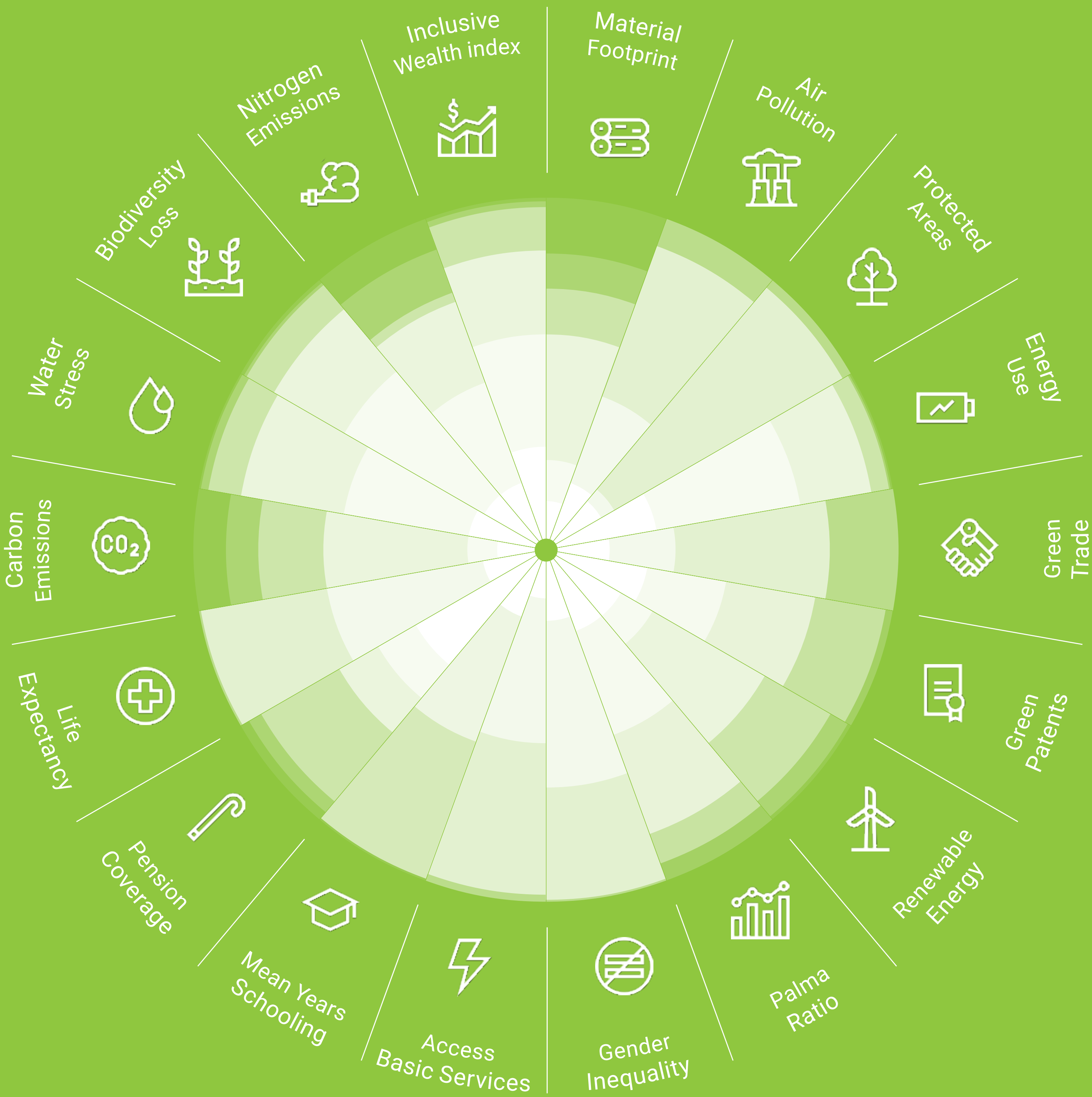
Working Paper:
The Green Economy Progress Measurement Framework
[3rd Edition]



PAGE PARTNERSHIP FOR ACTION ON GREEN ECONOMY

UN environment programme · International Labour Organization · UNDP · UNIDO · unitar

ISBN: 978-92-807-4156-8
Job number: DTI/2646/GA

Suggested citation: United Nations Environment Programme (2024). The Green Economy Progress Measurement Framework (Third Edition): Accelerating the recovery through the transition towards climate-neutral economies. Geneva.

Copy-edited by Simon Lobach

PAGE gratefully acknowledges the support of all its funding partners:
European Union
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany
Ministry for Foreign Affairs, Finland
Ministry of Climate and Environment, Norway
Ministry of Environment, Republic of Korea
Swedish International Development Cooperation Agency
State Secretariat for Economic Affairs, Switzerland

Acknowledgements
The Third Edition of the Green Economy Progress Measurement framework was commissioned by the Management Board of the Partnership for Action on Green Economy (PAGE). The United Nations Environment Programme (UNEP) led its production – on behalf of PAGE – and partnered with Cambridge Econometrics.

Coordination
At UNEP, the production of the paper was coordinated by Ronal Gainza, Economic Affairs Officer, PAGE Secretariat, and Ricardo Isea, Consultant, PAGE Secretariat, under the overall guidance of Asad Naqvi, Head of the PAGE Secretariat, Resources and Markets Branch, Industry and Economy Division. José Pineda, Senior Consultant at UNEP and DevTech Systems Senior Advisor provided overall technical guidance. The content of the paper was cleared by Elisa Tonda, Chief of the Resources and Markets Branch, Industry and Economy Division, UNEP, and Steven Stone, Deputy Director, Industry and Economy Division, UNEP.

At Cambridge Econometrics, the modelling work was coordinated by Stijn Van Hummelen (Belgium), Managing Director.

Authors
The drafting of the paper was co-led by José Pineda, UNEP Senior Consultant and DevTech Systems Senior Advisor, and Bence Kiss-Dobronyi, Senior Economist at Cambridge Econometrics. Calculation of the Green Economy Progress Measurement Framework was developed by José Pineda. The modelling work was carried out by Bence Kiss-Dobronyi and Ioannis Gutzianas. Ronal Gainza, Asad Naqvi and Ricardo Isea from the PAGE Secretariat provided inputs in drafting and editing several sections of the paper.

Contributing authors: Stijn Van Hummelen and Ioannis Gutzianas, Cambridge Econometrics.

Research Assistance: Lorenzo Agnelli, Mayu Suzuki and Matteo Consiglio, Interns at UNEP.

Communication campaign: Vanessa Domingos Esteves, Rosario Caddeo and Sébastien Crettaz.

Administrative Assistance: Desiree Leon and Suzan Lazaro Nshoka from UNEP, and Vanita Bardeskar from UNITAR.

Peer review
This paper greatly benefited from a consultation workshop held on 26 April 2023. PAGE appreciates the technical inputs from all participants, notably from the discussants: Niklas Hagelberg, Global Coordinator, Climate Change, UNEP; Andrea M. Bassi, CEO of KnowlEdge Srl and Associate at IISD; Elsa Galarza, Director Graduate School of Public Management at the Universidad del Pacífico in Peru; Xin Zhou, Research Leader, Integrated Sustainability Centre, Institute for Global Environmental Strategies (IGES); David Carlin, Head of Climate Risk at UNEP FI; Hector Pollitt, Senior Economist, Climate, at the World Bank; and Ribeus Mihigo Munezero, Data Analyst and Python Programmer Consultant, Global Green Growth Institute (GGGI).

Note
The Methodology of the Green Economy Progress Measurement Framework was developed by José Pineda and Gisèle Mueller under the guidance of Sheng Fulai of UNEP back in 2017. Technical guidance for the theoretical framework was provided by Carmen Herrero, University of Alicante; Antonio Villar, Universidad Pablo de Olavide; and Eduardo Zambrano, California Polytechnic State University. Gerardo Milano provided excellent research assistance. Leonardo Ortega provided significant assistance with the construction of the database of indicators.

Working Paper: The Green Economy Progress Measurement Framework

[3rd Edition]

Accelerating the recovery through the transition towards climate-neutral economies

Glossary

APEC	Asia-Pacific Economic Cooperation
CCS	Carbon Capture and Storage
DAC	Direct Air Capture
FOEN	Swiss Federal Office for the Environment
E3	Energy-Environment-Economy
E3ME	Energy-Environment-Economy Macro-Econometric Model
ETS	Emission Trade Systems
EU	European Union
FTT	Future Technology Transformations
GDP	Gross Domestic Product
GEP	Green Economy Progress
GEPMF	Green Economy Progress Measurement Framework
GGGI	Global Green Growth Institute
GGKP	Green Growth Knowledge Partnership
GHG	Greenhouse Gas
GPP	Green Policy Platform
GVA	Gross Value Added
HDI	Human Development Index
IAMs	Integrated Assessment Models
ILO	International Labour Organization
IGE	Inclusive Green Economy
IPCC	Intergovernmental Panel on Climate Change
IPCC AR6	Intergovernmental Panel on Climate Change 6th Assessment Report
IRENA	International Renewable Energy Agency
IWI	Inclusive Wealth Index
OECD	Organisation for Economic Co-operation and Development
OECM	One Earth Climate Model
PAGE	Partnership for Action on Green Economy
PPP	Purchasing Power Parity
SDGs	Sustainable Development Goals
SCP-HAT	Hotspot Analysis Tool for Sustainable Consumption and Production
SQ	Status Quo
UN	United Nations
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar
WDI	World Development Indicators
WIPO	World Intellectual Property Organization

Contents

List of Tables

List of Figures

1 Introduction

In a world grappling with unprecedented challenges, where overlapping climate, health, economic, and geopolitical shocks continue to shape our collective destiny, a profound transformation is imperative. Today, we stand at a crossroads, where the need for solutions to protect our planet and secure human well-being has never been more urgent.

Never before has humanity faced such a convergence of challenges. At the forefront of our concerns, the Triple Planetary Crisis endangers our very existence as a species. Climate change, with its severe heatwaves, devastating storms, and rising sea levels, tests the limits of our ecosystems and our resilience; pollution, choking our air, poisoning our waters, and harming our health, has become an urgent global concern; and rapid biodiversity loss threatens the intricate web of life upon which our survival depends.

And as if that wasn't enough, the COVID-19 pandemic unleashed unprecedented disruption, exposing the fragility of our interconnected global systems. Economies staggered, societies fractured, and inequalities deepened, leaving millions in precarious circumstances. And although recovery packages managed to tame the most immediate impacts of the pandemic, they lacked sufficient green emphasis, failing to seize the opportunity to accelerate bold economic and societal transformation. Moreover, the ongoing War in Ukraine continues to propagate ripples of instability across regions, further compounding the complexities of our time.

With less than six years to meet the deadline of 2030, the Partnership for Action on Green Economy (PAGE) has reaffirmed its commitment to accelerate action to promote an Inclusive Green Economy (IGE) — a transformative paradigm that can chart a course beyond recovery, while realizing progress on the Sustainable Development Goals (SDGs) and ensuring a resilient future.[1]

1.1. What's New in the Third Edition?

This Third Edition of the Green Economy Progress Measurement Framework[2] introduces novel and innovative elements that push forward the understanding and advancement of the IGE transition. The paper includes a quantitative estimation of the impact of recent global shocks, a methodological upgrade that connects the Green Economy Progress Index (GEP Index) with a modelling tool, and an assessment of the effects of policy and investment options. These advancements provide invaluable insights for reframing the economy and accelerating the net-zero transition while the world recovers from major crises.

Capturing the Impact of Major Shocks: One key innovation in this Edition is the comprehensive examination of the IGE transition, both pre-COVID-19 and in the wake of shocks like the War in Ukraine and the pandemic. By measuring the effects of these disruptions on IGE trajectories, the paper unveils the extent to which global events have shaped sustainable development pathways, thus facilitating a deeper understanding of the challenges presented by unforeseen events.

1 An inclusive green economy is, in its simplest expression, "low carbon, efficient and clean in production, but also inclusive in consumption and outcomes, based on sharing, circularity, collaboration, solidarity, resilience, opportunity, and interdependence. It is focused on expanding options and choices for national economies, using targeted and appropriate fiscal and social protection policies, and backed up by strong institutions that are specifically geared to safeguarding social and ecological floors. And it recognizes that there are many and diverse pathways to environmental sustainability." (UNEP 2015).

2 See section 2.1 for a methodological description of the Green Economy Progress Measurement Framework's key components, including the Green Economy Progress Index (GEP Index) and the Dashboard of Sustainability indicators.

Methodological Upgrades and Future Projections for Scenario Comparison: The Third Edition introduces an upgraded methodology that links the GEP Index with a macro-econometric model, the E3ME model[3]. This novel approach not only enables a retrospective assessment of the IGE transition but also facilitates future forecasting and scenario comparison until 2030 through an "Adjusted GEP Index"[4]. This methodological upgrade reflects the flexibility of the Green Economy Progress Measurement Framework (GEPMF), enabling a forward-looking perspective that allows for informed decision-making and strategic alignment with long-term sustainability objectives.

Assessing Policy and Investment Impacts: Recognizing the critical role of policy and investment in driving the IGE transition, the paper goes beyond mere measurement and analysis. It assesses the impacts of policy and investment options on IGE trajectories, specifically aiming to accelerate the net-zero transition while recovering from major shocks. This assessment equips decision-makers with evidence-based insights, enabling them to make informed choices that simultaneously address the challenges posed by recent crises and advance sustainability goals.

3 See section 2.3 for a methodological description of the E3ME model.
4 See section 2.2 for a methodological description of the "Adjusted GEP Index".

Key Findings

Progress Towards an Inclusive Green Economy (2014-2019)[5]:

- Prior to the pandemic, countries experienced significant progress towards an inclusive green economy globally, with 83 out of the 110 countries in the sample (over 75 per cent) showing improvements compared with the values of the two previous editions[6]. In addition, 29 per cent achieved positive progress (or had no regress) across the Dashboard of Sustainability indicators, as well as a positive GEP Index score.

- However, across countries, progress often occurred in areas where improvements were less relevant in relative terms. In other words, countries mostly experienced progress in areas where the GEP index's weights were low (most favorable initial conditions relative to the critical threshold in each country).

- Among PAGE countries, the GEP Index shows that 14 (out of 17 PAGE countries with data) made progress towards an IGE over the period 2014—2019, with Uruguay and Thailand heading the list. Still, most PAGE countries experienced regress in material footprint (14 out of 17 countries) and renewable energy share in total energy supply (13 out of 17 countries). The only countries with progress in material footprint were Uruguay[7], South Africa, and Mongolia, while the countries with progress in renewable energy uptake were Uruguay, South Africa[8], Thailand, and China. On the other hand, the Dashboard of Sustainability reveals that none of the PAGE countries experienced progress with regards to a reduction of greenhouse gas (GHG) emissions.

Challenges and Opportunities in the Post-Covid-19 era:

- Recent global shocks have caused a setback in inclusive green economy trajectories. An Adjusted GEP Index linked to the E3ME model[9] that was applied to compare different investment and policy scenarios, covering 58 countries, showed that the COVID-19 pandemic and the war in Ukraine have negatively affected countries' ability to progress towards an IGE, akin to the regression experienced during the 2008 global financial crisis.

- However, under the 1.5°C scenario, massive investments into various decarbonization measures[10] can reinvigorate progress in transitioning towards inclusive green economies. The outcome of the 1.5°C scenario is not only a neutral (or slightly positive) impact on economic growth but also the reduction of global greenhouse gas (GHG) emissions by over 40%. Additionally, the best performance of countries on the GEP Index – during the period 2023—2030 – is observed under the 1.5°C scenario. Caution is needed, though, as such a scenario would involve, in the absence of additional measures, certain challenges in

5 The methodology employed in this first part of the analysis — i.e., the GEPMF — covers 110 countries, of which 17 are PAGE partner countries.
6 The first edition was published in 2017 and the Second Edition in 2021.
7 One important reason behind this progress in material footprint in Uruguay has been the launching of the National Circular Economy Action Plan in 2019, which highlights a series of policy commitments and concrete actions on circular economy in the country (e.g., the Action Plan for Sustainable Government Procurement).
8 In the case of South Africa, eight out of nine provinces embarked on drafting provincial green economy-related strategies, notably in renewable energy. For more information, see PAGE (2023).
9 The methodology employed in this second part of the analysis – i.e., the Adjusted GEP Index linked to the E3ME model – allows for 58 countries and regions to be covered, of which 7 are PAGE partner countries.
10 The 1.5°C scenario directs investments into various decarbonization measures that promote key aspects of an IGE transition (such as reducing air pollution and greenhouse gas and nitrogen emissions, improving energy efficiency, and adopting of renewable energies).

terms of material footprint (regress despite decarbonization investments)[11] as well as some notable trade-offs, including potential negative impacts on employment[12], slower short-term progress in reducing income inequality, and moderate growth in labour productivity in the medium-to-long term.

- For 6 out of the 7 PAGE countries analysed in the modelling exercise, the only valid option for a sustained IGE transition is the 1.5°C scenario. Nevertheless, there are important heterogeneities across PAGE countries, with Kazakhstan and South Africa benefiting the most across indicators from a net-zero transition pushed by decarbonization investments. Argentina[13] and India[14], on the other hand, would still experience some challenges in their progress towards an IGE, in the absence of supplementary measures, mostly due to a persisting regress in resource efficiency indicators such as material footprint per capita and electricity use per unit of GDP.

11 This result is consistent with the evidence indicating that renewable energy favours the reduction of the material consumption of fossil fuels, while increasing the Material Footprint of the other categories beyond fossil fuels. See R.M. Regueiro-Ferreira and P. Alonso-Fernández (2023).

12 The effects of the 1.5°C scenario on employment are "negative" in the sense that they are less than the counterfactual (same amount of investments as in the brown economy – e.g. increased fossil fuel consumption), but results are not worse than in the baseline scenario.

13 Lack of investments and maintenance in the sector are among the main drivers of such negative trend. Argentina has not made significant investments in its electricity transmission network in the last 25 years, which limits its ability of develop renewable energies. See Koop (2023).

14 For India, experts highlight important policy and regulatory challenges such as inconsistent federal and state-level renewable energy policies and excessive custom duties on renewable energy-related products. See Arasu (2022).

Key Policy Recommendations

Based on the key findings presented above, this paper puts forward three recommended policy actions for advancing an Inclusive Green Economy (IGE), in alignment with the 2030 Agenda for Sustainable Development:

- **Balancing Green Economy Progress: Prioritizing Lagging-Behind Areas.** Results from the Green Economy Progress Measurement Framework for the pre-COVID-19 period (2014—2019) show that most countries made progress in key areas relevant to an IGE, particularly in energy use per unit of GDP, life expectancy, gender inequality, access to basic services, and education –areas which were already well-performing as compared to other IGE areas. However, on average, countries regressed in terms of material footprint, nitrogen emissions, and greenhouse gas (GHG) emissions, and showed little progress in renewable energy uptake during this period. *While green economy progress made in the well-performing areas should be reinforced, it is crucial that countries prioritize areas where they are facing the most significant challenges and are lagging behind*.

- **Ensuring Fairness in the Green Transition: The Imperative of Just Transition Policies**. The findings from our modeling underscore the positive impacts of the 1.5°C scenario on greenhouse gas (GHG) emissions reduction, slightly positive impacts on economic growth and, overall, long-term progress towards an IGE. By prioritizing green investments, societies can lay the groundwork for a cleaner, greener future while also reaping the benefits of enhanced economic prosperity. Still, without additional measures, such a scenario comes with the risk of inferior employment outcomes compared to the status quo scenario (in which equal amounts of investment are directed to the brown economy, further pushing fossil fuel consumption) as well as slower progress in reducing income inequality and moderated growth in labor productivity in the medium-to-long term. *It is therefore crucial that green investments are coupled with just transition policies to ensure that the pathway to a more sustainable and low-carbon economy is fair and inclusive and that it protects workers (particularly women), promotes social inclusion, and ensures that no one is left behind*.

- **Reframing Strategic Policies for a Fair and Green Economic Transformation**. Reframing strategic policies is crucial to drive green and inclusive economic growth, create income and jobs, mitigate poverty, reduce economic and gender inequalities, and strengthen the ecological foundations of national economies, in line with the 2030 Agenda and the Sustainable Development Goals (SDGs). As countries navigate the complexities of the current global landscape and seek to achieve green economic transformation, *it is essential that inclusive green economy principles, targets, and objectives are prioritized at the highest level of decision-making and reflected across all areas of government policy, including national economic, social, environmental, finance, and development planning*.

2 Methodology

This Third Edition comprises an upgrade of the methodology employed in the two previous editions. The GEP Measurement Framework is first used to quantify the IGE transition prior to the COVID-19 pandemic (in the period 2014—2019) in over 100 countries. Then, it is linked to a macro-econometric model, the E3ME model, not only to evaluate the IGE transition looking backward (2020—2023), but also for forecasting future IGE trajectories until 2030. This is done by developing an "Adjusted Green Economy Progress Index" (GEP Index) and assessing the impacts of policy and investment options on the IGE trajectories, which would allow the world to accelerate the net-zero transition[15] while it is recovering from recent major shocks. The parts of the methodology that are similar to the methodology used in previous editions can be found in those editions, but are also summarized in Figure 1.

2.1 The Green Economy Progress Measurement Framework: Key Components

The GEP Measurement Framework is composed of a **GEP Index** and an accompanying **Dashboard of Sustainability indicators**. Figure 2 presents the GEP Measurement Framework and its parts. The **GEP Index** is used to compare the actual changes in green economy indicators with the desired changes as they were originally formulated. The GEP Index reflects the weighted progress achieved by countries with respect to targets set to remain within planetary boundaries and the relevant thresholds across several indicators.

The Dashboard of Sustainability aims to monitor the long-term sustainability of any short-term progress as measured by the GEP Index. It tracks developments in some of the main forms of natural capital (greenhouse gas emissions, water and biodiversity, emissions of nitrogen), as well as other key stocks of capital (e.g. human, health, Inclusive Wealth Index), as these can easily affect long-term sustainability. This Third Edition uses the footprint indicators incorporated in the Dashboard of Sustainability from the Second Edition. **It is also consistent with the 2030 Agenda for Sustainable Development, as it includes indicators correlated to specific targets from most of the 17 Sustainable Development Goals (Figure 3).**

A final overall ranking of progress in achieving targets (**GEP+**) is obtained by applying the Principle of Priority, which means that the focus is on the Worst Achievement (Protective Criterion): countries' least-performing indicator of progress.

15 "Put simply, net zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance. See www.un.org/en/climatechange/net-zero-coalition.

Figure 1: Methodological flow followed in the Third Edition
Note: Figure created by the authors.

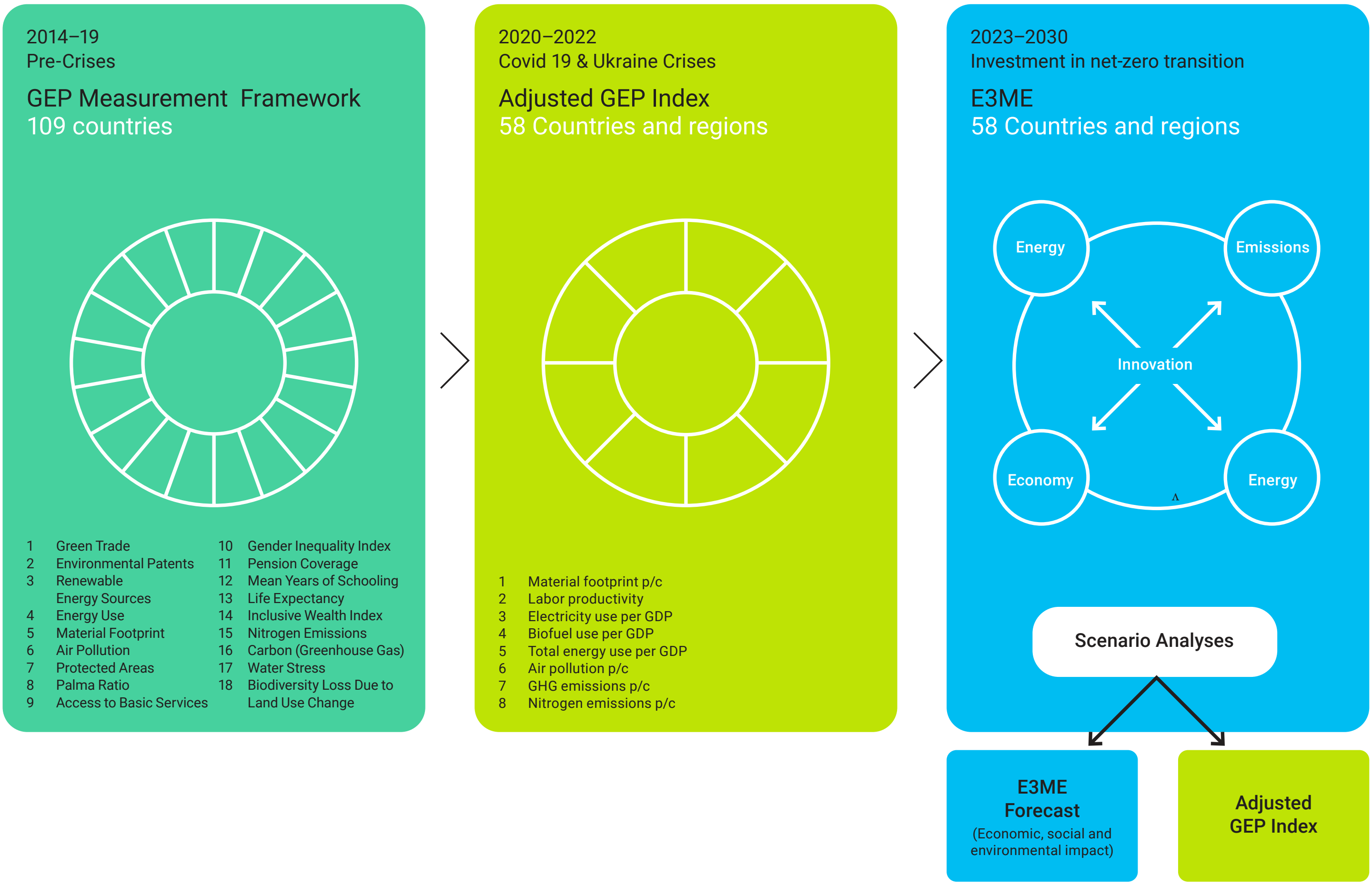
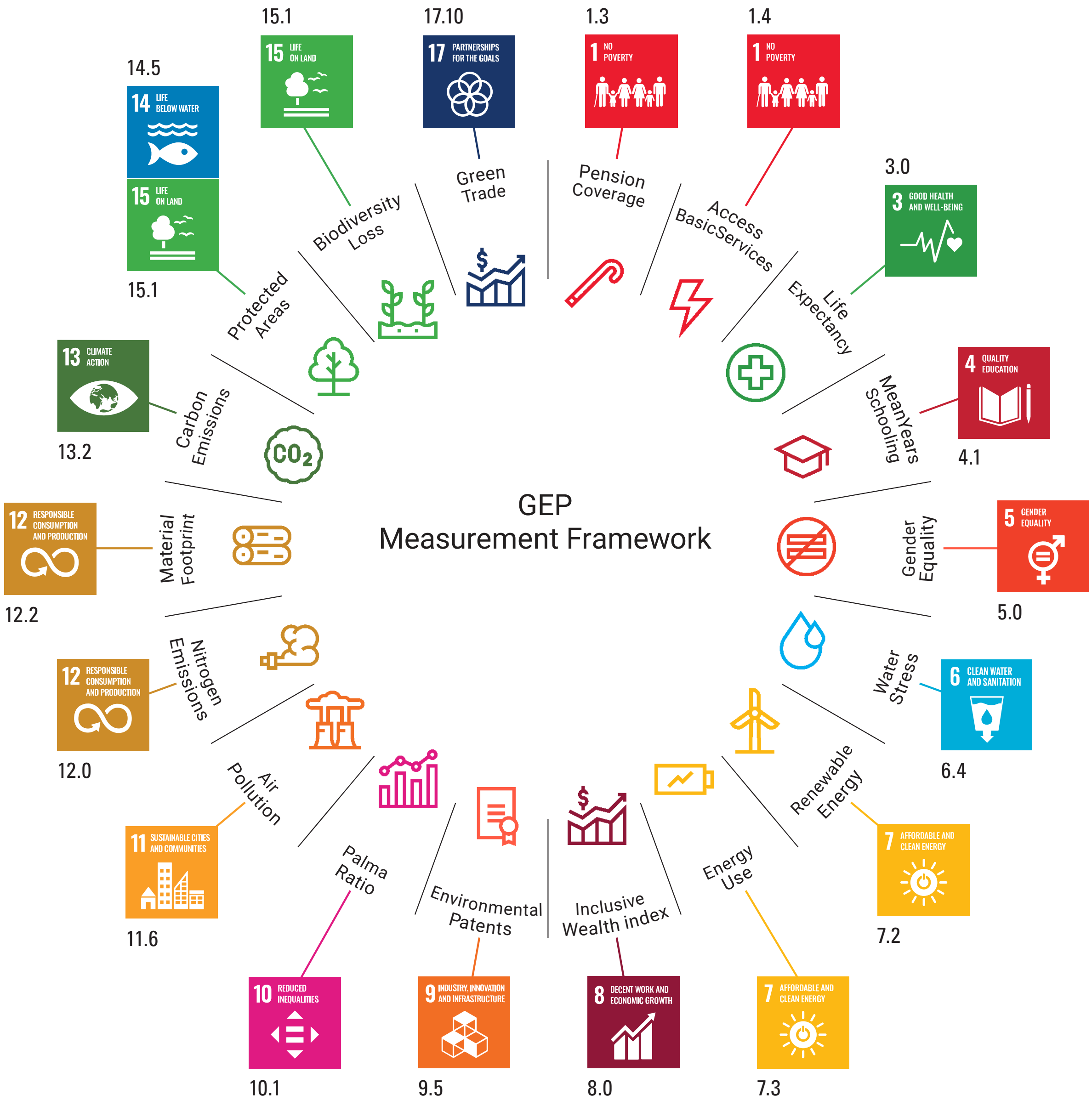


Figure 2: The Green Economy Progress Measurement Framework's parts
Note: Figure created by the authors

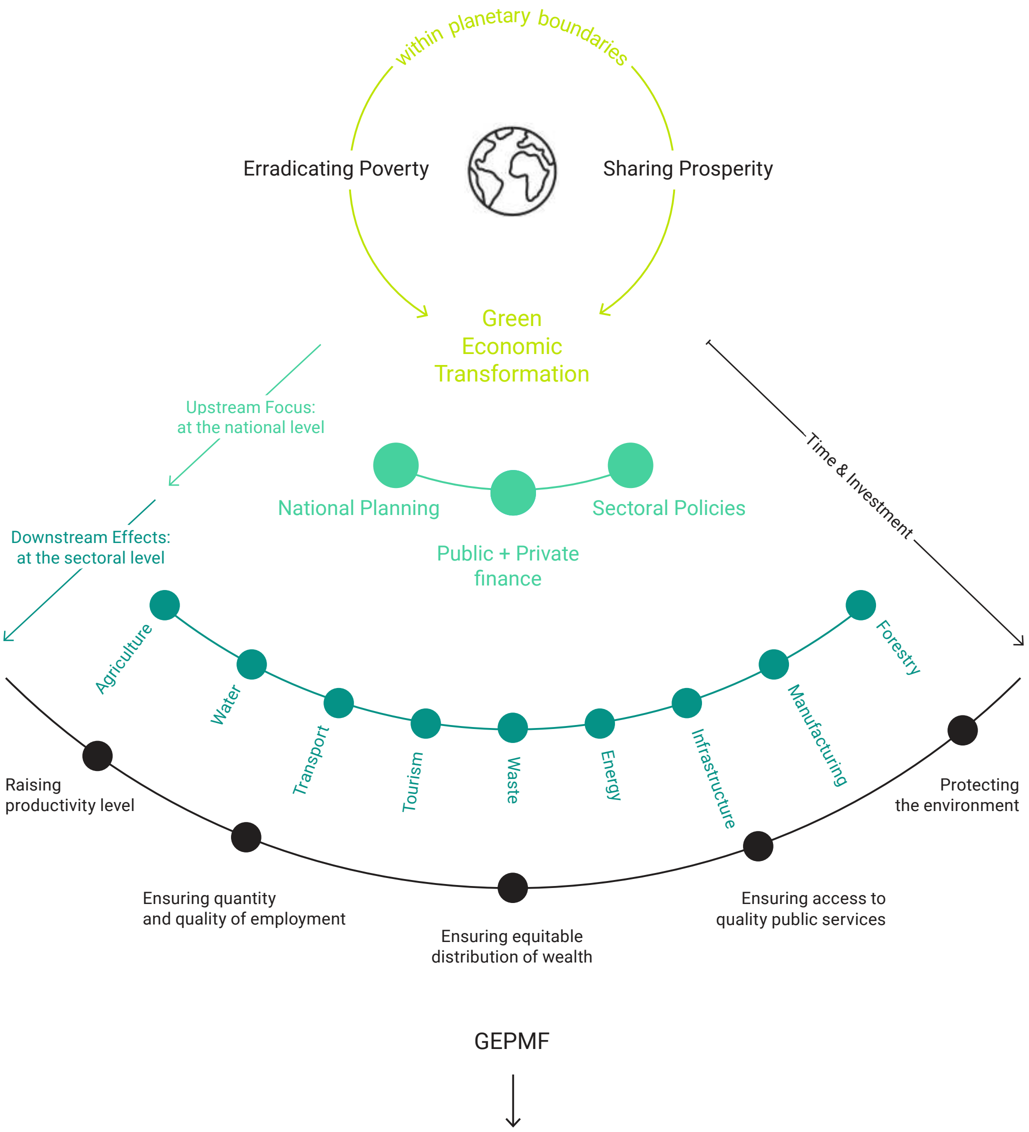
- GEP Index
- Dashboard of Sustainability

Figure 3: The Green Economy Progress Measurement Framework and the SDGs
Note: Figure created by the authors



The GEP Measurement Framework is a powerful tool to measure the needed economic transformation for achieving the SDGs. It encompasses indicators[16] that are linked to addressing poverty eradication and the sharing of prosperity, as well as to planetary boundaries. Figure 4 gives an overview of the indicators included in the GEP Measurement Framework that are mapped in the Inclusive Green Economy Analytical Framework.

Figure 4: The GEP Measurement Framework to measure green economic transformation



GEP INDEX INDICATORS

- Green Trade
- Environmental Patents
- Renewable Energy Sources
- Energy Use
- Material Footprint
- Air Pollution
- Protected Areas
- Palma Ratio
- Access to Basic Services
- Gender Inequality Index
- Pension Coverage
- Mean Years of Schooling
- Life Expectancy

DASHBOARD OF SUSTAINABILITY INDICATORS

- Inclusive Wealth Index
- Nitrogen Emissions
- Carbon (Greenhouse Gas)
- Water Stress
- Biodiversity Loss Due to Land Use Change

Note: Figure created by the authors. Indicators in italic are in the GEP Index, those in bold are in the dashboard.

16 Indicators in the GEP index are outcome (or performance) indicators that are affected by policy choices. By contrast, most of the indicators in the dashboard are state indicators, because the focus of the Dashboard is to monitor stocks, in order to assess progress within planetary boundaries.

For this update, we kept the same set of indicators that are based on the Inclusive Green Economy analytical framework (PAGE 2017a; PAGE 2017b). The sources are also the same as in previous editions, but there have been small changes in the sample of countries covered for each indicator.[17] For this Third Edition, several footprint indicators were updated in the SCP-HAT, so that this paper captures the latest available information. Also note that the sample of countries is smaller for this edition, but the overall implication thereof in the aggregate results is limited, as it does not affect the countries with an overall GEP Index. Finally, the calculations of targets and thresholds follows the first and second editions of this paper (PAGE 2017b; PAGE 2021).

2.2 The Adjusted Green Economy Progress Index

This Third Edition makes an important innovation to the Green Economy Measurement Framework by connecting the index work with the E3ME macro-econometric model (which will be explained in the next section). The importance of this innovation is twofold. First, it allows for the capturing of recent events, such as the COVID-19 pandemic and the War in Ukraine. For this, a simplified version of the index is constructed, with a smaller (and in many cases different) set of indicators that are available at a higher frequency, so that they can capture more recent events. Second, the adjusted GEP Index is connected with the E3ME macro-econometric model, determining the more limited set of indicators that can be used, but more importantly, allowing the adjusted GEP Index to be calculated more dynamically and to be connected to the different modelling scenarios. This is a critical improvement of the framework, because it allows for the integration of different policy tools to enable better decision-making.

The adjusted GEP Index has historical data from 2003 to 2022, as well as forecast data for 2023—2030. Given this significant source of information, the adjusted GEP Index is calculated for 9 sub-periods. Of these, 6 sub-periods are composed of historical data (2003—06, 2006–09, 2009—12, 2012—15, 2015—18, and 2018—21), whereas 3 sub-periods describe forecast scenarios: 2021—24, 2024—27, and 2027—30. This division is very useful from a policy-making point of view, as it shortens the period for which progress is evaluated and is thus able to provide suggestions for policy adjustments. In addition, this choice for short sub-periods allows for distinguishing the effects of the COVID-19 pandemic and the recovery from it.

The data used in the adjusted GEP Index are coming from the sample of countries and indicators already available in E3ME macro-econometric model, to guarantee full integrations between the tools (see Table 1). Data are available for a sample of 58 countries, distributed (according to the Human Development Index groups) among the categories Very High HDI (44), High HDI (9), Medium HDI (2), and Low HDI (2). Note that in the sample there are seven PAGE countries: Argentina, Brazil, China, India, Indonesia, Kazakhstan, and South Africa.

Table 1 below shows the indicators assessed for this GEP Index. As can be seen, these indicators are divided into “goods” and “bads”. The “goods” indicate progress towards IGE as their value increases, whereas the “bads” indicate progress towards IGE when their value decreases.

17 For environmental patterns, the number of countries in the sample has been reduced by one; for renewable energy it has been reduced by two countries; for energy use by one; for Palma ratio by one; by access to basic services it has been increased by ten countries; for energy use it has been reduced by one country; for air pollution by one; for material footprint by one; for pension coverage it has been increased by 20 countries; and for mean years of schooling it has been increased by four countries.

Table 1: Classification of indicators of the GEP Measurement Framework in the Adjusted GEP Index

"Bads"	"Goods"
Material footprint per capita	Labour Productivity
Electricity use per GDP	Biofuel use per GDP
Total energy use per GDP	
Air pollution per capita	
GHG emissions per capita	
Nitrogen emissions per capita	

Note: Indicators in italic are included in the Adjusted GEP Index, those in bold are in the dashboard.

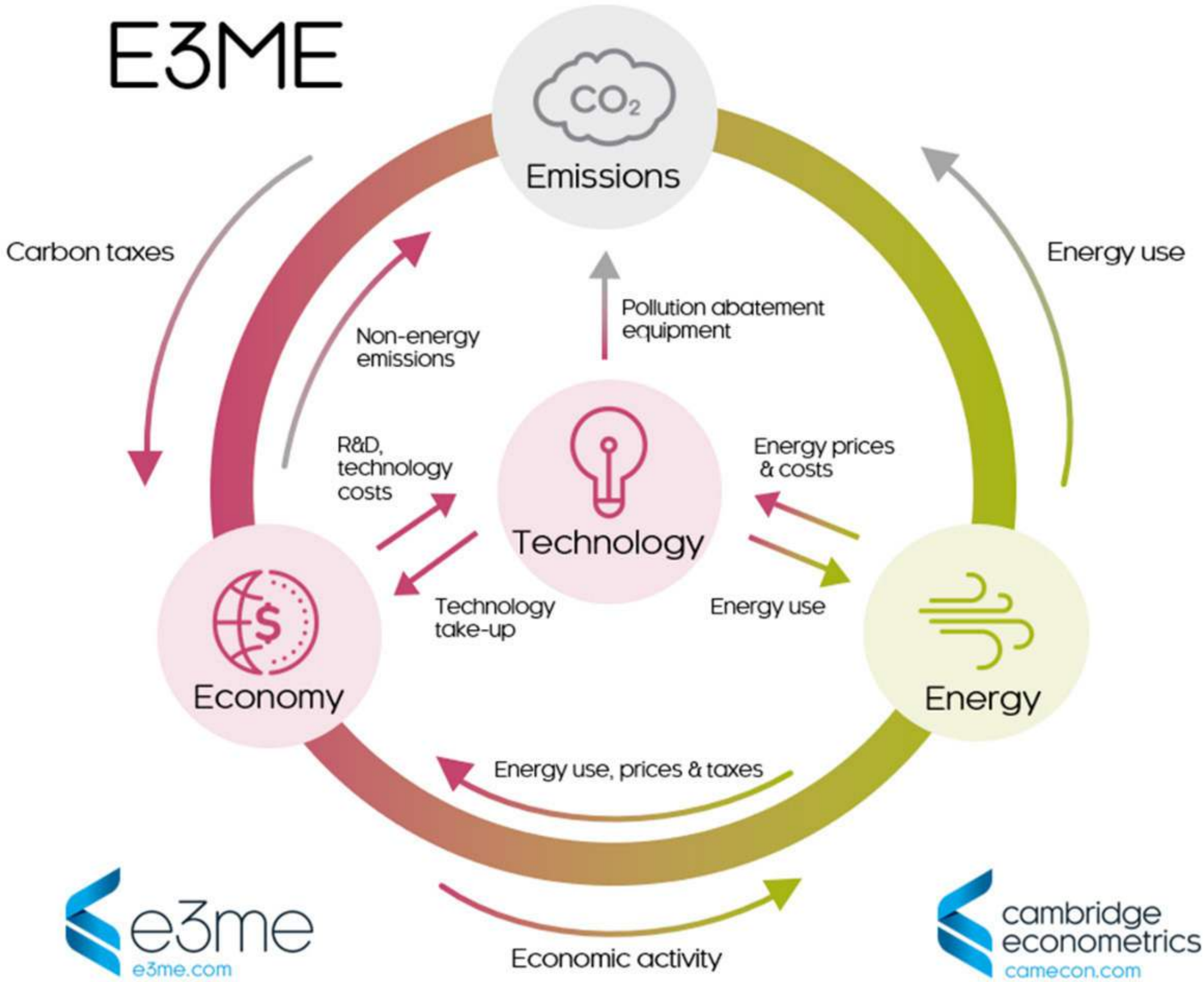
In general, the calculations of targets and thresholds follows the same type of calculations as for the main GEP Index, which can be found in the earlier editions.

From a methodological point of view, the adjusted GEP Index is expected to continue improving in two main dimensions. First, the country coverage is expected to continue growing as the work done by Cambridge Econometrics on the E3ME macro-econometric model continue to incorporate granular information on more countries. This is particularly relevant for developing countries, which are currently underrepresented in the sample due to challenges with data availability. Second, the availability of indicators to be included in the Index can be further improved. Future work could incorporate indicators related to gender inequalities and expand on other critical IGE issues.

2.3 The E3ME Macro-Econometric Model

For the forward-looking modelling analysis, the E3ME-FTT macro-econometric integrated assessment modelling framework was applied. The modelling framework comprises the E3ME model (Mercure *et al.* 2018; Lewney, Pollitt and Mercure 2019; Cambridge Econometrics 2022) and the FTT (Future Technology Transformations) model suite (Mercure 2012; Lam *et al.* 2018; Pollitt, Lee and Chewpreecha 2019; Knobloch *et al.* 2021)a representation of global power systems based on market competition, induced technological change (ITC. The E3ME model simulates the main economic-energy-environmental interactions, building on econometric parameter estimates (Mercure *et al.* 2018; Lewney, Pollitt and Mercure 2019), while the FTT suite introduces bottom-up modelling for several technologies that are especially important for the low-carbon transition. See Figure 5.

Figure 5: E3ME model schematic
Note: Figure provided by Cambridge Econometrics.



E3ME itself is an E3-type model, resembling the integrated assessment models (IAMs) that are frequently used for the assessment of global warming pathways, including economic and energy system outcomes (IPCC 2022). However, the economic core of the model is built on post-Keynesian theory and the ideas of complexity economics (Lewney, Pollitt and Mercure 2019; Mercure et al. 2019; Pollitt et al. 2021; Cambridge Econometrics 2022; Kiss-Dobronyi et al. 2023). The economy in the model is demand-led with supply-side constraints, positing that effective demand is a key driver of economic activity. Demand levels, prices, energy demand and various other factors are estimated based on historical time series data, using econometric equations (Lewney, Pollitt and Mercure 2019). A full set of the estimated equations is available in the manual of the model (Cambridge Econometrics 2022) or in Mercure et al. (2018). Demand is met through domestic and traded supply, which is linked to demand either through national input—output tables or through bilateral trade linkages (Lewney, Pollitt and Mercure 2019; Pollitt et al. 2021).

Importantly, E3ME is a non-equilibrium model, which means that — while supply always meets demand — it does not necessarily mean that supplied economic output will be the highest achievable, i.e., that its full potential is reached. The model does not assume that all economic resources are fully/optimally used, nor that the economy is in a state of equilibrium as a starting point (Lewney, Pollitt and Mercure 2019; Cambridge Econometrics, 2022; Kiss-Dobronyi et al. 2023). A change in government policy (and particularly green policy) can result in a better usage of resources, rather than distorting markets and leading to disequilibrium. This contrasts with the theoretical underpinnings of computable general equilibrium models (Mercure et al. 2019) and implies that better economic outcomes are possible when governments implement policies to facilitate the low-carbon transition and climate mitigation actions (Pollitt et al. 2021), in addition to other societal benefits.

Macro-econometric time series modelling is sensitive to the Lucas critique (Pollitt et al. 2021; Kiss-Dobronyi et al. 2023), which states that modelling based on observed behaviour from the past is unlikely to properly represent structural change in the future. To counter this effect, we integrate the FTT suite of models with E3ME for industries that are key for a low-carbon transition. The FTT models are bottom-up technology diffusion models calibrated for certain areas such as transportation (Lam et al. 2018; Knobloch et al. 2020), power generation (Mercure 2012) and residential heating (Knobloch et al. 2020; Knobloch et al. 2021). They represent the diffusion and adaptation of new technologies through a simulation process, where investors select the technologies in which they want to invest based on levelized cost, but make their choice under the assumption of bounded rationality. It is also assumes that technology choice is path-dependent, while the cost of individual technologies can decrease over time due to learning-by-doing and competition effects (Mercure 2012; Knobloch et al. 2020).

E3ME-FTT has been applied many times over the last two decades to assess impacts of government policy, as well as global shocks and pathways. Modelling of large-scale global scenarios for international organizations include the New Climate Economy report for the World Resources Institute,18 the modelling of several global decarbonization scenarios for IRENA,19 and the modelling of an inclusive green recovery scenario for UN PAGE and the ILO (Van Hummelen *et al.* 2021). Applications of the model also include region- and country-specific work, such as the recent assessment of recovery measures in several countries (Kiss-Do- bronyi, Fazekas and Pollitt 2021; Kiss-Dobronyi *et al.* 2023) or the analysis of the possibilities of decarbonization in Asia (e.g., the Asia Society Policy Institute, or academic publications like Lam *et al.* 2018; Pollitt, Lee and Chewpreecha 2019; Lee *et al.* 2022).

18 https://newclimateeconomy.report/
19 www.camecon.com/what/our-work/renewable-energy-generation-the-impact-on-the-global-economy-for-irena/

2.4 How to Limit Global Warming through IGE Investments despite Recent Shocks?

The objective of the modelling carried out for this paper is twofold: first, to provide forward-looking projections to the GEPI in order to consider how the index is impacted in a pathway that aims to mitigate climate change to certain levels. Second, the modelling aims also to assess how and at what investment level climate mitigation at a global level can be achieved, and how this compares to a counterfactual / status quo scenario in which equal amounts of investment are directed to business-as-usual economic activities, following current trends.

Therefore, we specify two plus two scenarios, as summerized in Table 2.

20 https://knowledge4policy.ec.europa.eu/publication/commission-staff-working-document-swd2020176-impact-assessment-stepping-europe%E2%80%99s-2030_en

21 www.camecon.com/what/our-work/assessment-of-the-impacts-of-an-ets2-for-transport-and-buildings/

Table 2: Specified scenarios

	Climate target (°C) by 2100	Average annual investment difference from baseline (% of global GDP)	Target of investment
Baseline	No target, above 3.5°C	N/A	N/A
1.5 °C	Limiting warming to 1.5°C	3.1%	Energy transition, energy efficiency, green technologies
1.5 °C *status quo*	No target, above 3.5°C	3.0%	*Status quo*, following historical structure
2.0 °C	Limiting warming to 2.0°C	1.2%	Energy transition, energy efficiency, green technologies
2.0 °C *status quo*	No target, above 3.5°C	1.1%	*Status quo*, following historical structure

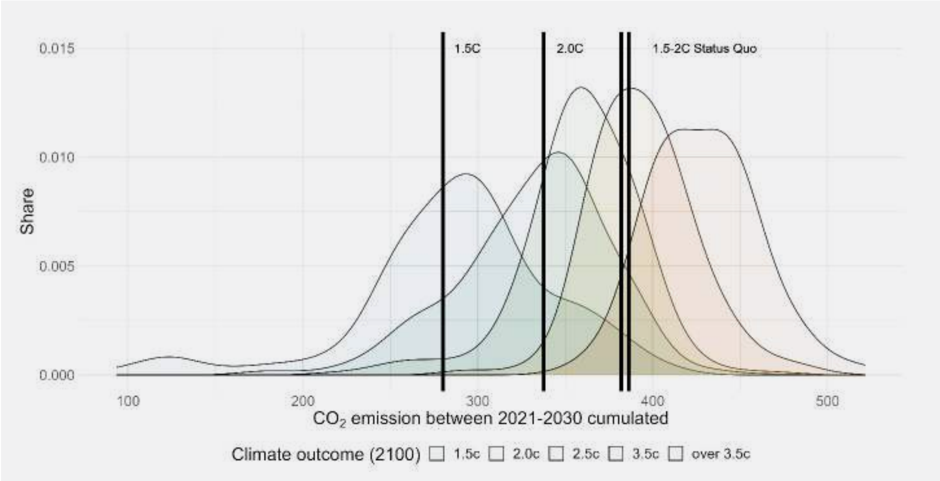
The scenario design is based on two previous modelling exercises: Semieniuk *et al*. (2022) oil and gas production assets through a global equity network of 1.8 million companies to their ultimate owners. Most of the market risk falls on private investors, overwhelmingly in OECD countries, including substantial exposure through pension funds and financial markets. The ownership distribution reveals an international net transfer of more than 15% of global stranded asset risk to OECD-based investors. Rich country stakeholders therefore have a major stake in how the transition in oil and gas production is managed, as ongoing supporters of the fossil-fuel economy and potentially exposed owners of stranded assets.

The simulations rely on an explicit representation of policies and investments covering the time period 2023—2030. This means that we do not present greenhouse gas (GHG) emissions in the period after 2030 directly, but employ results from 1775 different climate scenarios reported within the IPCC AR6 report (IPCC 2022) to estimate the likely climate outcomes. Our method is the following: we look at cumulated emissions of IPCC scenarios for 2023—2030 and assign climate outcomes by 2100 to these emission figures. We then assess where cumulated emissions from our scenarios fall within these distributions. Figure 6 shows that the plotted distributions belong to IPCC scenarios with varying climate outcomes, while the vertical black lines represent cumulated emissions in our scenarios.

Scenarios are set up so that emissions from the 1.5°C scenario fall within the 1.5°C distribution, and emissions from the 2.0°C scenario fall within the 2.0°C distribution, while for the *status quo* scenarios we do not target a specific climate goal. Note, however, that for the status quo scenarios, we end up with a probable climate outcome of about 3.5°C by 2100.

22 The appendix of the Semieniuk et al. 2022 paper provides a detailed overview of assumptions and policies considered.

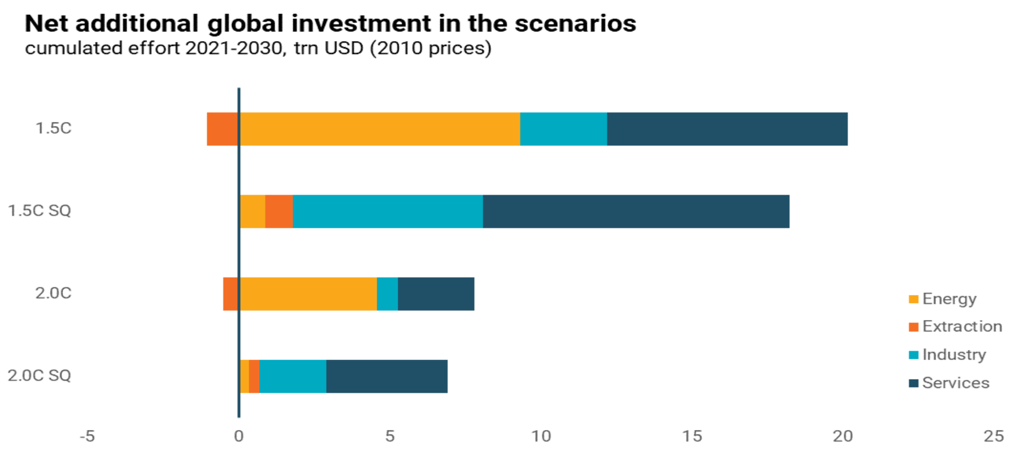
Figure 6: Cumulated emissions between 2023 and 2030 observed in IPCC scenarios and climate outcomes by 2100



To reach these goals, we implement policies targeting green investment and the adaptation of climate-friendly technologies. These include renewable-based power generation, electrification of transport, economy-wide energy efficiency, renewables in residential heating, as well as uptake of biofuels. The model estimations suggest that, in order to limit emissions by 2030 to a level that will make it still possible to limit global warming to 1.5°C by 2100, required net additional investment into these measures and technologies is equivalent to about 3% of annual global GDP on average between 2023 and 2030. Meanwhile, to limit global warming to a level well below 2°C, the model suggests that about 1.2% of annual global GDP is required.

Alongside the mitigation scenarios, the modelling also considers "*status quo*" (SQ) variants: scenarios where the same level of investment is made available to extend currently observed investment structures. Figure 7 presents an overview of the investment structures for all scenarios. In the case of the mitigation scenarios (1.5°C and 2.0°C), investments are concentrated in the power generation and green technology sectors, with induced investment in other economic sectors. Meanwhile, there is substantial disinvestment from the extraction sectors (due to falling demand for fossil fuels). In the SQ scenarios, industry and services receive the most investment, while investment in energy is relatively small, comparable to investment into extractive sectors.

Figure 7: Net additional global investment in the scenarios. Cumulated efforts 2021-2030, trn USD (2010 prices)



3 Results and Discussion

3.1 The Inclusive Green Economy Transition in a Pre-COVID-19 World

This section presents the results from the practical implementation of the GEP Measurement Framework methodology developed in UNEP (2017a) and updated in PAGE 2021, while using the latest available information for the set of indicators described in section 2.1. Table 3 presents summary statistics for these 13 indicators of the GEP Index (see next section). **On average, progress was highest on the indicators measuring energy use, life expectancy, gender inequality, access to basic services and education. Note that there was almost no progress on average for renewable energy. On the other hand, material footprint was the only indicator experiencing regress on average.**

Table 3: Progress on an Inclusive Green Economy by indicator – full sample

Variable	Obs	Mean	Std. Dev.	Min	Max
material footprint	108	-0.67	1.33	-7.38	1.35
air pollution	109	0.31	0.32	-0.23	1.10
protected areas	98	0.15	0.36	-0.04	2.44
energy use	103	0.50	0.44	-1.01	1.42
green trade	97	0.15	0.32	-0.22	1.62
green technology innovation	62	0.26	0.87	-0.57	4.60
renewable energy source	108	0.02	0.64	-3.11	2.45
Palma ratio	79	0.23	0.47	-0.90	1.24
gender inequality index	106	0.49	0.27	-0.02	1.13
access to basic services	96	0.38	0.26	-0.08	1.17
mean years of schooling	109	0.45	0.22	-0.02	1.26
pension coverage	88	0.34	0.90	-4.12	2.39
life expectancy	106	0.47	0.22	0.01	1.13

Source: Author’s calculations.

Figure 8, below, shows these results, but instead of indicating the share of countries performing within a given range, it gives a more complete picture of the entire distribution. From a policy perspective, these results can be regarded as good news. They show that in the pre-pandemic period, countries were making progress, on average (as can be concluded from the average progress in most indicators in Table 3, or the scarcity of red tones in the Figure 8).

On the other hand, progress is not always happening where it is most needed. Figure 7 illustrates this point for the cases of gender inequality and air pollution. Figure 9 shows a negative correlation between the weight of a given indicator, and the progress achieved in improving its value. For greater advancement of the IGE, there should be more progress achieved if the weight of that indicator (which reflects the relationship between the initial condition and the critical threshold) is higher.

It is important to remind ourselves that we should not focus on progress where it is easiest to achieve, but on progress where it is most needed.

Figure 8: Distribution of countries based on their performance per indicator (%)
Source: Author's calculations.

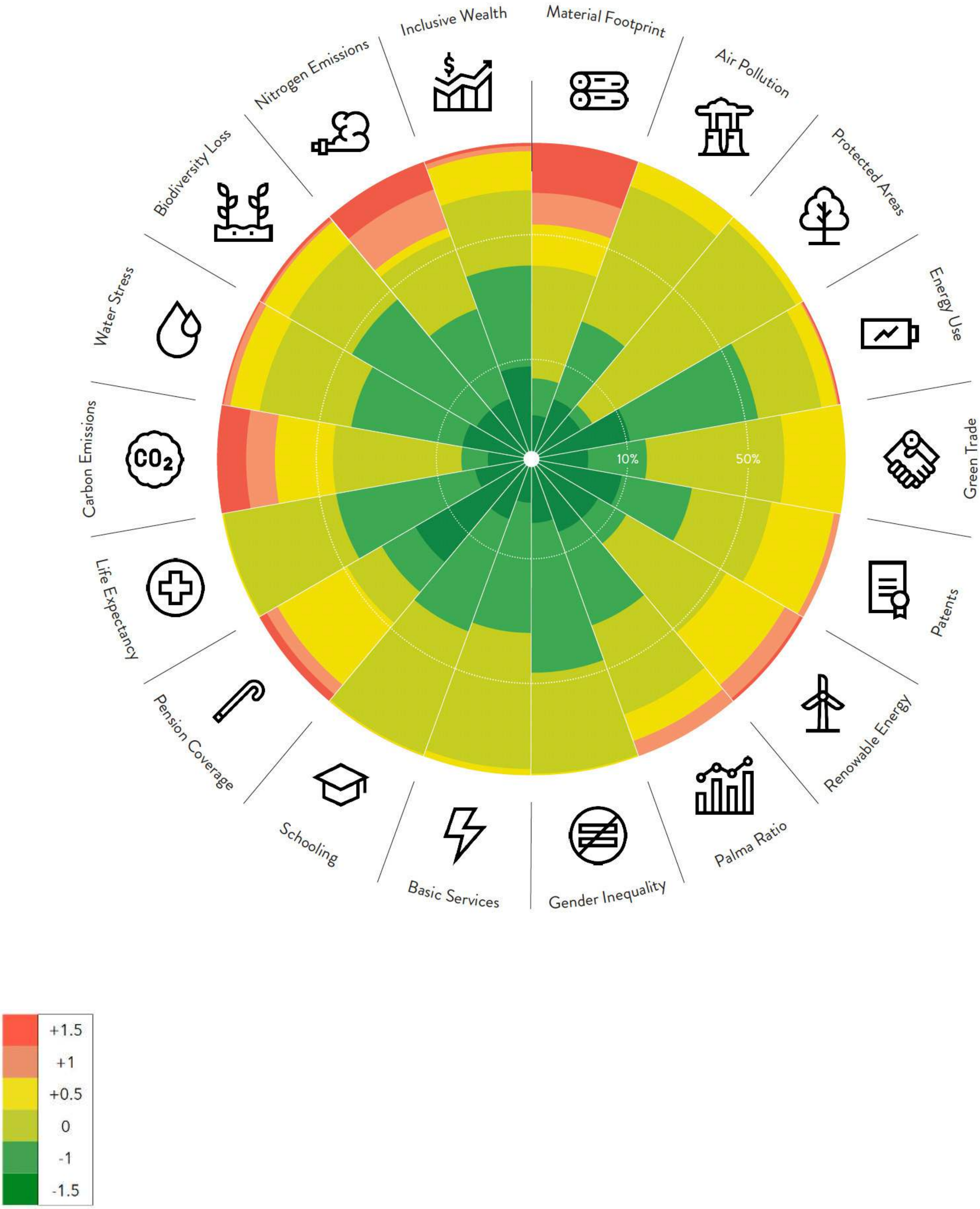
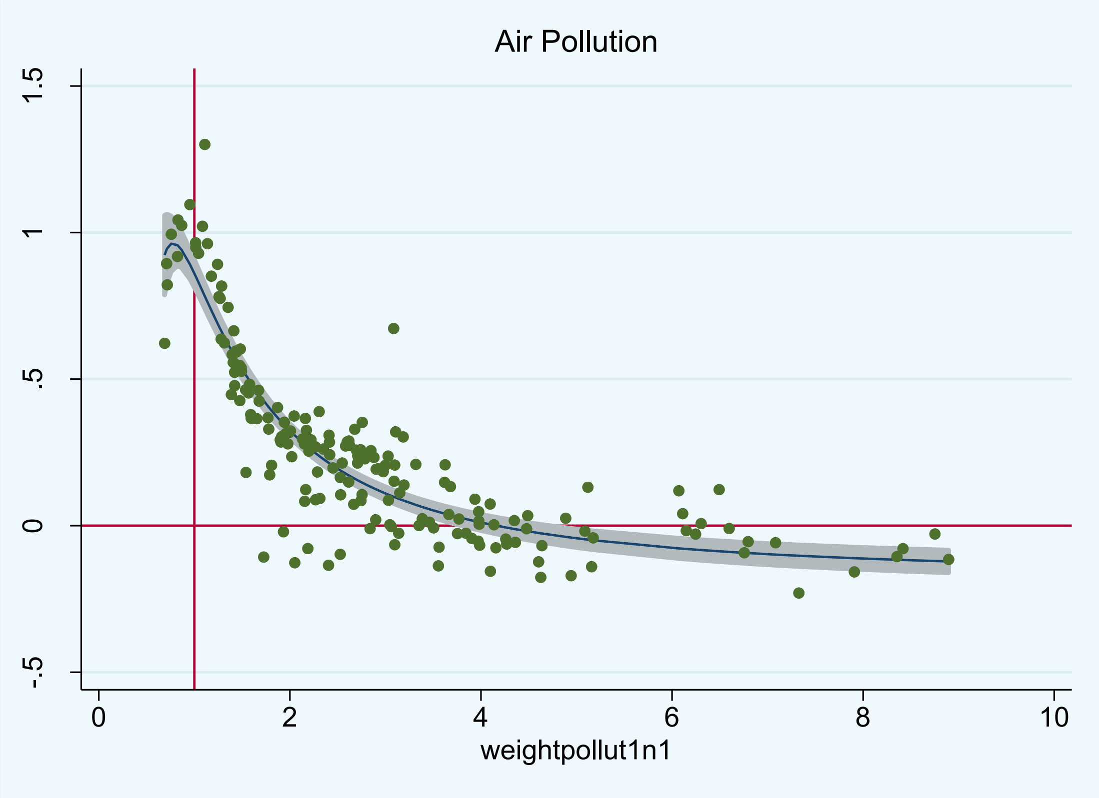


Figure 9: Correlation between progress and weight (selected indicators)

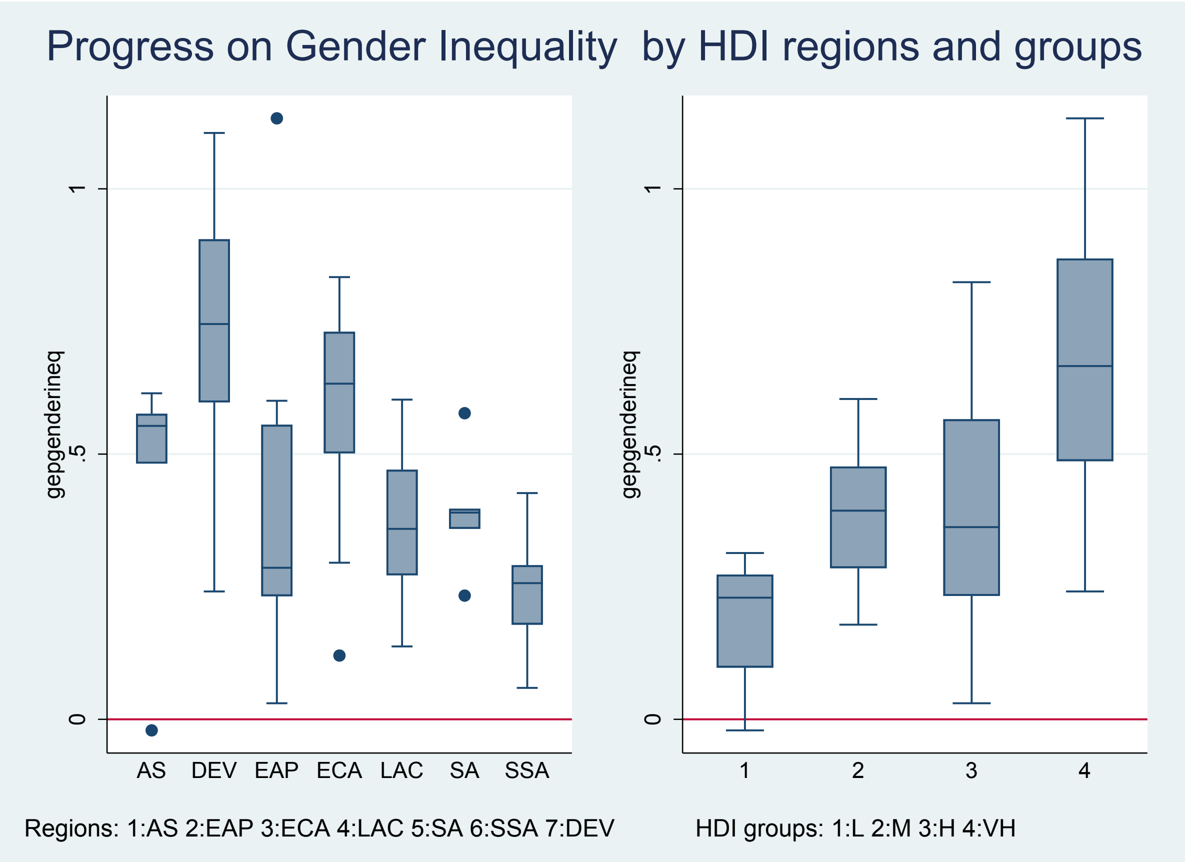


Source: Author's calculations.

3.1.1 Progress on Gender Inequality

An example can be found in Figure 10, which shows that progress on the gender inequality index[23] is widely shared across countries when we compare them across geographical regions or HDI groups. However, there are important heterogeneities across regions, with average progress being highest among developed countries and lowest for Sub-Saharan African countries.

Figure 10: Progress on gender inequality index



Source: Author's calculations.

Progress on gender inequality has been improving across the different editions. As shown in Table 4, the average progress in the gender inequality index has improved across the different editions. We can also see a reduction in the minimum value (lower regress) and a lower standard deviation, implying a lower dispersion in the distribution. The shift in the distribution of progress in the gender inequality index can be seen in Figure 11, where the Second and Third Editions have represented a movement towards the right with respect to the previous edition, indicating an improvement in this indicator across countries, as a larger proportion of countries are represented to the right of the 0 value (implying positive progress in an IGE) on the horizontal axis.

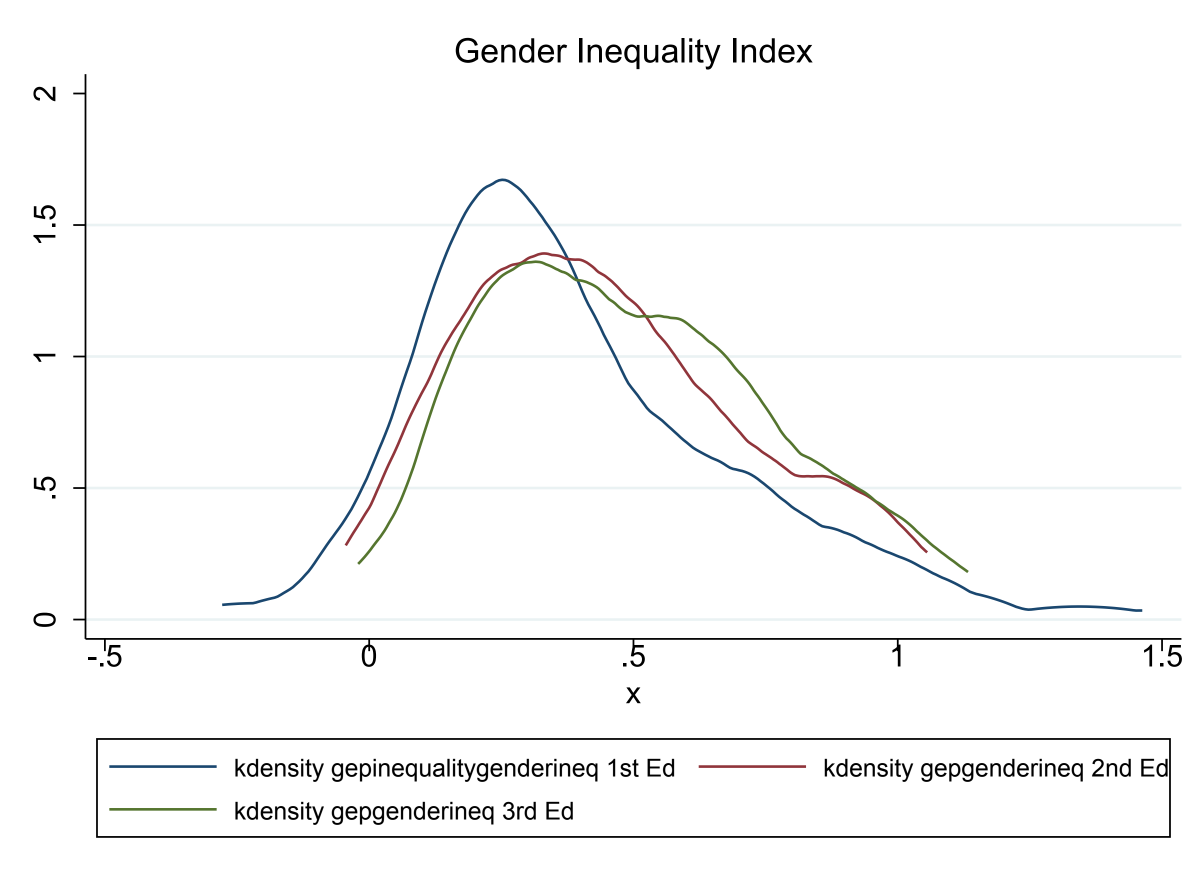
23 The gender inequality index, developed by UNDP, reflects gender-based disadvantage in three dimensions: reproductive health, empowerment and the labour market. Information about the different components of the index are available at https://hdr.undp.org/data-center/thematic-composite-indices/gender-inequality-index#/indicies/GII.

Table 4: Summary statistics of the Gender Inequality Index.

Variable	Observations	Mean	Std. Dev.	Min	Max
Progress on Gender Inequality 1st Ed	97	0.392	0.299	-0.278	1.463
Progress on Gender Inequality 2nd Ed	107	0.450	0.273	-0.044	1.056
Progress on Gender Inequality 3rd Ed	107	0.492	0.268	-0.021	1.133

Source: Author's calculations.

Figure 11: Progress on Gender Inequality Index (comparing with the results of PAGE (2017b) and PAGE (2021).



Source: Author's calculations.

3.1.2 The GEP Index: Measuring Progress in the Multidimensional Case

Table 5 presents a detailed summary of statistics for the GEP Index. The positive values in green showcase the progress achieved in more than 75 per cent of the countries included in the sample. We can also note that the average country experienced progress, although some countries experienced significant regress. The median value of the sample is 0.23, with the bottom 10 percentile having a value lower than -0.01, and the top 90 percentile having a value of 0.49.

Figure 12 presents the kernel distributions of the GEP Index for the same sample of 103 countries. As we saw in Figure 8, the distribution of the GEP Index has moved towards the right, indicating that according to the most recent data, more countries have experienced progress. On the other hand, extreme progress has become less common. Kenya is the only country with a GEP Index that is higher than one (1.23), but in the second edition this number was 1.57. On the other hand, there are seven countries that have GEP Indices higher than 0.55, which was the maximum value observed in PAGE (2017b). This means that there are more countries where progress has accelerated.

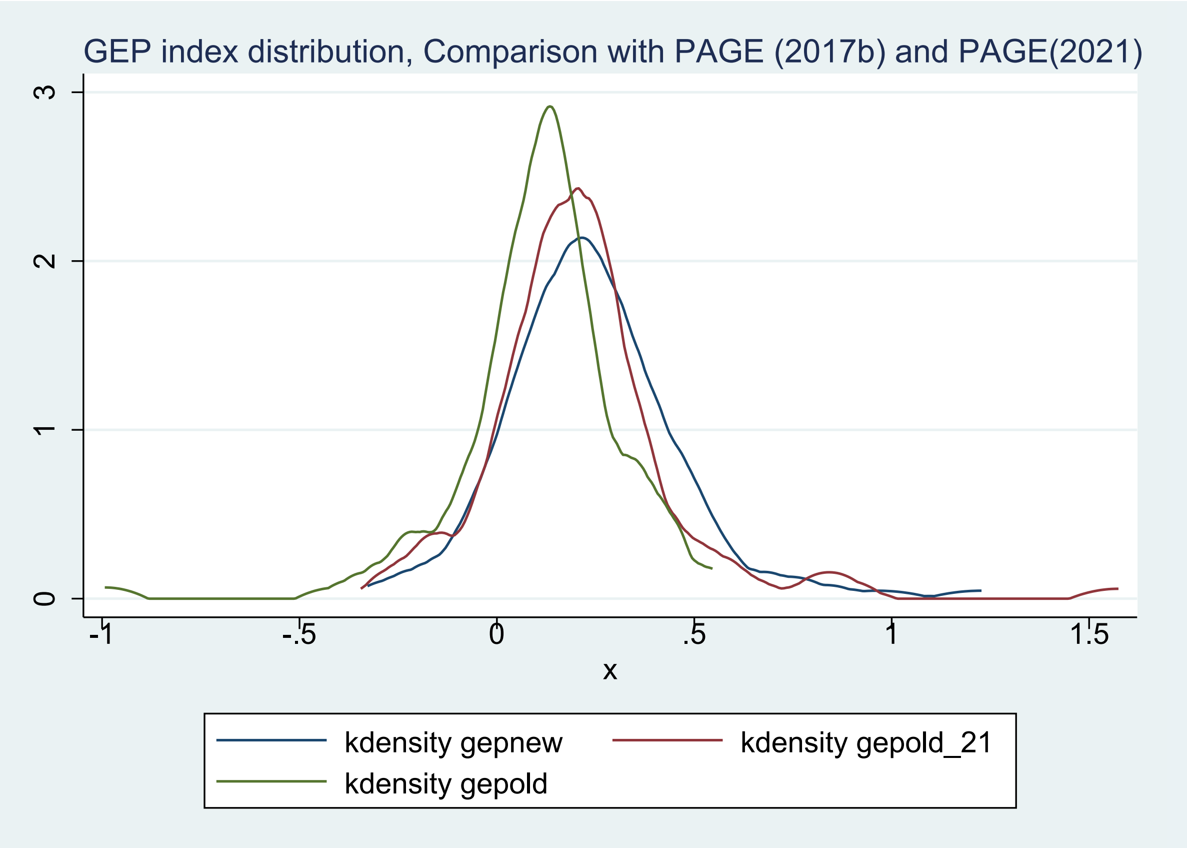
Table 5: Summary statistics of the GEP Index

Variable	Observations	Mean	Std. Dev.	Min	Max
GEP Index	110	0.24	0.23	-0.33	1.23

	1%	5%	10%	25%	50%	75%	90%	95%	99%
Percentiles	-0.22	-0.07	-0.01	0.00	0.23	0.35	0.49	0.59	0.96

Source: Author's calculations.

Figure 12: GEP Index (comparing with the GEP Index in PAGE (2017b) and PAGE (2021).



Source: Author's calculations. Note: GEP new corresponds to the updated calculations, GEP old corresponds to PAGE (2017b) and PAGE (2021).

Table 6 shows that there are seven countries that experience progress in the Third Edition while they showed regress in the Second Edition. There are 5 countries experiencing regress that previously had progress (in red). Finally, there is one country that did not have an index in PAGE (2021) and now has a negative value.

Table 6: GEP Index for countries changing sign between second and third edition

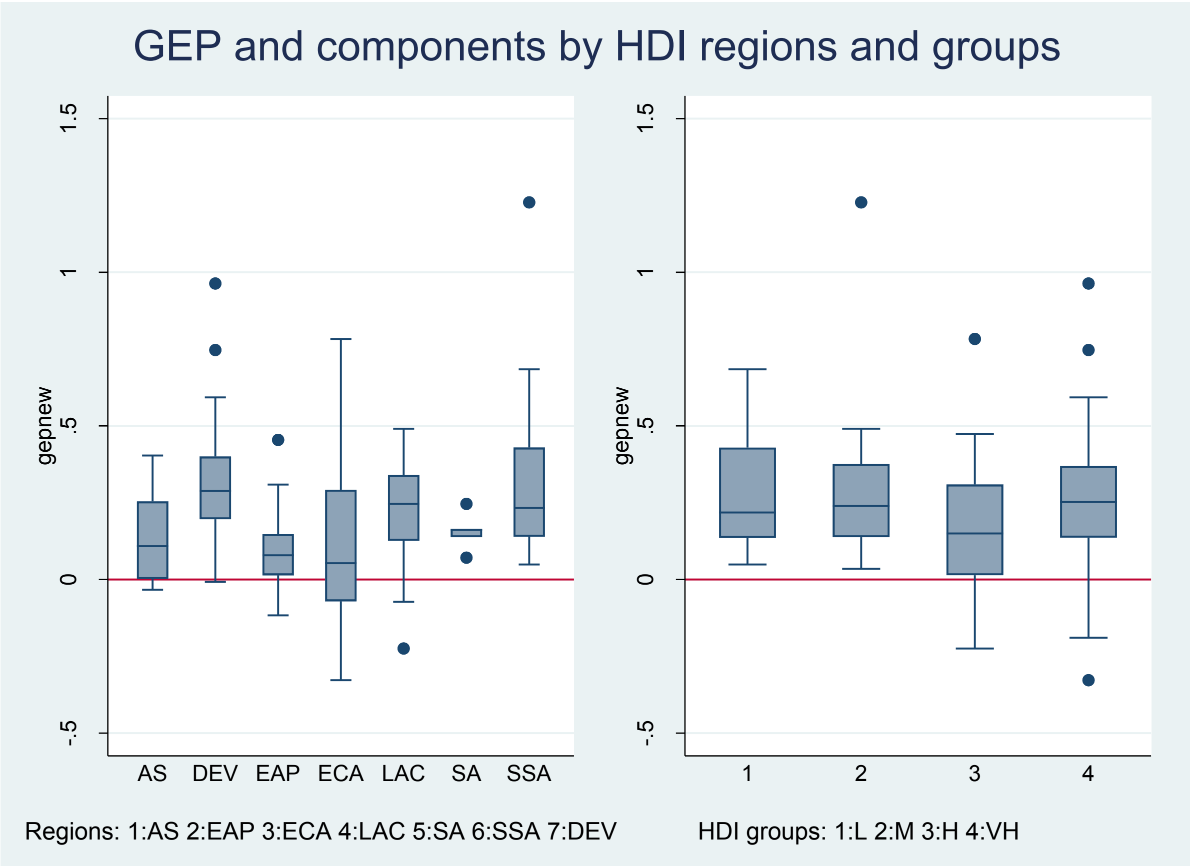
Country	GEP Index	GEP Index (PAGE, 2021)
Armenia	0.1499	-0.1590
Azerbaijan	0.02185	-0.1082
Benin	0.0956	-0.0283
Mongolia	0.1475	-0.2194
Romania	0.0154	-0.0343
Uruguay	0.3091	-0.2083
Viet Nam	0.0789	-0.3447
Algeria	-0.0330	0.2170
Brazil	-0.0010	0.0497
Costa Rica	-0.0724	0.04519
Kazakhstan	-0.3277	0.0172
Venezuela	-0.2245	0.1986
Bosnia and Herzegovina	-0.7075	–

Source: Author’s calculations.

We can also assess these results geographically and across development groups. The left panel in Figure 13 groups the results by region. East Asia and the Pacific, Europe and Central Asia show more mixed results. All South Asian and Sub-Saharan African countries experienced green economy progress. When assessing Latin America and the Caribbean, as well as Sub-Saharan Africa, we find that most countries in those regions have made green economy progress, as have the countries with a very high HDI.

If we now analyse the results by HDI category (right panel of Figure 13), we see mixed results. Among countries with a high and very high HDI, 17 and 10 per cent of countries showed a regress, respectively. However, in the medium- and low-HDI groups, all countries experienced progress (with a mean GEP Index of 0.28 and 0.27, respectively).

Figure 13: GEP Index results by regions and HDI groups



Source: Author's calculations.

Note: Four categories of human development can be distinguished: over 0.800 for Very High (VH), over 0.700 for High (H), over 0.550 for Medium (M), the remainder being Low (L).[24] 48 countries have a "Very High" HDI, 28 a "High" one, 19 a "Medium" one, and 13 a "Low" one.

24 Figure 2 categorizes countries into the following geographical regions: 1) Middle East and North Africa; 2) East Asia and the Pacific; 3) Europe and Central Asia; 4) Latin America and the Caribbean; 5) South Asia; 6) Sub-Saharan Africa; and 7) All countries with a very high HDI (HDI>0.8) and that do not belong to any of these regions (UNDP 2020).

3.1.3 Progress within Planetary Boundaries

Another way to look at the results is by assessing individual indicators. Table 7 shows that the indicators on which countries, on average, are experiencing regress include carbon footprint, emissions of nitrogen and the natural capital component of the Inclusive Wealth Index. Progress is achieved by the average country in the areas of water stress, land use-related biodiversity loss and Inclusive Wealth Index. The average progress in these areas equalled 0.30, 0.28, and 0.32, respectively. It should be noted that a small group of countries is experiencing significant regress across indicators (with progress being lower than -1).

Table 7: Summary of dashboard indicators (sample of countries with GEP Index)

Indicator	Obs.	Mean	Std. Dev.	Min	Max
Carbon footprint short term (footprint)	109	-0.39	0.85	-3.43	1.42
Water stress (footprint)	109	0.30	0.50	-0.90	1.34
Land use-related biodiversity loss (footprint)	109	0.28	0.67	-3.47	1.68
Emissions of nitrogen	100	-0.29	1.40	-6.90	1.39
Inclusive Wealth Index	98	0.32	0.52	-1.11	1.84
Inclusive Wealth Index (natural capital)	98	-5.86	7.55	-26.41	5.21

Source: Author’s calculations.

Comparison of results with production-side indicators

Table 8 shows the results for a subset of the Dashboard indicators, comparing footprint (consumption) indicators with their production-side counterpart. We can see progress being substantially higher (which can also mean lower regress) when we measured production side indicators rather than footprint indicators. Relatively similar results were only obtained for land use-related biodiversity loss, but even there, production yielded better results.

Table 8: Summary of Dashboard (production and consumption) indicators (sample of countries with GEP Index)

Indicator	Obs.	Mean	Std. Dev.	Min	Max
Carbon footprint short term (Consumption)	109	-0.39	0.85	-3.43	1.42
Greenhouse gas emissions (Production)	109	-0.32	0.82	-4.33	2.10
Water stress (Consumption)	109	0.30	0.50	-0.90	1.34
Water stress (Production)	109	0.16	0.99	-6.34	1.66
Land use-related biodiversity loss (Consumption)	109	0.28	0.67	-3.47	1.68
Land use-related biodiversity loss (Production)	109	0.34	0.42	-1.33	1.17

Source: Author’s calculations.

3.1.4 Overall Country Ranking (GEP+) using the GEP Index and the Dashboard

As discussed in PAGE (2017a), a ranking of all GEP Index and Dashboard profiles can be produced using the Protective Criterion. Giving priority to the so-called Worst Achievement, we rank countries according to the indicator in which they made least progress.

Results from the GEP Index and the three dashboard sustainability indicators show that there were 32 countries in our sample (29%) that achieved progress (i.e. no regress) in all indicators that compose the Dashboard of Sustainability, and that had a positive GEP Index score.[25] In Table 9, we showcase the results for the four best-performing countries in each HDI group, as more meaningful comparisons can be made among countries that are rather similar. It can be noted that for all HDI groups (except two countries in the Medium HDI group), the four countries that are heading the list within their group show progress for all indicators. The best-performing country for the Very High HDI group was Portugal.[26] In the High HDI group, it was Paraguay (with land use as its lowest performance), in the Medium HDI group, it was Zimbabwe (also with its lowest progress in land use), and finally, for the Low HDI group, Yemen headed the list (with its lowest progress on the GEP index itself).

Table 9: Rank GEP Index-dashboard profiles using the Protective Criterion (Top 4 countries per HDI group)

Rank	Country	Progress Greenhouse gas emissions	Progress Water stress	Progress Land use-related bio diversity loss	GEP Index	Worst performance (for Protective criterion)	HDI group
1	Portugal	**0.509**	1.327	1.455	0.488	**0.509**	Very High
2	Spain	**0.438**	1.632	2.093	0.450	**0.438**	Very High
3	Greece	**0.407**	1.816	3.073	0.607	**0.407**	Very High
4	Italy	**0.407**	2.254	0.439	0.328	**0.407**	Very High
1	Paraguay	0.821	0.476	**0.459**	1.308	**0.459**	High
2	Moldova	0.762	0.559	0.747	**0.326**	**0.326**	High
3	Jordan	0.437	0.371	1.901	**0.294**	**0.294**	High
4	Jamaica	0.326	1.304	0.340	**0.172**	**0.172**	High
1	Zimbabwe	0.341	0.985	**0.061**	0.135	**0.061**	Medium
2	Cameroon	0.270	0.532	**0.051**	0.497	**0.051**	Medium
3	Namibia	0.280	**-0.065**	0.357	2.590	**-0.065**	Medium
4	Angola	0.348	**-0.071**	0.077	0.651	**-0.071**	Medium
1	Yemen	0.552	0.371	0.720	0.243	**0.243**	Low
2	Gambia	0.591	1.196	0.231	0.161	**0.161**	Low
3	Côte d'Ivoire	0.095	1.568	**0.091**	0.422	**0.091**	Low
4	Togo	0.272	0.172	**0.069**	0.146	**0.069**	Low

Source: Author's calculations.

Note: Observations in bold indicate the minimum value among all categories. The ranking presented in this table is based on the following four categories: (a) the GEP Index; (b) greenhouse gas emissions; (c) water stress; and (d) land used-related biodiversity loss. If we would change the categories considered, this would also modify the ranking. Note that each of the Dashboard indicators is multiplied by its weight, while the GEP Index is multiplied by the average of the weights; see PAGE (2017b).

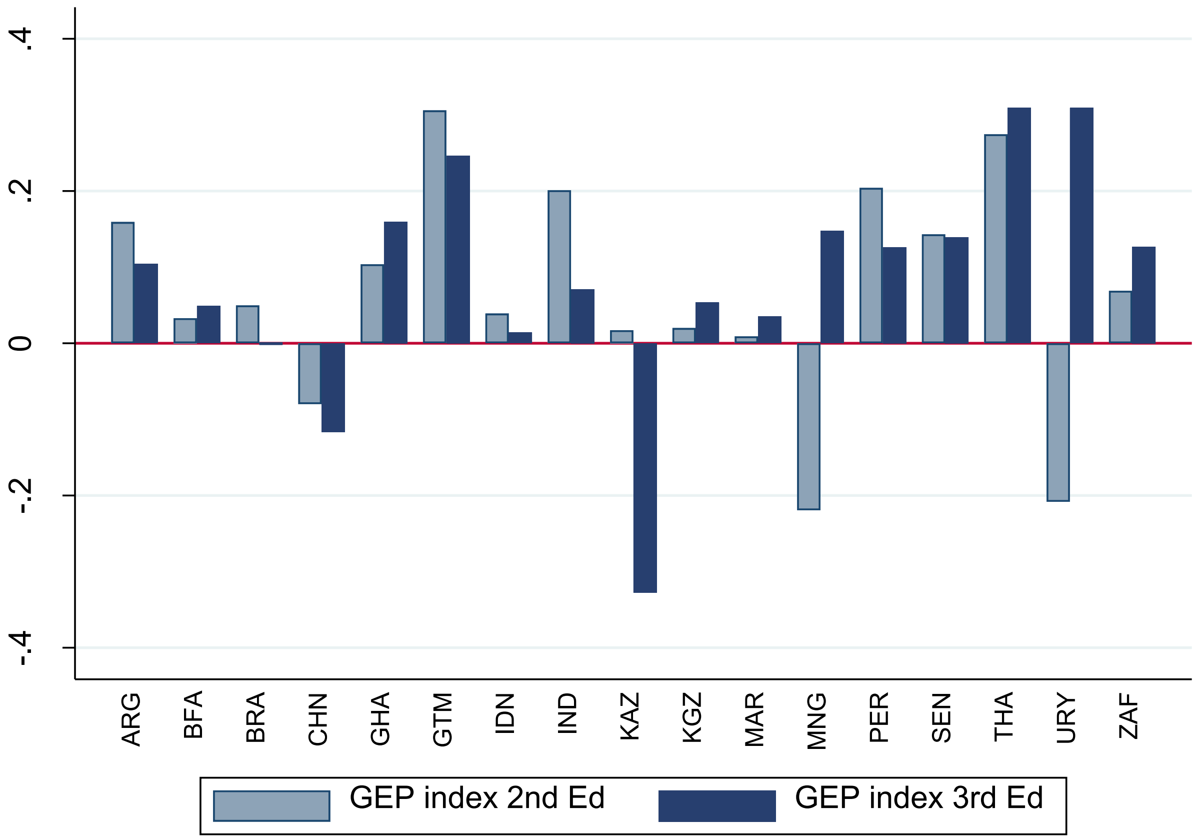
25 This represents 13 countries more than in the results presented in PAGE (2017b), and 2 additional countries compared to PAGE 2021.

26 The Worst Performance is the indicator determining the ranking. This means that no country had a better performance on its least-performing indicator than Portugal. The complete set of results can be found in Annex I.D.

3.1.5 Results for PAGE Countries

If we now zoom in onto the countries that are part of PAGE,[27] we find the results that are summarized in Figure 14. We were able to calculate a GEP Index for 17 out of the 20 PAGE countries,[28] and 14 out these 17 countries had a positive GEP index. This means that these countries have made progress towards an Inclusive Green Economy. The best-performing countries were Uruguay and Thailand, both with highest value 0.31, indicating an overall achievement of less than a third of the initial targets. Table 10 shows that there were only a few indicators where all countries experienced progress, including basic services, mean years of education, and life expectancy. Most (but not all) countries experienced regress in the areas of material footprint and renewable energy.

Figure 14: GEP Index results for PAGE countries (comparison between Second and Third Editions)



27 The list of PAGE countries is as follows: Argentina (ARG); Barbados (BRB); Brazil (BRA); Burkina Faso (BFA); China (CHN); Ghana (GHA); Guatemala (GTM); Guyana (GUY); India (IND); Indonesia (IDN); Kazakhstan (KAZ); Kyrgyzstan (KGZ); Mauritius (MUS); Mongolia (MNG); Morocco (MAR); Peru (PER); Senegal (SEN); South Africa (ZAF); Thailand (THA); and Uruguay (URY).

28 Due to a lack of information, we were not able to calculate the GEP Index for Mauritius, Barbados and Guyana, but all information that was available for these countries has been included in the analysis.

Table 10: GEP Index and its components for PAGE countries

Country	material footprint	air pollution	protected areas	energy use	green trade	environmental patents	renewable energy	Palma ratio	gender inequality	access to basic services	mean years of schooling	pension coverage	life expectancy	GEP Index
Argentina	-0.72	0.43	0.03	0.38	-0.13	0.22	-0.02	1.00	0.30	0.12	0.30	0.65	0.24	0.10
Barbados		0.26			-0.09		-0.22		0.39		0.30	0.21	0.23	
Brazil	-1.14	0.48	0.19	0.02	-0.05	0.23	0.03	0.35	0.30	0.22	0.56	0.06	0.37	0.00
Burkina Faso	-0.82	0.03			-0.04		-0.67	-0.58	0.10	0.23	0.08	-0.01	0.54	0.05
China	-2.76	0.12	0.04	0.49	0.20	0.58	-0.35	0.20	0.60	0.54	0.34	1.00	0.37	-0.12
Ghana	-1.95	-0.01	0.00	0.90	0.32		-0.67		0.18	0.43	0.24	0.34	0.31	**0.16**
Guatemala	-2.00	0.32	0.01	-0.31	0.12	0.20	0.01	0.72	0.28	0.32	1.26	0.11	0.42	**0.25**
Guyana		0.26			-0.11		-0.24		0.24	0.59	0.15		0.32	
India	-1.70	-0.08	0.00	0.47	0.13	-0.02	-0.37	-0.16	0.39	0.48	0.68	0.51	0.52	**0.07**
Indonesia	-2.38	0.17	0.26	0.71	0.02		-0.33	-0.61	0.26	0.85	0.25	0.18	0.42	**0.01**
Kazakhstan	-2.25	0.37	0.04	0.21	-0.01		-0.07	0.57	0.83	0.67	0.26		0.59	**-0.33**
Kyrgyzstan	-0.97	0.21	-0.04	0.05			-0.18	0.12	0.60	0.41	0.24	1.00	0.23	**0.05**
Mauritius		0.18		0.46	0.05		-0.17		0.26		0.75		0.20	
Mongolia	0.07	-0.04	0.01	0.43	0.15		-0.29	-0.13	0.56	0.33	0.38	1.00	0.50	**0.15**
Morocco	-2.18	-0.06		0.10	0.15	-0.02	-0.24	0.03	0.57	0.36	0.87		0.51	**0.04**
Peru	-2.15	0.24	0.31	0.20	0.23	0.85	-0.21	0.73	0.37	0.39	0.27	0.16	0.36	**0.13**
Senegal	-0.51	0.00	0.03	-0.29	-0.03		-0.11	0.39	0.31	0.24	0.32	0.42	0.43	**0.14**
South Africa	0.55	0.07	0.11	0.34	-0.08	-0.43	-0.19	-0.84	0.24	0.37	0.36	0.40	0.49	**0.13**
Thailand	-1.23	0.21	0.03	-0.06	0.27		0.08	0.57	0.03	0.17	0.34	2.15	0.44	**0.31**
Uruguay	0.25	0.96		-0.13	-0.18		0.32	0.57	0.41		0.18	0.79	0.28	**0.31**

Source: Author’s calculations.

Table 11 presents the results from the GEP Index and the three Dashboard sustainability indicators using the main option for PAGE countries. It can be concluded that only South Africa achieved positive progress (or no regress) in all indicators of the Dashboard of Sustainability, as well as a positive GEP Index score. Table 10 also shows that across PAGE countries, greenhouse gas emission was the area where the worst performance occurred. As a result, the progress that these countries achieved in the GEP Index may not be sustainable, as it was accompanied by a regress in the sustainability indicators on the Dashboard.

Table 11: Ranking of GEP Index-Dashboard profiles using the Protective Criterion, PAGE countries

Country	Progress Greenhouse gas emissions	Progress Water stress	Progress Land use-related biodiversity loss	GEP Index	Worst performance (for Protective criterion)	HDI group
Uruguay	-0.5860	0.1070	0.2411	0.3375	-0.5860	Very High
Argentina	-0.7552	0.1434	-0.0020	0.0902	-0.7552	Very High
Kazakhstan	-3.6517	0.3626	0.4465	-0.4196	-3.6517	Very High
South Africa	-0.4364	0.2862	0.9370	0.1263	-0.4364	High
Brazil	-1.0749	-0.0184	0.4363	-0.0008	-1.0749	High
Indonesia	-1.0792	-0.0644	0.0829	0.0109	-1.0792	High
Thailand	-1.3196	0.0321	-0.0610	0.3144	-1.3196	High
Peru	-1.9222	0.0034	0.7221	0.1201	-1.9222	High
Mongolia	-3.3093	-0.0121	0.0311	0.2753	-3.3093	High
China	-4.9699	-0.7917	-0.0428	-0.1399	-4.9699	High
Guatemala	-0.4480	0.0896	0.7983	0.2467	-0.4480	Medium
Ghana	-0.9540	0.0675	0.2047	0.1882	-0.9540	Medium
Morocco	-1.3383	0.4642	0.1004	0.0338	-1.3383	Medium
India	-1.4197	-0.1031	0.0298	0.1001	-1.4197	Medium
Kyrgyzstan	-2.0473	0.5831	0.2695	0.0457	-2.0473	Medium
Senegal	-0.0941	0.0628	0.1064	0.1666	-0.0941	Low
Burkina Faso	-0.2438	0.0595	0.0610	0.0931	-0.2438	Low

Source: Author’s calculations.

Note: Observations in bold indicate the minimum value among all categories. The ranking presented in this table is based on the following four categories: (a) the GEP Index; (b) greenhouse gas emissions; (c) water stress; and (d) land use-related biodiversity loss. If we would change the categories considered, this would also modify the ranking. Note that each of the Dashboard indicators is multiplied by its weight, while the GEP Index is multiplied by the average of the weights; see PAGE (2017b).

3.2. Economic, Social, and Environmental Impacts of Achieving Carbon Neutrality

While investing into decarbonizing the economy comes with an additional investment cost, the socioeconomic returns and environmental benefits could make it worthwhile. Socioeconomic returns that can be expected from climate mitigation are twofold: first, mitigation helps to avoid climate damages, including productivity losses due to rising temperatures and economic losses due to more frequent extreme weather events (Burke, Hsiang and Miguel 2015; IPCC 2022). Second, even though it is sometimes referred to as a "cost" of decarbonization, they are also investments in macroeconomic terms able to trigger new economic activity in several sectors. These investments can increase economic activity in aggregate, in particular if there is spare capacity in the economy (Kiss-Dobronyi et al. 2023) and if the effect of "crowding out" other investment opportunities is restricted. Decarbonization investment opportunities can lead to endogenous money growth (Pollitt and Mercure 2018; Mercure et al. 2019).

Figure 15 summarizes economic activity impacts (GVA) from the four scenarios, as relative differences from the baseline. The economic boost to relevant sectors from increased decarbonization investments can be seen in both climate mitigation scenarios. This is somewhat offset by a loss of GVA in the extraction sector in the mitigation scenarios, as fossil fuel use should be phased out at a much faster rate. The latter effect is less present in the SQ equivalent, with continued investment in fossil fuel extraction alongside sectoral investment patterns in line with recent history.

Figure 15: GVA and GDP impacts across the scenarios by sector

Note: Indicative climate damages are incorporated based on Burke, Hsiang and Miguel (2015). The black line shows the net effect.

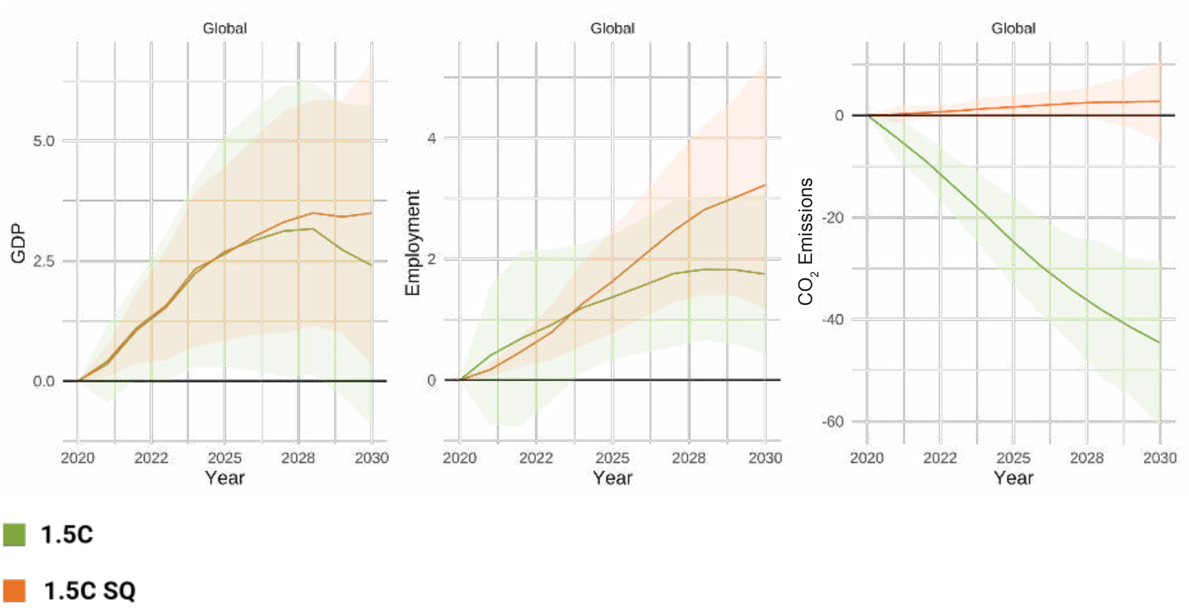
Source: Author's calculations.

When accounting for the indicative economic impact of climate damages, based on Burke, Hsiang and Miguel's (2015) seminal work, this visibly tips the scales towards the mitigation scenarios. Without climate damages, peak GDP impacts (the black line) for the mitigation scenarios are 1.2% and 2.7%, respectively, for the 2.0°C and 1.5°C scenarios. Meanwhile, peak impacts for the SQ scenarios are 1.4% and 3.4%, respectively, for the 2.0°C SQ and 1.5°C SQ. But when we include indicative climate damages, this picture changes: overall peak impact in the mitigation scenarios is now at -1.2% and 1.5%, respectively, for 2.0°C and 1.5°C. Meanwhile, impacts in the SQ scenarios turn negative, with peak impacts at -4.6% and -2.7%, respectively, for the 2.0°C SQ and the 1.5°C SQ.

This is explained by a combination of factors that can be observed in Figure 17. In both SQ cases, indicative climate damages are high and offset gains from new investments. This is also the case for the 2.0°C mitigation scenario. However, the effect is higher (more negative) in the case of 2.0°C SQ than in the case of 1.5°C SQ, because the magnitude of new investments is higher in the latter and therefore it can better balance out losses due to damages.

Finally, when comparing the mitigation and SQ scenarios, the mitigation scenarios significantly decrease emission levels, but also lead to lower employment additions. However, employment results are not worse than in the baseline scenario, because the net investment required for the investment compensates for potential employment losses in some sectors.

Figure 16: Employment and GHG impact across the scenarios



Note: Figures show the difference from the baseline scenario globally. The solid line is the global mean of the impact, while the shaded area is the standard deviation of impacts across E3ME regions.

Source: Author's calculations.

Figure 17: Country-level value added (GVA) and GDP results

Source: Author's calculations.

Differences between countries are illustrated in the country-level results, presented in Figure 17. Countries with high fossil exports, such as South Africa (coal), Kazakhstan (oil) or Brazil (oil) see considerable losses of GVA in the extraction sectors in the 1.5°C mitigation scenario. In some countries (e.g., South Africa, and Kazakhstan for the early years), these losses can offset potential gains from decarbonization investments, but in some other countries the gains outweigh the losses (Indonesia, Brazil). In countries where fossil matters less for the economy (India, Argentina), gains from investments easily offset losses from extraction.

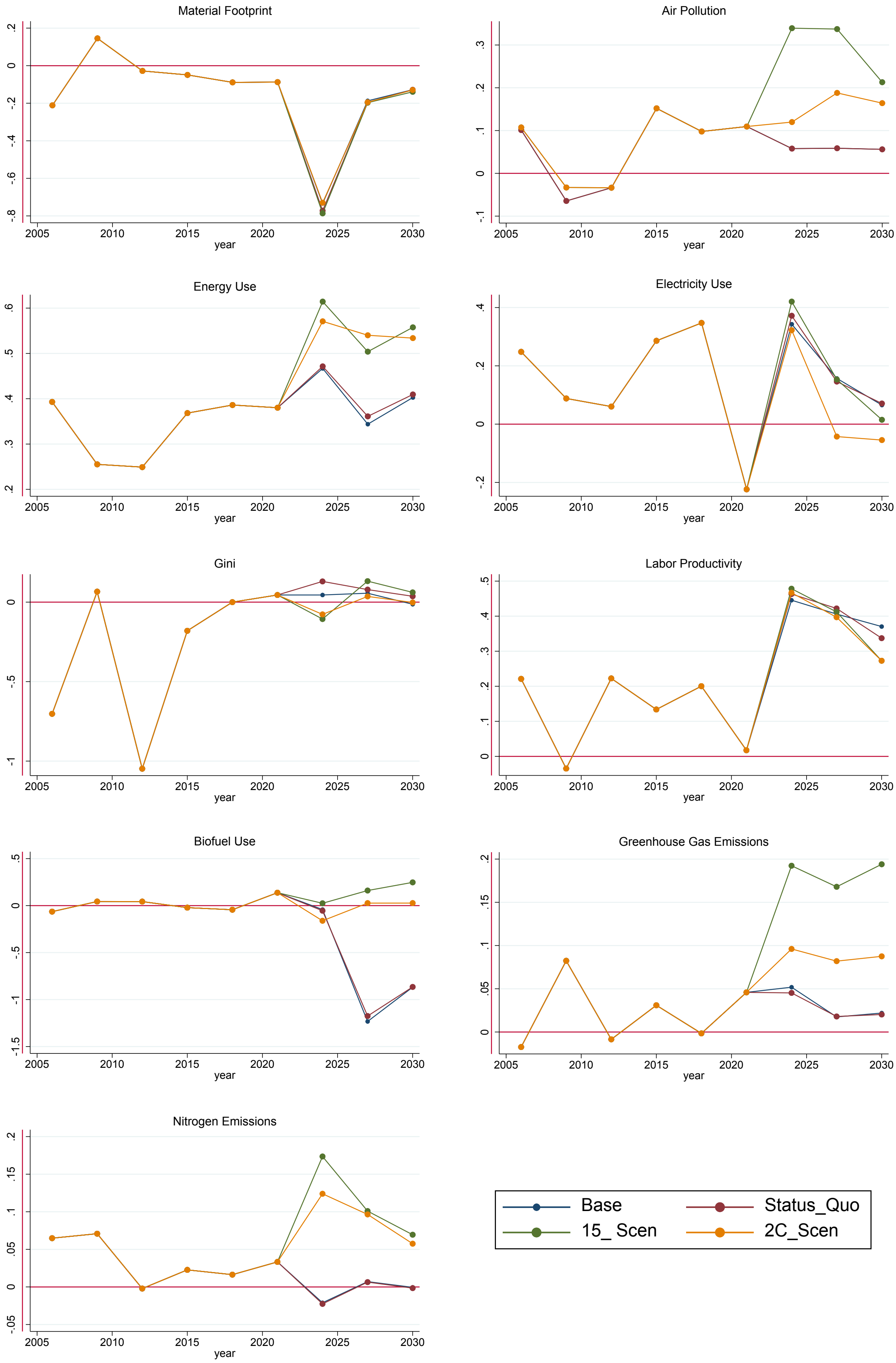
3.3. How is the IGE Transition Impacted by Recent Shocks and the Net-Zero Scenarios?

This section presents results for the four main scenarios discussed in the previous section: Base, Status Quo, 1.5ºC Scenario, and 2ºC Scenario. In addition, it will discuss the two alternative scenarios presented in the discussion of the effects of green or brown investments under the 1.5ºC Status Quo, and the 2ºC Status Quo (in comparison to their counterparts: the 1.5ºC and 2ºC Scenarios, respectively).

Figure 18 shows the results for each individual indicator for the main scenarios. Note that, similarly to the results listed in section 3.1.1, the material footprint is an indicator that is experiencing regress (negative progress). For this indicator, it is also important to mention that there is very little separation across scenarios, which indicates the importance of focusing policies in this area.

For the other indicators, although there are some variations, the general pattern is that progress will be the highest under the 1.5ºC scenario. This is particularly true for air pollution, biofuel use, GHG emissions, and nitrogen emissions. Results also seem to reflect interesting policy trade-offs. First, progress on income inequality tends to be lower in the short term under the 1.5ºC scenario, but it will be higher in the medium term (towards the end of the forecasting period). Second, the opposite happens for labour productivity, where progress tends to be higher in the short term under the 1.5ºC scenario, but lower in the medium term (towards the end of the forecasting period). This highlights the importance of additional policies in the net-zero strategy that allow for a better management of potential issues in short-term progress related to income inequality, and in medium-term progress related to labour productivity.

Figure 18: Indicators progress results (58 countries sample)

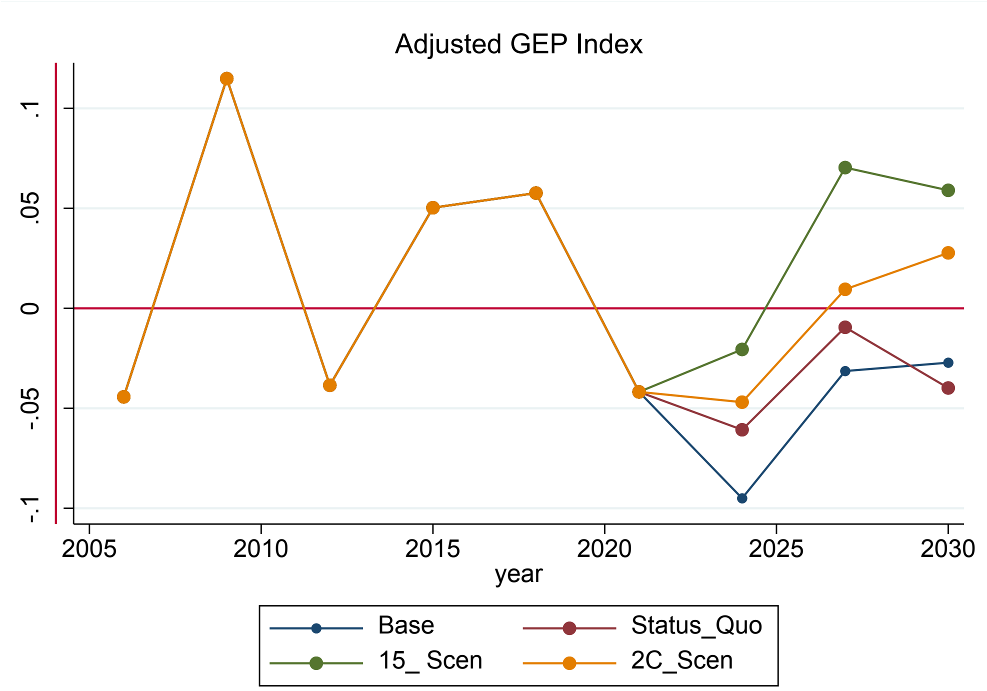


Source: Author's calculations.

Note: Median Value presented in the Figures, except the Gini coefficient measuring inequality, which is presented by its mean value.

Figure 19 shows the results of the Adjusted GEP Index for the main scenarios, covering the sample of 58 countries. The results clearly show that the recovery from the pandemic is faster and more sustained than under the 1.5°C scenario. In addition, it is also clear that neither the base nor the SQ scenarios can support the recovery or provide medium-term progress towards an IGE.

Figure 19: Adjusted GEP Index results (58 countries sample)



Source: Author's calculations.

Note: Median Value presented in the Figures.

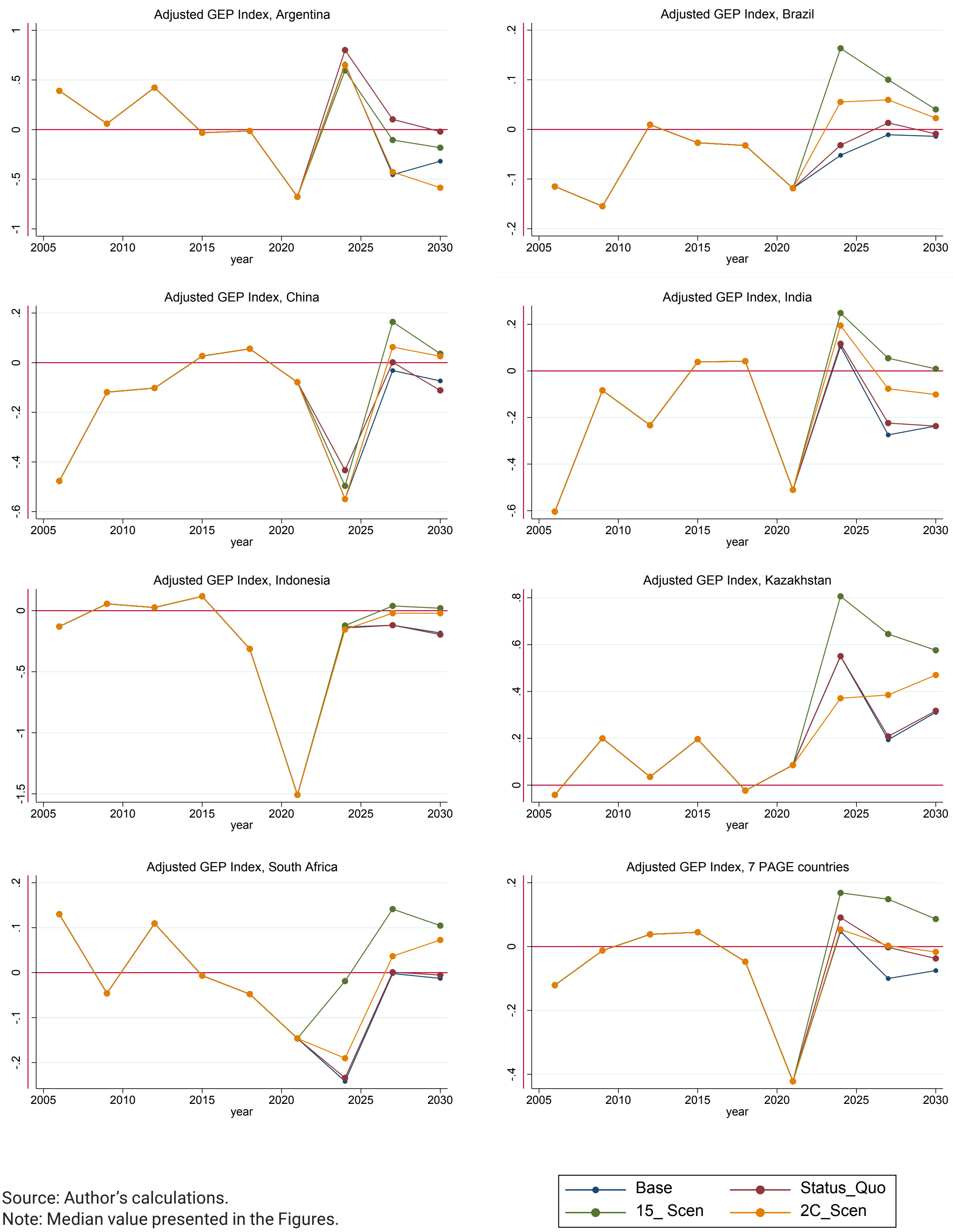
Figure 20 summarizes the impact of the crises on the indicators of the Adjusted GEP Index, as well as its evolution under a 1.5°C scenario.

Figure 20: Comparison of indicators of the Adjusted GEP Index before (2020—2022) and after investments (2023—2030) in the 1.5°C scenario.

Source: Author’s calculations.

Figure 21 shows the results for Adjusted GEP Index but only focused on the seven PAGE countries in the sample. The figure shows a similar picture as the general results. The other scenarios can provide a short-term recovery, but such recovery is unsustainable. For most of the 7 PAGE countries that were part of the modelling, the only valid alternative for a sustained IGE transition is the 1.5°C scenario. Nevertheless, there are important heterogeneities across PAGE countries, with Kazakhstan and South Africa benefiting the most from a net-zero transition. Meanwhile, Argentina and India still experience some challenges in their progress towards an IGE, mostly due to a persisting regress in resource efficiency indicators, such as material footprint per capita and electricity use per GDP. Additionally, income inequality remains an issue for Argentina.

Figure 21: Adjusted GEP Index results (PAGE countries)

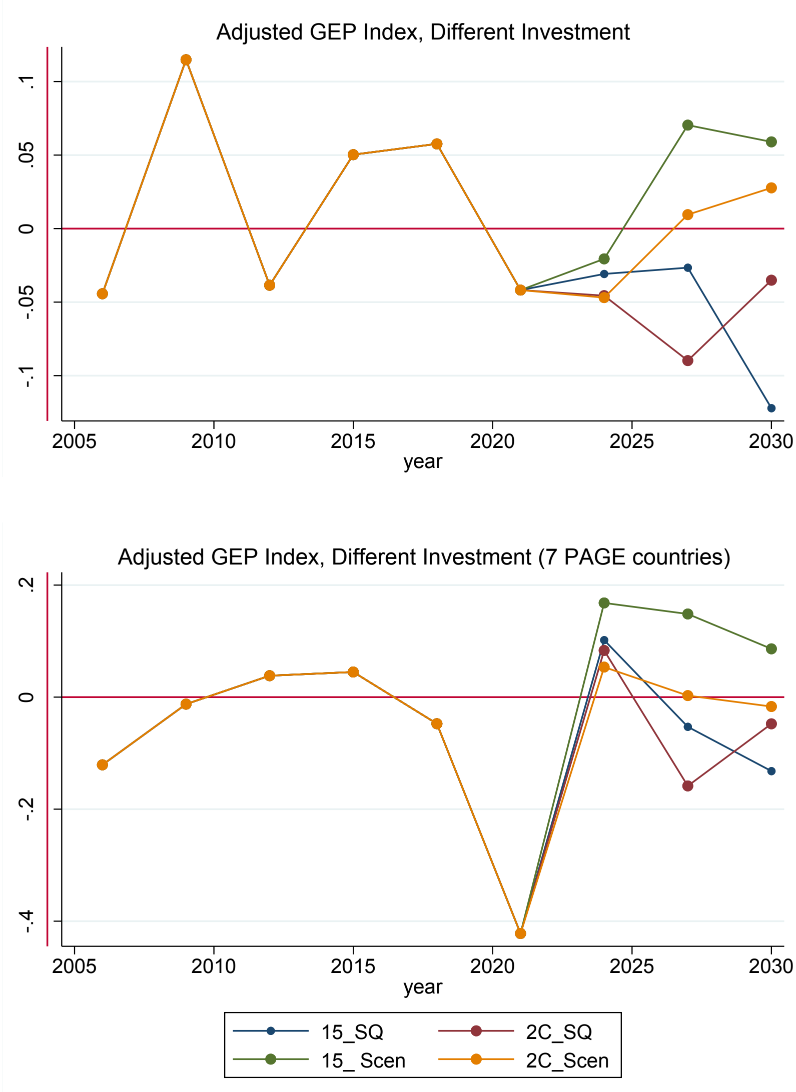


Source: Author's calculations.
Note: Median value presented in the Figures.

Finally, we compare the 1.5°C and 2°C scenarios with those that have a similar level of investments, but directed towards brown sectors, like in the Status Quo Scenario (1.5°C and 2°C Status Quo). Note that the most useful comparison is between the Status Quo Scenarios and their counterpart, rather than among the two Status Quo Scenarios. This is because for the Status Quo 1.5°C and 2°C scenarios their main drivers cross (different level of investments make scenarios diverge if the investment are less green). The 1.5°C is better than the 2°C scenario, but because the level of green investment is higher, its status quo scenario results tend to be worse than under the 2°C scenario, as the shift from green to brown investments in those scenarios is larger.

Figure 22 shows that if the levels of investments that will support the net-zero scenarios were to be allocated to brown investments, as in the Status Quo scenario, we will see countries moving further away from an IGE in the medium term. This highlights the importance of not only adding more investments to the policy mix, but also ensuring that these investments are green.

Figure 22: Adjusted GEP Index results, alternative financing scenarios (all sample and PAGE countries).



Source: Author's calculations.
Note: Median value presented in the Figures.

Conclusions

This publication presents an update of the methodology used for the Green Economy Progress Measurement framework, used at the global level with the latest data available. In this Third Edition, we could obtain a GEP+ for 110 countries. Results from the GEP Index and the three Dashboard sustainability indicators show that 32 countries (29%) were able to achieve positive progress (or no regress) for all indicators in the entire Dashboard of Sustainability, as well as a positive GEP Index score.

Regarding the GEP index, more than 75 per cent of the sample of countries experienced progress compared to their values in the two previous editions. It is important to note that seven countries have a GEP Index higher than 0.55, which was the maximum value observed in PAGE (2017b). However, the results also highlight that progress not always happened where it was most needed, as illustrated for the cases of gender inequality and air pollution. If policy-makers are able to induce higher growth in the areas with higher weights, the overall results will be even more positive. This is why, for a true transformative agenda, greater focus should be given to the areas where countries are lagging behind the most, and not to the areas where progress is just easier to achieve.

Out of the 17 PAGE countries analysed, we found that 14 had a positive GEP Index, indicating progress towards an Inclusive Green Economy. However, when we calculated the GEP+, using the Dashboard of Sustainability, it turned out that only South Africa had progressed (or not regressed) in all the indicators composing the Dashboard, while also having a positive GEP Index score. This may indicate that progress achieved in the GEP Index in PAGE countries may be unsustainable. The results from the Adjusted GEP Index show that the COVID-19 pandemic and the War in Ukraine are negatively affecting countries' progress towards an IGE. Nevertheless, the 1.5ºC scenario shows a potential path to a faster and more sustained recovery. There are some short-term trade-offs that these scenarios may face when compared to the baseline and the status quo, but the medium-to-long term shows clear advantages of carbon-neutral policies in terms of progress towards an IGE.

For PAGE countries, it is also clear that the only valid alternative for a sustained recovery is the 1.5ºC scenario. However, there are important heterogeneities across PAGE countries, with Kazakhstan and South Africa experiencing the better results in this scenario compared to Argentina or India. Regarding the type of investment, results show that if the investments for the net-zero scenarios were to be allocated to brown investments, countries would be moving further away from an IGE. This highlights the importance of not only adding more investments to the policy mix but also ensuring that these investments are green.

This Third Edition used an innovative approach to calculate current and future trends of the IGE transition by connecting the Green Economy Progress Measurement Framework to a Modelling Tool. This approach is not without limitations. Firstly, the development of an adjusted GEP Index dropped the number of indicators from 18 to 8 and the number of countries from 110 to 58. For future editions, the adjusted GEP index will need to be improved in two main dimensions: 1) country coverage, by adding more countries; and 2) the availability of indicators in the Adjusted GEP Index, such as those related to gender inequalities. The impact of IGE policies and investments on gender issues is an avenue to explore in the future.

Finally, material footprint is the indicator that is posing most challenges to countries, despite massive investments in the net-zero transition. Future editions should look closer at this indicator. For instance, they could identify the underlying reasons for this poor performance.

References

Arasu, Sibi. (2022). India to miss renewable energy goal, officials, experts say. The Associate Press. https://apnews.com/article/covid-health-india-energy-industry-0be8e0c7f9ec36723189c275055b5169
Barberà, S. and Jackson, M. (1988). Maximin, Leximin, and the Protective Criterion: Characterizations and Comparisons. *Journal of Economic Theory, 46: 3444*. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.297.1477&rep=rep1&type=pdf
Barro, R. and Lee J-W. (2013). A New Data Set of Educational Attainment in the World. *Journal of Development Economics*, 104: 184-198.
Bringezu, S. (2015). Possible Target Corridor for Sustainable Use of Global Material Resources. *Resources*, 4(1): 25-54.
Burke, M., Hsiang, S.M. and Miguel, E. (2015). Global Non-Linear Effect of Temperature on Economic Production. *Nature*, 527(7577): 235–239. https://doi.org/10.1038/nature15725.
Cabernard, L. and Pfister, S. (2021). *A Highly Resolved MRIO Database for Analyzing Environmental Footprints and Green Economy Progress.* Science of the Total Environment, 755: 142587.
Cambridge Econometrics (2022). *E3ME Model Manual*. Cambridge, UK: Cambridge Econometrics.
Chaudhary, A., Brooks, T.M. (2018). *Land Use Intensity-Specific Global Characterization Factors to Assess Product Biodiversity Footprints*. Environmental Science & Technology, 52: 5094-5104.
Dao H., Peduzzi P., Friot D., (2018). *National Environmental Limits and Footprints Based on the Planetary Boundaries Framework: The Case of Switzerland.* https://doi.org/10.1016/j.gloenvcha.2018.06.005
Dasgupta, P., Mäler, K.-G. (2001). Wealth and Sustainable Development. *World Economics*, 2 (3).
Desing et al. (2020). *Ecological Resource Availability: A Method to Estimate Resource Budgets for a Sustainable Economy.* Global Sustainability, Cambridge Core.
European Environment Agency, Swiss Federal Office for the Environment (2020). *Is Europe Living within the Limits of our Planet? An Assessment of Europe's Environmental Footprints in Relation to Planetary Boundaries.* Global Environmental Change.
Fleurbaey, M. and Blanchet D. (2013). *Beyond GDP Measuring Welfare and Assessing Sustainability.* Oxford: Oxford University Press.
Frischknecht, R., Nathani, C., Alig, M., Stolz P., Tschümperlin, L. and Hellmüller, P. (2018). *Environmental Footprints of Switzerland. Developments from 1996 to 2015. Extended Summary.* Federal Office for the Environment. State of the Environment No. 1811.
Green Growth Knowledge Platform (2013). *Moving towards a Common Approach on Green Growth Indicators*. Seoul, Paris, Nairobi and Washington DC: Global Green Growth Institute, Organisation for Economic Co-operation and Development, United Nations Environment Programme and World Bank.
Green Growth Knowledge Platform (2016). Measuring Inclusive Green Growth at the Country Level. Seoul, Paris, Nairobi and Washington DC: Global Green Growth Institute, Organisation for Economic Co-operation and Development, United Nations Environment Programme and World Bank.
Hartvig, Á.D. *et al.* (2022). Regional Rivalry: SSP3 Modelling of the War in Ukraine. *IAMC Annual Meeting*, College Park, MD, USA.
Herrero, C., Villar A. and Zambrano E. (2016). Technical Notes for the Construction of the Green Economy Progress Measurement Framework. Mimeo.
Herrero, C., Pineda, J., Villar, A. and Zambrano, E. (2020). Tracking Progress towards Accessible, Green and Efficient Energy: The Inclusive Green Energy index. *Applied Energy,* 279: 115691.
Intergovernmental Panel on Climate Change (2022). Summary for Policymakers, in *Climate Change 2022: Mitigation of Climate Change.* P.R. Shukla et al. (eds). *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK and New York, NY, USA: Cambridge University Press. www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf.
Kiss-Dobronyi, B. *et al.* (2023) Interactions between Recovery and Energy Policy in South Africa. *Energy Strategy Reviews* [Preprint].
Kiss-Dobronyi, B., Fazekas, D. and Pollitt, H. (2021). Macroeconomic Assessment of Possible Green Recovery Scenarios in Visegrad Countries. *Society and Economy*, 1(aop). https://akjournals.com/view/journals/204/43/3/article-p227.xml.
Knobloch, F. *et al.* (2020). Net Emission Reductions from Electric Cars and Heat Pumps in 59 World Regions over Time. *Nature Sustainability*, 3(6): 437–447. https://doi.org/10.1038/s41893-020-0488-7.
Knobloch, F. *et al.* (2021). FTT:Heat — A Simulation Model for Technological Change in the European Residential Heating Sector. *Energy Policy*, 153: 112249. https://doi.org/10.1016/j.enpol.2021.112249.
Koop, Fermin. (2023). Argentina targets huge expansion of renewable energy by 2030. Diálogo Chino. https://dialogochino.net/en/climate-energy/374748-argentina-targets-huge-expansion-of-renewable-energy-by-2030/#:~:text=Argentina%20has%20not%20made%20significant,to%20a%20lack%20of%20maintenance
Lam, A. *et al.* (2018). Policies and Predictions for a Low-Carbon Transition by 2050 in Passenger Vehicles in East Asia: Based on an Analysis Using the E3ME-FTT Model. *Sustainability*, 10(5): 1612. https://doi.org/10.3390/su10051612.
Leadley, P.W. et al. (2014). *Progress towards the Aichi Biodiversity Targets: An Assessment of Biodiversity Trends, Policy Scenarios and Key Actions*. Montreal: Secretariat of the Convention on Biological Diversity.
Lee, S. *et al.* (2022). Impact on the Power Mix and Economy of Japan under a 2050 Carbon-Neutral Scenario: Analysis using the E3ME Macro-Econometric Model. *Climate Policy*, 22 (7): 823–833. https://doi.org/10.1080/14693062.2022.2061406.
Lewney, R., Pollitt, H. and Mercure, J.-F. (2019). From Input-Output to Macro-Econometric Model. *27th International Input-Output Association Conference*, Glasgow, 5 July. www.iioa.org/conferences/27th/papers/files/3602_20190429051_Frominput-outputtomacro-econometricmodel-Lewneyv1.0.pdf.
Mercure, J.-F. (2012). Future Technology Transformations for the power sector (FTT: Power): A Global Model of the Power Sector with Induced Technological Change and Natural Resource Depletion. *Energy Policy*, 48: 799–811. https://doi.org/10.1016/j.enpol.2012.06.025.
Mercure, J.-F. *et al.* (2018). Environmental Impact Assessment for Climate Change Policy with the Simulation-Based Integrated Assessment Model E3ME-FTT-GENIE. *Energy Strategy Reviews*, 20: 195–208. https://doi.org/10.1016/j.esr.2018.03.003.
Mercure, J.-F. *et al.* (2019). Modelling Innovation and the Macroeconomics of Low-Carbon Transitions: Theory, Perspectives

and Practical Use. *Climate Policy*, 19(8): 1019–1037. https://doi.org/10.1080/14693062.2019.1617665.
Moulin, H. (1998). *Axioms of Cooperative Decision Making*. Cambridge: Cambridge University Press.
Nykvist, B. et.al. (2013). National Environmental Performance on Planetary Boundaries: A study for the Swedish Environmental Protection Agency. SEPA: Stockholm.
Partnership for Action on Green Economy (2017a). The Green Economy Progress Measurement Framework – Methodology.
Partnership for Action on Green Economy (2017b). The Green Economy Progress Measurement Framework –Application.
Partnership for Action on Green Economy (2023). South Africa Sustainability Report. https://www.un-page.org/knowledge-hub/south-africa-sustainability-report/
Palma, J.G. (2011). Homogeneous Middles vs. Heterogeneous Tails, and the End of the 'Inverted-U': the Share of the Rich is what it is all about. *Cambridge Working Papers in Economics* (CWPE) 1111. Cambridge: Cambridge University.
Netherlands Environmental Assessment Agency (2018). *Using Planetary Boundaries to Support National Implementation of Environment-Related Sustainable Development Goals*.
Pineda, J. (2012). Sustainability and Human Development: A Proposal for a Sustainability Adjusted HDI (SHDI). ASERS. *Theoretical and Practical Research in Economic Fields*. Vol. III: 2(6).
Pineda, J., Merino-Saum, A. (2019). Indicators for an Inclusive Green Economy – Manual for Advanced Training. Geneva.
Piñero, P., Sevenster, M., Lutter, S., Giljum, S., Gutschlhofer, J., and Schmelz, D. (2019). *National Hotspots Analysis to Support Science-Based National Policy Frameworks for Sustainable Consumption and Production.* Technical Documentation of the Sustainable Consumption and Production Hotspots Analysis Tool (SCP-HAT).
Pollitt, H. *et al.* (2021). Modelling the Economic Effects of COVID-19 and Possible Green Recovery Plans: A Post-Keynesian Approach. *Climate Policy*, 21(10): 1257–1271. https://doi.org/10.1080/14693062.2021.1965525.
Pollitt, H., Lee, S. and Chewpreecha, U. (2019). Introduction to the E3ME and FTT Models, in *Energy, Environmental and Economic Sustainability in East Asia*. Routledge.
Pollitt, H. and Mercure, J.-F. (2018). The Role of Money and the Financial Sector in Energy-Economy Models used for Assessing Climate and Energy Policy. *Climate Policy*, 18(2): 184–197. https://doi.org/10.1080/14693062.2016.1277685.
Regueiro-Ferreira, R.M. and P. Alonso-Fernández (2023). Interaction between renewable energy consumption and dematerialization: Insights based on the material footprint and the Environmental Kuznets Curve. Energy, Volume 266, 2023. https://doi.org/10.1016/j.energy.2022.126477
Rockstrom, J. et al. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society*.14(2): 32.
Semieniuk, G. *et al.* (2022) Stranded Fossil-Fuel Assets Translate to Major Losses for Investors in Advanced Economies. *Nature Climate Change*, 12(6): 532–538. https://doi.org/10.1038/s41558-022-01356-y.
Schmoch, U. (2008). Concept of a Technology Classification for Country Comparisons. Final Report to the World Intellectual Property Organization (WIPO).
Sheng, F. (2016), An Emerging Theory of an Inclusive Green Economy. Web log post. http://web.unep.org/greeneconomy/blogs/emerging-theory-inclusive-green-economy.
Statistical Office of the European Communities (1999). The Environmental Goods and Services Industry: Manual for Data Collection and Analysis. Paris: OECD Publishing.
Stiglitz, J. E., Sen, A., and Fitoussi, J. P., (2010). Report by the Commission on the Measurement of Economic Performance and Social Progress. Paris: Commission on the Measurement of Economic Performance and Social Progress.
Swedish Environmental Protection Agency (2013). National Environmental Performance on Planetary Boundaries. Report 6576.
United Kingdom Committee on Climate Change (2008). Building a Low-Carbon Economy – The UK's Contribution to Tackling Climate Change. http://archive.theccc.org.uk/archive/pdf/TSO-ClimateChange.pdf
United Nations (2011). *Working towards a Balanced and Inclusive Green Economy: A United Nations System-wide Perspective*. New York.
United Nations General Assembly Resolution A/RES/66/288. The Future We Want. New York: United Nations.
United Nations Development Programme (2014). *Human Development Report 2014. Sustaining Human Progress Reducing Vulnerabilities and Building Resilience. Technical Notes*. New York: UNDP.
United Nations Development Programme (2015). Human Development Data. http://hdr.undp.org/en/data
United Nations Environment Programme (2011). *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*. Geneva.
United Nations Environment Programme (2012). *Measuring Progress towards an Inclusive Green Economy*. Geneva.
United Nations Environment Programme (2014). *Using Indicators for Green Economy Policymaking*. Geneva.
United Nations Environment Programme (2015). *Indicators for Green Economy Policymaking – A Synthesis Report of Studies in Ghana, Mauritius and Uruguay*. Geneva.
United Nations Environment Programme (2021). *Green Economy Progress Measurement Framework. Second Edition*. Geneva*: UNEP*.
University of the United Nations / International Human Dimensions Programme on Global Environmental Change, United Nations Environment Programme (2014). *Inclusive Wealth Report 2014. Measuring Progress toward Sustainability*. Cambridge: Cambridge University Press.
Van Hummelen, S. *et al.* (2021). Modelling a Global Inclusive Green Economy COVID-19 Recovery Programme.
Villar, A. (2011). Who Meets the Standards: A Multidimensional Approach. *Modern Economy*, 2(4): 614-624.
World Health Organization (2014). *WHO Indoor Air Quality Guidelines: Household Fuel Combustion*. Geneva: WHO.

PAGE | PARTNERSHIP FOR ACTION ON GREEN ECONOMY

PAGE was launched in 2013 as a response to the call at Rio+20 to support countries addressing one of the greatest challenges of our time: building economies that improve human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. The partnership brings together the expertise, convening power and networks of five United Nations agencies – United Nations Environment Programme, International Labour Organization, United Nations Development Programme, United Nations Industrial Development Organization, and United Nations Institute for Training and Research – to support countries in addressing one of the most pressing challenges of the 21st century: transforming their economies into drivers of sustainability. PAGE supports nations and regions in reframing economic policies and practices around sustainability to foster economic growth, create income and jobs, reduce poverty and inequality, strengthen ecological foundations of their economies, and achieve the Sustainable Development Goals.

For further information:
PAGE Secretariat
UN Environment Programme
Resources & Markets Branch
11-13 Chemin des Anémones
CH-1219 Chatelaine-Geneva
Switzerland
page@un.org

un-page.org
linkedin.com/company/un-page/
twitter.com/_un_page
instagram.com/_un_page/
facebook.com/unpartnershipforactionongreeneconomy

European Commission
Supported by: Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, based on a decision of the German Bundestag
Ministry for Foreign Affairs of Finland
NORWEGIAN MINISTRY OF CLIMATE AND ENVIRONMENT
Ministry of Environment Republic of Korea
Sida SWEDISH INTERNATIONAL DEVELOPMENT COOPERATION AGENCY
Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra Swiss Confederation
Federal Department of Economic Affairs, Education and Research EAER State Secretariat for Economic Affairs SECO