately 38 °C) is a compromise between the optimal hydrolysis (45–50 °C) and fermentation (30 °C) temperatures. Further improvement of the SSF technique can be achieved through optimal enzyme selection.

The main advantages when applying the SSF method are the increase in the hydrolysis rate through the reduction of cellulase inhibition by released sugars, the lower requirement for enzymes, the higher yield of bioethanol production, the reduction of the need for sterilization conditions, the shorter residence time, the cost reduction, by eliminating the requirement for expensive separation processes and equipment.

The main disadvantages of the SSF technique are incompatible hydrolysis and fermentation temperatures, microbial tolerance to ethanol, and ethanol inhibition of enzymes.

The inclusion of pentose fermentation in the SSF method is another promising alternative, in a process called simultaneous saccharification and co-fermentation (SSCF). In this mode of

operation, both producing microorganisms must be compatible in terms of optimal pH and temperature. Furthermore, the development of microbial strains capable of growing at high temperatures can significantly improve the technical and economic indicators of the SSCF method. The SSCF technique has advantages in terms of its economic perspectives, but it has disadvantages in terms of its technical implications. By co-fermenting pentoses and hexoses in a common bioreactor, the investment cost is reduced, as well as the possibility of contamination.

Another holistic approach to converting lignocellulose-containing feedstocks into bioethanol is integrated bioprocessing (CBP). In this approach, cellulase production and fermentation require only one microorganism. Therefore, cellulose production, hydrolysis, and cellulose fermentation are carried out in a single step. In fact, the concept of CBP includes four biological reactions in one step: enzyme production (cellulases and hemicellulases), carbohydrate hydrolysis into sugars, hexose fermentation (glucose, mannose and galactose) and pentose fermentation (xylose and arabinose). The CBP technique has the following advantages compared to other integrated bioethanol production systems: the enzymatic systems and fermentation systems are fully compatible and therefore the cost of bioethanol production is reduced, high investment costs are not required, while at the same time part of the substrate is not spent on cellulase production.

In addition, a new method for the production of lignocellulosic bioethanol, simultaneous saccharification, filtration and fermentation (SSFF), has been developed and evaluated. SSFF is an integrated bio-process that allows for the simultaneous enzymatic hydrolysis of lignocellulosic biomass, filtration of sugars from hydrolysis and fermentation of the filtrate with Saccharomyces cerevisiae yeast. In the SSFF technique, the pre-treated lignocellulose-containing feedstock is enzymatically hydrolyzed in a bioreactor, while the suspension is continuously pumped through a cross-flow membrane. The process residue is returned to the bioreactor for hydrolysis and a purified sugar-rich filtrate is continuously added to the bioreactor for fermentation. The following table summarizes the appropriate process for producing bioethanol from indicative samples (Bušić et al., 2018).

**Table 2**. Bioethanol production process from various samples (Bušić et al., 2018)

| Raw material | Pre-treatment | Synthesis process | Bioethanol produced (g/L) |
|---|---|---|---|
| **Sugarcane bagasse** | NaOH | SSF | 51.7 |
| **Bagasse** | Enzyme / acid | SHF, SSF | 5.44 – 6.24 |
| **Eucalyptus Globulus wood** | Organic solution / enzyme | SSF | 42.0 |
| **Rice grain** | NaOH, enzyme | SSCF | 28.6 |
| **Corn husk** | enzyme | SHF | 45.5 |
| | | SSCF | 51.3 |
| | | CBP | 7.0 |
| **Cellulose material, beta-glucan** | - | CBP | 4.24 |
| | | | |

## 9. Bioethanol purification

After bioethanol is produced through the alcoholic fermentation process, it is necessary to increase its purity in order to improve its quality as a fuel. There are various methods for purifying the final product. The first method is a standard distillation that concentrates the ethanol up to 92.4–94% by weight. Circular distillation for ethanol purification is an energy-efficient alternative characterized by relatively low investment needs. The second method involves techniques such as ethanol dehydration to obtain anhydrous ethanol. The third method is separation through membranes, which have high separation efficiency, relatively low energy and operating costs, do not produce waste streams, and can be used to separate temperature-sensitive materials. Finally, adsorption is a separation technique in which gas molecules or solution components are adsorbed onto a solid surface (adsorbent). The adsorbent is a stable crystalline solid that has negligible or no solubility in water or alcohol. Substances are adsorbed to it according to their physical and chemical properties (Bušić *et al.*, 2018).



## 10. Bioethanol characteristics and utilization

Several studies have shown the viability of bioethanol production as a renewable energy source. The results of these studies indicate positive environmental benefits from the substitution of gasoline and 1G bioethanol by 2G bioethanol in most impact categories. Second generation bioethanol has indeed the potential to avoid greenhouse gas emissions (Wietschel *et al.*, 2021).

As mentioned above, the net calorific value of bioethanol is lower than that of conventional fossil fuels. However, a fuel can consist of a portion of bioethanol and a portion of conventional fuels, which is referred to as co-processing. Bioethanol is mostly used in the transportation sector as a blend component with gasoline or as an octane booster (ethyl tertiary butyl ether (ETBE), consisting of 45% by volume bioethanol and 55% by volume isobutylene). Many countries use ETBE, which is used to increase the octane number, but it is banned in the US and Canada due to carcinogenic emissions (Bušić *et al.*, 2018).

Another key parameter that hinders the widespread application of bioethanol is its increased cost, compared to conventional fuels. To reduce the cost of ethanol production, it is necessary to achieve high ethanol yields, in order to increase the income of the respective industrial activity, as well as a high ethanol concentration during fermentation, in order to be able to reduce the energy required for distillation and other stages of the process. Improved pre-treatment methods enhanced enzymatic hydrolysis with cheaper and more efficient enzymes, as well as improved fermentation systems are important research challenges in order to make lignocellulose-based ethanol production competitive with sugar- and starch-based ethanol (Galbe et al., 2007).

Furthermore, there is the issue of the variation in the properties of the feedstocks. Different physicochemical, structural and synthetic factors can significantly slow down the

bioethanol production process (Bušić et al., 2018). Also, the seasonality of the feedstocks may create difficulties in the availability of feedstocks.

## 11. Future prospects of bioethanol production



Recent advances in technologies, such as the use of agricultural waste containing polysaccharides and genetic manipulation to develop crops with high carbon content or to retain cellulase in their leaves, have opened a new horizon in bioethanol production. Bioethanol will certainly not be sufficient to meet the energy demand that is set to increase due to the sharp increase in population, vehicles and the depletion of natural resources worldwide. However, with each generation, bioethanol technology advances and production potential increases. The use of renewable sources or feedstocks produced from agricultural residues, forest waste, algae biomass, engineered crops and organisms, and specially engineered multi-substrate enzymes could lead to the development of newer technologies and, therefore, reduce the existing price of bioethanol to a competitive price on the global market. This will not only help preserve natural resources for a longer period of time but will also significantly reduce environmental pollution. Of course, there will always be concerns about the land available for growing feedstocks and the practice of crop rotation, as the effects on biomass composition need to be properly understood. The idea of fourth-generation biofuels could lead to significant changes in the near future (Niphadkar, Bagade and Ahmed, 2018).

Overall, it has been proven that the production of bioethanol and the application of a bioethanol-gasoline blend contributes to energy savings, replacing gasoline with a "green" fuel substitute. Improving bioethanol yield through process improvement can lead to a higher amount of bioethanol and contribute to saving more conventional fossil fuels. However, there is a potential for additional nutrients/catalysts and automated technology to increase processing costs. The idea of the bio-refinery is essential for the full use of renewable raw materials and for the production of higher value-added products that would reduce the cost of bioethanol production. Therefore, further research is recommended to develop processes that ensure the coverage of energy needs, while at the same time serving the rules of sustainability (Hossain et al., 2021).

## 12. Conclusions

In conclusion, it is observed that, based on the data presented, bioethanol can be an alternative fuel solution, given the urgent need for the energy utilization of alternative fuels. Multiple methods have been found that contribute to the pre-treatment of renewable energy sources such as biomass, for example, cellulase production and co-fermentation of sugars (pentose and hexose), as well as the separation and purification of bioethanol. However, bioethanol is still, based on production costs, not competitive compared to fossil fuels, as a reduction in its production costs is required. This will contribute to transforming bioethanol into an economically competitive alternative to conventional fossil fuels. By following this approach, the goal of drastically reducing the landfilling of forest and plant waste, in line with the rules of the circular economy for their energy recovery, can finally be achieved.

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# Session 3
# Climate Change Adaptation

# Development and application of a methodological framework for assessing the resilience of military infrastructure against climate change impacts

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**Abstract**
Mitigating climate change impacts and enhancing the resilience capacity of military infrastructure is essential for the Armed Forces, first, to ensure a high level of both readiness and sustainability transitions and, second, to contribute to each EU Member-State's (MS) specific energy and climate goals. According to this study's bibliographical research, there are not in place systematic methodological approaches that assess in quantitative terms existing resilience factors of military infrastructure against climate change impacts and offer tangible solutions, which aim to enhance these resilience factors. From all military assets, those of the airports deem to be the most vulnerable, due to their high exposure to extreme weather phenomena. This study is targeting to cover this identified gap by conducting an analytical methodology in very practical terms, following a similar concept and structure with the methods applied to civilian airport facilities, whist, at the same time taking into consideration the defence airport specificities, in terms of structure and operation. This methodological approach is test-based on the 116 Combat Wing, located at Araxos Airport, Achaia. Results indicate the climatic hazard that demands immediate action and provide a tool that estimates dedicated cost allocations.

***Keywords:*** *Climate change, adaptation, mitigation, resilience, military operations.*

**JEL Codes:** Q01, Q54, Q58, H56

# Climate risk assessment on Fisheries and Aquaculture in Greece

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**Abstract**

Climate change significantly impacts the biodiversity of marine fisheries and aquaculture in both direct and indirect ways. Rising sea surface temperature (SST) and sea surface salinity (SSS), sea level rise and increased acidification as well as extreme precipitation events disrupt fish populations, alter species distribution, reduce production, damage infrastructure, resulting in reduced biodiversity within marine ecosystems and aquaculture activities (Robert Blasiak, 2020; Daw et al., 2009). This research is part of the Horizon Europe project "Nexus Framework for Biodiversity-Relevant Transformative Change" (BIOTRAILS) and aims to assess the vulnerabilities and risks associated with climate change and to provide insights into how changing climate conditions may impact the sector of fisheries and aquaculture in Greece, with a particular focus on biodiversity. A climate risk assessment is conducted following the conceptual framework applied in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), where risks are evaluated as the dynamic interactions between climate-related hazards, exposure and socioeconomic and environmental vulnerabilities of the affected systems (Reisinger et al., 2020). The potential hazards are projected under three climate scenarios: SSP1-2.6, SSP2-4.5 and SSP3-7.0 for the future period 2031-2050 compared to the reference period 1995-2014. Projections show that SST and SSS are likely to increase under all three scenarios. The risk assessment results highlight critical risk aspects, which should be taken into account for planning adaptation and increasing resilience.

***Key words:*** *Climate change, climate risk assessment, fisheries, aquaculture, biodiversity, Greece*

**JEL Codes**: Q54.

# Deciphering the footprint of climate risks on shaping inflationary devaluation pressures in developed economies

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**Abstract**
This study investigates the dynamic linkages between the innovative transition and physical risk environmental indices and inflationary pressures that lead to currency depreciation in nine advanced economies with major international currencies (Australia, Canada, Switzerland, China, the Eurozone, Great Britain, Japan, New Zealand and the United States). Data covering the period 1 October 2014 – 29 December 2023 and two specifications of the Quantile Vector Autoregressive (Q-VAR) methodology at lower, middle and upper quantiles are employed. Findings reveal that the transition risk is more influential than the physical risk on currency markets in most cases. Environmental risk is mostly linked with the markets of the Australian dollar and the Euro. Both indices fail to function as stronger sources of externalities than the US dollar as only some spikes of elevated environmental risk can feed inflationary phenomena in international currency markets.

***Keywords***: *Transition risk, Physical risk, Inflation*

**JEL Codes**: E5, F3, G1

# An adapted model of climate change adaptation behavior

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**Abstract**

To support effective climate adaptation measures through policy and practice, it is essential to unravel the complex interplay between individuals' psychological considerations and how they respond to climate risks as active stakeholders. The current research evaluates an extended Private Proactive Adaptation to Climate Change Model (MPPACC) to predict adaptation behavior. It explores the role of beliefs, experience of climate hazards, risk perception, perceived adaptive capacity, climate anxiety, social norms, and maladaptation in shaping behavioral intention at the individual level in the context of climate adaptation. Data derived from self-reported questionnaires and a convenience sample of 802 participants from 71 global regions. Data analyses include Structural Equation Modeling, validity and reliability tests of the measurement model, and robustness checks of the structural model, including assessment of nonlinear effects, endogeneity, and unobserved heterogeneity. The results rely on the estimation of the adapted MPPACC model by means of both covariance-based and PLS-SEM methodology. Overall, bootstrapping findings from CB and PLS-SEM provide evidence of construct validity, good quality criteria, acceptable levels of fit indices and support the robustness of the proposed model. Climate anxiety, response efficacy, perceived costs, and maladaptation are important direct predictors of climate change adaptation behavior, after controlling for age, income, education, and gender. Research findings highlight numerous policy implications that enable policymakers to leverage psychological research in the design and implementation of effective environmental policy initiatives, thus promoting climate change adaptation and enhancing public support.

***Keywords:*** *Private Proactive Adaptation to Climate Change Model (MPPACC), Risk Perception, Perceived Adaptive Capacity; Maladaptation; PLS-SEM.*

**JEL Codes**: A14; Q00; Q51; Q56; Q5; Q58, Q59

# Value chain analysis and market analysis on advanced biofuels and RFNBOs of the FUELPHORIA Horizon Europe project

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**Abstract**

The present paper introduces a market analysis of nine value chains of advanced biofuels and renewable fuels of non-biological origin (RFNBOs). The value chains are developed in the EU-funded HORIZON Europe project FUELPHORIA (GA nr. 101118286). In particular, the present study focuses on the market outlook of these value chains, built upon the value chain mapping to highlight their overall structure, the key stages of value creation and the value created in each step, along with the material and product flows and key contributors. A market analysis is elaborated, covering the strengths, weaknesses, opportunities and threats for each value chain. A demand and capacity analysis at an EU level is conducted, for the short-term (the next two years) and the medium-term (the next five years), indicating estimated demand quantities and expected wholesale prices. Specific areas for market penetration are presented, for the end-uses of aviation, maritime and road transport fuels, and for fuels for electricity production.

***Keywords:*** *Advanced biofuels; RFNBOs; European Union; HORIZON; FUELPHORIA.*

**JEL Codes**: O47; O52; Q21; Q42; Q43; Q56; R41; R42.

# Session 4
# Sustainable Tourism and Transportation

# Drivers of air pollution in the Eurozone countries: An empirical analysis of the Environmental Kuznets Curve hypothesis

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**Abstract**

Air pollution remains an important issue in academic and empirical research since it is connected with climate change issues and quality of life. Given its importance in implementing climate resilience policies, the present paper discusses the Environmental Kuznets Curve hypothesis in the Eurozone countries using a less visible set of variables in the relevant literature. It includes methane emissions exclusively released from the energy sector and carbon dioxide intensity as environmental degradation proxies, whereas it uses population rates and Gross Domestic Product (GDP) to define growth. Furthermore, it investigates the impact of the tourism sectors on the air degradation variables to test the EKC curve. Research findings confirm the EKC in all econometric model specifications, whereas causality tests suggest two uni-directional relationships between growth variables and air pollution proxies. Practical implications call for increasing energy efficiency rates and adopting eco-friendly practices to establish sustainability options in socio-economic systems.

***Keywords:*** *environment, growth, energy, tourism*

**JEL Codes**: O44, N1,O13, Z32

# Payments for Ecosystem Services in the Tourism sector

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**Abstract**

The notion of Ecosystem Services (ES) has been introduced to assess ecosystems' values, indicating all the possible, tangible and intangible benefits that an ecosystem may provide. Payments for Ecosystem Services (PES) as a policy instrument has been developed in order to bridge the gap between ecosystems and what we can gain from their conservation or restoration; they occur when a beneficiary or user of an ES makes a direct or indirect payment to the provider(s) of that service. PES schemes within the tourism and hospitality sector are understudied although these two economic-environmental systems are inextricably interconnected. PES come as a support system during an era where ecosystems' integrity is of international concern and linked to several other policy-related tensions and challenges that national and international bodies are trying to address to prevent or reverse the multidimensional negative effects environmental degradation. In this context, the research aim of this study is the investigation of in-kind PES schemes' feasibility in a developed country, using case studies of public-private partnerships (PPPs) from the tourism industry. Specific practices within the industry will be reviewed and both quantitative (surveys) and qualitative methods (semi-structured interviews) will be employed to better understand the key stakeholders' viewpoints and attitudes on such policy directions and to investigate the management effectiveness of such schemes in of high biological value. The identification of Key Performance Indicators (KPIs) will also be carried out in order to incorporate PES schemes within a company's decision-making processes, goal-setting, monitoring and reporting systems, especially when criteria like in-kind support for biodiversity conservation are entering the certification process of well-renowned bodies such as the Global Sustainable Tourism Council (GSTC).

***Keywords:*** *Ecosystem Services; Payments for Ecosystem Services; tourism; KPIs; sustainable development.*

**JEL Codes:** Q56; Q57; Q01; Z31; Z32.

# Electric Vehicle Purchase Subsidization versus Public Transit Expansion – A Comparison for the Case of Greece

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**Abstract**

Governments within the European Union promote the electrification of road transport via the subsidization of electric vehicle ownership through rebates and tax reductions, including the Hellenic Republic. Building on previous research, we estimate with the use of Machine Learning models the number of EV car sales without the subsidization schemes run by the Greek Government, and thus calculate the environmental benefit of the schemes. These benefits are then compared to those that would be expected if the same amount of funds were instead directed to a competing GHG-emissions-reduction policy, specifically the expansion of the Athens Metro system. We use cost data from the current Line 4 project for the metro line construction and trains. We find that expected benefits of the EV vehicle subsidization schemes do not justify their cost and that an expansion of public transport infrastructure and improvement of its services offers a better Return on Investment.

***Keywords:*** *Road Transport, Public Transit, Electrification, Forecasting, Machine Learning*

**JEL Codes:** R41, R42, R48, Q41, Q42, Q47

## 1. Introduction

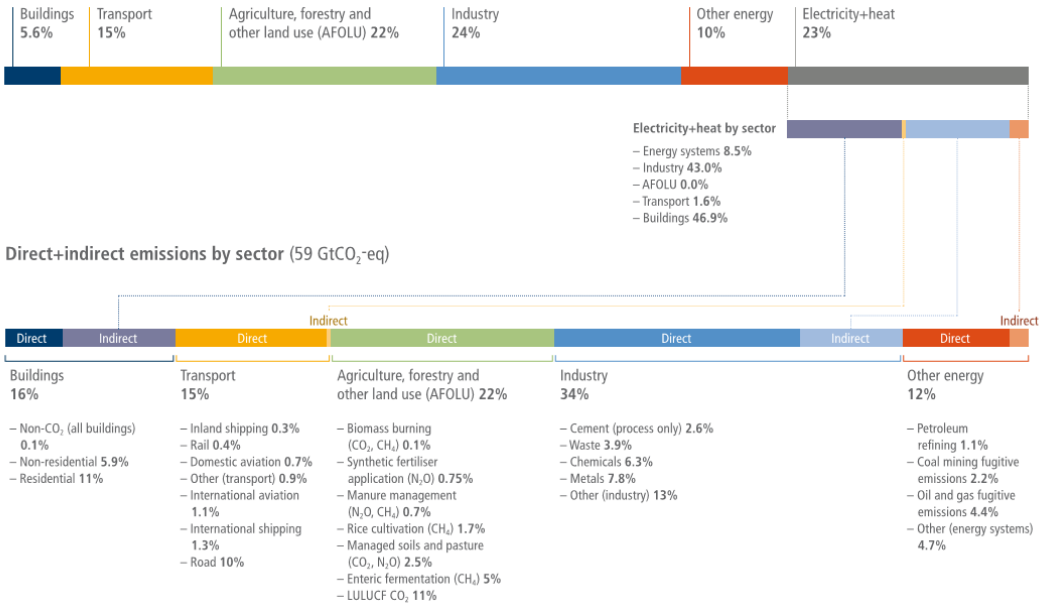
Transport is a major source of GHG emissions, roughly accounting for 15% of all emissions, of which road constitutes two thirds, i.e., 10% of the total, see (Intergovernmental Panel on Climate Change, 2022):

This makes the electrification of road transport an obvious choice for the reduction of GHG emissions. In this context, the Greek government has enacted a series of purchase subsidization schemes:

- «Κινούμαι Ηλεκτρικά» - "I Move Electrically", during 2020-2022, which subsidized the purchase or long-term lease of BEV cars with an amount of up to €7,000.
- «Κινούμαι Ηλεκτρικά ΙΙ» - "I Move Electrically II", during 2023, which subsidized the purchase or long-term lease of BEV cars with an amount of up to €9,000.

- «Κινούμαι Ηλεκτρικά ΙΙΙ» - "I Move Electrically III", during 2024 and is still ongoing, which subsidizes the purchase or long-term lease of BEV cars with an amount of up to €11,000.

Figure 1. GHG Emissions by Sector, (Intergovernmental Panel on Climate Change, 2022).




Concurrently to these subsidization schemes, the Greek government subsidizes the use of Battery Electric Vehicles (BEV) by exempting them from ownership taxes or Athens center circulation restrictions that apply to Internal Combustion Engine (ICE) vehicles. An alternative policy to reduce GHG emissions could be to facilitate modal shift towards environmentally friendly modes, such as public transit. In this paper, the case to expand the Athens Metro system with the funds allocated to the above policies is examined.

## 2. Theoretical Background

The factors that affect the demand of BEV passenger cars have been examined, among others, in (Glerum, et al., 2013), (Turan & Yücel, 2014), (Vergis, et al., 2014), (Christidis & Focas, 2019), (Akyol, 2020), (Rietmann, et al., 2020), (Al-Buenain, et al., 2021), and (Ebrie & Kim, 2022), as well as (Christidis, et al., 2021) and (Christidis, et al., 2022) by the authors of the present paper. This literature has identified purchase cost and the availability of charging stations as the main factors that affect households' willingness to purchase such a vehicle. Government subsidy schemes, including the policies adopted by Greece, aim to address both these factors by reducing the cost of purchasing and operating a BEV, as well as incentivizing the installation of charging stations.

The impacts of BEV purchase subsidies have been examined in (Liu & Wang, 2021) and (Caulfield, et al., 2022). More specifically, it was found in (Caulfield, et al., 2022) that there existed a gap in EV ownership favoring urban areas, as well as an income and equity gap between those that have adopted electric mobility and those who hadn't. On the other hand, (Liu & Wang, 2021) found that relatively high subsidies were required to properly incentivize individuals to choose BEVs rather than plug-in hybrid vehicles due to the former's technical limitation with regards to range.

## 3. Methodology

### *3.1 Demand Forecasting Models*

The demand forecasting model used in the present paper was first presented in (Christidis, et al., 2022) and it regards to two multilayer perceptron networks (MLP) which output the probabilities for individuals with given perceptions to choose different types of passenger cars (new or used, ICE, BEV, HEV, or hybrid). The MLP which predicts the choice for a used or new vehicle uses monthly disposable household income, the educational level of the household, and the perceived stability of their employment or professional status. The MLP that predicts the probabilities for the different motor unit cars to be chosen uses two linear combinations of perceptions as inputs:

- A cost component which takes into consideration perceived purchase, operation, and maintenance costs.
- An operational component which takes into consideration perceptions of technological maturity, range of operation and ease of refueling / recharging, and the social status conveyed to the individual.

The models were trained on the responses of 453 individuals. For reference, the distributions of some of the responses are replicated below:

Figure 2. Stated Intent to Buy a Car within the Next Year, (Christidis, et al., 2022).

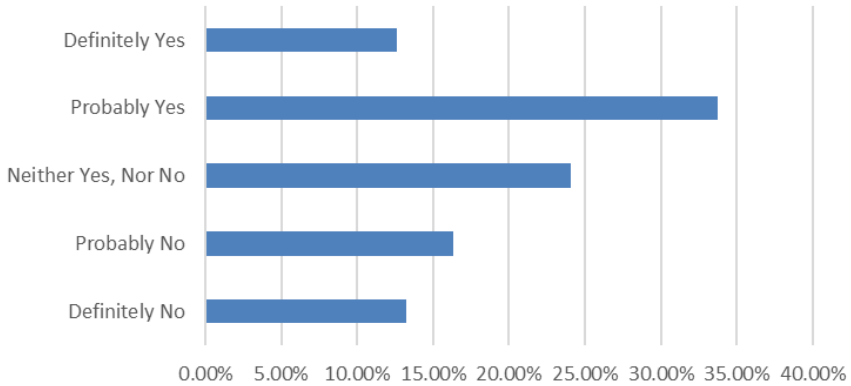


Figure 3. Stated Intent to Buy a Car of a Specific Type, (Christidis, et al., 2022).

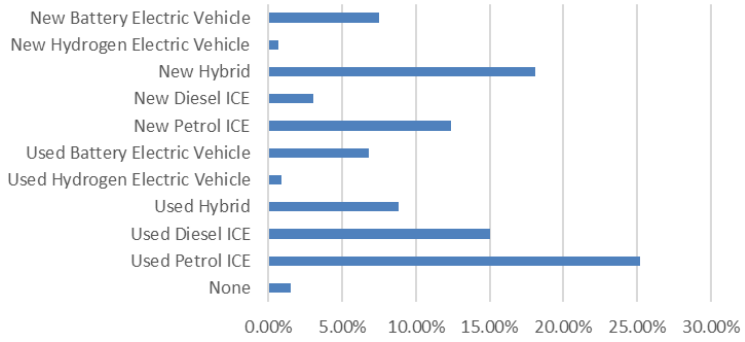



Figure 4. Purchase Cost Perceptions for Petrol ICE Cars, (Christidis, et al., 2022).

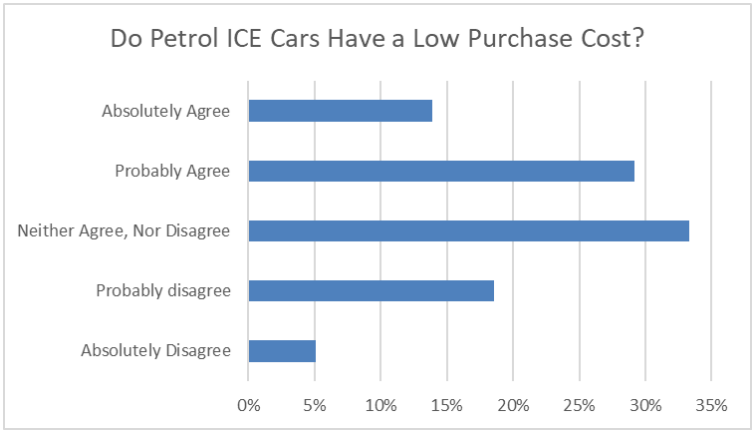



Figure 5. Purchase Cost Perceptions for Diesel ICE Cars, (Christidis, et al., 2022).

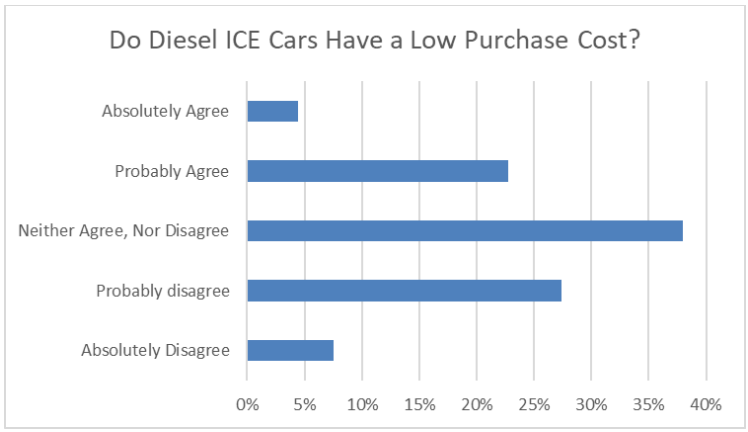


Figure 6. Purchase Cost Perceptions for BEV Cars, (Christidis, et al., 2022).

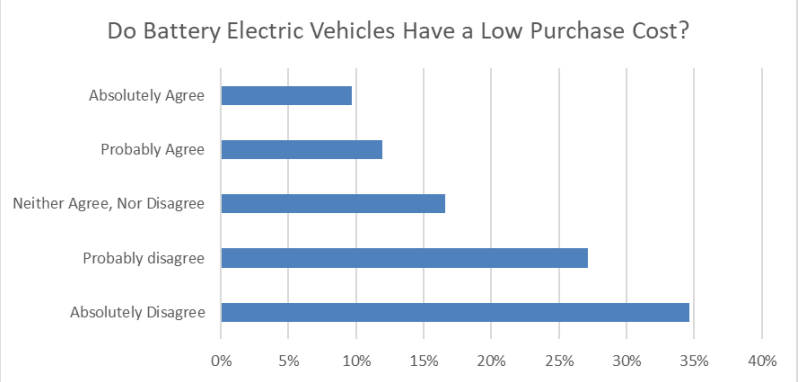



Figure 7. Purchase Cost Perceptions for Hybrid Cars, (Christidis, et al., 2022).

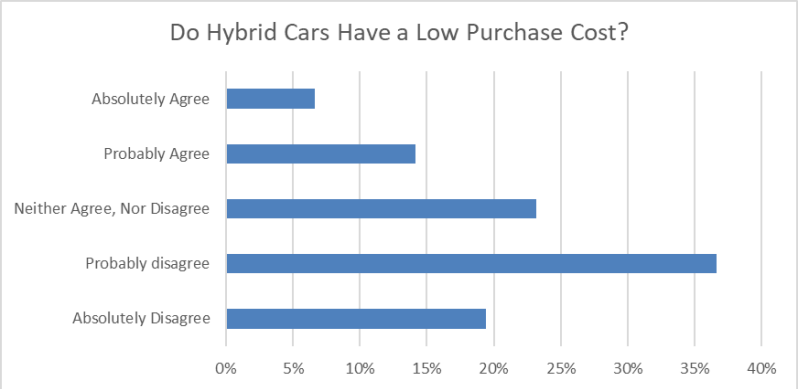
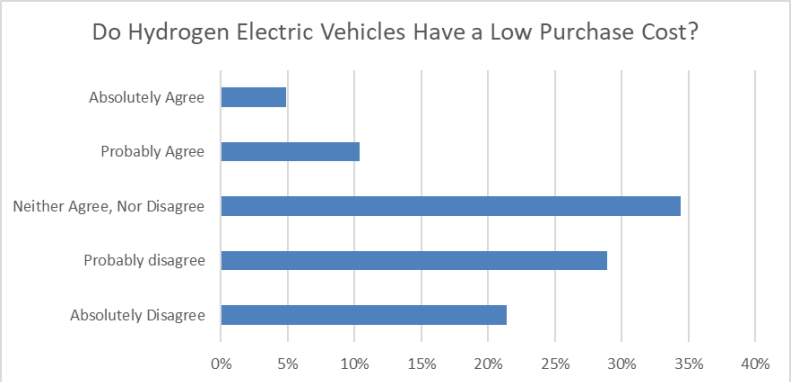


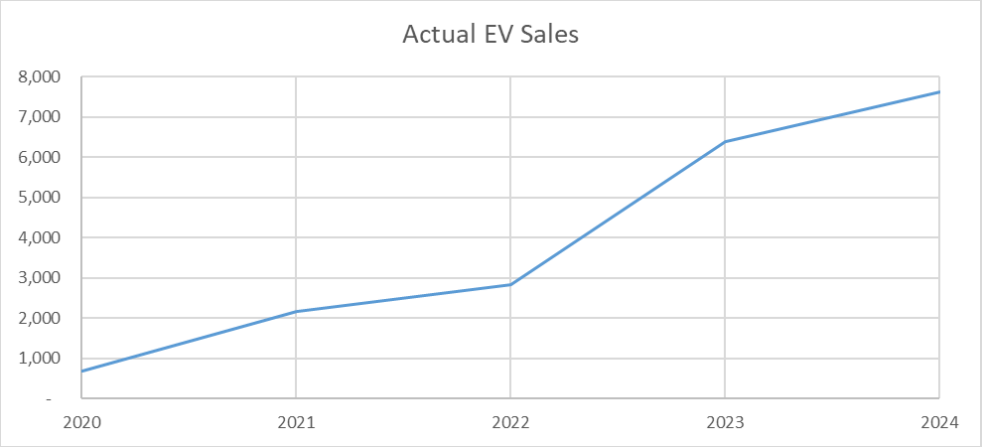

Figure 8. Purchase Cost Perceptions for Hydrogen Electric Cars, (Christidis, et al., 2022).




### *3.2. Demand for Different Policy Options*

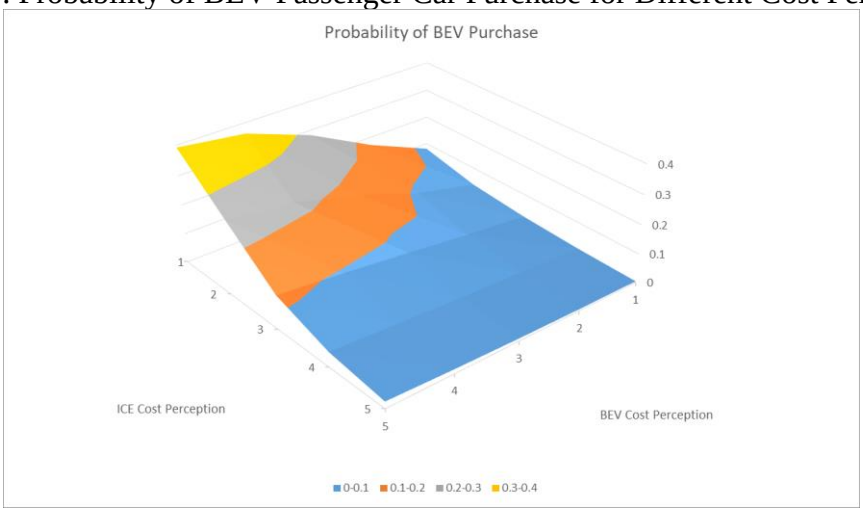
The demand for the current policy option is considered to be equal to the actual new registrations of BEV passenger cars as recorded by (evstats.gr, n.d.), (Σύνδεσμος Εισαγωγέων Αντιπροσώπων Αυτοκινήτων, 2024):

Figure 9. BEV Passenger Car Sales, (evstats.gr, n.d.), (Σύνδεσμος Εισαγωγέων Αντιπροσώπων Αυτοκινήτων, 2024).




In order to evaluate the demand under a policy of no subsidies, the probability to choose to buy a BEV is calculated using the aforementioned model where the cost input is set to "4", i.e., that people consider the cost of BEVs to be probably affordable, and "2", that it is probably unaffordable. The ratio of the two probabilities is then used to adjust the observed demand, see the output surface of the model below:

Figure 10. Probability of BEV Passenger Car Purchase for Different Cost Perceptions.




### *3.3. Calculation of Different Policy Option Costs and Benefits*

The costs and benefits of the two different policies, subsidies for the purchase of BEV vehicles and the expansion of the Athens Metro, are calculated as follows:

- Each new BEV registration per year is considered to have cost the taxpayer the amount of subsidy foreseen for that particular year.

- Ownership subsidies (such as reduced taxation or parking fees) for BEVs are not considered as they also apply to hybrid vehicles.
- BEV registrations exceeding the estimation of registrations for the non-subsidy case yield a GHG emissions reduction equal to the difference in emissions between BEVs and their direct substitute, hybrid cars for their lifetime, which is considered to be 15 years.
- It is assumed that individuals who replace their old ICE car that are replacing it with a BEV would have replaced it with a hybrid car in the absence of subsidies.
- The average vehicle-kms traveled per year for cars are estimated as 12,500km, see (Egis, Systema, 2017), whereas the occupancy of cars is estimated as 1.2, according to the same source.
- There is no benefit from the subsidy policy for new BEV registrations that happen regardless of subsidies.
- According to data from the Athens Metro Line 4 project:
    - One kilometer of new metro line, including stations and trains, costs €100,000,000.
    - The average distance between stations is 900m. The average daily traffic per station for the Athens Metro is 8,956 as of 2022, whereas the average commute is considered to be 15km.
    - The modal shift to Metro is considered to originate in equal measure (50% - 50%) from public bus and petrol ICE cars respectively.
- GHG emissions savings for the expansion of the Athens Metro line are limited to the trips by bus or car that are replaced by Metro and do not extend to any potential overall reductions in private car ownership and use, as these are beyond the scope of the present work.
- GHG emissions per mode and vehicle type, inclusive of well to tank and tank to wheel, are as follows, see (UK Government, Department for Business, Energy & Industrial Strategy, Department for Environment, Food & Rural Affairs., 2020):
    - BEV: 0.07301kgr $CO_2e$ / vehicle-km
    - Hybrid: 0.14658kgr $CO_2e$ / vehicle-km
    - Petrol ICE: 0.34841kgr $CO_2e$ / passenger-km
    - Urban bus: 0.09750kgr $CO_2e$ / passenger-km
    - Metro: 0.03130kgr $CO_2e$ / passenger-km

### *3.4. Comparison Between Different Policy Options*

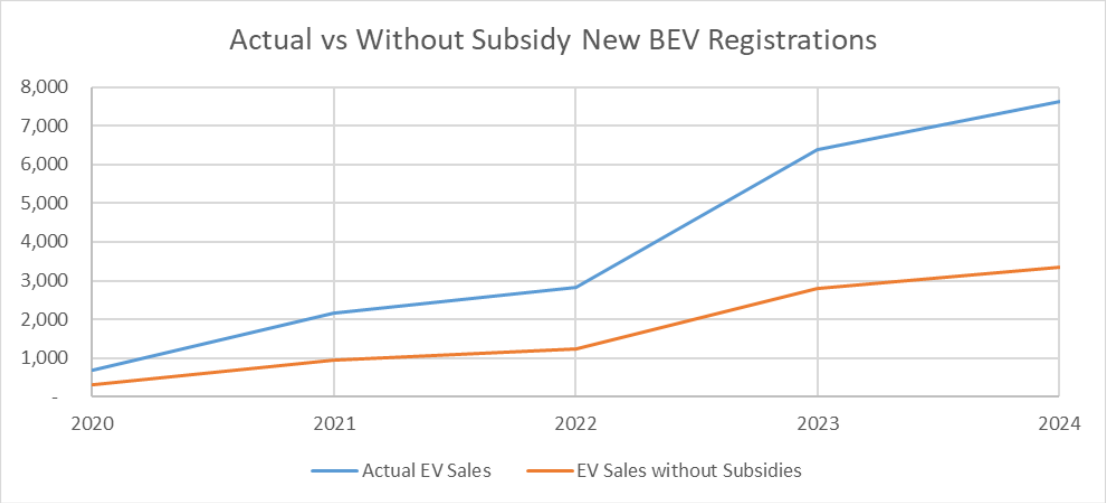
Given the cost of the subsidy program, an expansion of the Athens Metro system with an equal cost is considered and the metro passenger-kms estimated that can be attributed to it so that GHG emissions savings can be calculated. Likewise, the GHG emissions savings achieved through the subsidy programs are calculated. Dividing the GHG emissions savings of the two alternatives by their cost yields a $CO_2e$ kgr / € figure. The lower this figure is, the costlier, i.e., less effective, the policy.

## 4. Costs and Environmental Effects of Different Policy Options

### *4.1. New Battery Electric Vehicle Subsidy Policy*

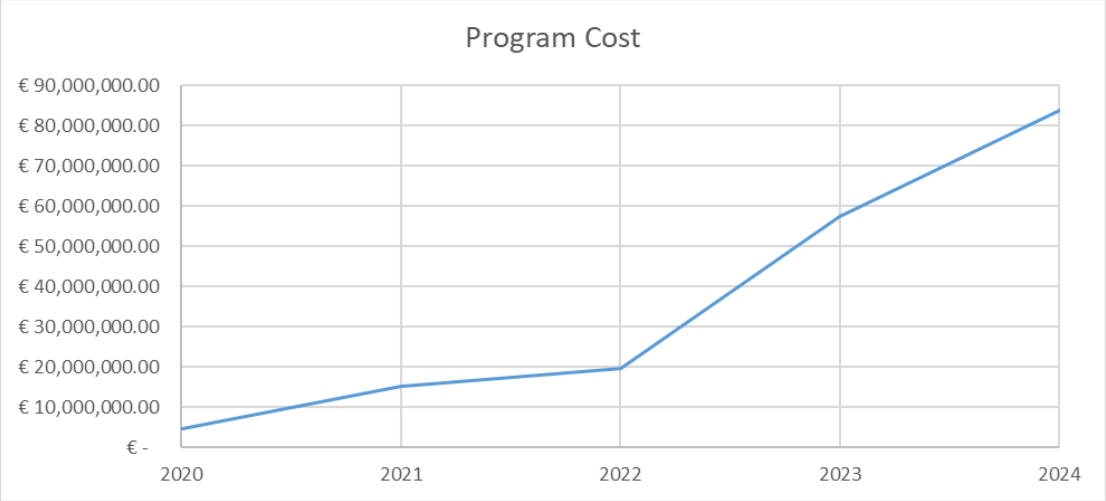
The number of new BEV car registrations without subsidies corresponds to roughly 40% of the actual ones:

Figure 11. BEV Passenger Car Sales: Actual vs Without Subsidies.



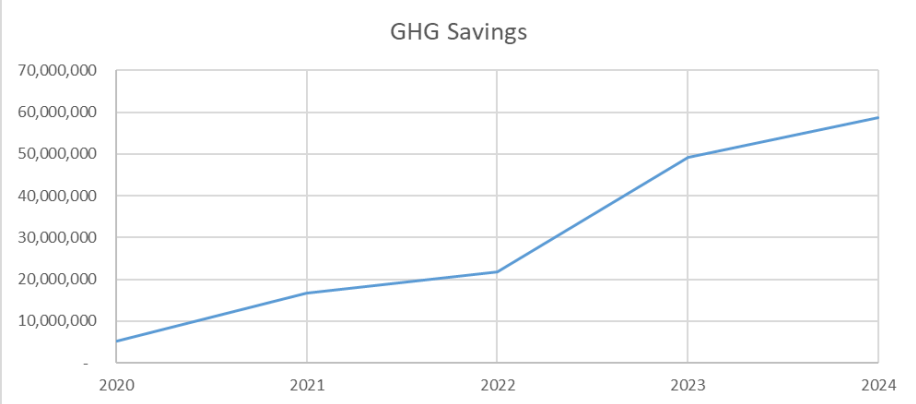

This corresponds to a total cost of €181,008,000 over five years:

Figure 12. BEV Passenger Car Purchase Subsidy Costs.



BEV GHG emissions savings for the vehicles' 15-year lifespan is attributed to the year of registration as follows:

Figure 13. BEV Passenger Car GHG Emissions Savings.




The above figures correspond to a **reduction of 0.84kgr of $CO_2$e per Euro** spent on the policy.

### *4.2. Athens Metro Expansion*

The cost of the subsidy policy corresponds to:

- An expansion of the Athens Metro System by 1.8km, with two new stations and a corresponding number of trains.
- An increase of ridership of 17,915 people per day who are attracted in equal measure from bus and passenger cars.
- Approximately 1,471,050,375 additional passenger-kms on metro.
- Approximately 285,769,925 kgr of $CO_2$e emissions savings over a 15-year period.

These figures correspond to a **reduction of 1.58kgr of $CO_2$e per Euro** spent.

## 5. Discussion

Given the above costs and GHG emission reduction benefits, it can be seen that expansion of the public transit system, specifically metro rail, offers at least 88% greater GHG emissions savings than the subsidization of BEV car purchases or long-term leases, while considering conservative assumptions. In reality, the difference is expected to be greater as the incentivization of not owning a passenger car for urban dwellers will also boost intercity public transport (rail, bus) over passenger cars, which will have additional benefits that were not considered in the present study.

Moreover, we have not considered the environmental costs of BEV car production, specifically for the mining and processing of heavy metals and rare earths for batteries and high-performance electric motors, which are significant. This further limits the environmental benefits of BEV subsidization compared to what we have calculated here. Moreover, the lifetime of metro infrastructure and vehicles far exceeds the 15-year period here assumed, and as such the actual benefits of public transit expansion are greater than what was considered in the present comparison.



The BEV sales subsidization policy also carries an obvious cost to taxpayers, as it incentivizes the consumption of relatively expensive imported vehicles by relatively affluent households, i.e., it is a policy whose benefits are not equally distributed in society while it leads to a reduction of the GDP by boosting the country's trade deficit. In contrast, metro systems serve individuals from all strata of society, and as such their benefits are more equally distributed, while most of the costs regard to locally provided construction materials and services.

Further to the above, an alternative policy recommendation could be formulated as follows:

- Abolish subsidization schemes and replace them with incentives against the ownership of ICE cars, such as:
    - Congestion pricing in Athens and Thessaloniki. The proceeds of such a scheme can be used to fund the expansion of the two cities' metro systems to realize their benefits without burdening the taxpayer.
    - Increased taxation for ICE cars to incentivize their replacement by hybrid or BEV cars. This will realize the benefits of BEVs without cost to the taxpayer.
- Expand the public transit network and maintain high levels of service (frequencies) to incentivize individuals to not own a private car.

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# Investigating the environmental footprint of university students' mobility

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**Abstract**

Investigating the travel behavior of young adults is a focus of research in urban areas internationally. In Greece, and especially in medium-sized cities such as Serres, where two academic institutions with a broad student community are based, mobility planning is largely concerned with young people mobility. The paper presents research conducted at the Department of Physical Education and Sports Science in Serres and attempts its adaptation to students of other academic disciplines and generally young adults living in Serres, concerning that those students have specific commuting characteristics. Recording attitudes and practices of young people of all categories, who are in the process of shaping their travel behavior, can provide useful information for mobility management and policy. The methodology was based on the Theory of Planned Behaviour and the survey instrument was designed according to its principles. The results of its application to physically active students demonstrated a series of environmentally friendly attitudes, however the environmental footprint of the mobility practices of these students was not negligible. Applying the methodology to students of different fields or other young adults is expected to provide useful insights and allow the formulation of specific proposals for the management of youth mobility and local policies.

***Keywords:*** *Travel behavior, young adults, university student mobility, Theory of Planned behavior, environmental footprint*

**JEL Codes**: R4; O21

# Case study: Research on sustainable tourism in Thassos

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**Abstract**

In the spring of 2019 a group of academics met on the island of Thasos for the "Academic Dialog: Black Forest – Green Thasos: How to Restore & Green after Large Natural Disasters?", hosted under the auspices of the German Academic Exchange Service (DAAD). Two teams met, one from the Hochschule für Forstwirtschaft Rottenburg (HFR) in Germany and one from the School of Forestry and the Natural Environment of the AUTh, Greece. The research was supervised by Professors Dr. Monika Bachinger (HFR) and Dr Polixeni Ragkou (AUTh). The methodology included visits to natural areas and to traditional island communities in order to assess the effects the recent fires had on the people, the landscape and the tourism industry. The second part of the research was to conduct interviews with key stakeholders of the island, representatives of the industries, citizen groups and local authorities. The results focused on the island's latent potential, the effects of overtourism on the island and the need to curb its effects and the need to develop alternative activities, such as forest paths, to turn the focus from 4S tourism to other forms and spread the benefits and the externalities of tourism across a wider area.

***Keywords:*** *Sustainable Tourism, Overtourism, Stakeholder analysis, Visitor Management*

**JEL Codes:** F64; N54; Z32; O44; P48; Q01; Q56

# Session 5
# Energy Poverty and Inequality

# Socioeconomic inequalities persistence and their mediating effect upon pro-environmentalism stances

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**Abstract**

The purpose of the study is to examine the demographic, socioeconomic, occupational, trust and political determinants that shape individuals' pro-environmental stances (in particular, whether they support that the protection of the environment should be priority or economic and job growth should be the priority in expense of the environment if needed) in a large sample of countries participating in the Joint European Value Study and the World Value Survey, for the period 2017-2022. The empirical models are estimated separately for three sub group of countries, based on GNI per capita as provided by the World Bank using the World Bank Atlas Method. The three country group classifications are namely the lower-middle income country group (19 countries), the upper-middle income countries (20 countries) and, the high-income countries (22 countries). Logistic regression models with heteroskedasticity-robust standard errors are estimated for all the country groups presented above. In all cases, the findings indicate that respondents of higher socioeconomic status have a higher probability to support pro-environmentalism stances in comparison to the remainder. Higher occupational class is also related to higher chances to support pro-environmental stances, for middle- and upper- income groups. Similarly, higher interpersonal trust levels are associated with higher probability to adopt pro-environmentalism attitudes. The evidence indicates a persistence in socioeconomic inequalities that affect own pro-environmental stances, through parental educational level, whereas there is a significant effect of partner's educational level also suggesting that individual environmental stances may be further shaped in the household level and not only at personal level. In addition, respondents who believe that the governments should have more responsibility in designing and organizing public policies, tend to support pro-environmental values in relation to the remainder. Due to the findings suggested that own environmentalism attitudes are also affected by parental socioeconomic characteristics as well as by partner's socioeconomic class, mediation models are estimated to disentangle the relationships of interest. The findings indicate that mediation effects do exist, underlining the complex and dynamic nature of the relationship between individual socioeconomic status and attitudes formation. In detail, for poorer income countries the evidence suggest that parental educational status contributes as a mediator in the relationship between individual socioeconomic class (as depicted by income and education) and pro-environmentalism attitudes, justifying the hypothesis of the dynamic and persistent effect of socioeconomic inequalities. The effect of partner's educational level is stronger among all mediators examined and present for all country groups examined, supporting the hypothesis that attitudes formation is shaped in the household environment as well and not just affected by own characteristics.

***Keywords:*** *pro-environmentalism; socioeconomic inequalities; persistence in socioeconomic gradient; mediation models.*

**JEL Codes**: D10; H31; I24; Z13.

# Powering progress: Bridging energy inequality and energy poverty in Sub-Saharan Africa

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**Abstract**

Ensuring universal access to affordable, reliable, and modern energy services is 7th among the 17 United Nations Sustainable Development Goals SDGs. However, the energy-related challenges have yet to be adequately investigated, particularly in Africa. The majority of Africans live in extreme energy poverty and face immense inequality, even though the continent is rich in renewable energy sources. This paper investigates energy transition, inequality, and energy poverty in four Sub-Saharan African countries using national datasets provided by the World Bank. We employ the Gini coefficient and Lorenz curve to visualize the uneven distribution of energy consumption and a multidimensional energy poverty index (MEPI) for determining energy poverty. Our results show positive energy consumption patterns toward cleaner energy in all these four countries. There has been a reduction in both energy inequality and energy poverty over time. However, a large share of the population continues to rely on coal and firewood, particularly in Malawi, Uganda, and Ethiopia. Energy inequality follows a downward trend, but increases among the poor and in oil consumption. Our results further indicate that education and off-farm employment engagement are vital determinants of using clean energies, including electricity and solar energy, and drive the way out of energy poverty. Our findings highlight the urgent need for immediate action to reduce energy poverty and disparities. Promoting education and employment diversification can facilitate energy transition and help the African population escape from energy poverty. Special assistance is needed to support for the poor and rural families to reduce energy poverty.

***Keywords:*** *Africa; energy transition; energy poverty; inequality; multi-dimensional poverty index (MEPI); solar energy*

**JEL Codes**: D12, Q40.

# Enhancing Energy Literacy to Alleviate Energy Poverty in Greece: Identifying Energy Consumption Knowledge and Behavioural Patterns

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**Abstract**

Energy poverty remains a pressing socio-economic issue in the European Union, particularly in Greece, where numerous households struggle to meet energy needs due to high costs, limited resources, and low energy literacy. Energy literacy, encompassing knowledge, attitudes, and behaviours related to energy consumption, is pivotal in alleviating energy poverty by shaping citizens' energy-related decisions and enhancing their resilience. This paper explores strategies to enhance energy literacy through a tailored approach that identifies diverse household profiles - energy personas and barriers using empirical data from a national survey. Through outlining detailed energy personas, the paper depicts the development of community-based interventions, including workshops, interactive tools, and hands-on demonstrations. These educational practices, guided by behavioural insights, aim to promote sustainable energy habits, effective energy management in a household, and informed participation in the clean energy transition. This approach prioritises targeted training for vulnerable households, especially those lacking digital skills, to enhance energy literacy. It also highlights the need for integrated, equitable education that addresses structural barriers and fosters energy awareness. Ultimately, by empowering communities and enhancing resilience, it paves the way for a sustainable and equitable energy future that benefits society.

***Keywords:*** *energy poverty, energy efficiency, energy literacy, energy personas*

**JEL Codes**: Q40, Q48, Q56, I32,

## 1. Introduction Literature review

### *Introduction to digital tools and climate data*

The Internet provides several advantages and benefits (Andreopoulou et al., 2011), offering a rich, dynamic environment for the exchange of information and resources (Andreopoulou et al., 2013). The use of digital tools, such as online remote sensing platforms

and geographic information systems (GIS), has expanded significantly in recent years, allowing for faster and more accurate monitoring of environmental changes (Andeopoulou, 2012). More specifically, the so-called "Green Informatics" contributes to the development and improvement of surveillance systems for the natural environment and natural resources, with the aim of protecting and restoring ecosystems (forests, lakes, rivers, wetlands, etc.) as well as the preventive response to natural disasters. Such actions include the creation of observatories and innovative remote sensing systems (e.g. for forest fires, river floods, soil erosion, climate change), the installation of early warning systems and the improvement of communication infrastructure and equipment, always in combination with GIS technologies (Andeopoulou, 2012).

In this context, the use of climate data from open sources, such as the World Bank Climate Knowledge Portal (World Bank, n.d.), offers the possibility of identifying trends in parameters such as precipitation, enhancing informed decision-making on natural resource management issues (Stakhiv & Stewart, 2010).

**Biodiversity in wetlands**

Wetlands play a key role in maintaining biodiversity, as they are a refuge for a large number of species of flora and fauna (European Environment Agency, n.d.). Lakes, in particular, are particularly vulnerable to climate fluctuations and anthropogenic interventions, such as over- pumping and pollution (Andeopoulou, 2012).

At the same time, modern management of natural ecosystems, including forests, lakes, rivers and other natural resources, is called upon to address the increased complexity and diversity of environmental characteristics, requiring a high level of coordination and information exchange between different administrative bodies and stakeholders (Andeopoulou et al., 2011). International literature has pointed out that changes in the water level and extent of a lake can have knock-on effects on the entire food chain, affecting fish reproduction, waterfowl migration and the overall balance of the ecosystem (GWP-Med, n.d.).

**The Case of Lake Koronia**

In Greece, Lake Koronia, located within the boundaries of the Regional Unit of Thessaloniki in the Region of Central Macedonia, is a typical example of a wetland facing serious problems of ecological degradation due to a combination of climatic and anthropogenic factors (Perivolioti et al., 2016). Lake Koronia, a Ramsar site, is shallow, polymixed, hypertrophic and until recently was the fourth largest lake in Greece. (Mitraki et al., 2004). Together with the neighboring Lake Volvi, to which it is connected by a narrow channel, they occupy a total area of 16,388 hectares (40°40'N, 23°19'E) and have been included in the Montreux Record since 4 July 1990, due to declining water quality (Ramsar Site No. 57). The area includes wetlands and forest ecosystems with significant biodiversity, supporting, among others, endemic fish species, nesting waterfowl as well as a significant number of migratory birds (Anatidae), while several rare and endangered aquatic plants are noted. (RSIS, 1998). As more local precipitation data are not available for the exact area of the lake, data covering the entire Central Macedonia Region were used.

Despite the relevant research that has been carried out regarding the problems of Lake Koronia (Kokkinakis and Andreopoulou, 2006; WWF Hellas et al., 2009; NECCA, n.d), the combined use of digital remote sensing tools and climate data, such as those provided by the World Bank Climate Knowledge Portal (World Bank, n.d.), remains limited (GWP-Med, n.d.). Furthermore, there are no sufficient quantitative analyses that clearly examine the correlation between specific variations in precipitation and measurable changes in the diameter or total area of the lake. (European Environment Agency, n.d.)

The present study attempts to partially fill this gap by focusing on a simple, but indicative, methodology of recording lake changes via Google Earth Web and correlating them with annual climate data (World Bank, n.d.). In this way, it hopes to complement existing research, contributing to a comprehensive approach to the management and restoration of Lake Koronia.

The aim of the work is to identify rainfall patterns in relation to the changing extent of Lake Koronia.

## 2. Methodology for Application Development

In this work, we aim to study how changes in precipitation can be related to changes in the size of Lake Koronia, utilizing two simple, freely accessible tools.:

The portal, **World Bank, Climate Change Knowledge Portal**, https://climateknowledgeportal.worldbank.org

The web app**, Google Earth Web,**
https://earth.google.com/web

This choice is based on the ease of use, free access and reliability of the data provided, making it suitable for the process even for researchers without advanced experience in statistical or geographical analyses.

### Localization of precipitation data

For the Central Macedonia region, we go to the World Bank Climate Knowledge Portal website and select "**Greece**" and then more specifically the region of "**Central Macedonia**". Lake Koronia is located within the boundaries of the Regional Unit of Thessaloniki, which is administratively under the Central Macedonia Region. Given that more local precipitation data are not available for the exact area of the lake, precipitation information covering the entire Central Macedonia Region was selected. Thus, a satisfactory, albeit more generalized, estimate of the precipitation affecting the wider area of the lake is achieved. Next, we focus on the variable related to "Precipitation - Rainfall". The system offers annual precipitation values, allowing us to identify significant fluctuations or trends over time.

**Collection and highlighting of important years**

In the data collection phase, priority is given to identifying the years with the most extreme precipitation, either particularly high or particularly low. First, all annual values are collected and then those that differ significantly from the average are selected. In this way, a limited number of "indicator" years are derived that represent either increased or decreased precipitation.

Then, the specific years are marked and depicted in a simple graph, which offers a first visual overview of the variation in precipitation during the study period, the aim here is to obtain a quick and understandable visualization.Choosing an easy-to-use analysis tool Tool: Google Earth Web

**Monitoring the dimensions of Lake Koronia**

Initially, we connect to Google Earth Web and locate Lake Koronia. The application offers easy navigation through maps and satellite images, often in different time periods. Thus, a first overview of the current state of the lake can be made, as well as comparison with older records. In this paper, we will deal with Lake Koronia for the period from 1985 to 2023.

**Using the measurement tool**

Google Earth Web has a built-in measurement tool to calculate the distance of the lake locations that we want to measure. This way, we can see if there has been a shrinkage of its area during years with low rainfall or, conversely, if there has been an increase/stabilization during periods of higher rainfall.

**Correlation with precipitation data**

The precipitation values we collected from the World Bank can be mapped to specific years. In cases of low precipitation, we check for any visible reduction in the size of the lake. Similarly, if some years are characterized by higher precipitation, we can investigate whether the lake maintained or increased its size.

**Benefits of the method**

Google Earth Web is free, does not require the installation of specialized GIS software, and allows for easy visual inspection of changes over time. Users can perceive the scale and geomorphological configuration of the lake in relation to the surrounding area.

**Recording of data and results**

At this stage, all the data that has emerged from the analysis is collected and documented. Initially, screenshots from Google Earth Web are saved, which depict the lake at different time periods and highlight its area measurements. These images act as a visual archive, helping to track changes over time. Then, a data table is created, in which the annual rainfall values (in

mm) are recorded. Also added to the same table are the corresponding measurements of the lake area, based on two fixed extreme points set for all years with either high or low precipitation. In this way, a combined view is ensured: on the one hand, the climate fluctuations, on the other hand, the corresponding changes in the area of the wetland. Immediately after, bar graphs are created, in order to visualize and make the fluctuations recorded in the table more easily understandable. Finally, a brief report is drawn up that brings together the most important findings, focusing on the correlations between rainfall and changes in the lake. This report summarizes the conclusions arising from the above process and highlights any points that require further research or processing.



## 3. Results

### Screenshots

### Screenshots from Google Earth Web.

Figure 1 shows the distance between two fixed selected points of the lake in 1985. This measurement serves as a starting point for comparison with later years, as it shows the extent of the lake in a period when climatic and anthropogenic pressures had not yet evolved to the extent observed in subsequent decades.

**Figure 1.** Screenshot during the measurement of 2 points of Lake Koronia in 1984.

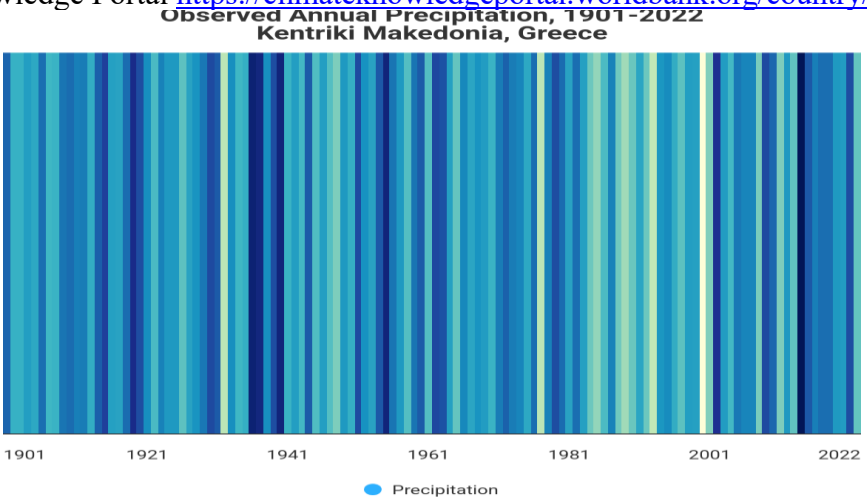

Figure 2 depicts the most recent state of Lake Koronia, as measured in 2023.

**Figure 2.** Screenshot during the measurement of 2 points of Lake Koronia in 2023.


**From the Climate Change Knowledge Portal:**

Initially, annual precipitation values were extracted for Central Macedonia, covering the period from 1901 to 2023. These data were visualized in a summary graph (Figure 3), in order to highlight the changes over time and identify specific years with extreme values (either high or low).

**Figure 3.** Historical precipitation data for Central Macedonia, 1901-2023. Source: World Bank Climate Knowledge Portal https://climateknowledgeportal.worldbank.org/country/greece




Next, we focused on the same years for which we had already taken measurements of the lake via Google Earth to investigate the potential correlation between precipitation levels and changes in lake area or diameter. In this way, a comparative analysis was obtained that combines climate data and satellite measurements, allowing a more thorough picture of the situation.

Figure 5 shows a graph of historical precipitation values, as recorded by the World Bank Climate Knowledge Portal. From this graph, we can distinguish intervals of higher or lower precipitation, which facilitates further correlation with the findings from the lake measurements in corresponding years.

**Charts - Graphs**



After collecting the annual precipitation values, we proceeded to create a simple bar chart using Excel. The vertical axis was plotted with the precipitation values (in mm), while the horizontal axis was plotted with the reference years. Then, specific years that showed extreme precipitation values, either high or low, were highlighted, in order to make the strong fluctuations more visible and to facilitate their further correlation with the rest of the analysis data. Table 1 brings together, in a single format, both precipitation data (in mm) and lake extent measurements (distance between two points). Through this parallel presentation it is easier to identify specific years with extreme precipitation and correlate them with a correspondingly reduced or increased lake extent.

**Table 1.** Aggregate table of annual rainfall values and some measurements of 2 fixed extreme points of Koronia Lake.

| Year | Precipitation (mm) | Measuring 2-edge lake distances (m) |
|---|---|---|
| 1985 | 413 | 10571 |
| 2003 | 543.69 | 9163 |
| 2006 | 578.04 | |
| 2008 | 437.15 | |
| 2012 | 547.82 | |
| 2013 | 462.78 | |
| 2014 | 755.09 | 6342 |
| 2015 | 632.41 | |
| 2020 | 544.21 | |
| 2021 | 648.83 | |
| 2022 | 456.81 | 8733 |

**Data visualization and comparison:**

Initially, the distance between two specific and fixed points of the lake, chosen so as to consistently reflect its extent over different periods of time, was measured. Then, for each year in which an extreme precipitation value was recorded, these values were integrated into a single

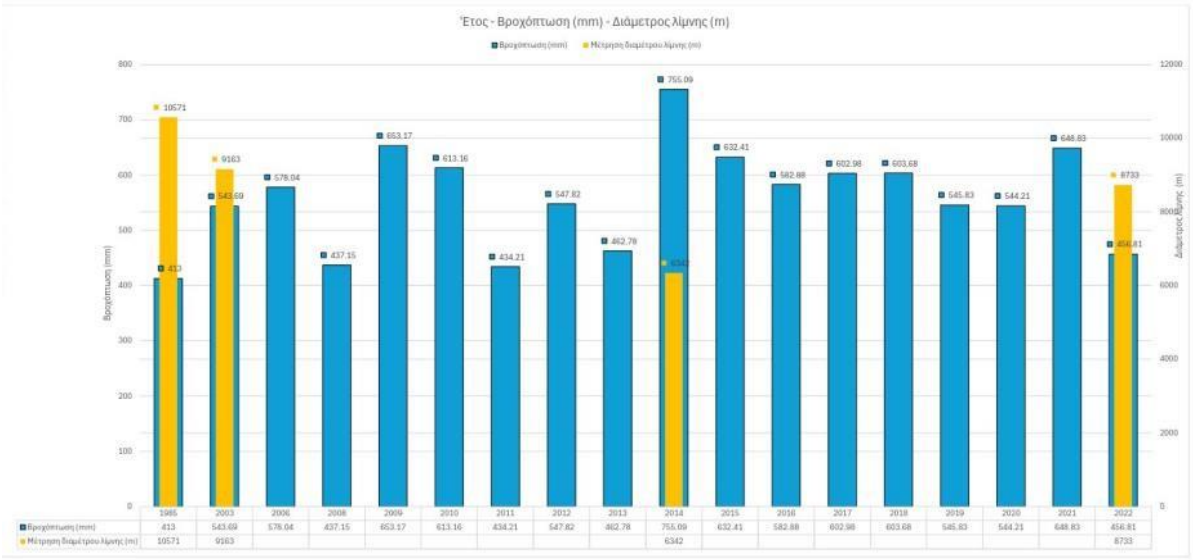
graph. Thanks to the second vertical axis, the annual precipitation and the size of the lake (as measured from the two points) are displayed simultaneously.

In this way, it is possible to observe whether precipitation is increasing and whether this is reflected in an increase or decrease in the lake, thus giving a more complete picture of the relationship between climatic and hydrological changes.



In Figure 4, a combined graph is presented that includes annual precipitation and a measurement of the lake dimension. The double scale on the two vertical axes allows us to see, at a glance, how precipitation varies in relation to the width of the lake, facilitating the identification of possible trends or extreme values.

**Figure 4.** Bar chart in Excel showing precipitation (mm) on the 1st vertical axis and the distance between 2 fixed extreme positions of the lake on the 2nd vertical axis.




## 4. Conclusions

The comparison of precipitation data with the measured distance between two fixed extreme points of Lake Koroneia reveals significant fluctuations during the period 1985–2022. Specifically, while in 1985 relatively low precipitation (413 mm) but a very long distance (10,571 m) was recorded, in 2003, with moderate precipitation (543.69 mm), the distance decreased to 9,163 m. In 2014, the highest precipitation of 755.09 mm was recorded, but the distance was now considerably reduced to 6,342 m, indicating that in addition to precipitation, other factors (such as water pumping for irrigation or increased evaporation) may have a decisive effect on the extent of the lake. Also, of interest is 2022, when rainfall ranged at relatively low levels of 456.81 mm, while the distance rose to 8,733 m, possibly indicating an attempt at recovery or water management that may be due to other interventions.

**Impact and importance**

The above findings highlight the complex relationship between precipitation and the size of Lake Koroneia: increased or decreased precipitation is not always linearly reflected in the extent of the lake.

Finally, these data highlight the importance of further research on human interventions that may affect the ecosystem, making collaboration between scientists as well as local and regional stakeholders necessary.

The World Bank Climate Knowledge Portal is free and user-friendly, facilitating the collection of reliable precipitation data. Thus, even users with basic skills can extract the necessary data, using them to gain a first insight into the climate conditions in the area of interest.

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# Economic and environmental impacts of sustainable wheat intensification: Insights from the eastern Indo-Gangetic Plains

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**Abstract**

Sustainable intensification offers a promising pathway to enhance agricultural productivity and environmental sustainability. However, existing studies primarily focus on the impacts of sustainable intensification on productivity and livelihood outcomes, while research on environmental sustainability is scant. Using farm survey data collected from the eastern Indo-Gangetic Plains in Nepal and an instrumental variable approach, we assess the impacts of zero-tillage (ZT) wheat on productivity, cost, profits, total energy use (TEU), and greenhouse gas emission intensity (GHGI). We find that ZT-wheat significantly increased productivity by 29% (739 kg/ha) and profitability by US$ 56 per hectare, while also reducing TEU by 31% (6,422 MJ/ha) and GHGI by 42% (247 kg $CO_2$ equivalent/ton). However, these benefits are unevenly distributed: wealthier farms tend to benefit more in terms of wheat productivity and profitability, while poorer farms contribute more to environmental sustainability. Our findings show that farmers' risk tolerance, influenced by out-migration driven labor shortages, is driving ZT-wheat adoption. In this context, new policy and extension efforts are needed to reduce risks and encourage farmers wider adoption of sustainable tillage technologies.

***Keywords:*** *wheat intensification, agricultural productivity, sustainable tillage technologies*

**JEL Codes:** Q01; Q12; Q16; O13.

# The new energy and climate architecture of the Eastern Mediterranean

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**Abstract**

The Eastern Mediterranean has been subject to geopolitical conflicts triggered by energy security concerns or other security aspirations promoted through claims on existing or assumed energy reserves. Yet, while frictions among the Eastern Mediterranean countries about maritime zones and continental shelf claims abounded in recent years, nearly provoking large-scale conflicts, the impact of the climate crisis on these countries has been extreme. The region is already experiencing dramatic changes and hardships attributable to climate change, and it is particularly vulnerable to the interconnected challenges stemming from climate change and environmental degradation. The UN Intergovernmental Panel on Climate Change has therefore labelled the region as a ‘‘climate change hotspot’’, expecting the warming across the Mediterranean to be about 20 percent higher than global averages in the decades to come. Thus, the regional states are faced with an existential dilemma: either they will remain locked in a fruitless energy competition or they will cooperate towards joint exploitation of their vast and untapped renewable energy potential and fighting against common existential, natural, environmental threats.

***Keywords:*** *Energy, Climate Change, Competition, Eastern Mediterranean, hydrocarbons, renewables, environmental degradation.*

**JEL Codes:** Q4; Q5

# Measuring Energy Poverty in Greece: Case Study of an Athenian Household

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**Abstract**

Although energy poverty has been a high issue of interest in recent years, not all the necessary actions have been taken at the policy level, in order to tackle the problem. There is no generally accepted definition of energy or fuel poverty even though often has been characterized as the inability to keep home in adequate comfort conditions at a fair price. The increasing energy prices, the low rate of wages, the low levels of benefits and the inadequate quality of housing, increase the percentage of energy poverty households in Greece, resulting in an increase in mortality and morbidity rates. Based on previous studies for the period 2003/2012 in Greece, 2.8-6% of deaths recorded on an annual basis can be attributed to energy or fuel poverty. The present study aims to take as a case study a typical household in the center of Athens, in real prices, for the years 2019 -2023 and to study the rate of energy poverty based on the 10% indicator (energy expenditure/disposable income) as defined by Boardman in 1991 as the households that needed to spend 10% or more of their incomes on energy services were considered to be energy/fuel poor. This case study did not take into account the required expenditure for thermal comfort as defined by World Health Organization (WHO), where in the main living rooms of a residence the temperature should reach 21°C and in the rest 18°C.

***Keywords:*** *Fuel poverty, public health, Indicators*

**JEL Codes**: Q41, Q48, I18.

# Session 6
# Forest Economics

# A text analytics literature review of the Faustmann natural resource economic model

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**Abstract**

The purpose of this paper is to conduct a literature review on the evolution of research concerning the Faustmann natural resource economic model. The Faustmann model was developed in 1849 as a method to maximize forest land expectation value (LEV) based on the optimal rotation period. This review focuses on research published between 1962 and 2024 and examines the topics of interest that have led the mathematical developments on the model. The study employs text analytics with VosViewer and bibliographic data from Scopus, following the PRISMA methodology. Articles were included based on relevance and type of publication. The aim was to create bibliographic and concept maps depicting the focus of interest in the Faustmann research over the years. To reduce the complexity of the maps, a thesaurus of terms was developed to group synonymous words and abbreviations into one label that best describes their collective meaning. The results of the text analysis were found to correspond with the conclusions of previous literature reviews which supports their accuracy. Through the graphical representation of the concepts that have been explored within the Faustmann literature we identified areas of interest, such as risk assessment, plantation management, climate change, sustainable development, biofuel and carbon sequestration. The study also identified geographical areas where most of the research has focused. Based on these results, we discuss areas of research that warrant deeper investigation, such as hybrid sylvicultural management approaches and different climate conditions.

***Keywords:*** *Faustmann model; literature review; text analytics; concept map; bibliographic map.*

**JEL Codes**: Q23; Q51; Q54; Q56; Q57.

# Environmental NGOs as a key determinant in the implementation of eco-innovation by businesses

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**Abstract**

Innovation is an important field of scientific research with a direct social impact. There are many types of innovation, which with their role can contribute to the management and protection of the natural environment and the transition to new economic models, such as the bioeconomy. The so-called eco-innovation, or ecological innovation can provide the above services. At a scientific level, there is no extensive research on the role that environmental non-governmental organizations (ENGOs) play in the adoption of eco-innovative practices within business. This paper aims to fill this gap by investigating the concept of ecological innovation and the contribution of Environmental NGOs to its application in business. The methodology of in-depth interviews was used to test the research question of how ENGOs put pressure on businesses to increase ecological innovation practices. The interviews took place with managers of 10 Greek ENGOs that agreed to participate from the total 26 that were approached. It was found that there is little convergence of what the definition of eco-innovation is, and what the managers think of this term. However, there were cases where ENGOs helped successfully several businesses to adopt innovation practices towards sustainability.

***Keywords:*** *eco-innovation, ENGOs, business, Greece*

**JEL Codes**: 32; O35; O36; Q55

# On the environmental accountability of blockchain systems

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**Abstract**

Blockchain technology is a relatively novel innovation with a far-reaching ability to revolutionize a variety of sectors, including finance, healthcare and energy. This popularity is based on the decentralization, security and immutability guarantees embedded within blockchain networks. However, the unique architecture and operations of blockchain systems also have negative consequences. The computational demands result to substantial amounts of consumed energy, while the rapid replacements of specialised equipment generate high volumes of electronic waste. As blockchain becomes more widespread, these adverse effects intensify. Different actors within blockchain systems can influence the characteristics, properties and activity levels of the network through their actions, subsequently determining its overall environmental impact. While actor accountability is crucial, the unique features of blockchain technology and the variety of different network architectures have complicated and hindered this process, allowing for unmonitored operations that cause environmental degradation. This research explores the relationships between system characteristics, actors and the blockchain's environmental impact. A novel framework is proposed for estimating the severity of this impact and assigning environmental accountability to involved actors. The framework is adaptable across different blockchain network types, facilitating the development of policies and regulations that will promote and enforce environmental accountability in blockchain systems.

***Keywords:*** *blockchain, environmental accountability, environmental regulation, DLT*

**JEL Codes**: O32; O33; O38; Q56

# Development of an Interactive Forest Fire Mapping Tool

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**Abstract**

Environmental change monitoring is essential for effectively managing and protecting terrestrial and marine ecosystems. Information needs for environmental protection have spurred significant technological advancements, leading to the availability of robust approaches and methods. Among these advancements, Remote Sensing science advances in terms of data and processing tools enable detailed analysis of the Earth's surface condition and changes. The availability of open satellite Earth Observation (EO) data facilitates remote sensing applications, allowing for information extraction of extended geographical areas and the generation of robust, accurate spatial explicit results with low costs. In that way, environmental and societal challenges related to issues such as disaster risk management can be nowadays addressed more effectively and reliably. This study aims to develop a cloud-based mapping tool for assessing burn severity, utilizing the extensive archive of the Landsat satellite mission and fire perimeter polygons from the European Forest Fire Information System (EFFIS). Originally, Landsat time series data was processed to calculate the Normalized Burn Ratio (NBR) spectral index. Subsequently, burn severity maps are generated over each fire perimeter using a threshold-based approach developed by the U.S. Department of Agriculture (USDA).

***Keywords:*** *forest fires, burn severity, NBR, dNBR, Landsat, EFFIS, interactive mapping, cloud computing*

**JEL Codes:** Q54, Q56, Q57, C81, O32

## 1. Introduction

The Earth is in a constant state of change, affected both by natural disasters and human activity. Remote Sensing (RS), which is defined as «the technique of obtaining information about objects through the analysis of data collected by special instruments that are not in physical contact with the objects of investigation» (Avery & Berlin, 1992), has enabled the systematic monitoring of these changes, with the use of satellite imagery and other data acquired from other platforms (i.e. Unoccupied Aerial Systems, UASs, terrestrial sensors). The launch of the Landsat satellite in 1972 marked the beginning of systematic Earth observation from space. Landsat satellites have been providing freely available high-resolution data, and the frequency of image acquisition has been increased to every 8 days with the combined use

of the latest Landsat 8 and Landsat 9 satellites (NASA - Landsat Science, 2021). Earth Observation (EO) data allows for the study and prediction of future environmental trends and is especially useful for monitoring natural disasters, such as forest fires, which have severe impacts on the biodiversity of the environment.

Furthermore, introduction of new processing approaches, relying among other on cloud computing technology, has enhanced the ability of the RS community to analyze large volumes of geospatial data and deliver critical environmental information (Yang et al., 2017). Cloud computing refers to the delivery of computing services—such as storage, processing, databases, networking, software, and analytics—over the internet («the cloud») (Gorelick et al., 2017; Mell & Grance, 2011). A relevant example would be Google Earth Engine (GEE), which is a cloud – based geospatial analysis platform that enables users to visualize and analyze satellite images of our planet. GEE has been exploited in a variety of studies on long-term environmental changes, as it enables the analysis of the Earth's surface on a large scale. By providing access to various collections of satellite datasets, users can map changes in land characteristics, such as vegetation cover, soil moisture, and land use / land cover. Especially in the case of fire management, cloud computing enables post-fire impact analysis, as in the case of burn severity mapping on a large scale.



Monitoring the increasingly frequent and intense forest fires, and assessing them through fire mapping, is one of the most important applications of remote sensing. Forest fires are among the most dangerous natural disasters and pose a persistent and serious issue throughout the Mediterranean, affecting approximately 500.000 hectares of land annually, with 80% of the area taking place in southern Mediterranean countries (WWF, 2024). They are a fundamental component of Mediterranean ecosystems and contribute to the degradation of both above-ground and below-ground vegetation, leaving the affected areas vulnerable to soil erosion (Mallinis et al., 2009). One of the most fire-prone countries in Europe is Greece, with yearly frequent forest fires caused by numerous factors, such as natural causes, human activity and climate conditions. Although natural causes lead to a small percentage of cases (3-4%), the management of fires caused by them is challenging, due to the isolated locations in which they occur (Koutsias et al., 2015). Natural causes of forest fires include lightning, rapid temperature increases, volcanic activity, earthquakes, and landslides (Goldammer et al., 2019). Moreover, nearly 90% of forest fires are caused by human activity, whether intentional or accidental. Careless actions, such as burning trash or improper handling of controlled fires, are responsible for about 50% of fires caused by humans (WWF, 2024). Burn severity mapping and ecological impact assessment are important for ecosystem recovery and restoration, as well as for fire management and mitigation of future fire risk.

In the matter of fire terminology, fire severity, also referred to as burn severity in cases where the Normalized Burn Ratio (NBR) is used, is defined as the ecological footprint caused by a fire on an ecosystem (Key & Benson, 2006). It is used to evaluate the effects that the fire has on the burned area and to quantify the volume of burned vegetation by studying changes in vegetation and soil conditions. Burn severity is used interchangeably with the term fire severity,

when its assessment is performed using the Normalized Burn Ratio (NBR), which evaluates changes in vegetation, organic matter, and soil properties before and after the occurrence of a fire. (Keeley, 2009). As far as fire categorization is concerned based on the size of the area burned, the term Megafire has been widely used having different thresholds and meanings in burn severity studies, although it has not been defined as a term. To overcome ambiguity, Linley et. al. (2022) suggested the definition of Megafire as a fire with a burned area of over 10.000 ha, arising from single or multiple related fire events (Linley et al., 2022). Thus, burn severity reflects the consequences of the fire on the environment (Key & Benson, 2006) and can be used to organize an efficient and well-structured management and restoration strategy for burned forest areas or forest Megafires.

**Study Area and Data**

The subject area of this study focuses on the fires with a recorded burned area of over 10.000 hectares (Megafires) in Greece from 2000 to 2023. Greece is a country located in Southeastern Europe, with diverse geographical features and a rich biological diversity. Its geomorphology consists of mountains, valleys, coasts, and island systems, allowing a variety of ecosystems to coexist spatially. The country has a Mediterranean climate, characterized by high temperatures and droughts, particularly during the summer months, and mild, wet winters (HNMS - Climate Of Greece, n.d.).

The year 2023 saw the most intense fire season in recent years in Greece. Although the number of fires was lower compared to past years, the size of the fires was exceptionally large, having a total of 175.759 hectares burned, the second-highest area recorded since 2007 (San-Miguel-Ayanz et al., 2024). Nearly all the fires occurred during July and August, including the largest recorded fire to date in the European Forest Fire Information System (EFFIS), which took place in the Dadia Forest National Park, burning 96.000 hectares of forest land. Two more fires, in Attica and Rhodes, exceeded 10.000 hectares, while nearly twenty others surpassed 5.000 hectares of burned areas. A total approximately 70.000 hectares of burned land were recorded in Natura 2000 areas, representing 40% of the total burned area (San-Miguel-Ayanz et al., 2024).

The data used to conduct this study were obtained from the European Forest Fire Information System (EFFIS) in shapefile vector format. These were used in combination with Landsat satellite images, to estimate burn severity and extract statistical results. The shapefile used for delineating the fires contains geographic polygons, the fire perimeters, combined with a database that includes properties for each one. The polygons represent the mapped boundaries of all fires with a recorded burned area of over 10.000 hectares in Greece from 2000 to 2023.

**Table 1**. Megafire polygons in Greece (EFFIS, 2024)

| Year | ID | Location |
|---|---|---|
| 2000 | 27727 | Samos |
| 2000 | 27429 | Corinthos |
| 2007 | 36887 | Messinia |
| 2007 | 36713 | Axaia |
| 2007 | 36845 | Evia |
| 2007 | 36885 | Lakonia Agrianoi |
| 2007 | 38429 | Arkadia |
| 2007 | 36821 | Ileia Pyrgos |
| 2007 | 37655 | Ileia Andritsena |
| 2008 | 39291 | Rhodes |
| 2009 | 2583 | Attiki |
| 2012 | 8783 | Chios |
| 2021 | 54081 | Attiki |
| 2021 | 51932 | Lakonia Gytheio |
| 2021 | 52249 | Ileia Ancient Olympia |
| 2021 | 213578 | Evia |
| 2023 | 217637 | Attiki |
| 2023 | 217438 | Rhodes |
| 2023 | 218736 | Dadia |

**The dNBR method**

The dNBR index is calculated based on the comparison between pre- and post-fire images. First, Normalized Burn Ratio (NBR) is computed for both sets of images. It highlights changes in vegetation, using the Near-Infrared (NIR) and Shortwave Infrared (SWIR) bands. Higher NBR values indicate healthy vegetation and lower NBR values indicate areas that have been burned or significantly damaged.

$$NBR = \frac{NIR-SWIR}{NIR+SWIR} \quad (1)$$

After NBR images for both pre- and post-fire conditions are obtained, the delta NBR (dNBR) image is calculated by subtracting the post-fire NBR from the pre-fire NBR image values. This difference index represents the burn severity, which itself reflects the extent of the fire's impact on vegetation. Areas with low dNBR values indicate minimal damage, whereas areas with high dNBR values indicate areas of severe fire damage, where vegetation has been destroyed or heavily impacted.

$$dNBR = NBRpre - NBRpost \quad (2)$$

These images are of critical essence for the fire damage assessment, as they support methodical fire management and recovery planning (Key & Benson, 2006). The dNBR index has been categorized into the following categories. It is important to note that this application does not study regrowth, and so these categories have been included as «Unburned».

**Figure 1.** Burn severity classes with dNBR calculation according to the thresholds set by Key and Benson (2006)



| Severity Level | dNBR Range (scaled by $10^3$) | dNBR Range (not scaled) |
|---|---|---|
| Enhanced Regrowth, high (post-fire) | -500 to -251 | -0.500 to -0.251 |
| Enhanced Regrowth, low (post-fire) | -250 to -101 | -0.250 to -0.101 |
| Unburned | -100 to +99 | -0.100 to +0.99 |
| Low Severity | +100 to +269 | +0.100 to +0.269 |
| Moderate-low Severity | +270 to +439 | +0.270 to +0.439 |
| Miderate-high Severity | +440 to +659 | +0.440 to +0.659 |
| High Severity | +660 to +1300 | +0.660 to +1.300 |

## 2. Methodology

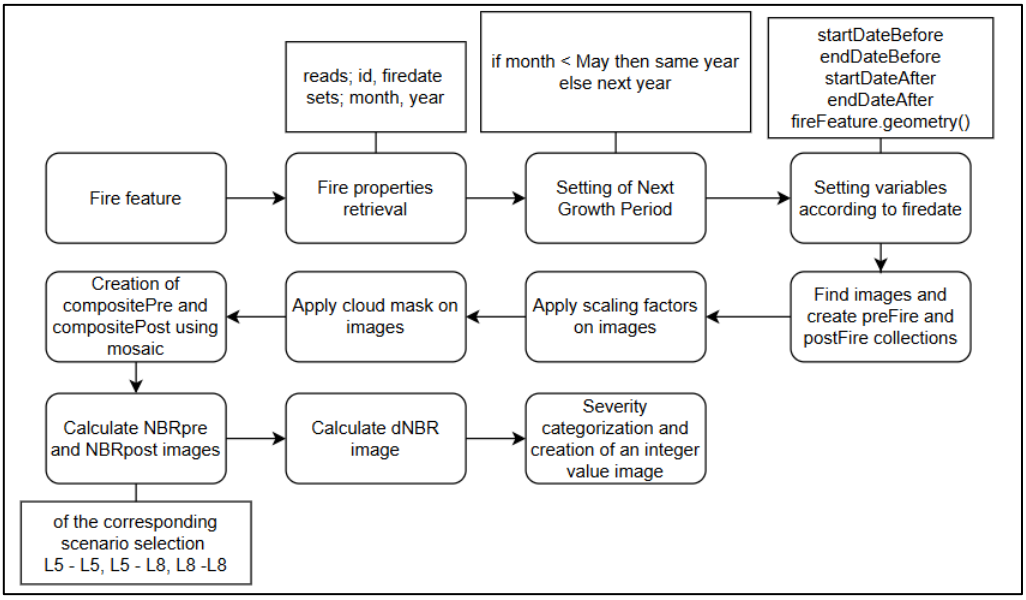
The process described concerns the study of burn severity in Greece through cloud computing and the use of satellite images, primarily from Landsat 5 and Landsat 8 satellites. The methodology used for assessing severity includes the calculation of the dNBR index, which calculates the difference between pre- and post-fire images to assess the damage sustained by vegetation. This tool allows for the visualization of data and the spatial distribution of burn severity, enabling users to examine specific fires and obtain statistical data.

The function recognizes a feature (geometry with properties) and extracts the id and the firedate. It searches for images for two time periods: one pre-fire and one post-fire. The post-fire images are searched for dates within the next growing period, according to the firedate. In other words, the post-fire period is set as the next May-August period after the firedate. Then a cloud mask is applied, so that pixels with cloud cover are removed. On those masked images the NBR index is applied, and a composite is created for each subcollection. That way, a difference image of dNBR is created, which is used to create a new image with integer values, each of which corresponds to the categories of the burn severity classification.

**Table 2**. Methodology steps for burn severity mapping

| | |
|---|---|
| **1.Data Preparation** | Fire data are sourced from the European Forest Fire Information System (EFFIS), which provides essential information on wildfire locations and dates. This data is used for the calculation of dNBR with the help of satellite images, specifically from Landsat. The Landsat satellite images are chosen carefully to represent the vegetation cover both before and after the fire. Pre- and post-fire images are selected to match the appropriate time periods, ensuring they capture the natural conditions of the area prior to the fire and the altered state after the fire has occurred. This careful selection process is important because it isolates the fire's impact, excluding seasonal changes or other environmental factors that may affect vegetation. |
| **2.Calculation of dNBR** | Using the GEE platform, a programming function is applied for every fire polygon. Pre- and post-fire Landsat images are searched within the Image Collections Datasets provided by GEE. The recorded firedate of each fire event is used, to create image subcollections of dates pre- and post-fire. It is important to note that based on the firedate of each polygon, either Landsat 5 or Landsat 8 images are used for pre- and post-fire images. After applying image scale factors given by GEE guidelines and calculating a composite for each subcollection, two NBR images are created, one depicting the pre- and one depicting the post-fire situation. Consequently, the dNBR index is calculated by comparing the pre- and post-fire NBR images to extract the area's burn severity. The dNBR images produced reflect the difference in vegetation cover and help categorize areas based on fire intensity. |
| **3.Visualization** | Using the GEE map panel, the calculated images and results from classified satellite images are visualized on maps. The visualization follows the color – coded classification provided by USGS. It is noted that no areas were classified as regrown. Instead, those categories were included as unburned areas. |
| **4.User Interaction** | The application provides interactive analysis through a user–friendly interface, allowing users to click on fire polygons and monitor their burn severity. That way, users can view properties and statistical information related to the distribution of severity for the specifically selected affected area. |

**Figure 2.** Function steps for producing an image with burn severity values




## 3. Results

The results of this study produced the forest fire Burn Severity Mapping Tool, as well as the severity classification assessment for Megafires in Greece. The interactive tool produces a severity classification map, with a color-coded legend and two click event panels. These panels load information after the user clicks on a fire polygon that has been assessed for its burn severity levels. When the user selects a polygon, the two panels load descriptive text and a statistical graph according to the user's selection. The tool produces pixel accurate results, which correspond to 30 x 30 meters on the ground.

**Figure 3.** Interactive mapping tool - Information panels based on the user's selection

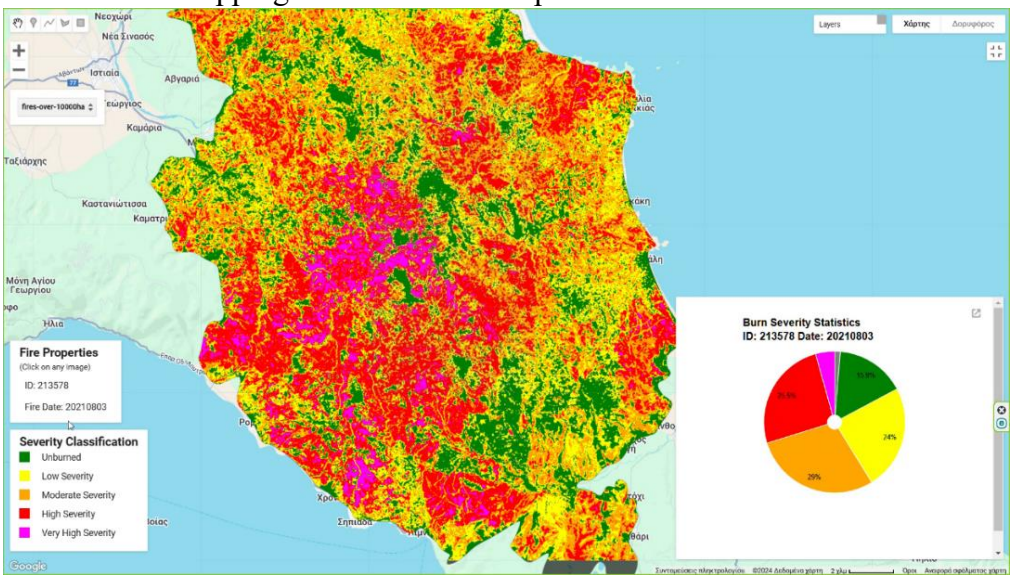
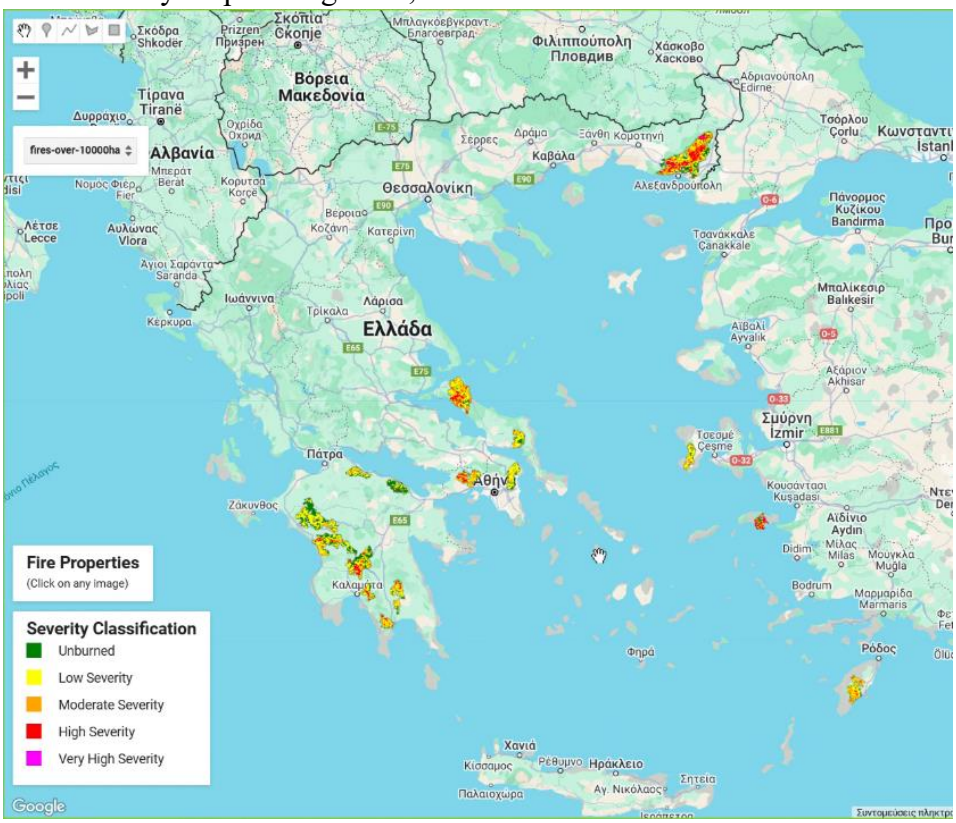


**Figure 4.** Burn severity map of megafires, Greece




The largest and most severe fire event took place in 2023 at the National Park of Leykimi – Evros – Dadia, with a total of 1281.49 km² of burned area and 128.42 km² classified as «Very High Severity» burned areas. Although this fire event burned the largest amount of area, it is not the most severe one. The fires in Samos (2000) and Attiki (2021) had more than 50% of their burned area classified as «High» or «Very High Severity» and the fires in Rhodes (2023) had more than 40% of their burned areas classified similarly, even though all these events resulted in less than 200 km$^2$ of burned area.

Large fire events, like those in Dadia (2023) and Evia (2021), also presented considerable percentages of «Low Severity» and «Unburned» areas. The «Unburned» areas could hint a sign of recovery, even though this does not automatically imply it. This provides concrete evidence that severity and magnitude are not correlated in fire events. These areas could still be affected by indirect fire effects, such as soil composition changes and water availability issues, and they may be more vulnerable to future disturbances. Areas with «Low Severity» levels may have experienced scorched vegetation, without suffering extensive loss of biomass.

The tool created and used for the needs of this study produces reliable results, having less than 5% of the fire polygons be classified as «Undefined». This percentage emphasizes the

effectiveness in accurately assessing burned areas, aiding in precise decision-making strategies for forest management and disaster response.

**Figure 9.** Burn severity of large fire events in Greece, 2000 – 2023 (area in km²)

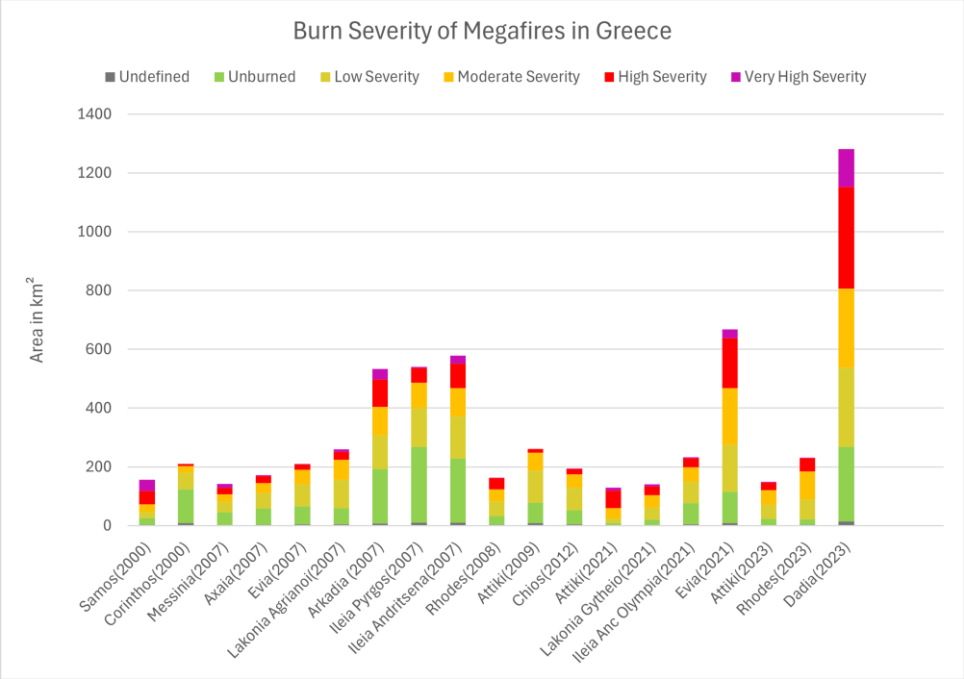
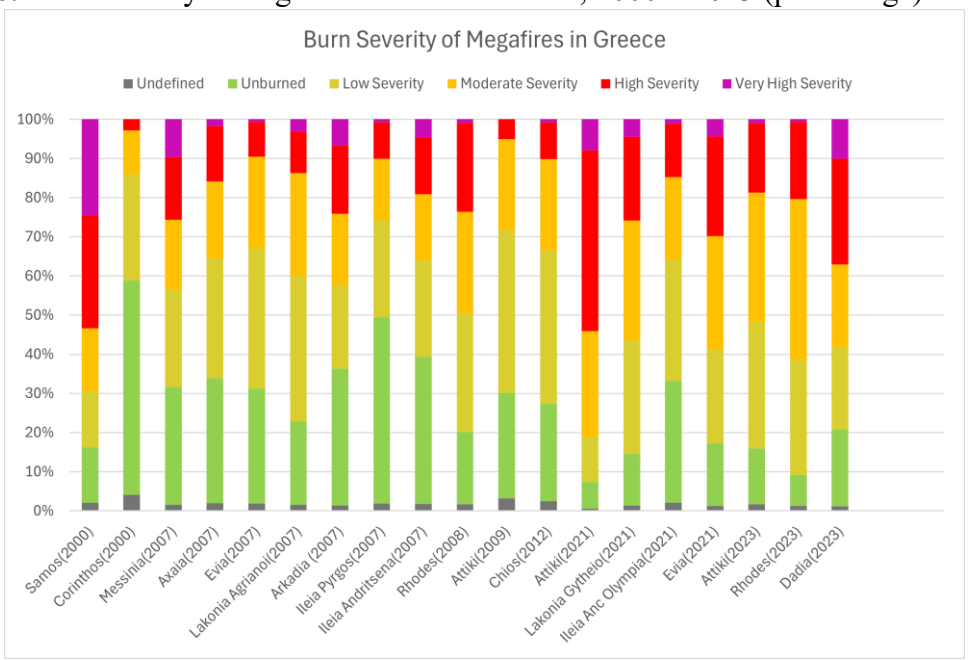



**Figure 10.** Burn severity of large fire events in Greece, 2000 – 2023 (percentage)



## 4. Conclusions

The study created an interactive mapping tool, providing accurate and reliable results about large fire events. Results support existing scientific literature, indicating that the size of a fire and the level of burn severity are not consistent or correlated.

Despite the vast areas covered, fires do not always result in extended severe destruction, with parts of the landscape showing «Low Severity» levels or even remaining «Unburned». This suggests wildfires have varied impacts, with some areas experiencing intense damage, while others are barely affected or not burned at all. For highly accurate results, combining burn severity studies with information on fuel availability, vegetation type, and local topography should help identify patterns of fire behavior, inform predictive models, and assist in developing effective fire management strategies to improve wildfire resilience in different landscapes.



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# Expectational and legitimation gaps in an experiment of SDG reporting in a public forestry organization

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**Abstract**

While increasing scrutiny is posed upon companies for their role on economic, social, and environmental issues (lately covered by the term ESG), there is a significant portion of research which calls for the enhancement of public organizations accountability for sustainable development. Therefore, there is a niche scientific discipline on UN's Sustainable Development Goals (SDGs) accounting and reporting for public sector organizations (PSO). Because governments, via the public sector they manage and supervise, have the role of controlling the performance of private sector on ESG issues, the literature refers that PSOs should -and the society expects them to- lead by example in sustainability management performance. However, this is not usually the case. In this research, we argue that organizations which deal with the management of natural resources should lead by example in environmental performance issues. When an organization does not fulfil such societal expectances, the case is described in the literature as an expectational gap. When, additionally, it doesn't comply with social values and norms, then we observe a legitimation gap. The present research describes the main types of expectational and legitimacy gaps; then, it experiments with the development of an SDG report for a Public Forestry Organization and finds that there is at least one expectational gap deriving from the fact that this organization is ready to report more on social and economic indicators, compared to environmental ones. Based on the findings, we propose future research in this field.

***Keywords:*** *legitimation theory, agency theory, sustainable development goals, forestry organizations*

**JEL Codes**: H83; M41; Q23; Q56

# Evaluation of the available indicators for Bioeconomy measurement within non-financial reporting frameworks

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**Abstract**

Lately, within science and policy, bioeconomy has emerged as a paradigm innovation which aims to change the classical model which upon countries base their economy on. Bioeconomy focuses on the utilization of renewable biological resources for materials, energy, and food to reduce reliance on non-renewable resources. Non-financial reporting protocols, such as the Global Reporting Initiative (GRI) protocol, and the Sustainability Accounting Standards Board (SASB), are essential tools for supporting industries' transition towards sustainability. These frameworks enable companies to disclose their environmental, social, and governance (ESG) impacts, promoting transparency and accountability in their sustainability efforts. However, no dedicated monothematic protocol to Bioeconomy exists yet. On the other hand, key indicators, such as GRI's 301 on materials and SASB's CG-130a.1 on the use of recycled materials and natural raw materials seem to align with bioeconomy objectives. The present research evaluates how these two protocols implicitly provide indicators for estimating a company's contribution to bioeconomy and proposes further research on the issue for a future development of a Bioeconomy Reporting Standard.

***Keywords:*** *Non-financial reporting, Bioeconomy, Sustainability, Renewable natural resources*

**JEL Codes**: Q01; Q23; M41; O13; Q56.

## 1. Introduction

The bioeconomy is an innovative economic model that promotes the sustainable use of renewable biological resources such as plants, animals, and microorganisms for producing goods, energy, and services (Bugge, Hansen, & Klitkou, 2016). It is designed to reduce dependence on fossil fuels and support the transition toward a circular and sustainable economy (European Commission, 2018). By utilizing biological resources instead of non-renewable materials, the bioeconomy plays a key role in addressing pressing global challenges, including climate change, resource depletion, and environmental degradation (OECD, 2020).

One of the fundamental principles of the bioeconomy is resource efficiency, where biological raw materials are used optimally to minimize waste and maximize economic and environmental benefits (D'Amato et al., 2017). This concept aligns closely with circular economy principles, which aim to maintain materials and products in use for as long as possible, reducing waste and pollution while regenerating natural systems (Geissdoerfer et al., 2017). The bioeconomy contributes to these efforts by closing resource loops, ensuring that agricultural, forestry, and industrial residues are repurposed into new valuable materials, biofuels, or energy (Stegmann, Londo, & Junginger, 2020).



In addition to its environmental benefits, the bioeconomy is an important economic driver. It has the potential to create new business opportunities, increase employment, and stimulate innovation in various sectors such as biotechnology, pharmaceuticals, sustainable agriculture, and green chemistry (McCormick & Kautto, 2013). The European Commission and other global institutions have recognized its significance, promoting bioeconomic strategies as part of broader sustainable development goals (SDGs) and climate action plans (European Commission, 2020).

Despite the increasing focus on sustainability and bio-based innovations, there is no dedicated global framework for measuring and reporting corporate contributions to the bioeconomy. Current non-financial reporting standards, such as the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB), include some indicators related to bioeconomy principles, such as material efficiency, waste reduction, and renewable energy use (GRI, 2021; SASB, 2021). However, these frameworks were not explicitly designed to assess bioeconomic performance. As a result, companies and policymakers lack a standardized approach to quantify, compare, and improve bioeconomic activities (Loiseau et al., 2016).

The absence of a Bioeconomy Reporting Standard creates challenges in assessing the impact of companies operating in bio-based industries. While sustainability reports often include general environmental and social impact metrics, they fail to capture the full scope of bioeconomy contributions, such as the share of bio-based materials in production, the level of circularity in resource use, or the reduction of greenhouse gas emissions through bio-based alternatives (Bracco et al., 2019). Therefore, a comprehensive reporting framework tailored to the bioeconomy is needed to enhance transparency, guide sustainable business practices, and support policymakers in developing effective bioeconomic strategies (Philp & Winickoff, 2018).

Bioeconomy measurement and reporting have been widely discussed in sustainability literature, yet a standardized framework for assessing corporate bioeconomic contributions remains underdeveloped (European Commission, 2021; Lewandowski, 2018). Non-financial reporting frameworks such as the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB) have incorporated indicators related to environmental performance, resource efficiency, and renewable material usage, but these do not explicitly measure bioeconomy-specific activities (Loiseau et al., 2016; Vis et al., 2020).

Existing studies have attempted to define and classify bioeconomy-related indicators by analyzing their alignment with sustainability goals. For example, research by Stegmann et al. (2020) highlights the importance of including circular bioeconomy metrics in corporate reporting, emphasizing biomass efficiency, waste valorization, and bio-based material flows. Similarly, Philippidis et al. (2018) propose a methodology for assessing bioeconomic progress through economic, environmental, and technological indicators. However, these approaches remain fragmented and lack systematic integration into corporate reporting structures.

This present paper aims to evaluate how existing non-financial reporting frameworks address bioeconomy-related activities and to propose recommendations for developing a dedicated Bioeconomy Reporting Standard. By analyzing the alignment of GRI and SASB indicators with bioeconomy principles, this research identifies gaps and opportunities in current reporting structures. Ultimately, the goal is to contribute to the establishment of a standardized methodology for measuring and reporting bioeconomic contributions, enabling businesses, investors, and policymakers to make informed and sustainable decisions.

It utilizes a comparative evaluation approach to assess the alignment of bioeconomy-related indicators within GRI and SASB frameworks. Following methodologies established by Meyer (2021) and Bugge et al. (2016), this study identifies key sustainability metrics that implicitly support bioeconomy measurement, such as GRI 301 (Materials), GRI 302 (Energy), and SASB's environmental performance indicators. Additionally, it applies a qualitative assessment to determine the degree of alignment between existing ESG indicators and bioeconomy principles.

By analyzing these indicators, the study contributes to the development of a standardized bioeconomy reporting framework, aiming to enhance corporate sustainability disclosures and facilitate the transition toward a circular bioeconomy.

## 2. Methods and Data

### *2.1 Methods*

This study employs a comprehensive approach to analyzing sustainability reporting frameworks, with a specific focus on evaluating environmental and economic indicators in relation to bioeconomy principles. The primary frameworks under investigation are the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB). These frameworks serve as established standards for corporate reporting on environmental and economic performance, thereby enabling organizations to transparently disclose their contributions to sustainability and bioeconomy objectives.

The methodology involves assessing the alignment of both the GRI and SASB indicators with the core principles of the bioeconomy. Key focus areas include resource efficiency, waste management, energy use, water resource management, and sustainable financial performance. The study classifies the frameworks' environmental and economic indicators into three distinct categories based on their relevance to bioeconomy principles: Fully Related, Relatively

Related, and Non-Related. Descriptive statistics are used to present the distribution of these indicators and their corresponding alignment with bioeconomy goals.

## 3. Results

The distribution of the frameworks' environmental and economic indicators into three distinct categories based on their relevance to bioeconomy principles is presented below.



*3.1 Environmental Indicators*

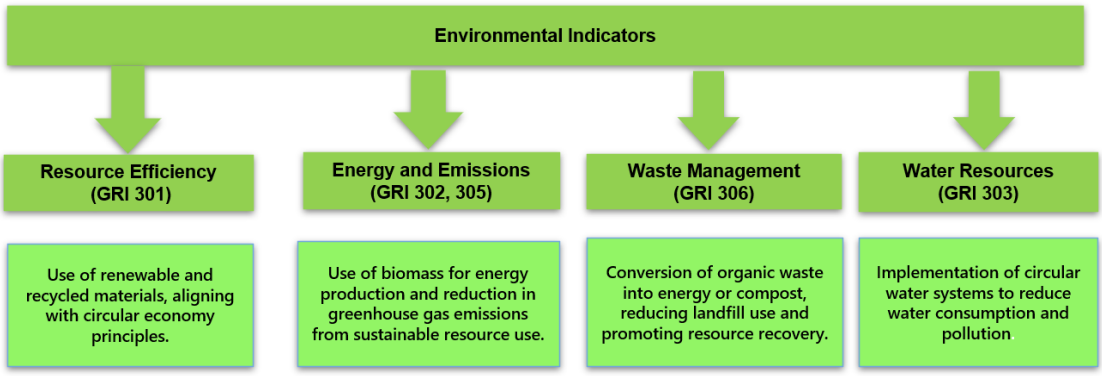
The environmental analysis highlights the extent to which sustainability reporting captures bioeconomic principles such as resource efficiency, energy use, waste management, and water resource sustainability.Table 1 shows that the majority of GRI environmental indicators are fully related to Bioeconomy.

**Table 1:** Classification of GRI Environmental Indicators by Relevance to Bioeconomy

| Fully Related Indicators | Relative Related Indicators | Non Related Indicators |
|---|---|---|
| ***301-2:*** *Recycled input materials used* | ***301-1:*** *Materials used by weight or volume* | ***417-2:*** *Incidents of non-compliance concerning product and service information and labeling* |
| ***301-3:****Reclaimed products and their packaging materials* | ***302-1:*** *Direct energy consumption by primary energy source* | ***306-3:*** *The volume of hazardous waste and their management methods* |
| ***302-4:****Reduction of energy consumption* | ***413-1:*** *Operations with local community engagement* | ***306-4:*** *The volume of non-hazardous waste and their management methods* |
| ***303-1:****Water withdrawal by source* | ***202-2:*** *Programs to promote sustainable use of natural resources* | |
| ***305-1:****Direct (Scope 1) GHG emissions* | | |
| ***305-4:****GHG emissions from waste management* | | |
| ***308-1:****New suppliers that were screened using environmental criteria* | | |
| ***308-2:****Negative environmental impacts in the supply chain* | | |
| ***304-1:****Locations of operation with biodiversity value* | | |
| ***306-2:****Waste by type and disposal method* | | |

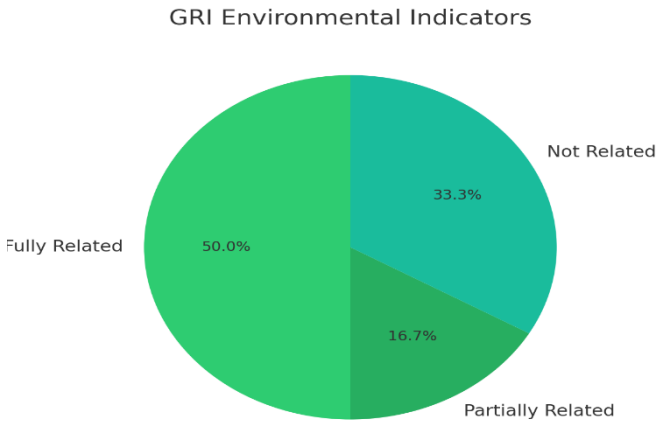
The findings indicate that 50% of GRI's environmental indicators are fully aligned with bioeconomy goals, particularly those related to recycling (GRI 301-2) and greenhouse gas emissions (GRI 305-1). However, 33% of GRI indicators were found to be unrelated to bioeconomy, suggesting gaps in measuring bioeconomic-specific sustainability outcomes. It is illustrated in Figure 1 how the GRI framework aligns with bioeconomy principles through its environmental indicators.

**Figure 1**: GRI and Bioeconomy - Environmental Indicators




Moreover, Figure 2 represents visually the distribution of GRI environmental indicators and their alignment with bioeconomy goals.

**Figure 2**: Distribution of GRI Environmental Indicators by Relevance to Bioeconomy




Similarly, SASB's environmental indicators show 48% full alignment with bioeconomic principles, mainly covering bio-based energy, sustainable sourcing, and waste management, as seen in Table 2. This table categorizes SASB economic indicators into three groups based on their degree of relevance to bioeconomy: Fully Related, Partially Related, and Non-Related. However, 20% of SASB indicators were classified as non-related, indicating that while SASB promotes sustainability, it does not fully integrate bioeconomic-specific reporting frameworks. Figure 3 shows how SASB integrates bioeconomy-related environmental indicators within its sustainability framework.

**Table 2:** Classification of SASB Environmental Indicators by Relevance to Bioeconomy

| Fully Related Indicators | Relative Related Indicators | Non Related Indicators |
|---|---|---|
| ***AGRO-130a.1:****Use of Renewable Resources and Biomass* | ***CG-440a.1:****Recycling and reuse of packaging* | ***CG-440a.3:****Reduction in waste packaging ending up in landfills* |
| ***AGRO-130a.2:****Managing biodiversity and sustainable sourcing of raw materials* | ***CG-440a.2:****Percentage of recycled materials in product packaging* | |
| ***AGRO-140a.1:****Used to Reduce Environmental Impact of Agricultural Production* | ***NR-110a.1:****Reduction in water consumption and water pollution* | |
| ***CG-130a.1:****Use of Recycled Materials and Natural Raw Materials* | | |
| ***CG-140a.1:****Waste Management and Recycling of Raw Materials* | | |
| ***NR-130a.1:****Use of Biomass for Energy Production* | | |
| ***NR-110a.2:****Implementation of Circular Water Management Systems* | | |

**Figure 3**: SASB and Bioeconomy - Environmental Indicators

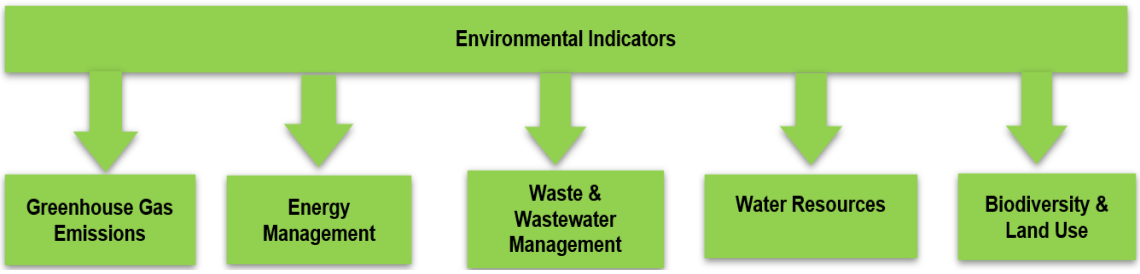
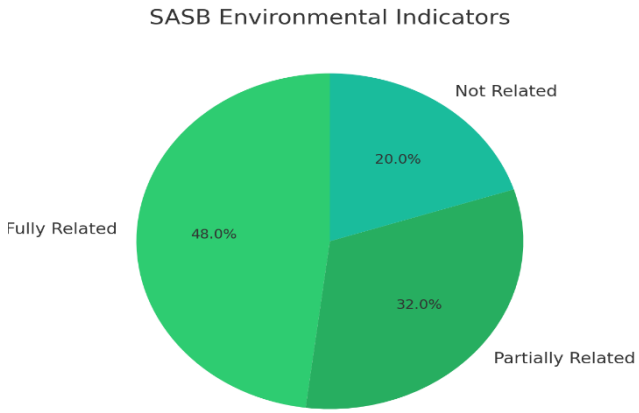



Figure 4 provides a visual representation of how SASB's environmental indicators align with bioeconomic principles.

**Figure 4**: Distribution of SASB Environmental Indicators by Relevance to Bioeconomy



*3.2 Economic Indicators*

From an economic perspective, the analysis focuses on whether financial indicators capture investments in bio-based industries, sustainable supply chains, and climate-related financial risks, as seen in Table 3.

**Table 3:** Classification of GRI Economic Indicators by Relevance to Bioeconomy

| Fully Related Indicators | Relative Related Indicators | Non Related Indicators |
|---|---|---|
| ***201-2:*** *Financial implications and other risks and opportunities due to climate change* | ***201-1:*** *Direct economic value generated and distributed* | ***201-3:*** *Coverage of the organization's defined benefit plan obligations* |
| ***203-1:*** *Development and impact of infrastructure investments and services* | ***202-2:*** *Ratio of basic salary and remuneration of women to men* | ***201-4:*** *Financial assistance received from government* |
| ***204-1:*** *Proportion of spending on local suppliers* | ***203-2:*** *Significant indirect economic impacts* | |

Findings indicate that 40% of GRI's economic indicators are fully aligned with bioeconomy principles, particularly in areas such as sustainable procurement (GRI 204-1) and infrastructure investment (GRI 203-1). However, 20% of economic indicators were unrelated, highlighting a lack of financial performance tracking for bio-based industries.

Figure 5 highlights how GRI's economic indicators align with bioeconomic principles, focusing on areas such as sustainable procurement and infrastructure investment.

**Figure 5:** GRI and Bioeconomy - Economic Indicators

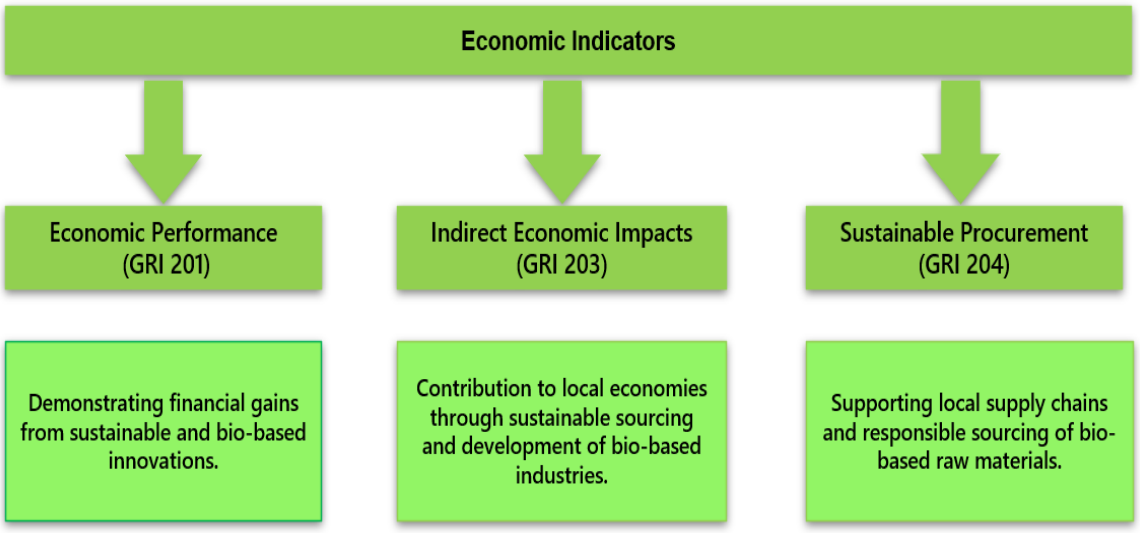
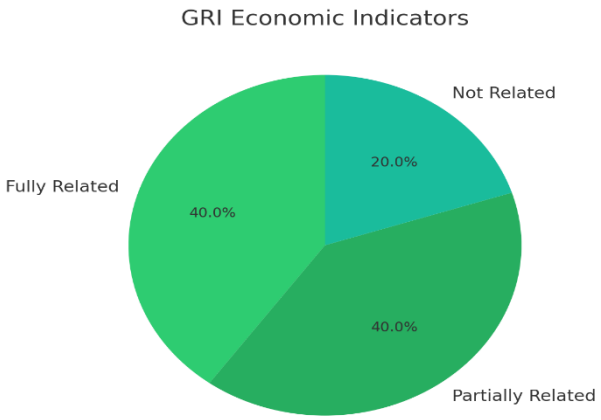



Figure 6 visually represents the distribution of GRI economic indicators in relation to bioeconomy goals.

**Figure 6:** Distribution of GRI Economic Indicators by Relevance to Bioeconomy




The SASB framework presents similar trends, with 36% of economic indicators fully aligned with bioeconomy goals, as seen in Table 4.

This table categorizes SASB economic indicators into three groups based on their degree of relevance to bioeconomy: Fully Related, Partially Related, and Non-Related.

**Table 4:** Classification of SASB Economic Indicators by Relevance to Bioeconomy

| Fully Related Indicators | Relative Related Indicators | Non Related Indicators |
|---|---|---|
| ***AGRO-130a.3:****Revenue from products certified as sustainable or renewable.* | ***CG-130a.3:****Total energy consumed* | ***CG-440a.1:****Description of environmental and social risks associated with sourcing priority raw materials.* |
| ***AGRO-130a.4:****Investments in circular economy and bio-based supply chains* | ***NR-140a.1:*** *Total water withdrawn* | ***CG-440a.2:****Percentage of raw materials third-party certified to an environmental and/or social sustainability standard, by standard* |
| ***CG-140a.2:****Financial impacts of climate-related opportunities, such as bio-based innovations* | | ***CG-440a.3:****Percentage of raw materials third-party certified to an environmental and/or social sustainability standard, by standard* |
| ***NR-130a.2:****Value of sustainable procurement programs aligned with bioeconomy principles* | | ***NR-110a.2:****Amount of gross global Scope 1 emission* |
| ***NR-140a.2:****Revenue generated from renewable or recycled materials.* | | |

Key indicators such as AGRO-130a.3 (Revenue from bio-based products) directly measure bioeconomic financial contributions, whereas 36% of SASB economic indicators were classified as non-related, emphasizing the need for improved financial reporting mechanisms within the bioeconomy sector.

**Figure 7:** illustrates how SASB integrates bioeconomy principles into its economic reporting.

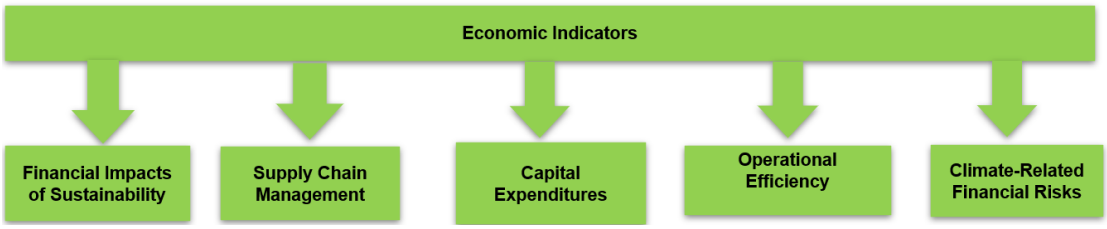
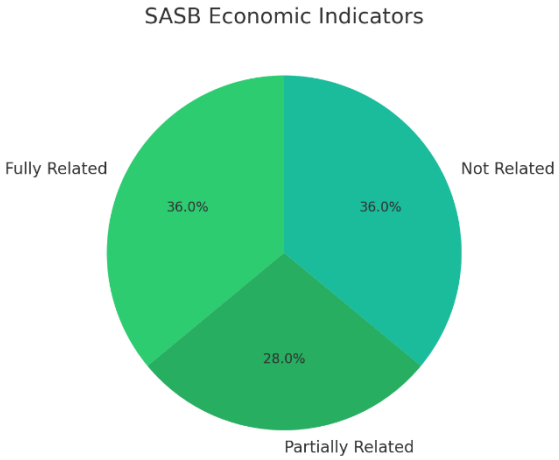



**Figure 7**: SASB and Bioeconomy - Economic Indicators

Figure 8 presents the distribution of SASB economic indicators and their alignment with bioeconomy goals.

**Figure 8:** Distribution of SASB Economic Indicators by Relevance to Bioeconomy




The classification of indicators as fully related, partially related, or non-related provides valuable insights into the existing gaps in non-financial reporting frameworks. While both GRI and SASB contribute significantly to bioeconomic sustainability, their current methodologies lack a structured framework for dedicated bioeconomic performance evaluation. The absence of specific bioeconomy metrics means that many sustainability indicators do not explicitly track the financial and environmental impacts of bio-based innovations, reducing their effectiveness in policy formulation, investment strategies, and corporate accountability.

## 4. Conclusions

The findings of this study demonstrate that while GRI and SASB frameworks contribute to sustainability reporting, they lack dedicated metrics to measure bioeconomic contributions comprehensively. The environmental analysis shows that while a significant portion of indicators support bioeconomy goals, there is still a considerable percentage of non-related indicators, highlighting gaps in tracking bioeconomic performance. Similarly, the economic analysis reveals that while some financial indicators align with bioeconomy principles, many do not effectively capture bio-based economic activities and sustainable investment flows.



These findings suggest the need for enhanced reporting mechanisms that incorporate specific bioeconomic performance indicators. Policymakers should consider developing a standardized bioeconomy reporting framework that integrates both environmental and economic dimensions, ensuring a more accurate assessment of bioeconomic progress. Moreover, GRI and SASB should refine their reporting models to include more quantifiable bioeconomic indicators, enabling corporations and investors to make informed decisions based on sustainable financial and environmental performance.

In conclusion, while GRI and SASB offer valuable sustainability reporting tools, their lack of bioeconomy-specific indicators limits their ability to fully capture the environmental and financial impacts of bio-based industries. The development of a dedicated bioeconomic reporting framework is essential to enhance corporate transparency, drive sustainable investment, and accelerate the transition toward a circular, bio-based economy. Future research should also focus on the relevance of social reporting indicators to bioeconomy, so as all the three pillars of sustainability are tested.

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# Forest Management Public Organizations and the adoption of ESG reporting: challenges and barriers

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**Abstract**

Public Sector Sustainability Accounting and Reporting is a subdiscipline in the broader Sustainability academic field, which seems to exist under the radar of its private organizations counterpart. Forests around the world, either private, or public, are usually controlled by the Public Administrations, namely Public Forest Service. Environmental, Social, and Governance (ESG) frameworks promise to enhance accountability in all organizations. However, there is little research in the literature about the intersection of public forest service and ESG reporting. Thus, the present research tries to understand the challenges of using this type of reporting in the Public Forest Administration, and the consequences it may have for sustainable forest management practices, and the resilience of forest ecosystems. Moreover, it examines the barriers that hinder these organizations to adopt such a reporting framework. To address these issues, the research analyses follows the methodology of in-depth interviews with managers of Public Forest Services from ten countries. The findings reveal that the current state of ESG adoption is rather low, and highlight gaps in criteria and implementation. The need for integrated, adaptable and transparent frameworks is underlined, supported by collaborative approaches prioritizing stakeholder participation, capacity building and knowledge sharing. Finally, the problem of financial and resource constraints is discussed.

***Keywords:*** *stakeholder theory, ESG, Forest Service, public sector accounting and reporting.*

**JEL Codes**: H83; O13; Q01; Q23; Q56; Q57

# Session 7
# Novel Research Activities

# Investigating How Extreme Events Trigger Nexus Effects and Developing a Nexus Methodological Framework to Increase Resilience

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**Abstract**

Climate change is already increasing the frequency and intensity of extreme events, significantly impacting human societies wellbeing and resilience. This is particularly exacerbated by trends in population growth, urbanization, and land use changes, which often increase the vulnerability and exposure of human systems. In addition, the complexity of modern human systems, such as the interconnectedness of critical entities that support them, makes urban settings especially susceptible to domino effects triggered by a single initial shock. The aim of this study is to understand and assess the Nexus effects of extreme events related to climate and other natural hazards, such as earthquakes, volcanoes, and tsunamis. An extended Water-Energy-Food Nexus schema is considered, incorporating Ecosystems, Climate, Soil, Transportation, Land Use, Health, and Information and Communication Technologies. The analysis synthesizes practical case studies of actual extreme events that have occurred over the last few decades, primarily in Europe. It considers the implications across three timescales: short-term, mid-term, and long-term. This study employs a modified Nexus-oriented literature review approach, examining nine different types of extreme events, i.e. droughts, earthquakes, floods, heatwaves, landslides, tornadoes, tsunamis, volcanoes, and wildfires. A minimum of three case studies is analyzed for each type of extreme event. For each case study, the Nexus tree approach is applied. The synthesis of the Nexus trees for each extreme event will create the Nexus signature of that specific event. Based on these signatures, an inventory of recommendations for decoupling the nexus interlinkages will be developed. These recommendations will be categorized into operational, tactical, and strategic levels, corresponding to the three impact horizons. Special focus will be given to the implementation of Nature-based Solutions. The ultimate ambition of the NEXUSNET taskforce is to provide tangible tools and capacity to improve urban resilience against climate change-induced and other extreme events.

***Keywords:*** *climate change, wellbeing, resilience, extreme events, urbanization*

**JEL Codes**: Q4; Q25; Q54.

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# Educational Activity to create a Digital Biodiversity Observatory through the Citizen Science Approach

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**Abstract**

Biodiversity and climate change are two concepts inextricably linked since climate change is the main driver of biodiversity loss and biodiversity loss accelerates climate change processes by reducing the ability of ecosystems to absorb CO2 (United Nations). Given that biodiversity is our strongest natural defense against climate change and according to scientists it is being lost worldwide at a devastating rate (IPBES, 2019), there is a need to record its species to find solutions for mitigation and adaptation to climate change. Within the framework of the ARSINOE research project, an Educational Activity was organized with the aim of engaging and raising awareness among students and teachers in the digital collection of plant and animal observations using the MINKA citizen science platform, for the creation of a biodiversity observatory for the Attica region. The entire effort was based on the concept of Citizen Science, that is, the practice of engaging citizens (in our case teachers and students) in scientific research and the collection of important information, which will contribute to the development of scientific knowledge related to the Sustainable Development Goals. Educators and students from 41 Secondary Schools and 1 Primary School in Attica participated in this Activity and managed to collect more than 8,600 observations on the MINKA platform.

***Keywords:*** *biodiversity observatory, citizen science, environmental sustainability, educational activities, climate change, Sustainable Development Goals.*

**JEL Codes:** Q5; Q57

# The role of citizen science in improving the quality of life in cities: an innovative approach established in the MI-TRAP project

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**Abstract**
Air pollution poses a critical challenge to urban environment affecting public health and quality of life. These complex issues require a deep understanding of regional variations in pollution sources and active community involvement to implement place-based mitigation measures. MI-TRAP addresses these challenges linking citizens' engagement methodologies with results from high resolution measurements of air quality parameters, i.e. ultrafine particles and black carbon. Citizen science leverages digital tools to actively engage the public in understanding their role in the Zero pollution strategy. By enabling citizens to identify issues, make observations, and contribute to decision-making, the project fosters trust and transparency, generating valuable data for policymakers to design robust environmental monitoring systems. This paper presents MI-TRAP's citizen engagement methodology, which integrates co-creation activities at different spatial levels. Central to these efforts is an *Online Survey* designed to link citizens' cognitive and mental health responses to air pollution levels for the identification of stressors impacting daily life and well-being, offering actionable insights for mitigation strategies. By bridging public engagement with data-driven solutions, MI-TRAP presents a comprehensive framework for enhancing quality of life. The findings highlight how citizen science can drive inclusive, impactful strategies to address air pollution, fostering healthier and more sustainable cities.

***Keywords:*** *Air pollution; urban environment; citizen science; social innovation; MI-TRAP project.*

**JEL Codes**: O31; O35; O52; Q53; Q55.

# Tackling Environmental Risks with Nature-Based Solutions in EU Policies: Insights from Case Studies across Europe

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**Abstract**

Environmental risks such as floods, droughts, and biodiversity loss pose significant challenges to sustainable development across the European Union. Addressing these risks requires innovative, integrated solutions that align with international policy frameworks, particularly the Paris Agreement and Nationally Determined Contributions (NDCs). In the EU context, this is supported by actions like the European Green Deal and the Biodiversity Strategy for 2030, which aim to reduce emissions, enhance resilience, and protect biodiversity. However, achieving EU climate and biodiversity targets remains challenging due to national and local variations in capacity, priorities, and the need for context-specific solutions. One promising solution is the implementation of Nature-based Solutions (NBS), which are increasingly recognised for their effectiveness in addressing climate and biodiversity challenges. The NATALIE project, part of Horizon Europe, explores the potential of NBS to enhance resilience, social innovation, and deliver multiple co-benefits, such as carbon sequestration, ecosystem restoration, and improved community well-being. This paper highlights key findings, focusing on: (i) examples of NBS addressing climate hazards while promoting resilience and sustainability, and (ii) the opportunities and challenges in integrating NBS into EU policies. Research from thirteen sites across the EU and Iceland provides evidence-based recommendations to scale up NBS adoption. Ultimately, the work aims to encourage policymakers, researchers, and practitioners to integrate NBS into local, national, and EU frameworks for sustainable implementation and long-term ecological and socio-economic stability.

***Keywords:*** *NBS; Nationally Determined Contributions; policies, hazards, NATALIE project.*

**JEL Codes:** O13

# Perspectives on Sustainability for Small-and-Medium-Sized Enterprises in Greece: A Quantitative and Qualitative Analysis

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**Abstract**

This research investigates the sustainability landscape of Greek small-and-medium-sized enterprises (SMEs), with a primary focus on the perceived enablers and barriers affecting sustainability practices. Utilizing a combination of quantitative and qualitative methodologies, we assess the economic, environmental, and social impacts of sustainability efforts in Greek SMEs. Insights from 124 SMEs via structural equation modeling (SEM), coupled with detailed case studies and interviews, provide a well-rounded understanding of the factors driving and hindering sustainability. The study reveals significant relationships between pressures/barriers and practices, as well as between supply chain sustainability practices and performance of Greek SMEs. A main finding of the conducted research is the presence of various patterns, which are subject-specific to the various sub-constructs of sustainability (i.e. environmental, social and economic sub-constructs). The findings serve as a significant resource for policymakers and SMEs owners/managers in Greece aiming to enhance sustainable performance.

***Keywords:*** *SMEs, Greece, Sustainability.*

**JEL Codes:** Q56; C31; C83.

## 1. Introduction

In Greece, SMEs account for a substantial majority of employment and value creation, with figures that surpass the European Union averages, making their engagement with sustainability imperative for national objectives. Despite their economic significance, SMEs often face distinct challenges in adopting sustainable practices compared to larger corporations, primarily due to limited resources, less formalized processes, and a lack of strategic frameworks geared towards sustainability (EU, 2018). SMEs often lack the resources and frameworks to effectively implement sustainability practices, which limits their ability to mitigate environmental and social impacts.

This study aims to bridge the knowledge gap by exploring the factors influencing the implementation of sustainability practices among Greek SMEs. The focus is to uncover both the enablers and barriers that shape sustainability trajectories within these enterprises.

The findings from this study aim to be of significant utility not only for scholars and researchers interested in sustainability and SME topics but also for policymakers, SME managers, and owners who are responsible for strategic and operational decisions.

## 2. Literature Review



SMEs represent a significant portion of the business landscape worldwide, contributing to economic growth, innovation, and employment (OECD, 2018). Despite their relevance, research traditionally focused on larger corporations, leaving a gap in understanding the specific sustainability dynamics within SMEs (Dey et al., 2018).

The adoption of sustainable practices in SMEs is influenced by various external and internal drivers. External drivers include regulatory pressures, market demands, and stakeholder expectations (Cambra-Fierro et al., 2011). Government legislation, in particular, has been identified as a prominent factor compelling SMEs to integrate environmental and social practices (Masocha and Fatoki, 2018). Internal drivers often pertain to the organizational culture, values, and leadership within SMEs, with the personal commitment of owners and managers playing a crucial role in initiating and sustaining sustainability efforts (Ghadge et al., 2017).

On the other hand, SMEs face numerous barriers that negatively affect their sustainability efforts. Financial constraints are often presented as a primary challenge, limiting the ability to invest in sustainable technologies and practices (Jabbour et al., 2016). Bureaucratic hurdles and lack of explicit guidelines also pose significant obstacles, particularly in Greece where administrative burdens are prevalent (Ghazilla et al., 2015). Additionally, SMEs often lack the necessary knowledge and expertise to implement effective sustainability strategies, leading them to rely on external consultants for guidance (Vargas-Hernández, 2021).

The link between sustainability practices and performance in SMEs has been extensively explored, with varying results. Studies suggest that while certain practices lead to improved environmental and social performance, their impact on economic performance is less straightforward (Abdul-Rashid et al., 2017). Malesios et al. (2018) argue that specific practices such as lean management and customer relationship initiatives can positively influence economic outcomes, underscoring the need to align sustainability strategies with core business objectives.

## 3. Methodology

### *3.1 Research Objectives*

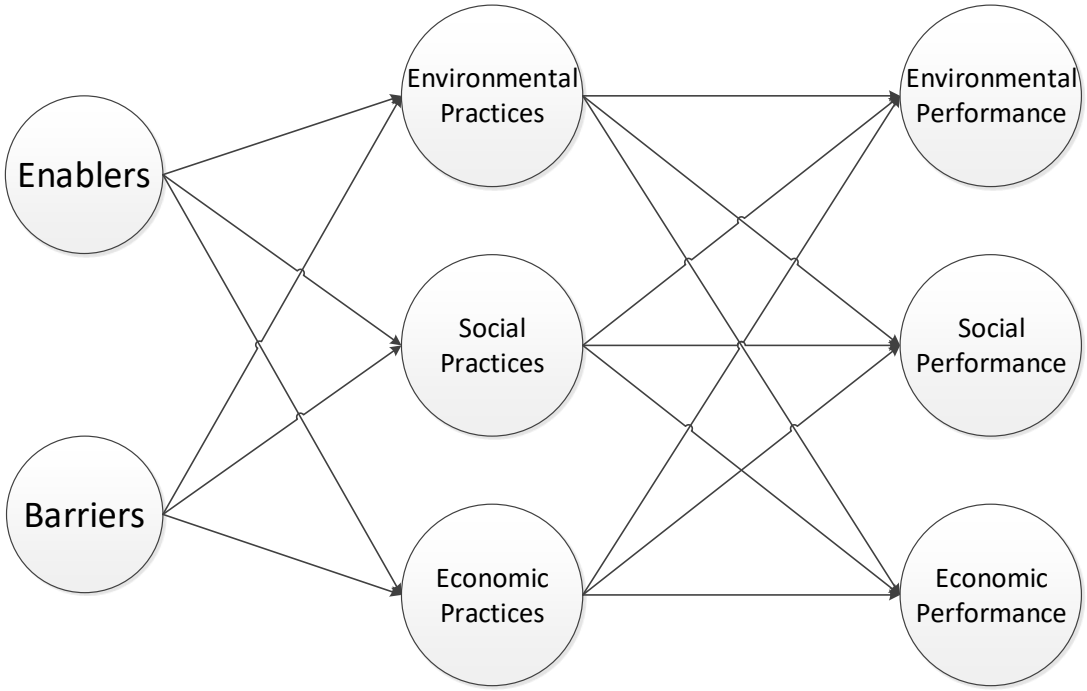
The aim of the study is to provide a holistic understanding of the enablers and barriers affecting sustainability practices across economic, environmental, and social dimensions, using Greece as a case study.

The key research objectives (RO) of this paper are:
**RO1:** Assess the current status of sustainability management in Greek SMEs
**RO2:** Identify drivers and barriers to the adoption of sustainability practices in Greek SMEs
**RO3:** Examine causal relationships among constructs of sustainability
**RO4:** Propose key strategies for effective implementation of sustainability practices in Greek SMEs.

By combining both quantitative and qualitative approaches, this comprehensive set of research objectives allows for a more holistic understanding of the factors influencing sustainability practices in Greek SMEs, ultimately leading to richer insights and more actionable strategies.

The general framework of our approach and followed analysis is described visually in the following figure (Figure 1). Through this diagram we aim to examine the causal relation of enablers and barriers to sustainability practices and performance of SMEs.

**Figure 1.** Research framework for the association between external and internal drivers/barriers with sustainability of SMEs




### *3.2 Qualitative Analysis (Case Studies)*

We conducted detailed qualitative case studies involving face-to-face interviews with owners and managers of selected Greek SMEs. Interviews were semi-structured, allowing for both guided questioning and open-ended responses, thereby capturing the nuanced perspectives

of participants. The case studies aimed to provide deeper insights into the strategic and operational realities faced by SMEs in implementing sustainability practices. More specifically, to gain informative points on the attitudes and perceptions of SME managers and owners towards sustainability practices and performance and identify the most important drivers for the implementation of sustainability practices in SMEs in Greece, as well as barriers that hamper their implementation.

### *3.3 Quantitative Analysis (Data Collection)*

The study adopts quantitative research approach by gathering data from a total number of 124 Greek SMEs. The survey was completed using a structured questionnaire and an on-line survey platform. Certain quotas included in the design of the survey have ensured that the sample collected is representative of SMEs in Greece, including the wide geographical distribution of the collected companies. More than 100 questions utilized for the analysis, measuring all examined aspects (Demographics, Enablers, Barriers, Economic/Environmental/Social Practices, Economic/Environmental/Social Performance). The total questionnaire can be provided upon request. A comprehensive example of the questions is shown below:

**Table 1.** Example of questions presented in the questionnaire

| Enablers | Barriers |
|---|---|
| 1. Requirement from customer<br>2. Non compliance to the regulations lead to the bad reputation<br>3. My competitors in the industry have sustainability | 1. Lack of time to design, implement and monitor sustainability measures<br>2. Financial constraints<br>3. Absence of clear benefits for the firm |

| Practices aspects | Performance aspects |
|---|---|
| **Economic:**<br>1. Have you set certain financial/economic targets for the next period (the next 5 years)?<br>2. Do you seek to hire senior/middle management staff from the local community?<br>3. Do you place significant emphasis on local suppliers and local sourcing? | **Economic:**<br>1. Turnover Growth<br>2. Proportion of spending on local suppliers (%) |

| Practices aspects | Performance aspects |
|---|---|
| **Environmental:**<br>1. Do you keep formal records of the raw materials/associated process materials/semi-manufactured goods-parts used in production?<br>2. Do you utilize recycling materials as inputs in your production processes?<br>3. Do you screen your suppliers using criteria pertaining to environmental management and performance? | **Environmental:**<br>1. Considering your waste production, how efficient would you say is your operation<br>2. Considering your energy consumption, how efficient would you say is your operation |

| Practices aspects | Performance aspects |
|---|---|
| **Social:**<br>1. Do you have an occupational health and safety management system in place?<br>2. Do you promote diversity within the organization and provide equal opportunities to all staff, both current and prospective employees? | **Social:**<br>1. What is the (approximate) amount invested in CSR activities by your company in the last year?<br>2. Do you keep records of health and safety data within the enterprise |

### *3.4 Quantitative Analysis (Statistical Analysis and Methods)*

The quantitative data were analyzed using Structural Equation Modeling (SEM) as outlined by Bollen (1989). This is a robust statistical technique that enables the examination of complex relationships between observed and latent variables. SEM was chosen for its ability to model multiple relationships simultaneously and to assess the direct and indirect effects of enablers and barriers on sustainability practices.

We assessed the reliability and validity of the latent factors to ensure robust estimates. Reliability was tested using Cronbach's alpha, where a value greater than 0.6 is considered acceptable. Convergent validity was verified by calculating the percentage of total variance explained by the factors, with a value exceeding 50% indicating adequate validity. The SEM models were estimated using AMOS software (Arbuckle, 2006).

## 4. Results

### *4.1 Results of Qualitative Case Studies analysis*

The basic information on the selected companies is provided in Table 2

**Table 2.** Basic characteristics of the selected SMEs

| Case studies | Year of establishment | Main activities | Sector |
|---|---|---|---|
| SME 1 | 2002 | Wine company | Processing, Trading |
| SME 2 | 1994 | Dairy products industry | Processing |
| SME 3 | 1974 | Production and trade of sugar | Manufacturing |

SME 1 has experienced significant financial growth over the last decade. They emphasize environmental sustainability, notably by reducing energy and water consumption, implementing LED lighting, developing photovoltaic panels, and recycling glass. Their occupational health and safety standards are high, supported by extensive employee training. They comply with all safety regulations and hold notable certifications, including ISO 9001 and NSF.

SME 2, a family-run business with a 20% growth and 132 employees. The company prioritizes recycling and waste management, aiming for a 10% annual reduction in organic waste. Health and safety standards are high, with significant employee involvement in hazard identification. They hold certifications such as ISO 9001, ISO 14001, IFS, and BRC.

SME 3 experienced a downturn of 15-20% in the previous year. They emphasize low energy and water consumption, over 50% of their waste is reprocessed. Health and safety standards are average, with previous non-compliance leading to fines. The company invests a significant amount in corporate social responsibility activities. Overall, the SMEs exhibit varying levels of financial performance and commitment to sustainability, with a shared focus on health and safety standards and employee training.

The major findings from case studies are significantly revealing. In terms of **Economical Practices/Performance**, funding for SMEs in Greece is a priority, however there are specific problems and challenges that constitute the acquiring of funding and successful completion of

financed projects problematic, mainly due to issues related to bureaucratic bottlenecks and administrative burden faced by SMEs in applying these projects (RO1). Spending's of SMEs on local suppliers is quite low. This barrier constitutes a major issue and problem since they are struggling to find local suppliers and most of the time resort to suppliers further distant apart (RO1). Economic crisis taken place in the country has large negative impacts in the financial performance, however during the last years there have been positive indications of stabilization in their financial results and even increases in turnover and profits of SMEs



In terms of **Social Practices/Performance**, the selected Greek SMEs tend to focus more on occupational safety than on health promotion. The main reasons for this are lack of economic resources along with insufficient information on health promotion. Although most of Greek SMEs are aware of and receive certifications such as ISO 9001, the general sense on behalf of the managerial staff in these companies is that their customers are not interested in certifications.

In terms of **Environmental Practices/Performance,** qualitative analysis indicated that selected Greek SMEs are currently struggling with improving their efficiency regarding waste management and disposal in an environmentally friendly way. Waste handling is an issue that requires further improvement (RO2). The average waste reduction rate year by year on these companies is constantly less than 10%. However, although on average only a poor 20% of waste is separated by the company for recycling, there is also an optimistic view that indicates progress towards efficient handling of wastes due to the reporting of approximately 35% of reprocessing of waste and further utilized within the business. Regarding energy consumption and efforts to reduce it, SMEs in Greece are mainly focused on make savings through efficient LED lighting and the installation of photovoltaic (PV) cells in the rooftops of the company's premises (RO1). Finally, SMEs seek to achieve adequate environmental performance in various ways, for instance are certified with several environmentally friendly certifications (e.g., BRC, IFS, No genetic Modified Products).

### *4.2 Results of Quantitative SEM analysis*

A total number of 124 Greek SMEs were analyzed in the study. The major characteristics of the SMEs are presented in the following Table (Table 3).

The calculated measures for checking validity and reliability of any constructed factor for the hypothesized model, show that the factors satisfactorily meet the reliability and validity requirements, so all latent constructs are suitable for further analysis through SEM modelling (Table 4).

**Table 3.** Major characteristics of SMEs

| **Sector** | **N** | **%** |
|---|---|---|
| Manufacturing | 17 | 13.7% |
| Financial services | 12 | 9.7% |
| Other services including IT and consultancy | 26 | 21.0% |
| Construction, contracting and building management | 9 | 7.3% |
| Energy | 8 | 6.5% |
| Logistics and transportation | 9 | 7.3% |
| Leisure, hotels and restaurants | 8 | 6.5% |
| Education | 14 | 11.3% |
| Medical and pharmaceutical | 10 | 8.1% |
| Environmental Management | 3 | 2.4% |
| Trading | 8 | 6.5% |
| **No of Employees** | **N** | **%** |
| 0-10 | 49 | 39.5% |
| 11-50 | 0 | 0.0% |
| 51-100 | 16 | 12.9% |
| 101-250 | 59 | 47.6% |
| **Position/Role** | **N** | **%** |
| CEO | 11 | 8.9% |
| General Manager | 26 | 21.0% |
| Director | 24 | 19.4% |
| Owner | 35 | 28.2% |
| President | 10 | 8.1% |
| Vice President | 1 | 0.8% |
| Full time employee | 14 | 11.3% |
| Other | 3 | 2.4% |
| **Family Business** | **N** | **%** |
| Yes | 41 | 31.1% |
| No | 83 | 66.9% |
| **Total** | **124** | **100.0%** |

**Table 4.** Reliability and validity measures for factors

| Factor | Cronbach's α | % of explained variance |
|---|---|---|
| **Enablers** | 0.902 | 56.39 |
| **Barriers** | 0.856 | 58.16 |
| **Economic Practices** | 0.894 | 61.53 |
| **Environmental Practices** | 0.959 | 67.39 |
| **Social Practices** | 0.958 | 74.93 |
| **Economic Performance** | 0.524 | 48.29 |
| **Environmental Performance** | 0.884 | 81.17 |
| **Social Performance** | 0.486 | 50.87 |

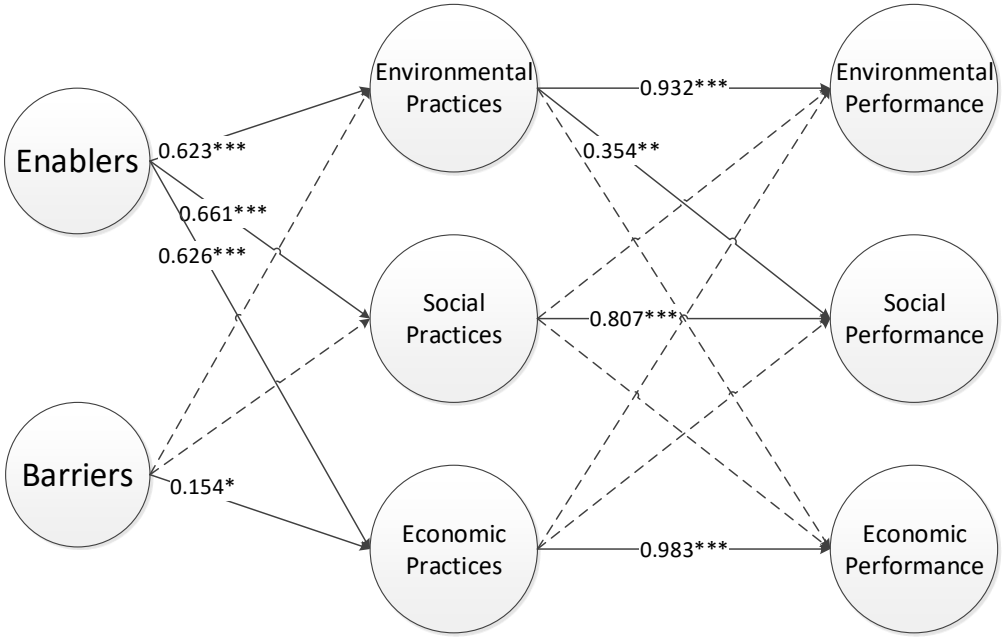
Goodness-of-Fit (GoF) measures for SEM results reveal satisfactory fits for all models, considering that all measured values exceed or approach the desired values (Table 5).

**Table 5.** Goodness-of-Fit (GoF) measures for all models

| **GoF measures** | | | |
|---|---|---|---|
| **RMR** | **GFI** | **AGFI** | **PGFI** |
| 0.096 | 0.973 | 0.971 | 0.913 |

Regarding the results of SEM and the fit of the hypothesized model structure on the Greek SME data (Figure 2), we observe the superiority of External and Internal Enablers as moderators of Sustainability Practices, whereas moderate associations or no associations are observed between the Barriers factor and Sustainability Practices. Statistically significant positive connections were presented between Environmental Practices and Environmental Performance, Social Practices and Social Performance and Economic Practices and Economic Performance. However, no other associations are present with only exception the relationship between Environmental Practices and Social Performance.

**Figure 2.** SEM results for the Greek SMEs (------ non-statistically significant association).
*(*) 10% level of significance; (**) 5% level of significance; (***) 1% level of significance*




## 5. Discussion & Conclusions

The case study findings highlight key aspects of sustainability management in Greek SMEs (RO1) and the barriers they face in adopting sustainable practices (RO2). Economically, SMEs struggle with bureaucratic obstacles in securing funding and rely on distant suppliers due to a lack of local options. However, financial performance has shown signs of stabilization in recent years. Socially, occupational safety is prioritized over health promotion due to financial constraints, and while many SMEs obtain certifications, customer interest remains low. Environmentally, waste management efficiency is a challenge, though some progress is observed in waste reprocessing (RO2). Energy-saving efforts focus on LED lighting and photovoltaic installations, with SMEs also pursuing various environmental certifications (RO1).

The quantitative analysis using Structural Equation Modeling highlights the significant role of both external and internal enablers in fostering sustainability practices in Greek SMEs (RO1). The findings highlight the significant role of both external and internal enablers in fostering sustainability practices. External factors, particularly regulatory pressures and market demands, emerge as pivotal catalysts driving sustainability adoption (RO2). These findings align with previous research (e.g., Cambra-Fierro et al., 2011; Masocha and Fatoki, 2018) that emphasizes the influence of government policies and consumer preferences in steering SMEs towards sustainable practices. Additionally, internal enablers such as leadership commitment and organizational culture are identified as equally crucial. Furthermore, the analysis reveals key causal relationships among constructs of sustainability (RO3).

The positive correlations between specific sustainability practices and their respective performance indices, as identified in the SEM analysis, provide valuable insights into the potential benefits of sustainability integration. Environmental practices are strongly associated with improved environmental performance, highlighting the efficacy of targeted initiatives such as waste management and energy efficiency in achieving ecological goals. However, the weaker associations between cross-dimensional practices (e.g., economic and environmental performance) suggest that holistic approaches are necessary for maximizing overall business performance. Similar findings reported by Abdul-Rashid et al. (2017) and Malesios et al. (2018) suggest that blended strategies encompassing multiple sustainability dimensions may yield more robust outcomes. Building on these insights, the study proposes key strategies for the effective implementation of sustainability practices in Greek SMEs (RO4).

In conclusion, this research underscores the critical role of both enablers and barriers in shaping sustainability practices among Greek SMEs. The combined analyses offer several strategic implications for policymakers and SME managers. Policymakers should streamline regulatory processes, reduce bureaucratic burdens, and provide targeted regional support to foster equitable sustainability growth across all areas. SME managers/owners in Greece looking to enhance sustainability within their organizations should focus on aligning sustainability initiatives with their core business strategies to achieve tangible performance benefits. Limitations of the study include potential biases in self-reported data and the challenges in generalizing findings beyond the Greek context. However, the multi-method approach mitigates some of these limitations by providing a rich, triangulated dataset.

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# Session 8:
# Quantitative Methods in Environmental Economics & Management

# Natural resource management under deep uncertainty and congestion costs: Simultaneous versus serial dictatorship management

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**Abstract**

In this paper, we explore the problem of resource allocation with explicit resource dynamics, focusing on the allocation of resources from multiple sources to multiple users. The harvesting of the resource is subject to congestion costs, while resource dynamics are characterized by deep structural uncertainty. In this context harvesting agents are ambiguity averse and express concerns for model misspecification. The aim of the research is to study the optimal dynamic management of resources by examining alternative solutions based on simultaneous use of the resource (e.g., extraction, harvesting) by all users, or serial dictarorship harvesting where each user harvests the resource in a predetermined sequence. Simultaneous harvesting implies congestion costs. These costs do not emerge under serial dictaorship harvesting. Simultaneous non cooperative harvesting is determined as a feedback Nash equilibrium of a minmax problem through the solution of a Hamilton-Jacobi-Bellman-Issacs (HJBI) equation for a linear-quadratic differential game. Simultaneous cooperative solutions are obtained by the solution of the corresponding HJBI equation. Serial dictorship harvesting solutions are obtained by serial optimization of the corresponding HJBI equations. The advantage of the serial dictatorship solution is that it is free of congestion costs. Its disadvantage is that it cannot be obtained in a direct way as a cooperative solution. We remedy this disadvantage by developing an innovative regulatory framework in which serial dictatorship harvesting paths under ambiguity aversion and model misspecification concerns, can be identical with cooperative harvesting paths without congestion costs.

***Keywords:*** *Natural resource management, optimal dynamic management, uncertainty*

**JEL Codes:** O13

# The Influence of European Environmental Policies towards Carbon Neutrality: A Quantile Analysis of Green Technologies and Policy Effectiveness

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**Abstract**

We develop a conceptual framework to study the influence of green technologies and policy effectiveness across tiers of carbon emissions' productivity in the EU-28 over 2010-2019, a quite vibrant and fruitful period of efforts to set the scene for climate neutrality. Econometric results indicate that climate change policy action via assimilation of national policies exhibits asymmetric impact across tiers, especially for low performers. Evidence from a panel quantile estimator showcases that green fiscal policy via energy taxes is not a precondition for climate-neutrality. Green technologies promote progress, across tiers, pinpointing that governments need to further incentivize the use of clean energy and eco-innovation to achieve carbon neutrality. Furthermore, we investigate the unexplored so far, impact of environmental policy performance, to find that effective auditing of environmental policies paves the way towards successful transition. This study contributes to SDGs 7, 8, 9, 12, 13 and 16.

***Keywords:*** *European environmental policy & climate change; Climate neutrality; Green policy & Green Technology; Sustainability; Europe*

**JEL Codes**: C50, O52, Q55, Q56, Q58.

# Probability Oriented Environmental Data Analysis: Comparing Athens and Thessaloniki

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**Abstract**

The target of this paper to offer a Probability Oriented Study on the main air pollutants in the main two industrial Greek cities in Athens and Thessaloniki. As the number of observations is big enough the Normal distributions could be useful choice. We decided to work with more distributions, to see how well fit the collected data per year, which have as a basis the Normal distribution. Among the candidate distribution are the generalized Gaussian, $gG(x;\ \mu,\sigma,p)$ with $\mu$ the position parameter $\sigma$ the scale parameter, $p$ the shape parameter $gG(x;\ \mu,\sigma,p) = \left[2\Gamma\left(1+\frac{1}{p}\right)A(p,\sigma)\right] - 1\ exp\{-|A(p,\sigma)| - p\ |x-\mu|p\}$ and $A(p,\sigma) = \sigma\left[\Gamma\left(\frac{1}{p}\right)\Big/\Gamma\left(\frac{3}{p}\right)\right]^{\frac{1}{2}}$ $:= \sigma T(p)$. The exponential power $eP(x;\ \mu,\alpha,\beta)$ with $\mu$ the mean, $\alpha > 0$ the shape parameter, $\beta$ the scale parameter and $eP(x;\alpha,\beta) = \frac{\alpha}{\left[2\beta\Gamma\left(\frac{1}{\alpha}\right)\right]}\ exp[\beta - \alpha\ |x-\mu|\alpha]$ and $\beta = \frac{\sigma[T(p)]}{2}$.

Despite these two generalizazion, which are very similar, the $\gamma$-order Generalized Normal distribution, emerged from Logarithm Sobolev Inequalities (LSI) and offers a physical extension of the existent multivariate Normal distribution. Therefore, it is adopted as the shape parameter $\gamma$ haw the ability to offer with particular values, fat tailed distributions, which is a common characteristic in many pollutants.

***Keywords***: *pollutants, air pollution; Greece*

**JEL Codes**: Q5; Q53

# A configurational approach to eco-innovation and innovation performance relationship: Does size matter?

**George Koutsouradis[1], Kostas Kounetas[1] & Kostas Tsekouras[1]**

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**Abstract**

This research fills the gap, identified in the extant literature, regarding the relationship between eco-innovation and innovation performance employing the Fuzzy Set Qualitative Comparative Analysis (fsQCA) approach within the configuration theory framework. We analyse data from 2,123 innovative Manufacturing firms across eight European countries. The results highlight how the combination of product and process eco-innovations, and the firm's internal and external knowledge sources lead to high innovation performance. Configurations vary significantly with firm size. Small firms benefit from simultaneous engagement in product and process eco-innovation when supported by innovation collaborations. Medium firms benefit from comprehensive investments in their internal knowledge base combined with eco-innovations. Large firms benefit from product eco-innovation combined with R&D investments. This research provides useful insights into the use of eco-innovation to achieve high innovation performance and offers eco-innovation strategies for managers focusing on sustainable business practices.

***Keywords:*** *Eco-innovation; knowledge base; innovation performance; firm size; fsQcA; innovation laggard European countries.*

**JEL Codes:** O3; O32

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# Ecologically Optimal Quantities Extraction. Conflicting cases.

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**Abstract**

Analyzing the issues of extraction of environmental resources for developed and developing countries has become an important multidisciplinary topic. Since the design of efficient action against environmental degradation has to consider the intertemporal response of the whole society, dynamic modeling can be used as an appropriate tool. This work uses Nash and Stackelberg differential game solutions to explore strategic interactions. For the Nash equilibrium, it is found that in establishing the cyclical strategies during the game between the exploiters on the one hand and the benevolent social planner on the other, the discount rate of the exploiters is required to be greater than the discount rate set by the planner. That is, exploiters must be more impatient than the social planner. In the case of the hierarchical setting, the analytical expressions of the strategic variables and the steady state value of the environmental approval are important outcomes of this study. We find the analytical expressions of the reward functions, implemented by policymakers an easier task. Finally, we can show the conditions under which conflict is more intensive in the two cases of equilibrium, according to the shadow price of the environmental damages.

***Keywords:*** *Differential games, Environmental degradation, Nash game, Stackelberg game.*

**JEL Codes:** O44, Q56, Q58

# Session 9
# Health and Unexpected Events

# Unraveling the Future: Forecasting Unexpected Natural Disasters in the Mediterranean and Balkan Region Amid Climate Change

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**Abstract**

In recent years, the world has witnessed an alarming increase in the frequency and intensity of unexpected natural disasters, such as floods, wildfires, earthquakes and severe storms. Trend analysis reveals a disturbing link between climate change and the rising incidence of such catastrophes, with regions once deemed relatively safe now becoming vulnerable to environmental upheaval. Notably, extreme rainfall in parts of Western Europe and intensified drought conditions in the Mediterranean have disrupted local economies and posed significant risks to public safety. As meteorological predictions suggest that the trend will continue, with an expected increase in the severity of these disasters, it is crucial for policymakers and communities to prioritize robust disaster preparedness strategies and promote sustainable practices to mitigate future impacts. Our first attempt focuses on comparing prior decades to the current, primarily suffering decade, as well as comparing different regions of the world. Furthermore, in terms of both occurrence and loss, trend analysis demonstrates the severity of the current climate disaster. We hope to shed insight on the Mediterranean and Balkan regions by examining populations that have been seriously traumatized by recent natural disasters, such as Ianos, Daniel, Elias, Boris, Kirki, and others. Understanding these trends not only aids in forecasting but also emphasizes the urgent need for collective action in addressing the underlying factors contributing to this escalating crisis.

***Keywords:*** *Climate crisis; Unexpected events; Natural disasters; Forecasting.*

**JEL Codes**: C53; C33; O52; O57; Q54.

# Leadership as a Pillar of Change: Pioneering Sustainability Reporting in Healthcare Systems

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**Abstract**

As healthcare systems face increasing sustainability challenges, leadership plays a crucial role in driving transformative change. Effective leaders are essential for integrating sustainability reporting, which aligns operational practices with environmental, social, and governance (ESG) objectives. This article examines how leadership can facilitate this alignment, ensuring operational efficiency and sustainability goals are met. It highlights the dynamic role of leadership in adopting robust sustainability frameworks and embedding ESG principles into healthcare systems. Furthermore, highlights the importance of leadership in fostering a culture of awareness and capacity-building among healthcare professionals, enabling organizations to meet evolving sustainability demands and enhance their long-term resilience and impact. To deepen the understanding of healthcare systems' needs and address the ongoing discourse on sustainable reporting in healthcare, a survey was conducted within the Greek Healthcare System, involving 379 professionals from public and private organizations across various sectors, including administrative, nursing, medical, and technical services. The findings revealed significant gaps in awareness and implementation: 49.3% of respondents were unfamiliar with sustainability reporting, and 57.3% were unaware of ESG criteria within their organizations. Only 3.7% of the surveyed organizations produce sustainability reports, while 26.4% of participants reported awareness of ESG factors. These insights underscore the critical need for leadership to take an active and interactive role in embedding sustainability practices. By setting a clear vision, driving organizational commitment, and engaging stakeholders, leaders can ensure the successful integration of ESG principles and sustainability reporting.

***Keywords:*** *ESG compliance, Healthcare Sustainability, Sustainable reporting, Leadership, Environmental impact*

**JEL Codes**: Q5; Q56

# Virtual Reality Training in Occupational Health and Safety in High-Risk Industries: An Overview of Trends in the Mining and Petroleum Industries

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**Abstract**

The mining & metals sector and oil & gas industry, due to the nature of their business activities, often faces Occupational Health & Safety (OHS) issues of concern. These industries predominantly rely on theoretical/"static" OHS training, as transferring them to real-life conditions is often infeasible. Virtual Reality (VR) technology has emerged as a secure and innovative solution, offering immersive and interactive training in environments that are otherwise too dangerous or complex to replicate. This study investigates the application of VR technology in OHS training across all Greek companies in the mining and petroleum industries. The findings indicate that VR has been sporadically implemented, with only three (3) out of twenty-seven (27) companies reporting occasional use, primarily through external providers. However, these VR environments did not depict familiar spaces of the interested companies. The absence of tailored training scenarios and the lack of alignment with each company-specific OHS frameworks present significant barriers to the broader adoption of VR in these industries.

***Keywords:*** *Virtual Reality Training, Occupational Health and Safety, Modern Tools*

**JEL Codes**: M14; M53; O14

# Enhancing Mental Resilience of Employees in Supportive Frameworks for Vulnerable Populations

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**Abstract**

Mental resilience is a critical factor for employees providing services to vulnerable populations, as they are often exposed to high levels of stress and emotional strain. This qualitative study aims to explore strategies to enhance the mental resilience of employees working in supportive environments for vulnerable groups. It also examines the role of internal and external support mechanisms, as well as collaboration with third parties, such as helplines and other professionals. The research is based on interviews and qualitative analysis, aiming to capture the experiences and challenges faced by employees in these sectors. Factors that enhance their resilience will be analyzed, including support from colleagues and management, the development of coping mechanisms, and the use of external support services. Additionally, the study will investigate the dynamics of collaboration and communication with third parties and their role in managing occupational stress and empowering employees. The study's findings are expected to offer significant recommendations for the design of supportive frameworks that strengthen the mental resilience and well-being of employees, thereby contributing to the improvement of service quality for vulnerable populations.

***Keywords:*** *Mental resilience, employees, vulnerable populations, supportive frameworks, coping mechanisms, occupational stress, collaboration, external stakeholders, helplines*

**JEL Codes**: I12; I31; I38; J28; J81; M54; Z13.

## 1. Introduction

Professionals working with vulnerable populations, such as refugees and those in crisis, are often exposed to stressful situations that may affect their emotional and work well-being. According to the American Psychological Association (APA), the concept of mental resilience refers to the process of overcoming and adapting challenging situations, characterized by mental, emotional, and behavioral flexibility in responding to both external and internal demands. According to Duchek (2019), resilience is not a trait someone is born with, but rather a dynamic process that can be cultivated through proper organizational frameworks and support systems. Employees in humanitarian roles often work in stressful environments that can lead to empathy fatigue, institutional inadequacies, and heavy workloads that are further intensified by the challenges of engaging with diverse and vulnerable populations (Luthar et al., 2000).

This study aims to explore the ways to enhance mental resilience among employees in such roles by implementing qualitative research. Qualitative methods allow for a deeper understanding of individuals' experiences, coping mechanisms, and perceptions, as highlighted by Braun and Clarke (2006). Stokar et al. (2014) also showed the importance of peer support and training programs in resilience building, while Hobfoll et al. (2018) emphasized that resilience can be strengthened when organizations provide sufficient emotional and professional support.

The purpose of this research is to identify gaps in existing cooperation practices and propose actions for creating environments that foster mental resilience among employees working with vulnerable populations.

## 2. Literature Review

The challenges of enhancing mental resilience among employees, especially those working with vulnerable populations, such as refugees, are very often discussed in operational and social psychology. Resilience is defined as the capacity to adapt effectively to adverse and stressful environments through a combination of emotional, mental, and behavioral strategies (American Psychological Association, n.d.). In high-pressure environments, where employees frequently interact with populations at risk, it is important to understand mental resilience in order to achieve both individual well-being and organizational success.

Resilience is not a personal trait; it is influenced by external parameters such as interactions with the environment, social resources, and coping strategies (Elo & Kyngäs, 2008). According to Braun and Clarke (2006), workplace culture holds a significant role in fostering mental resilience since it may be influenced by colleagues' dynamics, management support, and access to counseling or training.

In addition, coping strategies are essential to building resilience. Elo and Kyngäs (2008) showed that employees often rely on both personal strategies and organizational support systems to handle work stress. Moreover, peer support has been identified as a key factor in supporting employees to navigate through emotional and work adversities.

However, as Braun and Clarke (2006) noted, there are main gaps in the training and resources provided by the organizations. Many training programs often focus on theoretical coaching, omitting hands-on strategies, practical simulations, and tailored coping mechanisms to address the unique challenges faced by the employees. Incorporating resilience-building programs focused on real-world scenarios with role rotation, enhanced communication protocols, and access to psychological support could greatly improve the effectiveness of these interventions (Elo and Kyngäs, 2008).

Especially for organizations that assist vulnerable populations that may face language barriers and cultural differences, organizational support cannot rely solely on existing, pre-

defined training. Considering the complexity of the operations of such organizations, usually supported by the government, NGOs, or volunteers, bureaucracy and idealized expectations may create additional stress (Vaismoradi, Turunen, & Bondas, 2013).

Considering the importance of mental resilience and the gaps in organizational training and support, this research attempts to highlight the importance of organizational support and tailored interventions in order to foster resilience among employees working with vulnerable populations. By addressing the gaps identified in the literature, such as training and external collaborations, organizations may create a more supportive environment that enhances both employee well-being and organizational outcomes.

## 3. Methods and Data

Research Design

This study employs a qualitative research design to explore the factors that enhance the mental resilience of employees working with vulnerable populations. The qualitative approach is particularly suited to capturing the depth and richness of participants' lived experiences, providing detailed insights into their coping mechanisms and the support systems that assist them. This method aligns with Braun and Clarke's (2006) emphasis on the importance of thematic analysis in qualitative research for uncovering complex human experiences. By focusing on narratives and perceptions, the study's approach aligns with its objective to identify actionable strategies for improving resilience frameworks.

Data Collection

The primary method of data collection was semi-structured interviews, designed to elicit open and reflective responses from participants. This format ensured a balance between guided inquiry and the flexibility to explore emerging themes. Participants were selected based on their direct experience in roles supporting vulnerable populations. Elo and Kyngäs (2008) highlight the importance of ensuring that participants have relevant experience to provide reliable and valid insights into the phenomenon under investigation. Inclusion criteria required participants to have a minimum of one year of professional experience and a willingness to discuss their challenges, coping strategies, and the support mechanisms they utilized.

The interview protocol included questions about sources of workplace stress, personal and organizational coping strategies, experiences with management and peer support, and suggestions for enhancing existing frameworks. Ethical considerations were paramount throughout the study, with all participants providing informed consent. Confidentiality and anonymity were rigorously maintained to ensure the ethical integrity of the research process, adhering to best practices for qualitative inquiry. The study protocol was approved by the relevant institutional review board.

Data Analysis

The analysis process combined thematic content analysis with word cloud visualization to comprehensively interpret and present the data. Interviews were transcribed verbatim to preserve the authenticity of participants' narratives. Braun and Clarke's (2006) framework for thematic analysis guided the coding process, identifying recurring patterns and organizing them into meaningful categories. Both inductive and deductive methods were employed, allowing the analysis to reflect theoretical constructs while remaining open to unexpected insights from the data. Major themes included the significance of management support, the role of team dynamics, and the accessibility of external support services.

To complement the thematic analysis, word cloud visualization was utilized to provide a visual representation of frequently occurring terms and concepts. This method aligns with Vaismoradi, Turunen, and Bondas's (2013) approach of enhancing qualitative findings with innovative visualization techniques, highlighting dominant topics such as "stress management," "resilience," and "collaboration." The combination of thematic analysis and visualization allowed for a multidimensional understanding of the data.

Tools and Software

Qualitative analysis was facilitated using NVivo software, which streamlined the coding process and ensured systematic organization of data. Word clouds were generated using specialized visualization tools to enable a clear representation of recurring terms and themes. These technological aids enhanced the rigor and accessibility of the analysis, supporting the methodological standards described by Elo and Kyngäs (2008).

Limitations

This study acknowledges several limitations inherent to qualitative research. The relatively small sample size limits the generalizability of the findings, as the focus is on depth rather than breadth. Additionally, qualitative analysis is subject to researcher bias, which was mitigated through cross-validation of the coding process by multiple researchers. Vaismoradi et al. (2013) caution against overgeneralizing qualitative findings, emphasizing the importance of contextualizing insights within the specific study setting.

## 4. Results

Key Themes Identified

After analyzing the qualitative data provided through semi-structured interviews, the following themes emerged. These themes reflect the lived experiences, challenges, and strategies adopted by employees working with vulnerable populations. The analysis also highlights areas of organizational and systemic improvement to support these employees better.

- Sources of Stress and Emotional Strain

Participants reported significant emotional and operational stressors associated with their roles.

The primary sources of stress included:

- Empathy fatigue: Witnessing the struggles of vulnerable populations, such as refugees, creates a deep sense of emotional strain, particularly when participants feel unable to address the root issues effectively.
- Institutional challenges: Participants noted frustration with bureaucratic delays and inadequate state resources, leading to feelings of helplessness.
- Workplace pressures: Tight deadlines, heavy workloads, and a lack of appreciation from management exacerbate workplace stress.
- Interpersonal difficulties: Handling irate or distressed individuals during phone calls or face-to-face interactions often led to heightened stress levels.



For example, one participant described feeling “deep sadness” when witnessing individuals whose lives could have been better if systemic support was more robust. Another noted the difficulty in responding to aggressive individuals without adequate managerial or peer support.

- Coping Mechanisms and Strategies

Participants utilized a range of coping strategies to manage stress:

- Social Support: Most participants relied heavily on conversations with friends and colleagues to process their emotional burden. This support system created a sense of solidarity and reduced feelings of isolation.
- Mindfulness and Activities: Engaging in activities outside of work, such as yoga or spending time with loved ones, helped participants decompress.
- Professional Detachment: Many employees developed a level of emotional detachment over time, allowing them to approach their work in a “robotic” way to avoid emotional burnout.

One participant noted, "I realized over the years that I had to stop overinvesting emotionally because it was affecting my well-being and my ability to do the job effectively."

- Support from Management and Colleagues

The support provided by management and colleagues varied significantly:

- Management Support: While some participants acknowledged receiving clear guidelines and occasional training, many felt unsupported by their supervisors. One participant shared an incident where their request for reassignment due to burnout was dismissed with humor by their manager.
- Peer Support: Support from colleagues was frequently cited as a critical resilience factor. Participants emphasized the importance of mutual understanding and shared workloads during particularly stressful periods.

For instance, one participant shared how four colleagues came together to help with an overwhelming task, significantly lightening the emotional and physical burden.

- Training and External Resources

Participants expressed mixed experiences regarding training and external support services:

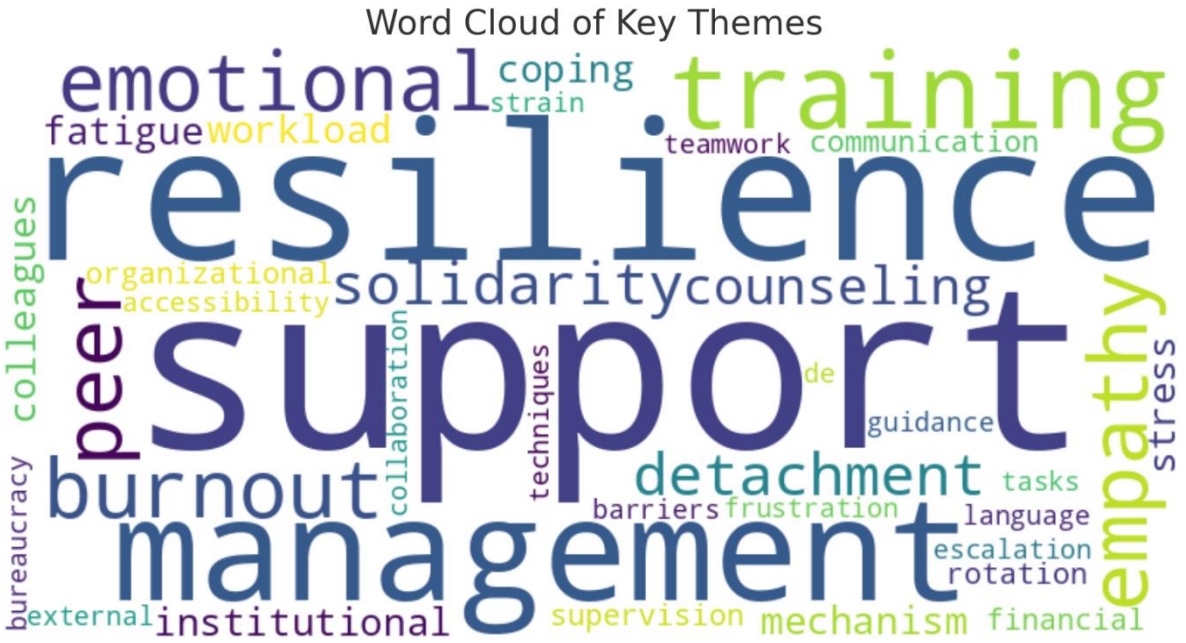
- Internal Training: While some organizations provided basic training on de-escalation techniques or emotional resilience, participants often found these sessions theoretical and detached from practical realities.
- External Counseling: Access to external resources, such as therapy, was reported as highly beneficial by those who could afford it. However, many noted that the financial cost limited accessibility for employees on lower wages.
- Challenges in Collaboration with External Parties



Collaboration with external entities often posed significant challenges, including:

1. Communication Barriers: Language differences and the lack of interpreters made collaboration with stakeholders and beneficiaries difficult.
2. Misaligned Expectations: Participants reported frustration when external parties provided conflicting or inaccurate information, leading to increased stress for both employees and beneficiaries.

- Suggestions for Improvement




Participants proposed several recommendations to enhance resilience frameworks:

- Rotation of Roles: To prevent burnout, participants suggested rotating tasks to provide variety and reduce prolonged exposure to emotionally taxing roles.
- Enhanced Training Programs: Practical, hands-on training tailored to real-world scenarios was seen as a critical need.

- Increased Supervision and Psychological Support: Regular supervision and access to professional counseling were highlighted as essential components of a supportive framework.
- Language Training: Providing free language training to employees would improve communication with external stakeholders and beneficiaries.
- Building Resilience Through Experience

Finally, participants acknowledged that resilience often developed naturally over time. Through repeated exposure to challenging situations, employees learned to balance empathy with professional detachment and recognize the limits of their influence. One participant reflected, "With experience, I've learned to accept that I can only control what's within my capacity, and that realization has been liberating."

## 5. Conclusions

This study highlights the profound emotional and operational challenges faced by employees working with vulnerable populations and emphasizes the critical need for robust support systems. Participants frequently reported feelings of empathy fatigue and frustration stemming from institutional inadequacies, such as bureaucratic delays and insufficient resources. These stressors were compounded by workplace dynamics, including inadequate managerial support and high workloads. The findings underscore the importance of addressing these systemic issues to prevent burnout and ensure the well-being of employees, which, in turn, enhances the quality of services delivered to vulnerable groups.

Despite these challenges, the research also revealed a variety of coping mechanisms and resilience-building strategies utilized by employees. Peer support emerged as a pivotal factor in fostering resilience, with colleagues providing practical assistance and emotional solidarity during particularly challenging periods. Activities outside of work, such as mindfulness practices and social interactions, also played a significant role in helping participants decompress and maintain emotional balance. Interestingly, many participants noted that resilience often developed through experience, as prolonged exposure to difficult situations helped them cultivate professional detachment and emotional boundaries, mitigating the impact of stress over time.

The findings also point to actionable recommendations for organizations to improve support frameworks. Enhanced training programs that provide practical, hands-on strategies for stress management and de-escalation are essential. Regular supervision and access to professional psychological support were frequently suggested as vital components for building resilience. Furthermore, initiatives such as role rotation, language training, and fostering open communication between employees and management can significantly reduce workplace stress and create a more supportive environment. Implementing these measures not only addresses the immediate needs of employees but also establishes a foundation for sustainable resilience and improved organizational outcomes.

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# Quantile connectedness in renewable energy companies and related commodities during Covid-19 outbreak

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**Abstract**
IMF indicated soaring metal prices, as cleantech firms are witnessing a meteoric rise in demand, and even dirty energy firms are changing their stance towards clean energy. Shock transmission (both positive and negative) is plausible as the world is chasing a net-zero emissions scenario. Therefore, we have investigated the top nine renewable energy companies globally with related metals (Nickel, Copper, Cobalt) from 3rd January 2017 to 3rd January 2022. This period also involves pre-Covid, Covid 1st Wave, Delta and Omicron. Our approach was QVAR, as suggested recently by Gabauer ( 2021), which is a logical extension of the initial connectedness approach proposed by Diebold and Yilmaz (2014). We found several outcomes. Shock transmission is happening from both cleantech and dirty energy firms to metals. Connectedness (shock transmission) is increasing in tails. Moreover, connectedness in the lower upper quantiles is asymmetric, with clean energy companies tending to transmit positive shocks to metals. Therefore, mean-based connectedness could be ruled out. Metals such as Nickel, Cobalt, and Copper emerged as the net receivers of shocks. The firms with higher market capitalization producing clean energy emerged as significant net transmitters of shocks (Enphase, Orsted and VWS). The total Connectedness Indices (TCIs) are heterogeneous over time. TCI sharply increased immediately after Covid-19 fallout and remained at a relatively higher zone than pre-Covid levels. Wind energy firms (SSE and Orsted) emerged as the net transmitter among all pairwise directional connectedness; furthermost wind energy firms (SSE, ED and EDP) emerged as the moderate net receiver of shocks. This research provides many inputs towards the wind energy sector for researchers, practitioners and policymakers.

***Keywords:*** *Renewable energy, Commodities, Covid -10, Quantile connectedness*

**JEL Codes:** Q2; Q21

# Organizational changes as a condition for sustainable development

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**Abstract**

The survival and growth of enterprises depend on their ability to adapt to changes, particularly concerning the environment and natural resources. Organizational changes in habits, practices, and structures are essential for aligning business operations with ecological demands, ensuring both organizational efficiency and environmental protection. Key drivers of such changes include technological advancements, environmental imperatives, societal shifts, globalization, and economic factors. Employees' responses to organizational changes vary from resistance, stress, and fear to positive adaptation and excitement. Managing these reactions effectively requires clear communication, leadership support, employee involvement, and targeted training. Resistance can be minimized through ongoing communication, gradual implementation, skill development, and fostering an understanding of the change's necessity. Therefore, organizations in order to keep up with developments related to the natural environment and natural resources, must be driven towards new organizational forms and continuously adapt. As the culmination of organizational changes, corporate social responsibility and environmental social responsibility are created. Environmental responsibility enhances business value by integrating ecological criteria, promoting eco-friendly products, and encouraging participation in environmental initiatives. Key practices include sustainable resource management, biodiversity protection, emission reduction, and offering green products and services. Moreover, development can be defined as development that meets the needs of the present generation while ensuring the ability of future generations to meet their own needs, an ability that will be ensured through the elimination of risks (Harris, 2000). This evolving concept emphasizes the need of the new contract: society, organizations, people, and the environment.

***Keywords:*** *Organizational Changes, Environment, Natural resources, Sustainable Development.*

**JEL Codes:** Q1

# Session 10
# Growth, Institutions and Policies

# From stationarity to sustainability. Lessons from the Classics

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**Abstract**

Classical Political Economists had a strong faith in the inexorable course of history towards material progress and social wellbeing. Yet, they disagreed on the faith of capitalism. Smith envisioned a sustainable growth depending upon the interaction of labour productivity, the level of the net revenue and the rate of saving. On the contrary, Malthus, Ricardo, James Mill and McCulloch depicted a dark future for the economic system, under the pressure of increasing population and nature's decreasing returns, leading to constantly falling net returns to industry, falling rate of profits and finally stagnation. Interestingly, there was one classical economist, John Stuart Mill, who offered a positive image of the stationary state as a superior level of civilization of a society that has resolved the problem of production and distribution of wealth among its members and focused on the personal improvement of its members. The aim of this communication is to examine the impact of the classical economic analysis of development in the long run, upon the description of the future of capitalist accumulation as a policy matter. Facing today's urgent problem of sustainability due to the climate crisis, it is urgent to learn from the debate in Classical Political Economy and beyond.

***Keywords:*** *Political Economy, Sustainable Development, Technological innovation*

**JEL Codes:** Q01; Q55

# Tracing the key determinants for a successful water management policy: Evidence from Classical Athens

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**Abstract**

This paper analyzes the key reasons for the success of the water management practices that were introduced in the city – state of Athens during the Classical times (508 – 323 BCE). It argues that the success should be attributed to two main factors that functioned simultaneously and in combination: investing on water management infrastructure and introducing effective water management institutions. Infrastructure included extensive public works such as the building of public wells, fountains, springs, aqueducts and cisterns, the building of an underground water supply network, the building of a sewage underground network for wastewater management, and finally, infrastructure for securing public hygiene. Institutions included the introduction of three categories of public magistrates who were assigned to implement the city-states' water management strategy. Their duties are analyzed in detail in the paper. It is further argued that the success of the Athenian water management practices was based on a combination of motives and disincentives; one the one hand, satisfactory salaries and public honors for those public magistrates who were assigned by the city-state to exercise these institutions and performed their duties effectively, and on the other hand, the imposition of heavy fines and / or dismissal from public office to the above magistrates who performed these duties ineffectively. The paper finally discusses if and how the Athenian water management strategies may be seen as an inspiration for modern societies on related environmental issues.

***Keywords:*** *Classical Athens; water management policies, public infrastructure, public goods; water management institutions; economic institutions*

**JEL Codes**: H41; H76; K20; N43; N53; Q28, Q58

# Beyond GDP: A Proposal for Estimating the Genuine Progress Indicator (GPI) for the Greek Economy

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**Abstract**

This study presents an extensive literature review of the "Beyond GDP" movement and introduces a proposal for the estimation of the Genuine Progress Indicator (GPI) for the Greek economy. While traditional Gross Domestic Product (GDP) measures often ignore important factors, such as environmental damage, social well-being, and income inequality, the "Beyond GDP" approach includes these dimensions, providing a more accurate view of the real prosperity of the society. Our study explores the theoretical foundations and the empirical applications of GPI in various countries, suggesting an initial framework for the development of the estimation of the Greek GPI equation. This proposal aims to contribute to the ongoing dialogue on the need for more holistic methods, for the estimation of the economic development and the overall prosperity of national economies, providing a basis for future empirical studies that could lead to a deeper understanding of the sustainable development potential in Greece.

***Keywords:*** *Beyond GDP; Alternative indicators of GDP; Genuine Progress Indicator (GPI)*

**JEL Codes**: C82, E01

## 1. Introduction

The Genuine Progress Indicator (GPI) has emerged as a holistic metric that seeks to address the limitations of Gross Domestic Product (GDP) by integrating economic, social, and environmental dimensions into the assessment of a nation's well-being. While GDP remains the dominant measure of economic performance, it fails to account for critical factors such as income inequality, environmental degradation, and the depletion of natural resources (Kubiszewski et al., 2013). Since its development in the 1930s, GDP has been widely used as a proxy for economic success, despite Simon Kuznets -the architect of national income

accounting- explicitly warning that GDP should not be used to measure societal welfare, as it excludes non-market activities and social disparities (Kuznets, 1934).

## 2. Literature Review

Over time, GDP has prioritized economic expansion at the expense of sustainability, failing to distinguish between activities that enhance well-being and those that generate negative externalities (Cook & Davíðsdóttir, 2021). In response, the GPI emerged as an alternative framework, building upon the Index of Sustainable Economic Welfare (ISEW), introduced by Daly and Cobb (1989), to offer a more comprehensive measure of prosperity. Unlike GDP, which treats all economic activity as a net positive, GPI distinguishes between activities that contribute to well-being and those that impose social or environmental costs. For example, GDP increases both when pollution is created and when it is cleaned up, treating both as economic gains. In contrast, GPI subtracts environmental degradation, healthcare costs from pollution, and crime-related expenditures, providing a more realistic assessment of a country's net economic and social welfare (Talberth et al., 2014; Kim & Moon, 2024).



As concerns over socio-economic disparities and environmental sustainability have intensified, international institutions such as the United Nations, the European Union, and national governments have increasingly recognized the need for alternative indicators that more accurately capture inclusive and sustainable progress (Jansen et al., 2023). OECD reinforces these concerns, emphasizing that GDP-centric economic assessments overlook key dimensions of well-being, particularly in relation to inequality and environmental sustainability (Stiglitz et al., 2018). European Commission has promoted Beyond GDP initiatives, supporting the adoption of alternative frameworks that integrate social equity, environmental protection, and economic resilience (Benczur et al., 2024).

The estimation of the Genuine Progress Indicator (GPI) for Greece is particularly significant given the country's economic, social, and environmental challenges in recent decades. Greece has faced a prolonged economic crisis, spanning over a decade, beginning with the global financial collapse of 2008 and evolving into a sovereign debt crisis that led to multiple bailout agreements, strict austerity measures, and structural economic adjustments (Eurostat, 2023). The crisis resulted in a severe and prolonged GDP contraction, wiping out nearly a quarter of Greece's economic output and causing historically high unemployment rates. Even after Greece exited the international bailout programs in 2018, the effects of the crisis lingered, with many households still struggling to recover lost income, while public services and infrastructure suffered from years of underfunding. While traditional GDP-based assessments suggest signs of recovery post-2017, these metrics fail to capture the broader socio-economic consequences, including deteriorating public services, rising poverty, and declining living standards (Kalimeris et al., 2023).

Furthermore, environmental sustainability remains a pressing issue, as unsustainable economic activities, including coastal overdevelopment, deforestation, and pollution, continue to impose high ecological costs that are not accounted for in GDP-based analyses (EEA, 2020). These hidden social and environmental costs highlight the urgent need for alternative indicators

like GPI, which provide a comprehensive assessment of national progress, incorporating both well-being and sustainability factors.

The calculation of GPI follows the generalized equation:

$$GPI = A + B - C - D + I \qquad (1)$$

where:

- **A** represents income-weighted private consumption,
- **B** accounts for the value of non-market services that contribute to well-being,
- **C** denotes private defensive expenditures incurred due to environmental deterioration,
- **D** measures the cost of environmental degradation and depletion of natural resources,
- **I** includes net capital formation and other long-term investments in sustainability.



## 3. Methods and Data

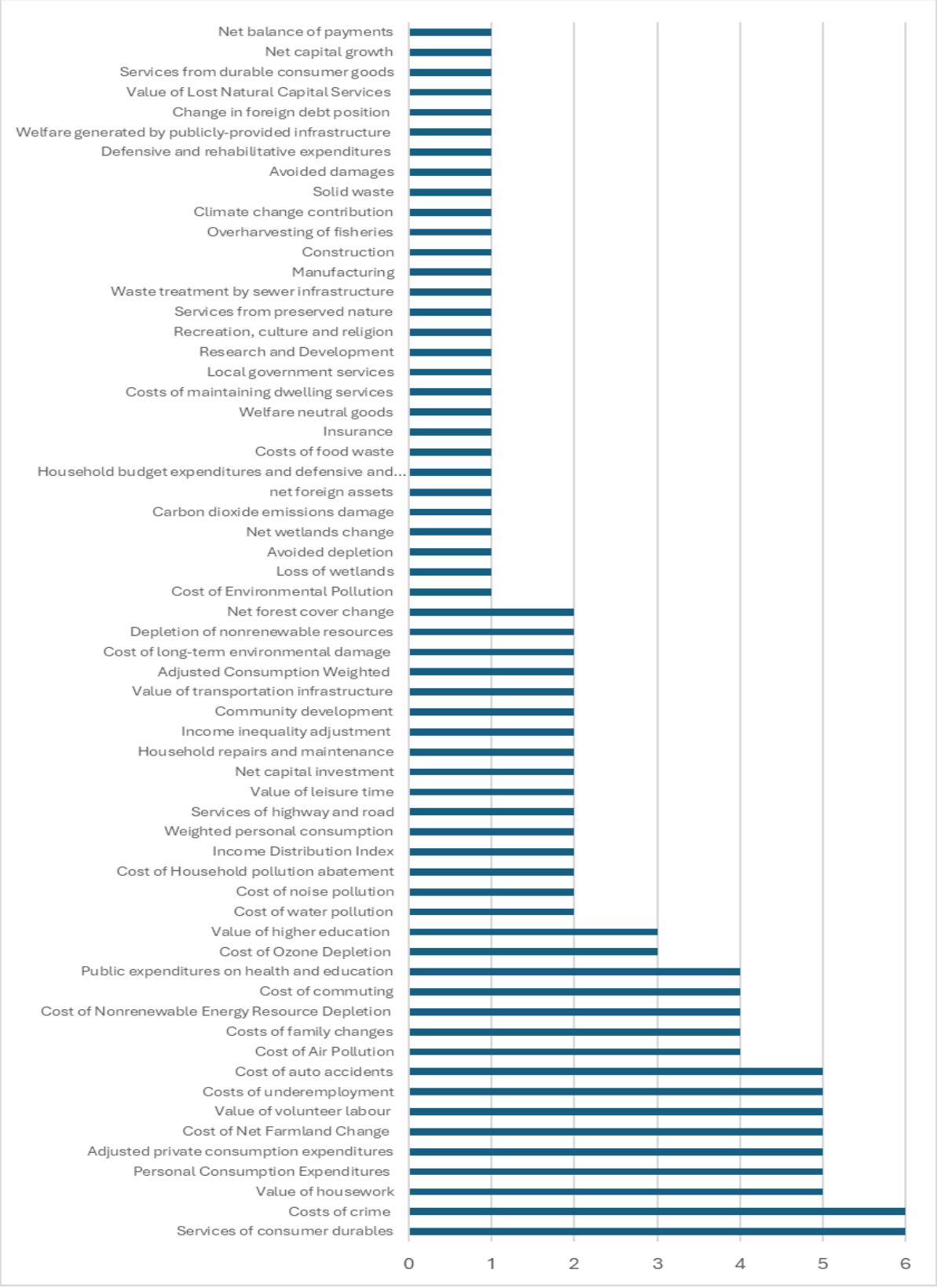
Key challenge in estimating GPI is the selection of appropriate indicators for each component, ensuring they accurately capture economic, social, and environmental dimensions. Unlike GDP, which is limited to market transactions, GPI integrates a wider range of metrics from internationally recognized sources, including Eurostat, the OECD, and environmental agencies, as well as national authorities such as the Hellenic Statistical Authority (ELSTAT) and relevant government ministries. Since GPI accounts for both market and non-market factors, the choice of indicators is crucial. For example, income-weighted private consumption corrects for inequality, while non-market contributions highlight the economic value of unpaid labor and public services. By incorporating pollution-related healthcare costs, resource depletion, and crime-related expenditures, GPI ensures that economic progress is assessed not just by production but by its actual impact on society.

To ensure consistency and comparability, the indicators chosen for Greece are based on established methodologies used in previous GPI applications and sustainability assessments. These data sources ensure consistency and comparability while also reflecting Greece-specific socio-economic and environmental conditions. More specifically, by carrying out a literature review, the research ended up in 6 most representative GPI-related studies which may be useful as prototypes for the construction of the Greek GPI formula.

The 6 GPI studies were selected as they were seen the most relevant that could be implemented in the Greek context. The geographical scope of the studies was very broad, including GPI studies from all over the world. More specifically the following studies were selected:

- Australia (Karatopouzis et al., 2022);
- Iceland (Cook and Davíðsdottir, 2021);
- Brazil (Andrade and Garcia, 2015);
- S. Korea; (Kim & Hoon, 2024);
- Italy (Gigliarano et al., 2014);
- USA-Oregon (Kubiszewski et al., 2015)

**Figure 1:** Number of common variables in the selected GPI studies (second stage)



By collecting these studies, we researched which of the variables employed in all 6 studies were most commonly employed. For the frequency of the variables a two-step approach was implemented:

- At the first stage a simple python script was used for employing Levenshtein Distance between the different variables;
- At the second stage, a manual process to group/ ungroup specific variables was used.

The result of the second stage processing was to create a more robust taxonomy of the most common variables that can also be used for the estimation of the Greek GPI (s. Figure 1).

Based on that, proposed indicators for Greece's GPI estimation include:

**1. Income-Weighted Private Consumption (A):**

- Adjusted personal consumption expenditure, incorporating income inequality measures, such as the Gini coefficient (Eurostat, OECD).
- Actual individual consumption per capita, considering purchasing power parity (PPP) adjustments (Eurostat).
- Household final consumption expenditure, adjusted for income disparities (Eurostat, ELSTAT).
- Net services from consumer durables, subtracting expenses on consumer durables to account for depreciation (Eurostat, OECD).

**2. Non-Market Contributions (B)**:

- Valuation of unpaid labor (household work, child and elder care) using time-use surveys and replacement wage methods (Eurostat, OECD, ELSTAT).
- Volunteer work and informal sector contributions, capturing shadow economy adjustments through legal but unreported activities (World Bank, ELSTAT).
- Public expenditures on healthcare, education, and social services, reflecting their direct well-being contributions (Eurostat, ELSTAT).
- Non-defensive government expenditures, including housing, cultural services, and public infrastructure investments (Eurostat, European Commission).

**3. Private Defensive Costs (C)**:

- Crime-related defensive expenditures, including police services, private security, and legal costs (Eurostat, ELSTAT).
- Medical costs associated with pollution exposure, including respiratory diseases, hospital admissions, and premature mortality rates from air pollution (EEA, Eurostat, WHO).
- Traffic accident-related costs, incorporating medical treatments, vehicle damage, and loss of productivity (Eurostat, OECD, ELSTAT)

**4. Environmental Costs (D)**:

- Depletion of non-renewable resources, such as fossil fuel consumption, mineral extraction, and deforestation (EEA, Eurostat).
- Air and water pollution costs, considering emissions of $CO_2$, NOx, PM2.5, and NH3, and their health and ecosystem impacts (EEA, OECD).
- Biodiversity loss and ecosystem degradation, assessed through land-use change, deforestation rates, and conservation costs (EEA, Eurostat, ELSTAT).
- Climate-related damages, measuring economic losses from wildfires, heatwaves, floods, and other extreme weather events (EEA, ELSTAT, European Commission).
- Broad ecological costs, incorporating air pollution embodied in trade, costs of nuclear energy production, and emissions from land-use changes (European Commission, EEA).

**5. Investment & Adjustments (I):**

- Public and private investments in renewable energy, sustainable infrastructure, and environmental conservation (Eurostat, OECD).
- Research and development (R&D) spending on sustainable technologies and green innovations (European Commission, OECD).
- Green infrastructure and ecosystem restoration efforts, including reforestation programs, wetland conservation, and biodiversity protection projects (ELSTAT, EEA).
- Net capital formation, reflecting investments in long-term productive assets that contribute to sustainable economic growth (Eurostat).

Since the final selection of indicators is still under consideration, further analysis will focus on data availability, methodological consistency, and comparability with international GPI estimations. The goal is to ensure that Greece's GPI estimation reflects both global best practices and country-specific realities, allowing for a more comprehensive assessment of national progress beyond GDP.

## 4. Discussion

Our empirical analysis will trace Greece's GPI trajectory over the past decades, comparing it with GDP to assess whether economic growth has translated into genuine progress. Given the country's economic turbulence, preliminary findings suggest that while GDP has fluctuated in response to financial crises and recovery cycles, GPI has likely followed a different path. The divergence is expected to be significant, as environmental degradation, social inequality, and the erosion of public services have offset many of the economic gains reflected in GDP. By incorporating hidden social and environmental costs, this analysis will provide a more comprehensive picture of Greece's economic sustainability. Ultimately, the results will help determine whether Greece has experienced uneconomic growth—a scenario in which GDP increases without corresponding improvements in well-being, equity, and long-term prosperity.

As economies worldwide shift towards more inclusive and sustainable growth models, the need for Beyond GDP indicators has become increasingly evident. This study aims to bridge the gap in economic assessment by estimating Greece's GPI and evaluating its historical trends alongside GDP. By incorporating social well-being, income distribution, and environmental sustainability, GPI offers a more comprehensive measure of national progress, highlighting the hidden costs of economic expansion that traditional GDP metrics overlook.

The findings of this research will contribute to the Beyond GDP discourse, providing valuable insights into whether Greece has experienced uneconomic growth, a situation where rising GDP does not equate to improved well-being. Moreover, this study seeks to inform policy decisions by demonstrating how alternative economic metrics can guide sustainable development strategies. As Greece aligns with the European Green Deal and Sustainable Development Goals (SDGs), adopting complementary indicators like GPI can help shape evidence-based policies that promote long-term prosperity, environmental resilience, and social equity. The adoption of GPI-based assessments could help Greece identify policy gaps and prioritize long-term well-being over short-term economic expansion. Countries like the U.S. state of Maryland, Canada, and Finland have already incorporated GPI-like frameworks into their economic policy-making.

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# Water commons. The case of Stagiates

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**Abstract**

Water is one of the planet's most precious resources and its management is vital for life on earth. In many countries, water management is a state responsibility, taking into account the natural conditions, the population needs and the institutional and cultural specificities of each place (Bakker, 2010). In Greece, recent reforms in local government, combined with the implementation of neoliberal policies, have led to significant changes in water governance, often disrupting existing institutions and established practices by which local communities managed water at the local level. In this context, this paper examines how the intransigence of top-down policies, despite the good intentions that may exist, can have adverse consequences at the micro level of local communities, disrupting their relationships with local resources and the role of water as an environmental and economic, as well as social and cultural good. The study focuses on Stagiates, a small community that has been struggling for more than 15 years against the uniform implementation of the 2010 administrative reform (prescribed in light of the Greek government-debt crisis), which threatens to dismantle their 350-year-old, functionally-credible water commons. Through a case-study methodology and Historical-Institutional Analysis, the work highlights the complex dialectic between formal and informal institutions and the role of water for the sustainability and resilience of local communities.

***Keywords:*** *water; commons; institutional change*

**JEL Codes**: B52; H83; O13; O17 Q25

# Exploring farmers' intentions towards adoption of environmentally friendly pest management practices

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**Abstract**

This article investigates the factors affecting Greek farmers' intentions to adopt biopesticides, functional biodiversity (e.g., cover crops) and beneficial insects in four major crops, namely table grapes, peach, citrus and horticultural crops (e.g., greenhouse tomato and pepper). Specifically, the main objective of this study is to answer two fundamental questions. Firstly, what are the motives and barriers farmers face regarding the adoption of these practices? Secondly, do any motivational differences exist on farmer's intentions between farmers operationalized in cultivating different crops? To answer these questions, we employ an extended version of the Theory of Planned Behavior, which incorporates descriptive and personal (or moral) norms, openness to innovation, and concerns (health, environmental and risk) as additional constructs. We also consider the effects of farmers' demographic characteristics (such as age and education), farm structural characteristics (like size and profitability), and the institutional environment (including institutional techno-economic support and advisory). Addressing these questions can help us better understand farmers' decision-making processes, which in turn can lead to the development of more effective policies and tools towards compliance with national and European environmental regulations and directives.

***Keywords:*** *Pest management; farmers' intentions; biopesticides; beneficial insects; functional biodiversity.*

**JEL Codes**: Q12; D91; Q16

# Constructing environmental subsidy rules. The feedback case.

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**Abstract**

In this work, we assume that there is a market of a specific extracted environmental resource and only one extracting firm, therefore acting as a monopolistic exploiter for the entire market. The resource maybe a renewable (e.g. fish biomass) or non renewable (e.g. fossil fuels). We consider a simple subsidies scheme, i.e. per unit subsidy, inducing the unique exploiter to extract a target resource level. We examine the construction of dynamic subsidy rules, based on a performance index, and such that they are comparable with the basic static scheme. The requirement for the rule's construction is only local information. We found that the present value of that constructed dynamic subsidies paid is smaller than in the benchmark case of the static subsidies paid, therefore is worthiness for the regulator the above construction. To be more specific, the dynamic rule constructed such that each moment subsidy paid is lower per unit subsidy than the static subsidy paid. The subsidy rate works having the feedback property in the sense that is based on the state variable which in turn is the historic performance of the monopolistic exploiter.

***Keywords:*** *Optimal control, Environmental subsidies, Monopolistic firms.*

**JEL Codes:** O44, Q56, Q58

# Session 11
# Environmental Innovative Policies & Applications

# Revisiting the determinants of environmental policy stringency: Findings from a panel data for 33 countries, 1995-2020

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**Abstract**

To address the alarming threats posed by the loss of environmental quality, policy actions are pivotal and range from command-and-control instruments to market-based mechanisms and voluntary schemes, with countries around the world pledging specific targets and commitments to alleviate the problem. This study explores determinants underpinning Environmental Policy Stringency (EPS) using an unbalanced panel dataset of 27 OECD countries and 6 BRIICS from 1995 to 2020. The analysis is conducted exploring the issues of cross-sectional dependence, parameters' heterogeneity, the associated second generation unit root tests for testing stationarity, as well as cointegration. Then adequate methods are applied in the model specifications allowing for the estimation of LR and SR relationships between environmental policy instruments and macro-level dynamics. Using the complementary databases of the World Bank, the United Nations and the OECD we identify country-level of environmental policy stringency, country-level determinants of market and non-market instruments as well as country level determinants of technology support instruments. The results inform decision-makers on the proposed variables but also contribute to the theoretical debates of driving forces of environmental policy formulation among national jurisdictions, giving room to fruitful insights for future empirical research.

***Keywords***: *Environmental policy stringency, policy determinants, cross-country assessment, panel data analysis.*

**JEL Codes**: E01; O29; Q56; Q58

# Empirical Evidence on Non-linear Relationships between Bitcoin Mining and Carbon Emissions

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**Abstract**

While numerous studies have explored the relation between environmental impacts and Bitcoin mining activities, the existing literature provides limited evidence on the non-linear relationship between carbon dioxide emissions and market-related variables, as well as Bitcoin mining variables. Combining data from three different databases over a four-year period, this study employs the Gradient boosting machine technique, a machine learning algorithm, to analyze the impact of Bitcoin mining on carbon emissions, while also highlighting the importance of each variable in predicting emissions. According to the findings, energy consumption and market price are the most significant factors, while market capitalization and transaction fees also influence emissions, suggesting that economic indicators are indirectly associated with the increase of undesirable environmental outcomes. The results indicate that non-linear models are effective instruments for revealing intricate relations between Bitcoin's attributes and carbon emissions, showcasing the necessity for further extensive investigation.

***Keywords:*** *Bitcoin; Carbon emissions; Non-linearity; Machine Learning; Gradient boosting machine.*

**JEL Codes**: O13; O16; Q56; C45.

## 1. Introduction

The effective tacking and mitigation of climate change impacts whilst enhancing the resilience capacity of military infrastructure, is a priority that has gradually gained momentum over the last couple of decades. Natural hazards and climate change can negatively impact military (fixed) installations, military assets, supplies and operations and are of concern to EU security and defence [1]. Consequently, in all documentation of strategical context, the correlation between climate change and operational effectiveness is clearly highlighted. Notable examples are:

- The EU Military Staff/European External Action Service (EEAS) in collaboration with the European Defence Agency has issued a climate change and defence roadmap to ensure a coherent approach on the aforementioned connection [2].
- NATO's Action Plan for Climate Change and Security NATO, 2021, sets out the framework for delivering NATO's agenda on climate change and security over the short, medium, and long term. This Action Plan comprises specific tasks and deadlines, which should be integrated across all defence levels of hierarchy.

Moreover, many EU MS Ministries of Defence have recently attempted to assess the correlation of climate change related hazard implications and the defence infrastructure assets [3]. However, either only little information in the EU context exists in systematic terms or it is accessible [4].

With this study, it is attempted to address the challenge deriving from this lack of evidence issue, by developing a methodological framework that defines and enhances the resilience of EU military infrastructure, against climate change impacts. For doing so, it utilizes the main infrastructure assets in one of the largest Airbases of the Hellenic Military Aviation (116Combat Wing, situated at Araxos, Patra). Hence, the following elements constitute the objectives of the study:

- To identify critical hazards associated to climate change impacts, which are interacting with major defence infrastructure assets (e.g., buildings, utility networks, etc.).

- To identify and evaluate existing resilience factors to gauge the level that fundamental elements of military infrastructure can anticipate, absorb, cope, recover and eventually adapt to climate challenges.

- To propose policy interventions, accompanied with financial estimations of plans needed to mitigate climate risks, in the prospect of achieving climate neutrality.

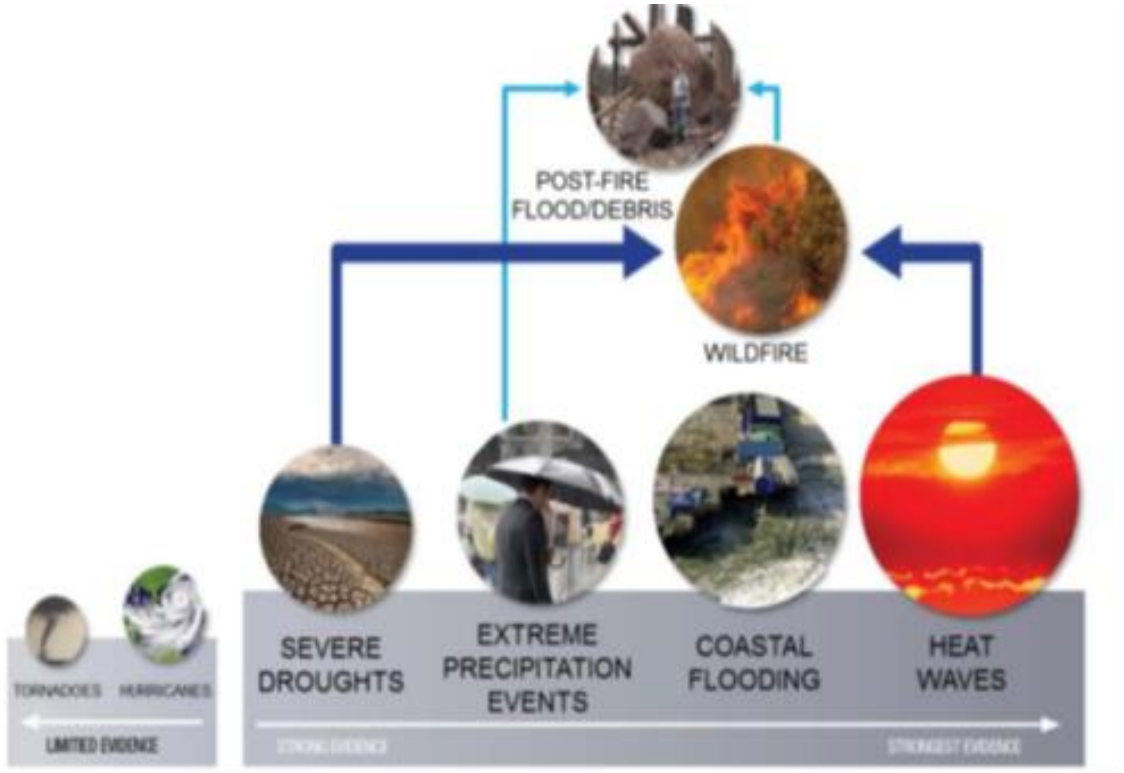
## 2. Climate change and resilience - defence perspectives

### *2.1 Natural hazards and climate change*

Europe already faces a significant number of defence and security threats, which will be exacerbated by natural hazards and climate change. They will also modify the conditions in which the military operate, adding uncertainty, adversity and complexity. Further degradation of living conditions in some regions of the world, for example the Sahel and the Horn of Africa, at least partially associated to natural hazards and climate change, may potentiate migration and conflict. Natural hazards and climate change can also open new opportunities for hybrid attacks [1].

The occurrence of a natural hazard in a particular location is just one of a number of conditions for disaster. Communities' infrastructure and assets may or may not be present within the impact area, may or may not be vulnerable to the impacts, and may or may not be able to cope, adapt and quickly recover [5], [6]. Figure 1 summarizes some of the existing scientific evidence (less towards the left) for a relation between the changing characteristics of a natural hazard and climate change. Main hazards depicted in relation to operations are extremely high and low temperatures, floods, storms, limited visibility.

**Figure 1:** Supporting evidence for changes in natural hazards due to climate change [1]




### *2.2 Climate change in the wider EU and NATO domains*

In its June 2020 Conclusions on Security and Defence, the EU Council invited the High Representative to propose, together with the Commission and the European Defence Agency (EDA), and in close dialogue with Member States, a set of concrete short-, medium-, and long-term actions addressing the links between defence and climate change [7]. This process led to the issuance of the EU Defence and Climate Change Roadmap [2].

NATO has recognized climate change as one of the defining challenges of our times. Beyond fundamentally altering our planet's climate, it is a threat multiplier, exacerbating existing security risks and creating new risks such as increased competition over natural resources, that affects Allied security, both in the Euro-Atlantic area and in the Alliance's broader neighbourhood [8]. As endorsed by Foreign Ministers at their meeting on 23-24 March 2021

[9], NATO's climate change and security agenda encompasses measures to increase our awareness of the impact of climate change on security, along with clear adaptation and mitigation measures, while at the same time upholding the priorities of the safety of military personnel and operational and cost effectiveness.

### *2.3 Climate change in the Greek national defence*

The concept of Greek Defence Sustainable Development, in terms of the wider concept of the "Greek(n) Armed Forces", is the balanced state amidst the economy, the society and the environment in contradistinction to the growth without restrictions. The Hellenic Ministry of Defence (HMoD) has comprehended the deeper meaning of sustainability in defence matters and established a Sustainability Directorate in the Hellenic National Defence General Staff (HNDGS).

Under the "overarching" of its highest political leadership, in 2007, it issued the first edition of a holistic Environmental Protection Policy. In 2014, in the framework of the Greek Presidency of the EU Council, the Policy document was revised, and the second edition attached emphasis in the way that the military activities taking place in peacetime (both every day works and operational exercises) would be aligned with the sustainable development principles and procedures, thus acquiring a more environment friendly character [10].

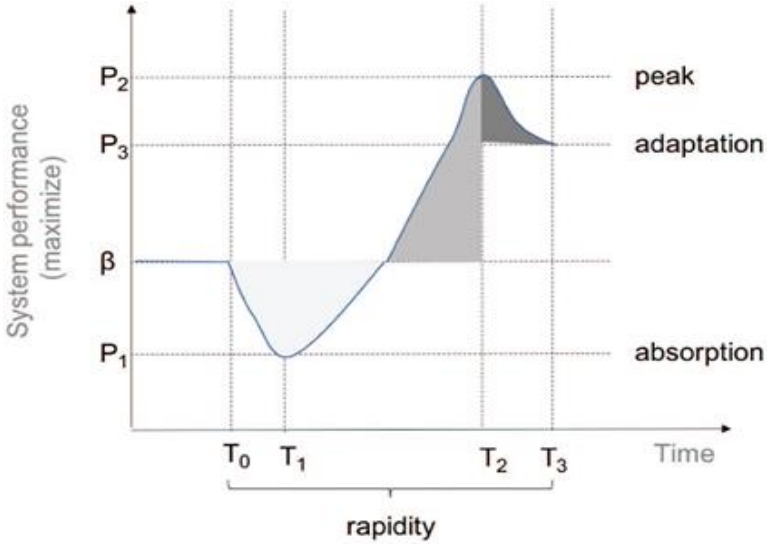
Moreover, as a follow-up action of aforementioned initiatives of EUMS/EDA (with the Climate Change & Defence Roadmap) and NATO (Climate Change & Security Action Plan), the political leadership of the HMoD assigned the mandate to a Working Group of experts (named "HMoD Climate Change Task Force) to draft the Roadmap for the Adaptation of the Hellenic Armed Forces to Climate Change Impacts. This Roadmap was eventually issued in May 2023 [11]. The roadmap aims to fulfill its objectives, based upon two fundamental pillars: that of climate adaptation (leading to resilience) and that of climate mitigation (achieving climate neutrality).

## 2. The resilient infrastructure model

### *3.1 The process model*

Traditionally resilience of infrastructures is defined as the ability to rapidly recover from performance losses owing to a disruption [12]. Herein, resilience is understood as a threefold concept: (1) the capacity to absorb a shock or disturbance; (2) the capacity to adapt to change; and (3) the rapidity of the recovery process [13], [14]. Over the last two decades many studies [15] have focused primarily on a rapid recovery to a pre-disaster state [16]- [20]. Figure 2 illustrates the aforementioned 3-triangle model.

Figure 2: Triple resilience triangle (Source: [18]).




### *3.2 Key Performance Indicators (KPIs) of resilient airports*

The resilience challenge for an airport impacted by a disaster is to adapt their logistics and cargo performance beyond the normal level of operations to cope with the increase of incoming flights and freight as part of the unfolding disaster response operations. The following three throughput related KPIs [21] are defined to measure the ability of the airport to rapidly adapt to these new requirements: (1) The total amount of cargo handled per hour; (2) the total amount of idle cargo, i.e., cargo that is still in the system (in tons); and (3) the average throughput time of one unit of cargo (in hours). It is evident that these KPIs are referring to civilian and not military airports.

## 4. Case studies of European civilian airports initiatives towards resilience enhancement

### *4.1 The London's Heathrow*

According to the literature review conducted, the first and one of the largest airports in Europe that adopted the KPI based methodology for assessing its infrastructure resilience against climate change impacts, was London's Heathtow. Heathrow Airport (HA) published its first Climate Change Adaptation Report and Risk Assessment in May 2011. The second relevant report has been produced under the second round of voluntary reporting under the Adaptation Reporting Power (ARP). It explains how Heathrow has implemented the actions set out in the 2011 report. According to these Reports, two (2) main models are utilized to update and review of climate change risks relating to climate variables of interest to Heathrow:

- H++ scenarios publication [22].
- CMIP5 and IPPC AR5 Reports [23]

### *4.2 Indicative examples of Greek airports, situated in 10 Greek islands.*

In 2020, a study was officially published [24], in which certain parameters were calculated according to meteorological data since 1955, aiming to indicate the level of climate change in the Eastern Mediterranean area, using a case study of 10 Greek civilian airports. More specifically, in the airports of: Chania, Chios, Iraklion, Corfu, Limnos, Mytilene, Naxos, Rodes, Zakynthos and Skiathos. Relevant data concerned daily mean minimum temperature and mean headwind direction component (the component of wind parallel with the runway in-use).

Using this data, take-off performance was analyzed for the DHC-8-400/ a typical short-range turboprop airliner, and the A320, /a typical medium scale turbofan airliner. For airports with longer runways, a steady but unimportant increase in take-off distances was found. For airports with shorter runways, the results indicate a steady reduction in available payload.

### *4.3 The Athens International Airport (AIA)*

Environmental protection is a priority for the largest Greek Airport and AIA is committed to protect the environment and preventing or lessening negative impacts, through a comprehensive Environmental Policy and Procedures. Therefore, in 2019, AIA's Administration decided to launch a study [25], in order to perform a comprehensive risk assessment of climate-related risks to the direct and indirect operations of Athens International Airport and to its assets.

In order to perform this assessment, the following baseline scenarios were utilized:
- A regional climate model is therefore employed to forecast the evolution of the most important meteorological parameters in the future [26].
- A computational fluid dynamics model is also run to predict future extreme meteorological conditions (i.e., extreme temperatures and wind speed) in the area of AIA.
- The Intergovernmental Panel on Climate Change [27] emission scenarios.

The tool that is increasingly used in the analysis and assessment of climatic hazards is the development of a risk matrix. Risk identification and quantification of the likely consequences and likelihood of the climate risks identified in the risk assessment has been based on the corresponding methodology applied for Heathrow Airport [28].

The risk assessment result was the identification of 27 different risks, which led to suitable adaptation response actions. These actions have been classified into 3 basic categories to reflect the severity of the risk, the uncertainty in what is required (or the uncertainty in the climate science) and the urgency of action. The related processes are referring to outdoor working processes (susceptible to extreme temperatures and excessive rainfall) the maintenance level of drainage and fuel supply systems (for the same reasons), the continued robustness of the various paved areas (roads/apron/runways), in order to ensure adaptation to withstand the increased temperatures expected.

## 5. The proposed methodology for military airports

### *5.1 Main principles*

The application of the proposed methodology has two (2) approaches.

**First**, addressing the military Air- Base as an integrated (one) major infrastructure. The following stages are highlighted:

- Specific climatic data has been gathered, about the main physical climatic hazards that can pose serious problems for the effective operational activities and mission of the Air- Base.
- For each of the aforementioned climatic hazards, specific thresholds of intensity are being designated, based on the evidence and information provided by the Air- Base's specialized personnel.
- Climatic statistical data has been acquired and processed, not only covering the last 15 years of the Air Base's operations, but also projecting the trends for the upcoming decades (until 2100), using the main existing respective scenarios (Representative Concentrations Pathways/RCP 4.5 & 8, developed by IPCC0.

**Second,** in terms of addressing the Air- Base as a sum of critical infrastructure clusters, following the sequence depicted below:

- These clusters are being broken into specific infrastructure assets, as well as corresponding processes.
- The assets and the processes are linked with operational significance (both in terms of supporting the effective execution of the Air-Base's mission and in terms of designated working personnel).
- The final level of process has to do with the interface aspect, in other words with the determination of the degree of interconnection between them, especially in the case of one asset interrupts its activities to define the number of other assets affected.
- These pieces of information are then integrated with the climatic projected scenarios adopted also in the first approach level and the definition of impact assessment scale (1-5 from very low to extremely high) assumptions.

The outcome of this two-level approach is an estimation of risks / vulnerability magnitudes associated with each of the infrastructure assets' resilience against climate change related hazards. This estimation, in the format of a risk based climatic resilience matrix, will be the basis for conducting a resilience enhancement plan (in terms of providing some tailored solutions for the assets), in the next phase of the research study.

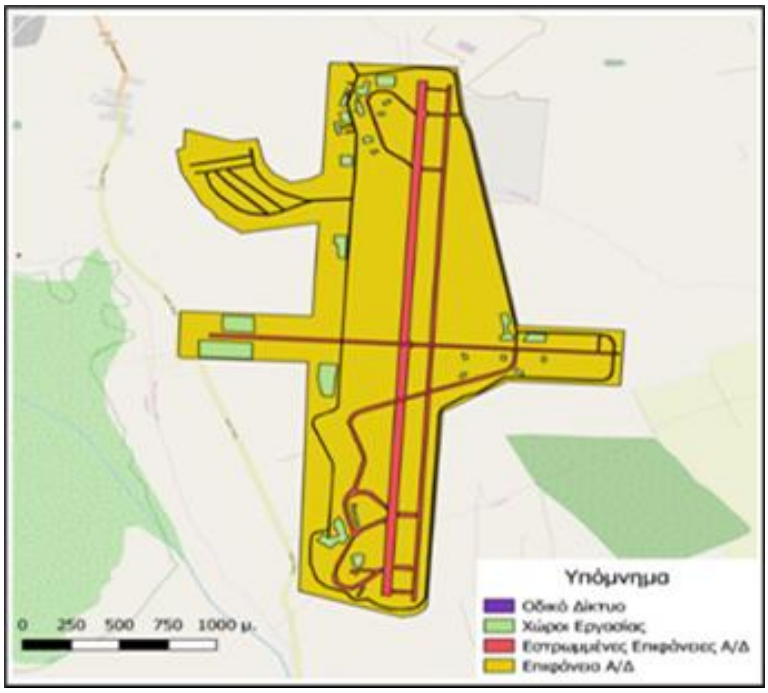
### *5.2 Application to the 116Combat Wing (CW)/ Results*

The Airbase is divided into 2 areas: The military base (116CW) which covers the vast majority of its surface and the civilian apron which operates under the auspices of Hellenic Civil Aviation Agency of mainly during spring and summer time, serving as a hosting airport for touristic reasons. The general layout of the Airbase is shown in Figure 3 below. The following climatic hazards were identified as critical, according to the consultation process with the Airbase's expert personnel:

1. **Low cloud altitude**, with the threshold of 400ft and above combined with BKN quantity between 5/8 and 7/8.

2. **Excessive rainfall**. The rainfall per se, isn't a phenomenon that can cause problems to the airport's operation, but as a root-cause of limited visibility. The threshold of 1600m is being set.
3. **Excessive heat**. According to the Technical Orders of the F-16 air-crafts, an average temperature of 28,6oC is considered as the low threshold.
4. **Wind parameters**. According to the manufacturer's Technical Orders (TOs) of the F-16 air-crafts, winds with exact vertical direction to the departure-landing direction which exceed velocity of 25knots (approx. 46,3 km/h or 6,2 in the Beaufort scale) are considered as hampering flight conditions. Since the orientation of the 116CW's runway is North-South, the "problematic" wind directions are east and west.

**Figure 3:** Layout of Araxos Airbase (Source: Google maps)




By obtaining and utilizing the statistical meteorological data by the Hellenic Meteorological Agency, the frequency of occurrence of the aforementioned thresholds were estimated, A set of occurrence scores was set for each threshold. As a result, heat and low cloud altitude were identified the climatic hazards with the highest occurrence factors. Moreover, the future provisions in the Recommended Critical Path (RCP) scenarios were utilized in order to assess the likelihood factors for the next decades (covering a medium-2050 and a long-2100 term periods). RCP is a statistical tool predominantly used for estimating future GHG concentrations, as well as the other critical climatic indexes referring to temperatures, wind, rainfalls, etc. By implementing appropriates formulas future occurrence frequencies were assessed. Based on those assessment, heat and low cloud altitude remained as the climatic

hazards with the highest likelihood factors. Occurrence and likelihood factors are an integrated expression of the climatic probability factors.

Following the second approach of the methodology, which combines infrastructure building/assets with related processes working/operating processes and activities, the whole infrastructure inventory is divided into ten (10) main clusters, as follows**:** 1)Fighting Aircrafts Squadrons (335-336), 2) Maintenance Depot Squadron, 3) Transport Depot Squadron, 4) Supply Chain/Materiel Squadron, 5) Buildings/Infrastructure and Utilities Maintenance Squadron, 6) Operations Support Squadron, 7) Personnel /Administrative related Services Squadron, 8) Guarding-Security Squadron, 9) The 116CW'S Main Headquarter Building Complex and 10) The 116CW's Command Operations Centre.



The 10 clusters are consisted of fifty-nine (59) infrastructure assets, in total. In order to implement the proposed 2-way approach, a set of three (3) KPIs is inserted:
- The operational importance/contribution they have in fulfilling the CW mission (KPI1: Operational significance)- Score from 1 to 3 (low to high)
- The impact on the asset's operation combined with the "cascade effect" that occurs, due to the fact that the climate-related challenges faced of one asset may influence a significant number of others (KP2: Operation & Interconnectivity impact)- Score 1 to 5 (according to the amount of assets involved).

- The human factors in terms that the use of certain infrastructure assets is obviously performed by the people who live and/or work in the buildings. (KP3: Impact on personnel). Score from 1 to 5, according to the number of people working).

The 3 KPIs are altogether multiplied, and their product is the overall climatic severity factor. In detail terms the scores, as described below are categorized to low-medium-high severity:

- **Scores between 1 to 15**, correspond to low climatic severity factors.
- **Scores between 15 to 30**, correspond to medium climatic severity factors.
- **Scores more than 30,** correspond to high climatic severity factors.

According to the results as they are calculated, the following scores are recorded, regarding the 59 infrastructure clusters:

- For the heat hazard, 29 assets are of low severity, 16 of medium and 14 of high.

- For the wind and the limited visibility due to excessive rain hazards, 44 of low, 13 of medium and 2 are of high severity, respectively.

- For the low cloud hazard, the corresponding scores are 44 of low, 11 of medium and 4 of high severity.

The climatic severity factor is further linked to the climatic probability (a combination of the likelihood of occurrence of the 4 aforementioned phenomena, related to existing information and data covering the period from 1980 and onwards, as well as the estimation of occurrence deriving from the 2 basic RCP scenarios, as they were aforementioned). In that perspective, it

is feasible to conduct the complete asset climatic resilience risk assessment matrix of the 116CW. Consequently, the overall climatic risk classification scores are as follows:

- For total score (climatic severity factor * climatic probability factor) 1-50 the overall climatic risk is classified as Low (green).
- For total score 50-150, the risk is classified as medium (yellow)
- For total score above 150, the risk is as high (red).

Overall, the respective occurring distribution of the climatic risks on the 59 infrastructure assets, is as follows:

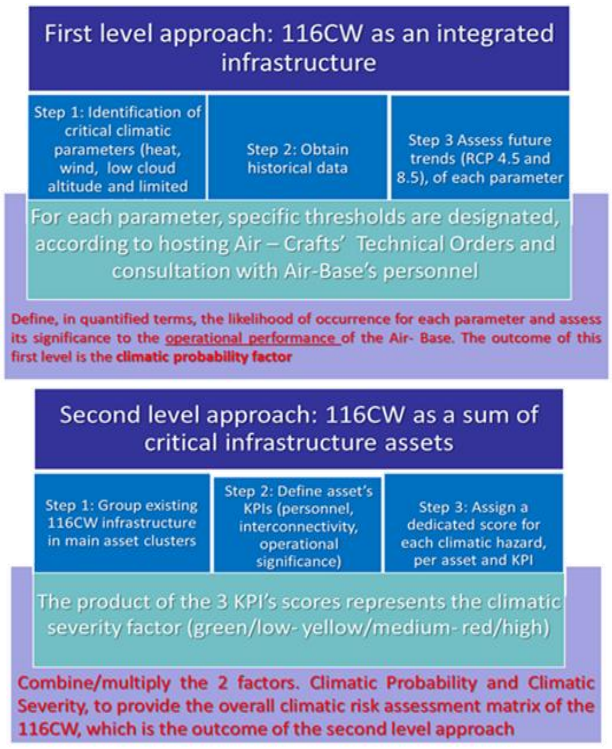
- Eleven (11) are assessed as high climatic resilience risks.

- Thirteen (13) are assessed as medium climatic resilience risks,

- Thirty-five (35) as assessed as low climatic resilience risks.

The aforedescribed two (2) – levels of approach methodology is reflected in the following 2 schemes of figure 4:

**Figure 4:** 2 -level proposed approach of 116CW




## 6. Conclusions

### *6.1 General framework*

This 2-level approach appeared in the majority of past research attempts, which were performed in the case of civilian airports. More specifically, the first-level approach (116CW

as an integrated infrastructure) offers us the capability to analyze the situation, by focusing primarily on the operational aspect of the Air- Base. From a statistical point of view, the following points deem necessary to underline:
- Heat and low cloud altitude hazards refer to respective thresholds with very high occurrences (averaging more than 80 days per year), therefore they have a consequently very high impact to the Air-Base's operational performance.

- Wind conditions refer to thresholds, (one for west and one for east direction), with very low occurrence (averaging less than one time per year), hence they don't pose a significant operational "threat" for the Airbase.



- Limited visibility (attributed to excessive rainfall) refers to a threshold that has a low statistical occurrence (roughly 5 times per year), so it is also regarded as a factor with low significance.

With regards to the projections of the RCP scenarios, the following conclusions can be drawn:
- Heat and low-cloud altitude parameters are most likely to be regarded as parameters with very high operational impact.

- Wind conditions are being upgraded from "very low" to "low" significant parameters (1 to 2).

- Limited visibility due to heavy rain conditions are being upgraded from "low" to "medium" significant parameter (2 to 3).

- To connect the low-cloud aspect with the relative humidity/ heat discomfort and WBGT factors (also not being able to extrapolate specific values of the associated phenomena, such as minimum base height of cloud as well as break-in quantity).

**Overall, the first level approach** indicates that specific climatic conditions, related to heat and low cloud altitude have posed and will most likely continue to pose significant impact of operational character to the unimpeded execution of 116CW's mission.

Moving on to the second-level approach, this one is focusing on analyzing the climate change impacts on specific infrastructure of the Araxos Airbase, taking into consideration the wider context of the basic climatic hazards that have proven to interfere with the operational activities of the 116CW.This approach, again, is based on the correlation of appropriate KPIs, which is leading to the overall asset climatic risk assessment. The respective Matrix can be analyzed in two (2) ways:

- The *vertical* analysis (meaning the comparison of the impact that each climatic hazard has on the assets).
- The *horizontal* one (focusing on the integrated impact caused by climate change related effects on each asset).

In the first/vertical analysis case, it is obvious that heating conditions have the predominant role in the impact aspect. Out of the 59 total assets, almost 1/4 of them (15) are classified as very high, meaning that they require mitigation actions in the short-term (in the upcoming couple of years) and more than of the other 1/4 (18) are classified of medium risk, requiring mitigation actions in the upcoming 5 years. Wind conditions have a relatively much lower envisaged impact with zero high risks and the vast majority (52) of the 59 assets classified as low, whilst only 7 as medium.

Limited visibility (due to excessive rain) conditions have a slightly increased (in comparison with the wind) impact, mainly on the infrastructure assets, which are linked with outdoor activities and work processes (e.g., for aircraft maintenance infrastructure or fuel supplying, both to aircrafts and vehicles). 17 such assets are categorized as medium out of the total 59, 42 as low, with zero assets as high. Low cloud altitude conditions have a slightly increased (in terms of magnitude) score in the vulnerability matrix with the limited visibility conditions (3 assets are classified as high, 21 as medium and 34 as low). This score is justified because it is mainly deriving from the increased probability factor, since the hot and humid climatic characteristics of a typical Western Greece landscape such this of Araxos; favor the occurrence of these conditions.

In terms of applying the second / horizontal analysis of the matrix findings, it is evident to note that infrastructure assets with a relatively high operational significance are most likely to have a high overall score. In the second line of priorities of the assets (with medium climatic vulnerability risks), we encounter infrastructure assets related to auxiliary/" peripheral" maintenance processes for aircrafts, vehicles and other ground equipment, the ammunition storage facilities, water supply network components, storage facilities for materials and equipment aimed to be utilized for repairing damages caused by climatic hazards in buildings, in roads and in the runways/aprons network.

### *6.2 Uncertainty/validity of the study's results*

Although the proposed methodology is attempting to quantify climate change related risks to the main infrastructure assets of the Air- Base, it is inevitable that it also entails a certain degree of subjectivity, which consequently creates a level of uncertainty in the results. This subjectivity is part of several processes, including, the setup of the specific KPIs for assessing and calculating the climatic severity on the assists, the classification assigned to each KPI's margins (e.g. low to very high), the scale of magnitude attributed for each KPI per asset (in terms of 3 or 5 level scale), the dedicated scores allocated for each index.

In broader terms, the study's results were being shared and consulted with the 116CW's involved personnel, in order to get feedback that ensures an adequate degree of validity. In particular, the elements of human resources and correlation of climate change effects and operational capabilities of the Air-Base's infrastructure, have been a part of technical discussions with 116CW's specialized personnel, that took place in parallel of conducting this study. The KPIs which were utilized, were the ones selected amongst a series of potential examples discussed (e.g. outdoor vs indoor activities, degree of difficulty or related work processes taking place in each infrastructure clusters, etc.)

### *6.3 Novelty of the study*

The process of developing a methodological framework for defining and enhancing the resilience of military infrastructure against climate change impacts has never been performed and tested in quantitative terms for military Air- Bases in the EU Armed Forces. This conclusion is based on the existing literature review. In addition, it must be stressed that the so far conducted studies in the civilian domain, do not follow a concept of risk assessment with an

approach directed to the infrastructure per se, but rather to the work processes, which take place (related to cargo and passengers transport).

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# From Data to Insight: Using Unsupervised Learning to Explore Financial and Sustainability Patterns in S&P 500 Firms

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**Abstract**

In this study we explore the clustering patterns of the S&P 500 companies using information from quarterly financial data, the ESG (Environmental, Social, and Governance) ratings, financial ratios, and stock returns, leveraging state-of-the-art machine learning techniques. By applying clustering in various variable setups, we are seeking to uncover patterns and relations between the different variables of our dataset, offering a fresh perspective on financial performance, sustainability, and market behavior. Unsupervised learning does not require labeled data, making it ideal for exploratory data analysis where the goal is to uncover hidden patterns or groupings in the data. A refined group of financial ratios was used to enhance interpretability. The financial ratios were categorized into six groupings, each representing a distinct dimension of financial performance: Liquidity, Efficiency, Profitability, Solvency, Cash Flow, and Market Valuation. These are the main groups of financial ratios most used to generate the financial snapshot of each organization. A battery of alternative algorithms were employed including k-means, Hierarchical clustering, Density-Based Spatial clustering, and Gaussian Mixture clustering. The results indicate that machine learning methods and specifically in this case unsupervised learning adds value beyond traditional industry/sector classification methods used for financial analysis by governments, rating agencies, and the companies themselves by incorporating the sustainability dimension. These findings mirror what others, like Menten et al. (2024) and Kaminskyi & Nehrey (2023), have observed. These clusters can be used by financial experts and asset managers to choose high-performing clusters, overweight and underweight curtain clusters, and match asset allocations to sustainability goals.

***Keywords:*** *ESG, machine learning, sustainability goals.*

**JEL Codes:** Q56

# Enhancing environmental-forestry education through Big Data and Analytical Tools for Sustainable Development

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**Abstract**

The paper "Enhancing Environmental-Forestry Education through Big Data and Analytical Tools for Sustainable Development" explored how the use of big data and analytical tools can contribute to improving environmental-forestry education. The aim was to focus on the potential of these technologies to enhance understanding of ecological issues and promote sustainable development. The study presented some examples where data analysis helped create interactive educational content. It also mentioned how these technologies can support students in developing critical thinking and decision-making skills. Finally, the paper briefly presented the challenges and opportunities associated with integrating such technologies into the educational process.

***Keywords:*** *Sustainable Development, Forestry, Technological Innovation, Climate Change, Environment and Development; Sustainability*

**JEL Codes**: Q01, Q23, Q55, Q54, Q56

# Optimizing Renewable Energy Systems Placement Through Advanced Deep Learning and Evolutionary Algorithms

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**Abstract**

As the world shifts towards a low-carbon economy, the strategic deployment of renewable energy sources (RESs) is critical for maximizing energy output and ensuring sustainability. This study introduces GREENIA, a novel artificial intelligence (AI)-powered framework for optimizing RES placement that holistically integrates machine learning (gated recurrent unit neural networks with swish activation functions and attention layers), evolutionary optimization algorithms (Jaya), and Shapley additive explanations (SHAPs). A key innovation of GREENIA is its ability to provide natural language explanations (NLEs), enabling transparent and interpretable insights for both technical and non-technical stakeholders. Applied in Greece, the framework addresses the challenges posed by the interplay of meteorological factors from 10 different meteorological stations across the country. Validation against real-world data demonstrates improved prediction accuracy using metrics like root mean squared error (RMSE), mean absolute error (MAE), and mean absolute percentage error (MAPE). SHAP analysis enhances transparency by identifying key meteorological influences, such as temperature and humidity, while NLE translates these insights into actionable recommendations in natural language, improving accessibility for energy planners and policymakers. The resulting strategic plan offers precise, intelligent, and interpretable recommendations for deploying RES technologies, ensuring maximum efficiency and sustainability.

***Keywords:*** *Renewable Energy Sources; Machine Learning Techniques; Evolutionary algorithms; RES placement; Meteorological Data Analysis; Explainable Artificial Intelligence*

**JEL Codes**: O44; O47; O52; Q43; Q56.

# New paradigms in the role of ICT over environmental degradation

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**Abstract**

In the era of development, the world is facing severe challenges, and environmental degradation is one of them. However, the globe has tried to introduce several initiatives to fight for environmental sustainability, such as the Sustainable Development Goals. The leading role of the proposed goals is to balance development and environmental anxiety. Therefore, to these issues, artificial intelligence and technological advancements play a vital role in the natural resource economy in the digital age. Policy analysts are always looking for solutions and have come up with several viable remedies to this problem. Consequently, information & communication technology (ICT) plays a significant role in sustainability in the digital era. However, under the theme of natural resource sustainability, the effectiveness of ICT has a significant impact on sustainability. Accordingly, the current study investigates the long-run effect of income per capita, tourism, natural resources rents, urbanization, and ICT on environmental sustainability in 36 OECD economies from 2000 to 2018. The current research employs an Augmented Mean Group (AMG) and two-step GMM to investigate the study's objectives. Results show the positive contribution of urbanization, natural resources, and tourism to CO2 emissions, while ICT reduces emissions. Besides, an inverted EKC curve is also validated for selected economies. In addition, the moderate effect of ICT on urbanization, natural resources, and tourism shows a significant decline in CO2 emissions. In light of the findings, this study recommends several crucial measures for environmental sustainability.

***Keywords:*** *SDGs, ICT, EKC, AMG, GMM*

**JEL Codes:** Q01

# Session 12
# Corporate Social Responsibility & Environmental Social Governance

# Approaches to Integrating ESG Principles & Processes into Local Governments

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**Abstract**

Today's society faces many social, environmental and economic challenges that affect both our local and global environment. If these impacts are not addressed, they will have far-reaching consequences for future generations. In recent years, a new vision for corporate and public management has gradually emerged in terms of fulfilling both legal and ethical responsibilities for existing and future generations. The integration of environmental, social and economic values is a real challenge faced by public leaders at all levels of governance and even more so at the local level. The goals and priorities at the level of society, with the encouragement of their leaders and politicians, should be the development of Social Responsibility. Consequently, the exercise of Social Responsibility policies in the logic of CSR and at the level of commitment to achieving specific goals and accountability for them, is considered very important. The research concerns an initial approach to integrating ESG accountability processes according to the GRI Standards and specifically the materiality analysis stage for nineteen Local Government Authorities (LGAs) and two public authorities of Public Benefit in Cyprus. It is based on interviews with either elected officials or employees of the above organizations and qualitative analysis, with the aim of identifying and capturing the strengths and vulnerabilities of the organizations, the interested groups and the most essential for their operation and role according to their responsibilities. The findings of the study, although initial, are expected to offer important conclusions and proposals for the formulation of the exercise of Social Responsibility policies. And this is based on the goals of Sustainable Development, and the integration in a systematic way into the political agenda of local authorities in accordance with the principles of Social Responsibility of companies or even some public interest organizations such as Universities.

***Keywords:*** *CSR, ESG, Local Government, Sustainable Development, Accountability*

**JEL Codes**: Q5; Q56

# Exploring the Impact of Corporate Social Responsibility on Employee Mental Health, Resilience, and Job Satisfaction

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**Abstract**

Corporate social responsibility (CSR) has emerged as a critical factor in shaping organizational success, fostering stakeholder trust, and enhancing corporate reputation. While the beneficial impacts of CSR on organizational performance and public perception are well-documented, the effects of CSR initiatives on employee mental health, job engagement, resilience, and overall satisfaction remain less explored. This study employs a detailed questionnaire to examine how CSR-related practices impact employees' mental resilience, job satisfaction, turnover intentions, and adaptability, with a focus on companies within the NGO's landscape.

By collecting comprehensive data on employees' experiences with CSR initiatives—including environmental practices, social responsibility measures, leadership styles, and communication within the organization—this research seeks to identify key correlations and differentiations among variables related to mental health and job satisfaction. The findings aim to provide actionable insights for organizational leaders and HR professionals on integrating CSR into organizational policies to promote sustainable employee well-being and engagement. This study's outcomes are anticipated to support the development of CSR strategies that foster a resilient, engaged, and satisfied workforce.

***Keywords:*** *Corporate Social Responsibility, Corporate Sustainability, Employee Mental Health, Organizational Change*

**JEL Codes**: I21; I31; I38; J28; J81Q01; Q52; Q56

## 1. Introduction

Corporate Social Responsibility (CSR) has emerged as a pivotal element in organizational strategies, transcending its traditional focus on external stakeholder engagement to influence internal dynamics, including employee well-being. Broadly defined, CSR encompasses voluntary corporate initiatives aimed at addressing societal, environmental, and economic concerns, aligning business practices with the broader good (Carroll, 1991). Organizations that actively invest in CSR not only enhance their public reputation but also cultivate trust and loyalty among employees, fostering a positive workplace culture (Glavas, 2016).

Despite the substantial body of research examining CSR's external impacts, its influence on employees—particularly on mental health, resilience, and job satisfaction—remains

underexplored. Most studies have concentrated on how CSR enhances organizational performance or public perception, with limited emphasis on the psychological and behavioral outcomes for employees (Aguinis & Glavas, 2012). Given the increasing prevalence of workplace stress and the demand for organizational support in fostering employee resilience, this gap warrants urgent attention. While some evidence suggests that CSR initiatives may improve job satisfaction and engagement, their specific effects on employees' mental health and adaptability in challenging circumstances are not well-documented (Dhanesh, 2014).

This study aims to bridge this gap by investigating the relationships between CSR practices and key employee well-being metrics, including mental resilience, job satisfaction, and turnover intentions. By analyzing data from employees within NGO contexts, this research seeks to illuminate the nuanced ways in which CSR initiatives influence workforce dynamics. The insights gained are expected to provide actionable recommendations for organizational leaders and HR practitioners on leveraging CSR to foster sustainable employee engagement and mental health, ultimately contributing to a more resilient and satisfied workforce.

## 2. Literature Review

*CSR and Organizational Performance*

Corporate Social Responsibility (CSR) has long been associated with enhanced organizational performance and stakeholder trust. Empirical evidence highlights that organizations adopting robust CSR policies experience improved financial performance, brand loyalty, and consumer trust (Orlitzky et al., 2003). CSR initiatives contribute to creating a favorable corporate image and securing a competitive edge by demonstrating a commitment to ethical and sustainable practices (Carroll & Shabana, 2010). Stakeholder theory underscores how CSR efforts align organizational goals with societal expectations, fostering deeper relationships with both internal and external stakeholders (Freeman, 1984). These benefits collectively underscore CSR's role as a strategic tool for organizational success.

*CSR and Employee Outcomes*

While CSR's external benefits are well-documented, its internal impacts—particularly on employees—have gained increasing scholarly attention. Research reveals that CSR initiatives positively affect employee engagement, job satisfaction, and organizational commitment (Brammer et al., 2007). Employees perceive CSR practices as a reflection of organizational values, strengthening their emotional connection with the company (Kim et al., 2010). Moreover, CSR enhances employees' sense of pride and motivation, fostering a culture of shared purpose and collaboration (Rupp et al., 2006). However, the specific pathways through which CSR impacts mental health and resilience remain less explored, highlighting a critical area for further investigation.

*Gap Analysis*

Despite growing interest in CSR's internal implications, a significant research gap persists in understanding its influence on employees' mental health and resilience. Existing studies predominantly focus on engagement and satisfaction, neglecting critical dimensions such as stress reduction, adaptability, and psychological well-being (Glavas & Piderit, 2009). With increasing workplace complexities and mental health challenges, examining how CSR practices mitigate stress and foster resilience is essential. Addressing this gap will provide a holistic understanding of CSR's impact, enabling organizations to craft strategies that align employee well-being with broader sustainability goals.



## 3. Data Collection

This study employed a structured questionnaire to collect comprehensive data from employees working within the NGO sector. The questionnaire was designed to capture respondents' perceptions of CSR-related practices, including environmental sustainability policies, social responsibility measures, leadership styles, communication quality, and organizational culture. Questions were tailored to measure both the direct and indirect effects of these practices on employees' mental resilience, job satisfaction, and intentions to leave their organization. Participants were selected through purposive sampling to ensure representation from diverse organizational roles and backgrounds.

*Variables Studied*

The study focused on both independent and dependent variables:

Independent Variables: CSR dimensions (e.g., environmental sustainability, social responsibility), leadership approaches (e.g., empowering leadership), communication practices, and employee participation.

Dependent Variables: Employee mental resilience, job satisfaction, turnover intentions, job engagement, and adaptability to workplace challenges.

The data collected allowed for a multidimensional analysis of how variations in CSR practices and organizational dynamics influenced employee well-being outcomes.

Statistical Techniques

To identify significant associations and test the study's hypotheses, a range of statistical techniques were applied:

Chi-Square Tests: Used to explore relationships between categorical variables, such as demographic factors and perceptions of CSR practices.

ANOVA (Analysis of Variance): Applied to compare means among different groups, such as levels of job satisfaction across various leadership styles.

Spearman Correlations: Employed to assess the strength and direction of associations between ranked variables, such as the relationship between CSR dimensions and mental resilience scores.

These methods provided a robust framework to examine the interplay between CSR initiatives and employee outcomes, ensuring that the findings were both statistically significant and practically relevant.



## 4. Results

Chi-Square Test Results

The Chi-Square tests were conducted to examine the relationships between categorical demographic factors and differentiated CSR-related variables. The key findings are presented in the table below:

| Factor Variable | Differentiated Variable | Chi-Square Statistic | p-Value | Significance |
|---|---|---|---|---|
| Gender | Employee Resilience | 9.90 | 0.042 | Significant |
| Gender | Intentions to Turnover | 13.85 | 0.031 | Significant |
| Do You Have Children? | Social Sustainability Aspects | 17.34 | 0.001 | Highly Significant |
| Do You Have Children? | Empowering Leadership | 11.72 | 0.039 | Significant |
| Do You Have Children? | Employee Resilience | 12.33 | 0.015 | Significant |

The results indicate significant associations between demographic factors (e.g., gender and parental status) and specific CSR-related variables. For instance, employees with children displayed stronger associations with social sustainability aspects and empowering leadership. Similarly, gender differences were evident in resilience and turnover intentions.

These findings suggest that demographic characteristics influence how employees perceive and are impacted by CSR initiatives, underscoring the need for tailored CSR strategies to address diverse workforce needs.

***Anova***

***ANOVA Results***

The ANOVA tests examined the effects of categorical demographic factors on continuous CSR-related variables. The significant results are summarized below:

| Independent Variable | Factor Variable | p-Value | Significance |
|---|---|---|---|
| Total Environmental Sustainability Policies | If Yes, What Kind of Special Needs Do You Have | 0.029 | Significant |
| Total Environmental Sustainability Policies | How Many Years Are You Working in the Field of NGOs | 0.001 | Highly Significant |
| Social Sustainability Aspects | Educational Level | 0.015 | Significant |
| Cultivation of Learning Culture | How Many Years Are You Working in the Field of NGOs | 0.005 | Significant |
| Empowering Leadership | How Many Years Are You Working in the Field of NGOs | 0.008 | Significant |
| Employee Participation | How Many Years Are You Working in the Field of NGOs | 0.023 | Significant |
| Communication | How Many Years Are You Working in the Field of NGOs | 0.002 | Highly Significant |
| Employee Resilience | Educational Level | 0.006 | Significant |
| Job Engagement | Educational Level | 0.005 | Significant |
| Job Engagement | How Many Years Are You Working in the Field of NGOs | 0.036 | Significant |
| Intentions to Turnover | Educational Level | 0.003 | Significant |
| Mental Resilience | Educational Level | 0.032 | Significant |

These results demonstrate that demographic factors, such as educational level and years of experience in the NGO sector, significantly influence perceptions of and engagement with CSR practices. For example, employees with higher educational attainment displayed greater sensitivity to social sustainability aspects, while years of experience shaped perceptions of leadership and communication practices.

The ANOVA findings highlight the importance of tailoring CSR initiatives to align with employees' educational and professional backgrounds, ensuring that programs resonate across diverse workforce demographics.

***Spearman Correlation Results***

The Spearman correlation tests examined the strength and direction of relationships between ranked variables, focusing on CSR practices and employee outcomes. The significant correlations are summarized below:

| Variable Pair | Correlation Coefficient (ρ) | p-Value | Significance |
|---|---|---|---|
| Position in Company vs. Areas of Work Interest | -0.260 | 0.003 | Significant |
| Position in Company vs. Environmental Sustainability Policies | 0.206 | 0.021 | Significant |
| Position in Company vs. Social Sustainability Aspects | -0.200 | 0.026 | Significant |
| Social Sustainability Aspects vs. Employee Resilience | 0.706 | <0.001 | Highly Significant |
| Social Sustainability Aspects vs. Job Engagement | 0.577 | <0.001 | Highly Significant |
| Cultivation of Learning Culture vs. Empowering Leadership | 0.753 | <0.001 | Highly Significant |
| Communication vs. Employee Resilience | 0.500 | <0.001 | Highly Significant |
| Employee Resilience vs. Mental Resilience | 0.782 | <0.001 | Highly Significant |
| Job Engagement vs. Job Satisfaction | 0.496 | <0.001 | Highly Significant |

The results demonstrate strong positive correlations between various CSR dimensions and employee resilience, engagement, and satisfaction. Notably, "Cultivation of Learning Culture" exhibited robust correlations with "Empowering Leadership" and "Communication," underscoring their interdependence. Additionally, "Social Sustainability Aspects" strongly correlated with "Employee Resilience" and "Job Engagement," suggesting that these CSR dimensions play a pivotal role in fostering a motivated and resilient workforce.

These insights highlight the critical role of CSR practices in shaping employee well-being and organizational dynamics, emphasizing the need for integrated strategies to maximize these benefits.

## 5. Discussion

### *Interpretation of Results*

The findings of this study underscore the profound impact of CSR initiatives on fostering a culture of resilience and satisfaction among employees. The strong correlations between CSR dimensions—such as environmental and social sustainability—and key outcomes like employee resilience and job satisfaction suggest that organizations that prioritize CSR not only contribute to societal well-being but also enhance their internal workplace environment. Notably, initiatives like "Cultivation of Learning Culture" and "Empowering Leadership" emerged as significant predictors of employee engagement and mental resilience. This aligns with prior research emphasizing the role of leadership in shaping positive employee outcomes (Avolio et al., 2004).



Moreover, the results highlight the importance of employee participation and communication in mitigating stress and fostering adaptability. These findings suggest that when employees perceive their organization as socially responsible and inclusive, they are more likely to experience enhanced psychological well-being and a stronger sense of purpose (Glavas & Piderit, 2009).

### *Theoretical Contributions*

This study advances the theoretical understanding of CSR by integrating its effects on employee psychological outcomes within the framework of organizational psychology. While previous studies have predominantly focused on external benefits of CSR, this research provides empirical evidence linking CSR practices to internal outcomes like resilience and job satisfaction. The robust associations observed between CSR dimensions and mental health outcomes extend the scope of stakeholder theory, illustrating how CSR practices can align organizational objectives with employee well-being (Freeman, 1984).

Additionally, the findings contribute to the emerging discourse on the role of leadership and participation in shaping organizational culture. By identifying specific CSR practices that enhance employee resilience and engagement, this study adds a nuanced understanding of how organizations can leverage CSR as a strategic tool for workforce sustainability.

### *Practical Applications*

The insights derived from this research have several practical implications for organizations, particularly NGOs, aiming to integrate CSR into their operational strategies. First, organizations should prioritize the development and implementation of comprehensive CSR policies that address both environmental and social dimensions. For instance, fostering a "Learning Culture" and empowering leadership can significantly enhance employee engagement and adaptability.

Second, communication and participation should be at the forefront of CSR initiatives. By actively involving employees in decision-making processes and maintaining transparent communication channels, organizations can create an inclusive culture that promotes resilience and satisfaction (Kim et al., 2010).

Lastly, organizations should consider tailoring CSR initiatives to align with the demographic and professional characteristics of their workforce. For example, employees with higher educational attainment may respond more positively to CSR practices emphasizing social sustainability, while those with extensive experience in the NGO sector may prioritize leadership and communication aspects.

By integrating these strategies, organizations can create a supportive and resilient workforce, ultimately driving both employee satisfaction and organizational success.

## 6. Recommendations

To design and implement CSR policies that enhance employee well-being, organizations should focus on fostering leadership practices that emphasize empowerment, support, and inclusivity. Leaders should be trained to integrate CSR values into managerial decisions, reflecting a commitment to the holistic development of employees (Avolio et al., 2004). Active participation of employees in the design and implementation of CSR initiatives is equally essential. Feedback mechanisms should be established to allow employees to express their opinions and contribute ideas, ensuring that CSR efforts resonate with their needs and aspirations (Glavas & Piderit, 2009).

Embedding CSR principles into the organizational culture is a critical step. This can be achieved by aligning CSR goals with the company's mission and values, reinforcing these principles through regular workshops and team-building activities that emphasize sustainability and social responsibility (Carroll & Shabana, 2010). Open and transparent communication about CSR objectives, progress, and outcomes is vital. Organizations can use meetings, newsletters, and digital platforms to provide regular updates, fostering a shared sense of purpose among employees (Kim et al., 2010).

CSR initiatives should also be tailored to the specific needs of employees. Organizations can leverage demographic and survey data to identify these needs and adapt programs accordingly. For example, employees with families may value initiatives that promote work-life balance, while younger employees may prioritize efforts focused on environmental sustainability (Aguinis & Glavas, 2012). Additionally, continuous training and development opportunities should be provided, such as workshops on sustainability, mental health seminars, and leadership courses. These programs can equip employees with the skills and knowledge to thrive in a socially responsible workplace.

To ensure effectiveness, organizations must establish metrics to assess the impact of CSR initiatives on employee well-being and organizational outcomes. These strategies should be regularly reviewed and adapted based on data-driven insights, ensuring alignment with evolving employee and organizational priorities (Orlitzky et al., 2003). Mental health should be prioritized through programs that provide access to counseling, stress management

workshops, and wellness activities. By creating a supportive environment for mental health, organizations can significantly enhance employee resilience and productivity (Glavas, 2016). Finally, collaboration with external stakeholders, such as community organizations and NGOs, can amplify the scope and impact of CSR initiatives. Such partnerships not only extend the benefits of CSR but also align with employees' values and interests, fostering a deeper connection between their work and societal contributions. By implementing these strategies, organizations can design CSR policies that not only achieve societal and environmental goals but also cultivate a resilient, engaged, and satisfied workforce.



## 7. Conclusions

This study underscores the profound impact of Corporate Social Responsibility (CSR) initiatives on enhancing employee well-being, resilience, and job satisfaction. The findings reveal significant associations between CSR practices—such as environmental sustainability, social responsibility, and inclusive leadership—and positive employee outcomes, including increased engagement, mental resilience, and reduced turnover intentions. These results highlight the importance of embedding employee-centric goals within CSR strategies to foster a supportive and inclusive workplace culture (Aguinis & Glavas, 2012; Glavas & Piderit, 2009).

By demonstrating that CSR practices not only benefit external stakeholders but also significantly contribute to internal organizational health, this research expands the scope of CSR's potential impact. Effective CSR strategies, particularly those emphasizing communication, participation, and tailored approaches to employee needs, can transform organizational dynamics and enhance both individual and collective performance (Kim et al., 2010; Orlitzky et al., 2003). Furthermore, the integration of CSR principles into leadership development and organizational culture offers a pathway for sustaining these benefits over the long term (Avolio et al., 2004).

Despite the compelling findings, this study also highlights areas requiring further exploration. Future research should investigate the longitudinal effects of CSR initiatives on diverse workforces, particularly across varying cultural and demographic contexts. Such studies would provide deeper insights into the evolving dynamics of CSR and its potential to address emerging workplace challenges, such as mental health crises and the need for adaptive resilience (Glavas, 2016). Additionally, exploring industry-specific impacts of CSR could help refine strategies tailored to unique organizational settings.

In conclusion, aligning CSR initiatives with employee-centric goals is not merely a strategic advantage but a necessity for fostering a resilient, engaged, and satisfied workforce. As organizations navigate an increasingly complex and interconnected world, the commitment to socially responsible practices will serve as a cornerstone for achieving sustainable growth and collective well-being.

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# The impact of sustainable development goals at the national level

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**Abstract**

The study explores how companies contribute to economic, social, and environmental sustainability by analyzing sustainability indicators. The thesis assesses the sustainability reports of Greek companies by using a method that grounded in the latest Global Reporting Initiative (GRI) Guidelines. Initially, the evaluation examines how well GRI principles are integrated into the organization, preparation, and composition of Corporate Social Responsibility (CSR) reports. The analysis includes eight balance sheets from Greek companies published in 2022. The results suggest that the integration of key principles and management approaches is fairly adequate, indicating that CSR reports are marked by sufficient transparency, reliability, balance, and completeness. Moreover, the study proposes potential improvements or adjustments in achieving sustainable development goals to benefit both the business community and society. This analysis significantly contributes to sustainable development by providing guidelines to enhance business practices towards a more sustainable and balanced future.

***Keywords:*** *Sustainable Development, ESG, Investment, Corporate Social responsibility*

**JEL Codes:** Q01; M14

# Incorporating the TCFD Recommendations in corporate reporting: A study on the large-cap companies listed in the Athens Stock Exchange

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**Abstract**

In the context of climate finance, global initiatives of corporate environmentalism have acquired a pivotal role in stimulating firms to become more actively involved in climate change accounting and reporting of their progress toward climate risk mitigation. Climate-related accounting and reporting is a crucial element in evaluating the extent to which a business entity through its operations is supporting shifts to a low-carbon economy and allocating capital to endorse climate solutions. This study examines the reporting practices of the large-cap companies listed in the Athens Stock Exchange (ASE) in terms of climate-related financial disclosures, focusing on underlying risks and opportunities. Specifically, it seeks to shed light on the alignment of the sample firms with the Recommendations set forth by the Task Force on Climate-related Financial Disclosure (TCFD) by employing a quantitative content analysis approach. The study's findings offer meaningful insights as to whether domestic large corporations disclose information on climate risks and opportunities in relation to four critical thematic areas: (i) Governance, (ii) Strategy, (iii) Risk Management, and (iv) Metrics & Targets. While adopting the TCFD Recommendations is voluntary, the results indicate that most sample firms disclose adequate information regarding climate-related information. However, considerable variation occurs in the four thematic areas, with relatively more comprehensive disclosures identified in terms of risk management and corporate governance mechanisms. The analysis encapsulates managerial, policy, as well as research implications: it offers evidence supporting the standardization of relevant both national and regional reporting frameworks, it allows us to infer both progress made and areas for further improvement by domestic corporations, and highlight aspects where more in-depth research could reveal critical determinants of corporate climate-related reporting in Greece.

***Keywords***: *TCFD recommendations, climate change, climate-related risks and opportunities, large-cap companies, corporate accounting and reporting.*

**JEL Codes**: Q01, Q54, Q56, M14

# Collaboration Between Companies and NGOs: Creating Inclusion and Mutual Benefits

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**Abstract**

In today's rapidly evolving social and economic landscape, collaboration between companies, Non-Governmental Organizations (NGOs), and other Civil Society stakeholders is essential for fostering workforce inclusion and promoting social well-being. This presentation explores the strategic partnership opportunities between businesses and NGOs to support the integration of vulnerable social groups, including individuals with disabilities, single parents, and former substance users, into the labor market. The collaboration framework is built on two key levels: awareness and education. The first level emphasizes raising awareness among companies about the benefits of a diverse workforce and addressing fears around differences through sensitization programs. These programs enable businesses to understand the challenges and strengths of marginalized groups, while recognizing the advantages that diversity brings to their work environment. The second level focuses on educating companies on how to adapt working conditions to meet the unique needs of these groups, such as flexible working hours for single parents or special accommodations for people with disabilities. This cooperative approach leads to a mutually beneficial relationship, where the alignment of employee skills with business needs drives productivity and innovation. It is not merely a philanthropic gesture but a strategic choice that enhances corporate social responsibility and fosters a more sustainable business model. Through this partnership, companies contribute to social cohesion while tapping into underutilized talent pools, sparking new ideas, and nurturing a more empathetic corporate culture. Ultimately, the integration of diverse perspectives and experiences generates significant benefits for both businesses and society at large.

***Keywords:*** *Corporate Social Responsibility (CSR), Workforce Inclusion, Vulnerable Social Groups, Non-Governmental Organizations (NGOs), Diversity and Inclusion, Social Cohesion, Strategic Partnerships, Flexible Work Arrangements*

**JEL Codes**: M14; J71; I38; L31; O15

## 1. Introduction

In modern society, issues of social exclusion and inequalities in the workplace remain critical. Vulnerable social groups, such as people with disabilities, single parents, and former substance users, often face significant barriers to entering the labor market. This reality not only

limits opportunities for these individuals but also deprives businesses of access to a wide range of talents and perspectives.

At the same time, the world is experiencing a rise in conflicts, economic and environmental crises, and growing social inequalities, all of which contribute to an increasing number of people living in precarious conditions. According to the World Health Organization, vulnerability refers to the extent to which individuals, communities, or organizations are unable to anticipate, cope with, resist, and recover from the impact of a disaster. This highlights the urgent need for solutions that enable people to rebuild their lives, strengthen resilience, and regain autonomy and dignity. One of the key ways to achieve this is through access to decent and sustainable employment.



Labor market statistics further emphasize the challenges faced by vulnerable groups. According to the International Labour Organization (ILO), individuals with disabilities experience unemployment rates twice as high as those without disabilities. The Organization for Economic Co-operation and Development (OECD) reports that in Latin America, indigenous populations face 1.5 times higher unemployment rates than non-indigenous populations, while in Europe, migrants experience unemployment rates 50-100% higher than native-born citizens. Additionally, the ILO identifies a significant portion of the global workforce as the "working poor": approximately 7.1% (225 million workers) live in extreme poverty, earning less than $2.15 per day. These figures highlight the importance of addressing labor market inequalities and the role of collaborative efforts between NGOs and businesses in promoting inclusion.

In this context, partnerships between companies and Non-Governmental Organizations (NGOs) take on significant importance. These collaborations not only facilitate the integration of marginalized individuals into the workforce but also foster social cohesion and generate mutual benefits for businesses and society as a whole (Austin, 2000).

**Purpose and Objectives of the Study**

This study examines the dynamics of collaboration between companies and NGOs, focusing on the potential for integrating vulnerable social groups into the workforce. The aim is to highlight how such collaborations can create a sustainable business environment, promote acceptance and equality, and provide solutions to social issues. Additionally, the research seeks ways for companies to develop human-centered policies based on workforce diversification and strategic inclusion of vulnerable groups (Porter & Kramer, 2011).

**Research Questions and Significance of the Topic**

The main research questions guiding this study are:

- How can collaboration between companies and NGOs reduce barriers for vulnerable groups to access the labor market?
- What are the key success factors for these collaborations?

- What are the mutual benefits for businesses, NGOs, and society as a whole?

The importance of this topic goes beyond corporate social responsibility, as it pertains to creating a new workplace culture that enhances productivity and creativity through diversity. Furthermore, companies investing in such collaborations can gain reputation, competitiveness, and social recognition, while NGOs achieve their social objectives (Visser, 2011).
Through this study, it is demonstrated that integrating vulnerable groups into the workplace is not merely an act of charity but a strategic choice that fosters innovation, social justice, and sustainable development.



## 2. Literature Review

### 2.1 Theoretical Framework for Collaboration Between Companies and NGOs

The collaboration between companies and Non-Governmental Organizations (NGOs) is a multidimensional phenomenon closely tied to the concepts of Corporate Social Responsibility (CSR) and social inclusion. According to Porter and Kramer (2011), CSR goes beyond philanthropy, serving as a strategic approach that enhances sustainable development and creates shared value. Such collaborations are based on mutually beneficial relationships between the private and non-profit sectors, aiming to promote social welfare and address inequalities. It is important to note that including individuals from socially vulnerable groups in recruitment does not mean creating unnecessary positions out of charity. Instead, it means overcoming any related reservations. It is crucial to understand that being vulnerable does not equate to being less capable professionally. It may simply require adapted working conditions, such as wheelchair ramps in the building or offering remote work options where feasible, for example, for single-parent families.

The concept of social inclusion, as defined by Austin (2000) and Visser (2011), focuses on creating an equitable environment where vulnerable groups gain access to opportunities that were previously inaccessible. Within this framework, collaboration between companies and NGOs emerges as a critical tool for bridging social and workplace inequalities, enabling the integration of individuals facing exclusion.

### 2.2 Forms and Levels of Collaboration

These collaborations can be classified into three main levels, each describing a different approach and focus:

**Level One: Awareness and Sensitization**

The first level involves raising companies' awareness about the value of including vulnerable groups and addressing biases against diversity. As noted by Doh and Tashman (2014), through educational programs and awareness campaigns provided by NGOs who are experts on such

issues, businesses can better understand the needs of these groups while recognizing their contribution to developing a multifaceted organizational culture.
Additionally, this can be achieved through meetings and discussions between companies and NGOs on issues that may concern employers. Participation in joint job fairs can provide companies with the opportunity to engage directly with vulnerable populations, conduct interviews, and hold discussions. Moreover, companies can actively contribute to the training of individuals, either at NGO facilities or through on-the-job training, helping to create a framework of trust and mutual understanding.

**Level Two: Training and Adaptation of Conditions**

Once the specific conditions required by companies to foster a healthy and productive working relationship with potential employees are understood, it is essential to establish a clear and formal framework not only for recruitment but also for maintaining these workplace conditions.

For this reason, the second level pertains to the development of specific policies for adapting workplace conditions. Examples include flexible working arrangements for single parents or special accommodations for individuals with disabilities (Visser, 2011). Companies that adopt such policies create an environment that not only enhances productivity but also fosters trust between employers and employees.

The formalization of this framework is crucial to ensure that the working conditions for individuals are not negatively altered due to potential changes in personnel. It also guarantees that these policies remain universal for future hires and become so deeply integrated into the company's strategy that they eventually form an inherent part of its culture.

**Level Three: Long-Term Partnerships and Continuous Support**

The third level involves long-term strategic partnerships that include ongoing support for vulnerable groups through targeted initiatives. Austin (2000) and Porter and Kramer (2011) argue that such collaborations contribute to sustainable development by integrating social objectives into core business strategies.

In addition to the formal framework, it is crucial for companies to remain active in hiring and maintaining working relationships with vulnerable populations. This requires consistent engagement and communication with civil society organizations to take on a permanent form, along with recurring or updated training sessions whenever deemed necessary.

It is of utmost importance to recognize that society evolves, and so do the social challenges individuals face, creating new needs and vulnerabilities. Companies must stay informed and adapt accordingly to address these changes effectively.

### 2.3 Benefits of Collaboration for Companies and NGOs

#### Business Benefits

For companies, the benefits of including vulnerable groups extend far beyond fulfilling corporate social responsibility; they encompass tangible advantages such as enhanced reputation, talent attraction, and increased productivity through the establishment of a multicultural and inclusive organizational culture. As Visser (2011) highlights, diversity is not just a moral imperative—it is a significant competitive advantage in a market that demands flexibility, innovation, and adaptability.

When companies embrace diversity, they open the door to a broader talent pool, bringing in unique perspectives, skills, and experiences that can drive innovation. For example, hiring individuals from different cultural backgrounds can foster creativity in product design or marketing strategies tailored to diverse customer bases. Similarly, employing persons with disabilities can often lead to the development of more accessible products or services, opening up new market opportunities.

Moreover, inclusive organizations often enjoy higher employee engagement and satisfaction. Workers are more likely to feel valued and motivated in an environment that respects and celebrates differences. For instance, companies like Microsoft have implemented specific programs to recruit and support individuals on the autism spectrum, recognizing their exceptional problem-solving skills and attention to detail as assets in technical roles.

Flexibility also plays a key role in retaining top talent. By offering adaptive work arrangements, such as remote working options for single parents or tailored accommodations for employees with disabilities, companies can cultivate loyalty and reduce turnover. For example, SAP's Autism at Work program not only provides targeted recruitment efforts but also ongoing support, ensuring employees thrive in their roles while fostering trust and loyalty.

In a rapidly changing global economy, companies that prioritize diversity and inclusion are better equipped to respond to challenges and seize opportunities. They become innovators and leaders in their industries, demonstrating that inclusivity is not only ethically sound but also strategically essential for sustainable growth and success.

#### Social Benefits

For society, these collaborations empower vulnerable groups, increase employment opportunities, and reduce social inequalities. Doh and Tashman (2014) argue that social cohesion is strengthened when vulnerable groups gain an active role in the labor market.

## 2.4 Challenges and Limitations of Collaboration

Despite the significant benefits, collaborations between companies and NGOs are often accompanied by challenges that can impact their effectiveness and sustainability. Addressing these obstacles is vital for shaping partnerships that foster social inclusion and deliver meaningful value to all stakeholders.

### Administrative and Organizational Challenges

Managing collaborations often involves navigating complex administrative and organizational dynamics. Companies and NGOs frequently operate with distinct structures, processes, and priorities, making alignment difficult. For instance, companies may prioritize efficiency and financial profitability, while NGOs are driven by social impact and long-term community engagement. This divergence can create communication gaps or delays in decision-making processes.

For example, a multinational corporation partnering with a local NGO on a job training program for vulnerable groups may struggle to align timelines. While the corporation might aim for quick results to report on its quarterly impact metrics, the NGO might emphasize long-term capacity building, which requires a slower pace. Overcoming these challenges requires clear communication and well-defined roles to ensure both sides' objectives are addressed.

### Differing Goals and Priorities

A fundamental challenge lies in reconciling differing goals and priorities. As Porter and Kramer (2011) point out, when strategic objectives are misaligned, the collaboration's overall impact may be diluted. For example, a company might engage with an NGO primarily to enhance its brand reputation rather than commit to genuine social change, leading to superficial or unsustainable efforts. Similarly, an NGO might focus exclusively on its mission without accommodating the operational needs of the business partner.

A practical example can be found in partnerships focusing on workforce inclusion. A company might initiate a program to hire individuals with disabilities but face challenges if the NGO's emphasis is on broader societal advocacy rather than workforce readiness. In such cases, finding common ground—such as co-developing job-specific training programs—can bridge the gap and ensure mutually beneficial outcomes.

### Strategies to Overcome Challenges

Understanding these challenges is the first step toward building effective and sustainable collaborations. Practical strategies include:

Establishing a Shared Vision: Both parties should co-create a roadmap that aligns financial and social goals. For instance, integrating social objectives into the company's core business strategy can create a more cohesive approach.

Fostering Open Communication: Regular meetings and feedback loops can address misunderstandings before they escalate. Companies and NGOs can establish liaison roles to bridge organizational cultures.



Investing in Capacity Building: Both parties should invest in resources to strengthen their partnership. For example, companies can fund training programs for NGO staff, while NGOs can educate corporate leaders on the social issues they aim to address.

Examples of Successful Collaborations

One example of overcoming these challenges is Starbucks' partnership with NGOs to employ refugees in select countries. Initially, differences in priorities arose—NGOs wanted long-term refugee support, while Starbucks aimed to fill immediate labor gaps. Through dialogue and joint planning, they created a structured hiring program that met both goals, ensuring ongoing support for refugee employees.

Another successful case is Unilever's collaboration with Oxfam to assess its supply chain's impact on poverty. Although their initial objectives diverged—Unilever sought to improve supply chain efficiency, while Oxfam aimed to empower smallholder farmers—the partnership aligned through shared research and co-designed initiatives. By addressing administrative and strategic misalignments, companies and NGOs can transform these challenges into opportunities, fostering partnerships that are not only productive but also impactful in driving sustainable social change.

## 3. Methodology

*Caritas Hellas Case Study*

Research Questions

The study was guided by the following research questions:

1. What role do NGOs play in facilitating partnerships with companies to integrate vulnerable social groups into the labor market?
2. How do vocational training programs impact the employability and social integration of marginalized populations?
3. What are the mutual benefits for companies and NGOs when engaging in inclusive workforce initiatives?

Hypotheses

H1: Collaborative efforts between NGOs and companies enhance the employability of vulnerable groups through tailored vocational training and supplementary services.

H2: Companies benefit from participating in these initiatives by accessing untapped

talent pools and fostering a positive corporate social responsibility (CSR) image.
H3: Participants in these programs experience significant improvements in their professional skills, confidence, and access to employment opportunities.

**Methodological Approach**



A qualitative case study methodology was employed to explore the Caritas Hellas vocational training initiative. This approach allowed for an in-depth examination of the programs design, implementation, and outcomes.

## 4. Results

The results of this study, based on the Caritas Hellas case study, demonstrate the effectiveness of strategic partnerships between NGOs and companies in fostering workforce inclusion for vulnerable groups. These findings are organized into three sections: participant outcomes, organizational benefits, and broader social impacts.

1. Participant Outcomes

Vocational Skill Development

Training Impact:

A total of 32 participants, including refugees, migrants, and vulnerable local community members, completed the vocational training programs in housekeeping and cooking.

The training spanned 60 hours per course over two months and provided participants with both theoretical knowledge and practical skills required for employment in hospitality.

Skill Application:

Participants gained hands-on experience in culinary techniques and housekeeping operations, equipping them for immediate entry into the labor market.

Workshops on workers' rights, stress management, and interview preparation supplemented their technical training, fostering a holistic approach to workforce readiness.

Employment Opportunities

Direct Hiring Opportunities:

All participants were given the chance to interview with Sani/Ikos Group's Human Resources team. This resulted in increased employment prospects for participants, with many being offered roles in hospitality.

Career Support Services:

Participants benefited from CV preparation assistance and career counseling, which strengthened their job application profiles and confidence during interviews.

Feedback from Beneficiaries

Beneficiaries highlighted the transformative impact of the program:

A participant reflected on the importance of the culinary training, stating:

"The program not only taught me valuable culinary techniques but also equipped me with the confidence to work in a professional frame. This training was a necessity in helping me secure a job."
The nurturing environment provided by Caritas Hellas staff was frequently mentioned, with participants feeling respected and supported throughout the process.



2. Organizational Benefits
NGO Contributions
Caritas Hellas:
Successfully delivered targeted vocational training programs that addressed the needs of vulnerable populations, bridging gaps in employability. Demonstrated a replicable model of NGO-led workforce development, leveraging partnerships with corporate entities.
Neos Kosmos Social Spot:
Played a pivotal role in connecting participants with services, such as job counseling and stress management workshops, that complemented vocational training.
Corporate Partner Benefits
Sani/Ikos Group:
Gained access to a pool of motivated and skilled candidates for roles in their hospitality operations. Enhanced their Corporate Social Responsibility (CSR) profile by actively supporting workforce inclusion initiatives.
IEK Delta:
Contributed to societal well-being by designing and delivering effective training tailored to industry needs.

3. Broader Social Impacts
Social Cohesion and Inclusion
The program demonstrated how partnerships between companies and NGOs could foster social inclusion by integrating marginalized groups into the labor market.
Participants' increased employment opportunities helped reduce economic vulnerability and foster a sense of belonging within their communities.
Replication Potential
The success of the program highlighted a model that can be replicated in other regions or industries, showing the scalability of such initiatives. The structured approach to skill-building and direct engagement with employers provides a roadmap for other NGOs and companies to create mutually beneficial partnerships.
Long-Term Impacts
The program laid the foundation for participants' long-term career growth by not only enhancing their technical skills but also empowering them with workplace confidence and an understanding of their rights and responsibilities.
These results underscore the transformative potential of NGO-company collaborations in creating inclusive workforce solutions while addressing both societal and business needs.

## 5. Conclusion

The collaboration between Caritas Hellas, Sani/Ikos Group, and IEK Delta exemplifies the transformative power of partnerships between NGOs and the private sector in addressing workforce inclusion challenges. This initiative reflects the principles outlined in the literature, particularly the concept of shared value as articulated by Porter and Kramer (2011), whereby social impact and business strategy converge. By combining vocational training with holistic support services, the program offered a comprehensive model that not only enhanced participants' employability but also supported their broader social and economic integration.

The structure of the program aligns closely with the three levels of NGO-corporate collaboration identified in academic discourse. At the initial stage—awareness and sensitization—participants and corporate staff engaged in targeted skill-building and diversity-focused initiatives. These efforts underscore the vital role NGOs play in addressing bias and fostering inclusive workplace cultures (Doh & Tashman, 2014). The second stage—training and adaptation—was reflected in the tailored vocational programs and workplace adjustments designed to meet the specific needs of marginalized groups. Finally, the initiative embraced a long-term strategic approach, consistent with Austin's (2000) framework for sustainable partnerships, by embedding inclusive hiring and ongoing support into corporate practices.

For corporate partners such as Sani/Ikos Group, the program validated Visser's (2011) argument that diversity enhances both innovation and competitiveness. By engaging with underutilized talent pools, companies addressed pressing labor market gaps while strengthening their corporate social responsibility (CSR) profiles. The initiative revealed how inclusive hiring practices can evolve from philanthropic gestures into strategic business decisions that yield tangible benefits for both the organization and society.

From the perspective of NGOs like Caritas Hellas, the collaboration highlighted the potential of leveraging corporate partnerships to scale impact and deliver replicable solutions to social exclusion. The partnership enabled the organization to expand its mission and extend its reach, demonstrating how cross-sector collaboration can amplify social change efforts.

On a societal level, this case study reinforces the broader significance of well-aligned, multi-stakeholder initiatives in promoting social cohesion and addressing systemic inequality. By empowering vulnerable populations and facilitating their entry into the labor market, the program contributed meaningfully to economic development and community well-being. It stands as a practical application of the theoretical frameworks discussed in the literature, offering a replicable model for workforce inclusion initiatives across industries and regions.

Ultimately, the success of this program underscores the transformative potential of strategic collaboration between NGOs and businesses. It bridges theory and practice, illustrating how aligning organizational strengths and shared values can drive meaningful change, foster innovation, and promote long-term social and economic sustainability.

## 6. Suggestions for Future Research

### Further Study on Other Forms of Collaboration or Industries

**Exploring partnerships in diverse economic sectors:** Future research could investigate how collaborations between NGOs and companies operate in industries beyond hospitality, such as technology, manufacturing, or healthcare. This would provide a broader understanding of how inclusion initiatives can be adapted to the unique challenges and opportunities within different sectors.



**Investigating cross-sectoral collaborations:** Research could examine partnerships involving multiple stakeholders, such as governments, educational institutions, and international organizations, to assess their combined impact on workforce inclusion and social cohesion.

**Analyzing regional variations:** A comparative study of NGO-corporate collaborations in different cultural or economic contexts could shed light on how local conditions influence the effectiveness and sustainability of inclusion efforts.

### Development of Tools for Measuring Social Inclusion

**Designing comprehensive assessment frameworks:** Future research could focus on developing standardized tools to measure the impact of inclusion initiatives, incorporating metrics such as employment outcomes, workplace satisfaction, and long-term career growth of participants.

**Creating real-time monitoring systems:** Innovative digital tools and dashboards could be designed to track the progress of workforce inclusion programs, providing stakeholders with actionable insights and enabling dynamic adjustments to improve outcomes.

**Evaluating broader societal impacts:** Research could develop methodologies for quantifying the ripple effects of inclusion programs on community well-being, economic development, and social cohesion, offering a more holistic view of their success.

**Testing sector-specific indicators:** Tools tailored to specific industries could be created to evaluate how effectively inclusion initiatives address unique workforce needs while aligning with broader business and social objectives.

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| 43 | Leibniz University Hannover | Institute for Environmental Economics and World Trade |
| 44 | Mediterranean SPA Hotel | |
| 45 | Mesoyios College, Limassol, Cyprus | Department of Business Administration |
| 46 | National and Kapodistrian University | Department of Law, Law School |
| 47 | National and Kapodistrian University of Athens | Department of Economics |
| 48 | National and Kapodistrian University of Athens & Earthquake Planning and Protection Organization of Greece (EPPO) | Department of Geology and Geoenvironment |
| 49 | National Centre for Scientific Research "Democritus" | Environmental Research Laboratory |
| 50 | Panteion University of Social and Political Sciences | Institute of Human Resources and Urban Development, Department of Economic and Regional Development |
| 51 | Q Alphaplan Consultants. | |
| 52 | Q-PLAN International Advisors PC, Business Consulting | |
| 53 | Queensland University of Technology, Brisbane, Australia | School of Economics and Finance |
| 54 | Research centre in Applied Economics for Development, Algeria. | |
| 55 | RMIT University, Melbourne, Victoria, Australia | School of Fashion & Textiles |

| No | Institution | Department |
|---|---|---|
| 56 | Sofia University "St. Kliment Ohridski", Bulgaria | Faculty of Geology and Geography |
| 57 | Symbiosis International (Deemed University), Bangalore, India | Symbiosis Institute of Business Management |
| 58 | TUV Hellas (TUV Nord) | |
| 59 | UNESCO IHE Delft, Netherlands. | |
| 60 | United Nations Industrial Development Organization (UNIDO), Vienna, Austria | |
| 61 | United Nations University, UNU-FLORES. | |
| 62 | Universidad Panamericana, Mexico. | Facultad de Ingeniería |
| 63 | Universidade Católica Portuguesa, Portugal | Faculty of Biotechnology |
| 64 | University of Belgrade, Serbia | Department of Hydraulic and Environmental Engineering, Faculty of Civil Engineering |
| 65 | University of Belgrade, Serbia | Institute of Geodesy and Geoinformatics, Faculty of Civil Engineering |
| 66 | University of Bologna and Athens University of Economics and Business | Department of Economics |
| 67 | University of Castilla-La Mancha | Department of Political Economy and Public Finance, Economics and Business Statistics and Economic Policy |
| 68 | University of Greenwich, United Kingdom | |
| 69 | University of Guelph, Canada | Department of Economics |
| 70 | University of Jaffna, Sri Lanka. | Department of Agricultural Economics, Faculty of Agriculture |
| 71 | University of Nis, Serbia | Faculty of Mechanical Engineering |
| 72 | University of Nis, Serbia | Faculty of Occupational Safety |
| 73 | University of Oulu, Finland. | |
| 74 | University of Patras | Department of Economics |
| 75 | University of Patras | Laboratory of Economics of Strategy, Innovation & Sustainability – LENS, Department of Economics |
| 76 | University of Piraeus & Regulatory Authority for Energy, Waste and Water in Greece | Department of International and European Studies |
| 77 | University of Porto, Portugal | Interdisciplinary Centre of Marine and Environmental Research |
| 78 | University of Seville (USe)), Seville, Spain. | Department of Aerospace Engineering and Fluid Mechanics, Agroforestry Engineering Area, School of Agricultural Engineering (ETSIA) |
| 79 | University of Sousse, Tunisia | Faculty of Economic Sciences and Management |
| 80 | University of Tartu, Tartu, Estonia. | Institute of Chemistry |
| 81 | University of the Aegean | Department of Environment |

| No | Institution | Department |
|---|---|---|
| 82 | University of the Aegean | Image, Sound & Cultural Representation Laboratory, School of Social Sciences |
| 83 | University of the Aegean | Laboratory for Environmental Policy & Strategic Environmental Management, School of Environment |
| 84 | University of the Aegean | School of Environment |
| 85 | University of Thessaly | Department of Accounting and Finance |
| 86 | University of Thessaly | Department of Civil Engineering |
| 87 | University of Thessaly | Department of Economics |
| 88 | University of Thessaly | Department of Economics, School of Economics and Business Administration |
| 89 | University of Thessaly | Department of Environmental Science , Institute of Technology |
| 90 | University of Thessaly | Department of Planning and Regional Development |
| 91 | University of Thessaly | Faculty of Veterinary Medicine |
| 92 | University of Thessaly | Laboratory of Economic Policy and Strategic Planning, Department of Economics |
| 93 | University of Thessaly | Laboratory of Operations Research, Department of Economics |
| 94 | University of Thessaly | Physics Department |
| 95 | University of Thessaly | Civil Engineering Department |
| 96 | University of Thessaly & AMARANTHUS - Sustainability Research and Modeling Solutions | Civil Engineering Department |
| 97 | University of West Attica | Department of Business Administration |
| 98 | University of West Attica | Department of Informatics |
| 99 | University of Western Macedonia | Dept. Communication and Digital Media Department, School of Social Sciences and Humanities |
| 100 | University of Zagreb, Croatia. | Department of Biology, Faculty of Science |
| 101 | Warsaw University of Life Science, Poland | Institute of Environmental Engineering |

# Thank you very much!

# The Scientific & Organizing Committees