GRANULAR

CLIMATE NEUTRALITY FRAMEWORK

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Executive summary

This report presents a comprehensive framework designed to guide rural communities towards climate neutrality. The framework integrates objective indicators, a carefully curated set of policy measures, and actionable strategic recommendations to support local decision-making and track progress over time. It employs quantitative metrics such as greenhouse gas emissions, energy consumption, and waste management, which are refined for local application using methods like IPAT-based downscaling. These approaches ensure that data collected at broader scales is effectively adapted to reflect the unique conditions of rural areas.

The policy measures incorporated in the framework are drawn from established sources and focus on critical areas including renewable energy, transportation, sustainable agriculture, and waste management. Each policy is paired with both process and impact indicators, enabling local authorities to monitor real-time implementation and evaluate long-term outcomes. Public interest data, gathered through Google Trends analysis, informs a hybrid weighting approach that aligns technical rigor with community priorities, while stakeholder input further validated these findings.

Analysis within the framework reveals that the Energy domain is the most dominant in the pursuit of climate neutrality, whereas the Buildings and Waste sectors receive the least emphasis. This insight is supported by both literature and public interest data, underscoring the central role that energy plays in driving rural sustainability efforts. In contrast, the relatively lower focus on Buildings and Waste indicates potential areas for further policy attention and development.

The exploration of four distinct policy scenarios—Societal Commitment, Directed Transition, Techno-Friendly, and Gradual Development (adapted from Hainsch et al. 2022)—demonstrates varied strategic outcomes. For instance, the Directed Transition scenario increases Energy's weight to 25% and Industry to 22%, resulting in an average absolute rank change of 3.69, with all countries improving their scores under this model. The Techno-Friendly scenario, which raises Energy's weight to 30% and Transportation's to 20%, produces the largest reshuffling of positions, with an average rank change of 4.78. Meanwhile, the Societal Commitment scenario, emphasizing local empowerment and social justice, results in moderate shifts, and the Gradual Development scenario shows only minimal adjustments, with an average rank difference of 0.28. These results illustrate how different strategic priorities can reshape policy impacts and overall progress toward climate neutrality.

In conclusion, this framework offers a practical and adaptable tool that bridges local actions with broader sustainability objectives. By aligning technical assessment with regional priorities and validated stakeholder perspectives, it empowers rural communities to design, monitor, and refine their strategies for achieving climate neutrality. The framework not only supports effective policy development but also redefines rural prosperity by integrating environmental sustainability with social inclusion, laying a solid foundation for a more sustainable and resilient future.

2. Policy relevance linking to the Long-Term Vision for Rural Areas

This report presents a detailed monitoring tool aimed at guiding local-level actions toward climate neutrality, with a specific focus on rural areas. In designing this framework, particular attention has been given to aligning it with the Long-Term Vision for Rural Areas (LTVRA) and the broader EU vision for rural development (European Commission, 2021). Both frameworks prioritize sustainable development, resilience, and inclusivity, which are essential for addressing the distinct challenges and opportunities facing rural communities across Europe.

The LTVRA envisions rural areas as dynamic spaces that unlock their specific potential while tackling global challenges at a local scale. Similarly, the climate neutrality framework developed here is tailored to reflect local contexts, recognizing the unique environmental, social, and economic characteristics of rural areas. This is achieved by incorporating adaptable indicator weights and benchmarks that allow for flexibility in addressing local needs, while still maintaining a standardized approach to ensure comparability across communities. In line with the LTVRA's focus on harmonious territorial development, the framework encourages the implementation of place-based solutions that contribute to climate neutrality, economic sustainability, and community well-being (European Commission, 2018; 2020).

Additionally, the EU's vision for rural areas emphasizes resilience, connectivity, and prosperity through digitalization, sustainable resource management, and fostering economic opportunities. This climate neutrality framework integrates these priorities by promoting indicators that focus on GHG reduction, renewable energy, and sustainable food systems, thereby supporting rural areas in becoming providers of bio-based materials, renewable energy, and other high-quality services (European Commission, 2019). Moreover, the emphasis on participatory governance and multi-level collaboration reflects the LTVRA's and EU's commitment to inclusive and empowered communities.

In this context, the framework serves as a critical tool for rural areas aiming to contribute meaningfully to the EU's Green Deal and climate neutrality goals, which underscore decarbonized energy systems, nature-based solutions, and circular economies as pivotal for reducing emissions and safeguarding biodiversity—particularly in the context of sustainable food production (European Commission, 2018; European Commission, 2019; European Commission, 2020) while simultaneously enhancing local prosperity, fairness, and resilience (European Commission, 2019). Through its alignment with the LTVRA and the EU vision, this framework has the potential to empower rural communities in their transition toward a more sustainable and equitable future.

A dedicated focus on rural communities is justified not only by their distinct social, economic, and environmental attributes, but also by their pivotal contribution to achieving broader climate and sustainability objectives. Multiple policy papers and academic studies underscore the importance of rural areas in driving the EU's climate neutrality agenda—through renewable energy generation, carbon sequestration, sustainable agricultural practices, and safeguarding biodiversity (European Commission, 2018; 2019; 2020; 2021).

However, these same sources highlight a notable gap in frameworks that cater to the specificities of rural contexts, where demographic patterns, resource availability, and governance structures often differ significantly from urban settings. By centering on local-level rural action, this report addresses the lack of a comprehensive guiding framework tailored to the particular challenges and opportunities facing rural territories. As such, it not only underlines the critical role rural areas play in realizing EU-wide policy goals, but also ensures that the unique attributes of these communities are reflected in actionable, context-sensitive pathways toward climate neutrality.

The LTVRA underscores the critical role that rural areas play in addressing global challenges, including climate change. Far from being passive recipients of top-down policies, rural communities can serve as active agents of climate action, leveraging their unique assets—such as extensive natural resources, space for renewable energy infrastructure, and established traditions of sustainable practices. By harnessing these strengths, rural regions have the potential to significantly accelerate Europe's shift toward climate neutrality.

This emphasis on place-based solutions recognizes that rural contexts vary widely in geography, socio-economic conditions, and resource availability. Tailoring strategies to the specific needs and characteristics of each rural community helps ensure that climate initiatives are both effective and locally appropriate. In doing so, rural areas can transition from being seen as peripheral regions to central actors in the EU's environmental strategy, demonstrating how economic growth and ecological sustainability can reinforce each other. This foundational viewpoint informs the framework presented in this report, which seeks to align local-level adaptations with broader EU objectives for a sustainable and resilient rural future.

3. Literature review

3.1 What is Climate Neutrality

Climate neutrality, often referred to as carbon neutrality, is a crucial concept in the global effort to combat climate change (Note: While 'carbon neutrality' focuses on balancing carbon dioxide emissions, 'climate neutrality' encompasses the mitigation of all greenhouse gases.). It entails balancing the amount of emitted carbon dioxide with an equivalent amount sequestered or offset, resulting in a net-zero carbon footprint. This concept can vary depending on the scope—territorial, sectoral, or corporate neutrality—and requires a life-cycle perspective (covering scopes 1, 2, and 3), which accounts not only for direct emissions but also for indirect emissions embedded in production processes and imported goods. Achieving climate neutrality typically involves a combination of strategies such as reducing greenhouse gas emissions through energy efficiency, switching to renewable energy sources, modifying consumption patterns (for instance, shifting towards a more plant-based diet), and implementing carbon capture and storage technologies. The Paris Agreement emphasizes the need for global carbon neutrality by 2050 to limit global warming to 1.5°C above pre-industrial levels (Finkbeiner & Bach, 2021). In addition, practical measures like planting trees to offset individual carbon footprints, as seen in initiatives like the Carbon Neutrality Challenge in Hawaii, also contribute to this goal (Rollo et al., 2020). Additionally, while these targets are set at global and EU levels, implementing climate neutrality also requires a multi-scalar approach. This includes translating broader policy goals into actionable strategies for local communities, thereby ensuring that climate neutrality efforts are effective and inclusive at every level of governance.

Despite the clear objectives, the path to climate neutrality is fraught with challenges. For instance, the transition to renewable energy and improved energy storage technologies are essential to maintain a steady supply of electricity while reducing greenhouse gas emissions. However, this transition is complex and requires significant technological advancements and economic investments (Mielczarski, 2020). Furthermore, the ethical dimensions of climate neutrality highlight concerns about greenwashing and the need for transparent measurement and stakeholder involvement to ensure sustainability and justice in climate policies (Ziegler, 2016). The European Union's Green Deal, aiming for climate neutrality by 2050, underscores the necessity of integrating robust policy measures and governance tools to achieve these targets effectively (Dupont et al., 2023).

The European Union (EU) has set a target to become the first climate-neutral continent by 2050, as outlined in the European Green Deal. This ambitious plan aims to reduce GHG emissions by at least 55% by 2030 compared to 1990 levels and achieve net-zero emissions by mid-century. The EU's strategy for climate neutrality involves a comprehensive transformation across all sectors of the economy, including energy, industry, transportation, agriculture, and construction. The EU emphasizes the use of renewable energy sources, energy efficiency, electrification, and innovative technologies such as hydrogen and carbon capturing and storage to achieve these targets (Capros et al., 2019). Additionally, the EU's approach is supported by legally binding regulations, including the European Climate Law, which sets the framework for achieving climate neutrality and integrates this goal into EU policies (Szyrski, 2023).

3.2 Frameworks which measure Climate Neutrality

Monitoring and reporting on greenhouse gas (GHG) emissions can be approached differently depending on whether it is done at a territorial or corporate level. At a territorial scale, governments and policymakers often rely on the *Intergovernmental Panel on Climate Change (IPCC) guidelines for national GHG inventories* (IPCC, 2006, 2019) and the *EU Monitoring Mechanism Regulation* (European Union, 2013) to track and report emissions across entire regions and countries. Meanwhile, corporations frequently use frameworks such as the *Greenhouse Gas (GHG) Protocol* (WBCSD & WRI, 2004) and *ISO 14064* (ISO, 2018) to measure and disclose their organizational carbon footprints. Beyond these core standards, the *Corporate Sustainability Reporting Directive* (European Union, 2022) guides companies within the EU on how to integrate climate-related data into their broader sustainability reporting practices, while global initiatives like the *United Nations Global Compact* (United Nations Global Compact, 2015) encourage businesses to uphold environmental principles. Additional private-led initiatives, such as the *Carbon Disclosure Project* (CDP, 2023), provide voluntary platforms for transparent emissions reporting and environmental impact disclosure. Together, these international and regional frameworks ensure that both governments and companies have the necessary tools to measure GHG emissions consistently and reliably, serving as essential references against which specialized, or sector-specific measurement frameworks can be benchmarked.

Frameworks for measuring climate or carbon neutrality with indicators are essential for tracking and achieving sustainability goals. These frameworks integrate various indicators to assess carbon emissions and broader environmental impacts, but they differ significantly in their methodologies, target units, and specific focuses.

The Carbon Neutrality and Sustainability in Educational Campuses (CaNSEC) framework is tailored for educational institutions. It assesses carbon footprints and overall sustainability using five indicators for greenhouse gas (GHG) emissions and 24 indicators across four components: environment, society, economics, and academics. While the CaNSEC framework offers valuable insights, it remains specific to educational campuses and does not replace more comprehensive frameworks at territorial or corporate levels**.** This approach is specific to the academic setting, enabling institutions to benchmark their performance and drive improvements in sustainability (Jain et al., 2017).

In contrast, the scenario analysis for net zero framework is designed for companies, particularly in the German building sector and energy-intensive industries. This framework uses scenario analysis to align corporate strategies with scientific pathways to net-zero carbon emissions. Key indicators include technologies, energy and resource efficiency, and carbon pricing, focusing on strategic development and climate-related reporting practices for businesses (Ballesteros et al., 2023).

The PRIMES energy model is utilized at a regional and national level within the EU. It explores pathways towards climate neutrality by analyzing energy demand, supply, and costs. This model supports broad policy integration, emphasizing energy efficiency, renewables, and electrification as no-regret options. It also identifies the need for disruptive technologies and policies, demonstrating a macro-scale approach to achieving climate neutrality (Capros et al., 2019).

For urban environments, the Carbon Neutral Green City Indicators framework provides a comprehensive set of indicators for planning carbon-neutral green cities. It includes categories such as green land and ecology, green energy, green resource and transportation, and green living and institutions. This framework is focused on urban planning and management, emphasizing the need for detailed spatial and infrastructural indicators (Kim & Lee, 2013).

The IPCC methodology employs a tiered approach that provides varying levels of detail based on data availability and national circumstances, covering all major GHG-emitting sectors (e.g., energy, industrial processes, agriculture, land use, and waste). It uses standardized emission factors and default data sets, which can be refined with country-specific data, ensuring consistent and transparent global reporting. The Carbon Accounting for European City Neighborhoods framework adapts the IPCC methodology to assess greenhouse gas emissions in specific urban neighborhoods. It calculates the carbon footprint based on household energy use, mobility, waste treatment, and water use, providing a localized understanding of carbon impacts to support effective urban planning and stakeholder engagement (Pulselli et al., 2019).

These diverse methodologies illustrate the range of approaches to measuring and achieving carbon neutrality, each tailored to different units and scales, from individual educational institutions and companies to entire cities and regions. They highlight the importance of integrating various environmental, social, and economic factors to provide a holistic view of sustainability efforts. Each framework plays a crucial role in guiding organizations and regions towards more sustainable and carbon-neutral futures.

3.3 Domains of Climate Neutrality

Achieving climate neutrality is an urgent and multifaceted challenge that requires transformative changes across various sectors, including energy, transportation, agri-food systems, waste, industry, and buildings. These domains were identified in the literature as major contributors to global greenhouse gas emissions, with special relevance for rural areas, and thus serve as focal points for targeted mitigation strategies. Each of these domains plays a crucial role in the global effort to reduce greenhouse gas emissions and mitigate the impacts of climate change. The domain of energy is intricately linked to climate neutrality, as the type and amount of energy produced and consumed directly impacts emissions. Transitioning from fossil fuels to renewable energy sources like solar and wind, along with enhancing energy efficiency, is essential in this regard (Satola et al., 2022; Tsemekidi Tzeiranaki et al., 2023; Jeleński et al., 2021).

The transportation sector, with its significant contribution to emissions, demands a shift to low-emission and zero-emission vehicles, improved public transportation, and sustainable fuel options. Efficient logistics and smart traffic management systems further aid in minimizing emissions (Hussain et al., 2023; Zhang et al., 2023; Corlu et al., 2020). Similarly, agri-food systems requires sustainable farming practices, reduce food waste, and promote plant-based diets to lower their carbon footprint. Innovations in agricultural technology and support for regenerative agriculture can enhance carbon sequestration and reduce emissions (Castillo-Díaz et al., 2023; de Carvalho et al., 2022; Nicholson et al., 2021).

Effective waste management is another critical area, with comprehensive recycling programs, waste reduction initiatives, and advanced waste treatment technologies playing key roles in cutting emissions. Transforming waste into renewable energy through processes like anaerobic digestion can also contribute significantly (Soltanian et al., 2022; Olay-Romero et al., 2020; da Silva et al., 2019). The industrial sector, which relies heavily on fossil fuels and energy-intensive processes, needs to adopt energy-efficient technologies, integrate renewable energy, and utilize carbon capture and storage solutions. Circular economy principles can further reduce the environmental impact by minimizing waste and repurposing by-products (Franco et al., 2023; Mengistu and Panizzolo 2023; Morage et al., 2019).

Buildings, accounting for a large portion of energy consumption and emissions, must transition to energy-efficient designs, retrofit existing structures, and utilize renewable energy sources. Smart building technologies that optimize energy use and promote sustainable living practices are also crucial. By ensuring that buildings meet high environmental standards, the sector can significantly reduce its carbon footprint, enhancing the comfort and health of occupants while supporting climate neutrality objectives (Felicioni et al., 2023; Rodrigues et al., 2023; Mosca and Perini 2022). These concerted efforts across all domains are essential for achieving a sustainable and climate-neutral future.

The path to climate neutrality is complex, requiring coordinated efforts across the sectors listed above. These domains are deeply interconnected, influencing and being influenced by each other. For instance, transitioning to renewable energy impacts transportation and industrial processes, while advancements in waste management and agricultural practices contribute to reduced emissions in multiple areas. Success in achieving climate neutrality hinges on the collective transformation of these sectors, as they both impact and are impacted by the broader shift toward sustainability. In parallel, preserving and restoring well-functioning natural environments—such as forests, wetlands, and other ecosystems—is essential for maintaining biodiversity and enhancing carbon sequestration capacity. Combining sector-specific mitigation efforts with robust environmental conservation strategies ensures a more holistic pathway toward climate neutrality.

3.4 Rural Climate Neutrality context

Rural regions face unique challenges and opportunities in the pursuit of climate neutrality. These areas often depend heavily on agriculture, forestry, and other primary industries, which are both vulnerable to climate change and critical to global efforts to reduce greenhouse gas emissions. Addressing climate change in rural regions requires tailored strategies that leverage their specific strengths and address their distinct vulnerabilities.

One key aspect is the impact of climate change on agricultural productivity and rural incomes. Recent studies indicate that climate change is likely to exacerbate rural poverty, especially in regions with less favorable agricultural climates (Charles et al., 2019). For instance, climate change has been found to have an inverted U-shaped relationship with urban-rural income disparity in China, with extreme heat widening the income gap and extreme drought narrowing it (Xie, Wu, & Yao, 2023). This suggests that targeted adaptation strategies, such as improved agricultural practices and diversification of livelihoods, are essential to mitigate these effects.

Policy measures are also critical. The Agri-Environment-Climate Measure (M10) within the Rural Development Program 2014-2020 in Poland which aims to promote sustainable agricultural practices that protect biodiversity, improve soil and water quality, and reduce greenhouse gas emissions has shown positive results, with participating farmers reporting progress in income despite the increased workload and costs associated with program implementation (Krzyszczak et al., 2023). Such programs are vital for integrating climate concerns into rural development and fostering a transition to a low-carbon economy.

Community engagement and innovative planning approaches play a vital role in building resilience. Rural regions in Scotland and Australia highlight the importance of local knowledge and community-led initiatives. For example, in Scotland, rural communities are making significant efforts to reduce greenhouse gas emissions and adapt to climate change, supported by government policies (Pajot et al., 2009). Similarly, rural planning in Australia emphasizes the need for renewed discourse and innovative strategies to address climate challenges (Morrison et al., 2015).

Multi-level governance and cross-sector approaches are necessary to manage climate change impacts effectively in rural areas. In China, regional policies that integrate ecological efficiency and carbon neutrality promote high-quality development and environmental sustainability (Tan and Wang, 2021). Similarly, policy research in Latin America highlights the importance of addressing barriers in policy processes and promoting multi-sectoral governance to enhance climate resilience (Locatelli et al., 2017).

Given the unique characteristics and vulnerabilities of rural regions, it is essential to develop and apply tailored metrics that can accurately gauge progress toward carbon neutrality. Such an approach should encompass socio-economic indicators, environmental health assessments, and sector-specific emission metrics, enabling policymakers and stakeholders to set realistic targets and track outcomes over time. By focusing on measurable progress, rural areas can better identify synergies and trade-offs, informing strategies that balance economic development, social well-being, and ecological resilience.

To the best knowledge of the authors of this report, there has not been established a comprehensive framework to measure climate neutrality specifically tailored for rural regions and their unique characteristics. This gap underscores the need for further research and development of frameworks that can accurately capture the distinct environmental, economic, and social factors at play in rural areas.

3.5 Community-level context

Measuring climate neutrality from the bottom-up level and community perspectives is vital for creating effective and inclusive climate policies. While top-down frameworks often provide broad targets and standardized metrics, bottom-up approaches complement these by focusing on local nuances and stakeholder involvement. This approach emphasizes local participation and the unique environmental, economic, and social conditions of different communities, leading to more tailored and sustainable solutions. Moreover, involving communities in climate neutrality efforts helps build local capacity and resilience, ensuring that local voices and needs are considered.

One significant advantage of bottom-up assessments is their ability to capture the diverse impacts of climate change on various regions. For instance, the regional ecological efficiency in Jiangsu Province, China, varies significantly, demonstrating the need for localized strategies to achieve carbon neutrality (Tan and Wang, 2021). By understanding these local differences, policymakers can design interventions that are more effective in reducing carbon emissions and enhancing sustainability.

Community-based approaches ensure that the voices and needs of local populations are considered, leading to greater acceptance and long-term success of climate initiatives. Studies highlight that bottom-up assessments focusing on recent vulnerabilities provide valuable insights that top-down models might overlook, thus better addressing immediate adaptation needs (Conway et al., 2019).

Moreover, bottom-up and community-focused measurements foster innovation and practical solutions that can be scaled up. Localized efforts often lead to the development of unique, context-specific strategies that can be adapted by other regions facing similar challenges. For example, eco-innovation and environmental policies tailored to specific regions have been shown to significantly impact carbon reduction efforts (Tao et al., 2021).

The significance of measuring climate neutrality from a bottom-up level and incorporating community perspectives lies in creating effective, equitable, and sustainable climate strategies. This approach ensures that policies are contextually relevant, widely accepted, and capable of addressing the diverse impacts of climate change across different regions.

4. Data and Methods

4.1 Framework structure

This framework has been developed specifically to assess climate neutrality in rural areas, aiming to measure current progress toward climate neutrality, evaluate the implementation of relevant measures, and offer decision-makers actionable insights into both emissions levels and supporting policies. It is structured into three main sections: Objective Indicators, Policy Measures, and Levers of Action (see Figure 1). These sections align with the steps included in the foundational frameworks, albeit with slight variations to fit the specific context of our goals.

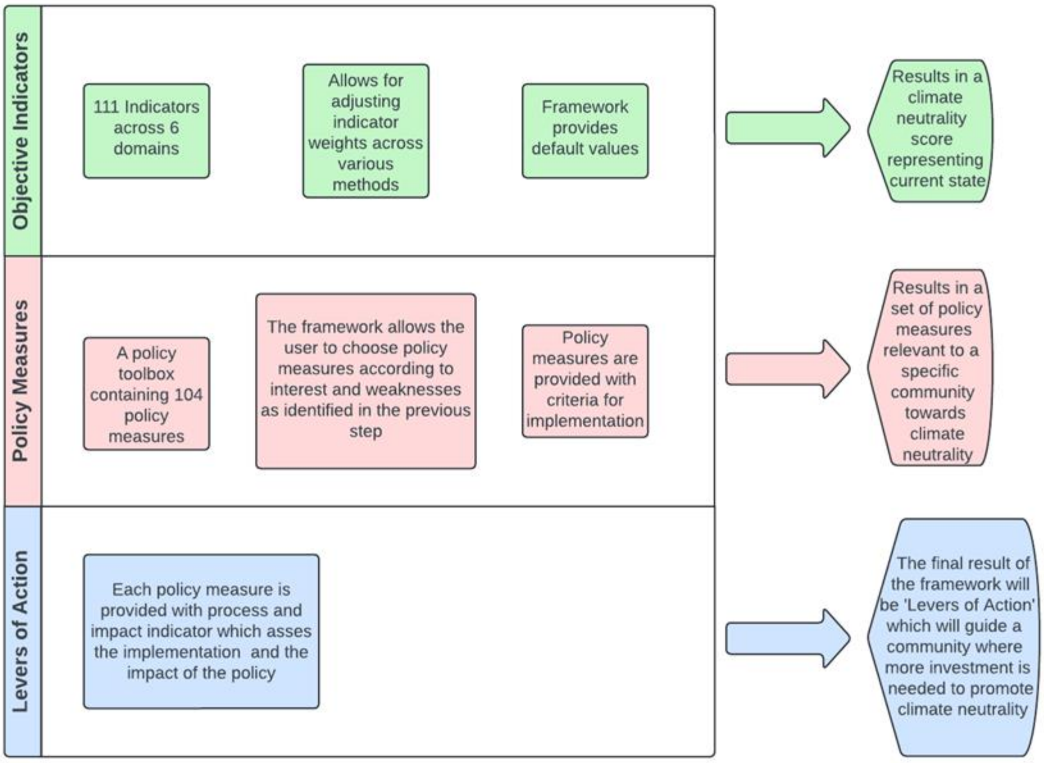
The Objective Indicators section focuses on quantifiable metrics that provide a snapshot of the current progress toward climate neutrality. This involves tracking emissions, energy consumption, and other relevant data. The Policy Measures section assesses the effectiveness and implementation of policies aimed at achieving climate neutrality. It provides guidance through a toolbox of policy measures relevant to each domain and value, allowing decision-makers to identify approaches best suited to their community's context.

Finally, the Levers of Action section identifies actionable steps and strategies for decision-makers to enhance climate neutrality, suggesting practical solutions and interventions based on the data and policy analysis. In summary, our framework leverages the strengths of existing models by integrating comprehensive indicators, stakeholder engagement insights, and a detailed analysis of policy measures. This structured approach ensures a robust assessment of climate neutrality and provides a clear pathway for continuous improvement and strategic planning. The following segments elaborate about each framework section and the principles behind them.

Our framework, designed to measure climate neutrality, draws inspiration from three recently published frameworks, each focused on different sectors' sustainability metrics. These frameworks provide a comprehensive base for assessing the current state of climate neutrality, the implementation of relevant policy measures, and offering actionable levers for decision-makers to enhance climate neutrality in their communities.

Velten et al., (2021) focuses on assessing structural changes through net-zero indicators to measure progress towards climate neutrality. It emphasizes the importance of strategic planning and actionable steps to achieve net-zero emissions by 2050. Kleanthis et al., (2022) identifies critical issues and challenges of the energy transition towards climate neutrality by engaging stakeholders across different geographical contexts, including national, regional, and continental scales. The findings underscore the necessity for tailored policies that address specific local and regional needs while promoting broader collaboration. Hebinck et al., (2021) evaluates sustainable food systems by integrating various metrics and indicators to assess sustainability, identify levers of change, and analyze policy interventions. The framework provides insights into food system dynamics, emphasizing the importance of a holistic approach to sustainability.

Figure 1 – Methodological approach



4.2 General approach

4.2.1 Wide sustainability choice and community perspective approaches

In designing our Climate Neutrality framework, we adopted a wide-ranging approach to capture the complexity of sustainability in various facets of human life. Rather than limiting our focus to direct impact indicators such as greenhouse gas (GHG) emission levels or air pollution levels, we extended our scope to include indirect impact indicators like renewable energy utilization and public transport efficiency. This broad approach acknowledges that sustainability encompasses a myriad of interconnected elements, each influencing the overall environmental, social, and economic well-being (Hebinck et al., 2021; Kleanthis et al., 2022; Velten et al., 2021). By measuring a comprehensive array of indicators, we aim to provide a holistic view of sustainability that reflects its multifaceted nature. We recognize that incorporating a broad set of indicators may increase the complexity of data collection and analysis; however, this expanded scope ensures a more comprehensive understanding of sustainability trade-offs and synergies at the community level.

Moreover, our framework is structured from the perspective of local community, rather than an entity such as a business. This choice is driven by the ultimate goal of our framework: to serve and benefit residents in rural regions. Consequently, many of the indicators are framed within the context of the consumer experience, such as fuel and electricity consumption, or are normalized to population size to ensure relevance and applicability. This user-centric approach aligns with the notion that consumption acts as a significant driving force within the sustainability paradigm. While production processes contribute substantially to pollution, it is the demand generated by consumers that drives production activities. Therefore, by focusing on consumption patterns and behaviors, our framework targets the underlying drivers of environmental impact, aiming to promote sustainable practices at the source.

By integrating both direct and indirect indicators and adopting a consumer-focused perspective, our framework provides a robust and nuanced understanding of sustainability. This methodology not only highlights the immediate environmental impacts but also considers the broader, systemic factors that influence sustainability outcomes. Ultimately, this comprehensive approach ensures that our framework can effectively guide and support sustainable development efforts in rural regions, fostering a more sustainable and resilient future for all residents.

4.2.2 Domain selection

Our framework domains related to climate neutrality were chosen through an extensive and structured literature review. To ensure comprehensive coverage of all domains pertinent to climate neutrality, we included the terms "Climate Neutrality," "Carbon Neutrality," and "Zero Carbon" in our review. These terms, although coined at different times, share the common objective of promoting a sustainable future.

We aimed to investigate whether there were shifts in the focus and domains associated with each term over time. Our review utilized two academic literature databases, "Web of Science" and "Scopus." The search included each term in conjunction with the word "indicators" to identify papers discussing quantitative frameworks for measuring sustainability. Specifically, we performed Boolean searches in Scopus and Web of Science (WoS) using (“Climate Neutrality” OR “Carbon Neutrality” OR “Zero Carbon”) AND (“Indicators” OR “Framework”).

Given the large number of papers retrieved from these searches, we refined our results to the recent five years, covering the period from 2018 to 2023, including a few highly relevant papers from 2017. We excluded highly technical papers, typically those from engineering fields focusing on narrow topics. Initially, the searches yielded 930 papers. We performed a preliminary screening based on headlines and abstracts, which reduced the number to 454 papers. A subsequent full-text screening further narrowed this down to 120 highly relevant papers. These selected papers were meticulously examined, and various sectors or domains (e.g., energy, economy) were recorded.

Following this comprehensive review, we categorized the identified domains into two types: sectoral domains, such as energy, transportation, and waste management, and cross-sectoral domains relevant to all sectoral areas, including environmental, economic, and social aspects. These cross-sectoral domains were called "values" in our framework, as they represent different values that each domain is expected to fulfill in a climate-neutral future. This thorough process ensured that our framework encompasses all critical domains related to the notion of climate neutrality.

The domain of governance was excluded for several reasons. The indicators in this domain are often broad in scope and predominantly qualitative, making them incompatible with our proposed methodology, which relies on clear and measurable indicators. Additionally, sustainable governance is a complex issue that deals more with governance structures, ethics, and balance of power rather than specific indicators or policies leading to climate neutrality. Therefore, it falls outside the scope of this research.

The topic of carbon sequestration was mentioned in the review, but we chose not to include it in the final framework. Firstly, there is the issue of greenwashing, where companies use various carbon-sequestering projects to falsely present themselves as environmentally friendly (Mu and Lee 2023). Newell (2012) contends that offset-based carbon sequestration initiatives can perpetuate illusions of corporate environmental responsibility, ultimately diverting attention from the necessity of direct emission reductions and undermining genuine climate action. Secondly, the UN clearly states that these types of sequestration projects should not be accounted for in the long term. Thirdly, the UN guidelines also specify that only natural sinks of carbon (e.g., oceans, forests) should be accounted for (UNFCCC 2021). These natural sinks are difficult to measure on a local level and might introduce bias when measured on a community scale rather than a national or international level. For instance, ocean-based carbon sequestration spans multiple jurisdictions, making it problematic to allocate a shared resource sink to a single local area. Therefore, we decided to exclude this domain as well.

4.2.3 Value selection

In the previous section, we introduced the concept of “values” as cross-sectoral domains, distinct from sector-specific areas such as energy or transportation. Although these values were recognized as sometimes being classified alongside domains, we decided to address them separately due to their overarching importance across multiple sectors. To this end, we conducted an additional structured literature review specifically focused on identifying and defining these values. To identify cross-sectoral values, we searched WoS and Scopus by combining each domain name (e.g., “energy,” “transportation”) with the phrase “social values”**.** Additionally, we included policy papers that outline the values a system should have in the future, such as the Green Deal and Industry 5.0. Some of the values found were excluded for not being directly related to climate neutrality (e.g., the safety and privacy of advanced energy systems) or because they extend beyond the scope of this framework, adding a layer of complexity that does not directly inform climate neutrality goals.

4.2.4 Indicator selection

The indicator selection process began with a structured literature review to identify specific, quantifiable indicators relevant to the domain of interest. Following a standardized approach, we used Boolean combinations in both Scopus and WoS—“Domain name” AND (“Indicators” OR “Framework”)—to capture domain-specific studies on measurable metrics. Despite the abundance of literature on climate and carbon neutrality indicators, there is a notable gap in frameworks specifically tailored to rural regions. This gap underscores the policy need that our research seeks to address, guiding the selection of indicators that are both relevant and actionable in rural contexts.

A total of 66 papers were collected and analyzed. The selection criteria focused exclusively on specific, quantifiable indicators, deliberately excluding vague or qualitative measures. This rigorous filtering ensured that only actionable and measurable indicators were considered.

To ensure the robustness and applicability of the selected indicators, each one was evaluated against the SMART criteria: Specific, Measurable, Achievable, Relevant, and Time-bound. Specifically, the SMART framework is a tool used to assess whether an indicator is well-defined (Specific), quantifiable (Measurable), realistically attainable (Achievable), directly related to the goals of the framework (Relevant), and capable of being tracked within a specific timeframe (Time-bound). Indicators that did not meet these criteria were excluded from the framework, ensuring that only the most effective and actionable measures were retained.

Given the lack of frameworks directly referring to rural regions, each indicator was inspected to best represent rural areas with their unique characteristics and related needs. For instance, while energy storage is an important feature for every energy system, in urban settings, it can be developed at the neighborhood, city, or even national level. In contrast, rural areas often have more degraded transportation infrastructure due to their large geographical distribution. Consequently, renewable energy and energy storage become crucial components in the resilience of energy systems in rural areas and must be developed at the community and individual levels. This distinction highlights the necessity of tailoring indicators for rural environments, where geographical constraints and dispersed populations demand customized solutions.

The collected indicators were then classified according to the different values they promote within the domain. This classification process involved examining the underlying principles and objectives each indicator aimed to support. By categorizing the indicators based on their promoted values, the analysis provided a clearer understanding of how various indicators contribute to the overall goals and priorities of the domain. For instance, within the energy domain, ‘share of renewable energy in total energy production’ and ‘energy storage capacity per capita’ were included because they met the SMART criteria and directly address rural energy resilience needs. In contrast, more qualitative indicators such as ‘perception of renewable energy reliability’ were excluded due to challenges in consistent measurement. These examples illustrate how the filtering process led to a set of concrete, actionable indicators suitable for evaluating climate neutrality in rural contexts.

4.3 Data management

4.3.1 Types of data sources

After conducting literature reviews to identify relevant domains, values, and indicators, we proceeded to gather data sources for these indicators. The For certain environmental indicators, a high-resolution (grid-level) dataset can be ideal because it allows granular analysis. However, grid-level data may not be meaningful or available for other indicators, such as economic metrics. Our aim is to support the entirety of the European Union, and high spatial-resolution data enables more fine-grained, localized analyses that communities can use to build a bottom-up understanding of their specific context. Nonetheless, such data sources are scarce and not always publicly available or easily interpretable..

Consequently, in the next phase, we expanded our scope from the grid level to the Nomenclature of Territorial Units for Statistics (NUTS) level where applicable, prioritizing NUTS-3 data over NUTS-2 for greater spatial granularity when available. This shift allowed us to access a broader range of data while maintaining a level of detail suitable for our analysis. As a last resort, we utilized national-level data. In cases where NUTS or national level data was used, we employed a downscaling method, which is elaborated in the next section. This method enables users to adapt and downscale the data for their specific community needs, ensuring the framework remains versatile and applicable at various geographical scales.

For several indicators, data was not available altogether, so we had to use proxy data. While proxy data may not provide a complete picture, it offers valuable insights and helps us understand the general direction and trends, ensuring our analysis remains informative and relevant.

4.3.2 Downscaling method IPAT

The IPAT method for downscaling data is a well-established approach in the literature for addressing various impacts. This method has been extensively discussed and utilized in numerous studies where, for instance Skånberg and Svenfelt (2022) investigated how population growth and affluence drive energy consumption, and Gütschow et al. (2021) analyzed country-level CO2 emission pathways. Other researchers have applied IPAT to examine global resource usage (Lamb et al., 2021), project future emission scenarios (Sferra et al., 2021; Van Vuuren et al., 2007), and explore climate-policy implications at different scales (Ekström et al., 2015). The IPAT equation, which stands for Impact = Population x Affluence x Technology, decomposes impacts into these three main drivers, providing a framework for analyzing the relationships between them and their contributions to changes.

The IPAT method is employed to downscale data from one scale to another by considering the influence of population size, economic activity (affluence), and technological factors on impacts. For example, in downscaling greenhouse gas emissions, the IPAT equation is used to determine how changes in population, GDP per capita, and emission intensity affect overall emissions at the national level. This method is particularly useful in scenarios where detailed regional data is available, and there is a need to translate these into more granular level.

Over time, the IPAT equation has been expanded to include more variables, leading to derivatives such as the STIRPAT model. The STIRPAT framework has been applied, for example, by Haseeb (2016) to examine rural-urban transformation, energy consumption, economic growth, and CO2 emissions, highlighting non-linear relationships. Similarly, Wang (2022) used STIRPAT to analyze how technological improvements affect carbon emissions in China's industrial sector. The STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model refines the original IPAT equation by incorporating stochastic elements and additional variables. This allows for a more nuanced analysis of the factors driving impacts, accommodating non-linear relationships and interactions between variables. The STIRPAT model can include variables such as policy measures, institutional factors, and cultural influences, providing a more comprehensive framework for impact assessment.

However, not all indicators are suitable for downscaling. For certain indicators, it makes more sense to analyze data at the national level rather than downscaling it. This is particularly true for systems that operate on a national scale, such as electricity grids and food systems. For instance, in Europe, most electricity systems are managed at the national level. Thus, evaluating the national reserve of electricity as a percentage of total production provides a more accurate reflection of the system's capacity and resilience than a localized analysis would. Similarly, food systems are often governed by national policies and infrastructure, making national-level analysis more appropriate.

The decision on the scale of analysis is made on an indicator-by-indicator basis, taking into consideration the operational scale and the nature of the impacts. For example, while it may be feasible to downscale emissions data using the IPAT framework, other factors such as national reserves or infrastructure capacities are best assessed at the national level to ensure the accuracy and relevance of the analysis. This tailored approach ensures that the data and resulting insights are meaningful and applicable to the specific contexts of the indicators being studied.

4.3.3 Normalization (scaling)

Normalizing data points is an essential process to ensure consistency and comparability across various indicators. In our framework**,** we applied a min-max normalization approach **to** rescale data on a scale of -100 to 100, outliers beyond this range were adjusted to remain within $-100,100$. This method allows each indicator to be assessed on a common scale, facilitating a more straightforward aggregation into a final score. Most indicators used the following formula:

$$Score = \frac{Value - Baseline\ Value}{Goal\ Value - Baseline\ Value} \times 100$$

For some indicators, normalization was based on historical values, reflecting the progress or trends over time. Other indicators were normalized by comparing them to values from other European countries or absolute benchmarks, depending on the indicator's nature and relevance of cross-country comparison. Each indicator was thus evaluated separately, ensuring that the normalization process suited the specific nature of the data.

However, determining the appropriate values for normalization was sometimes challenging. Ideal values were set for some indicators, such as the goal of zero greenhouse gas emissions, even though achieving such values might be impossible in the current context. On the other hand, certain values were more difficult to set due to the lack of consensus in the literature or because they varied significantly based on location. An example of this is the appropriate distribution of public transport stations per square kilometer, which can differ widely depending on urban density and local needs. For details on which normalization approach was used per indicator, please see the table in Annex 8.3. By referencing these specifics, users can better understand how each score was derived and modify normalization targets based on local data availability and conditions.

Therefore, our framework is designed to be adaptable, allowing adjustments to the normalized values according to the means and conditions pertinent to each context. This flexibility ensures that the framework remains relevant and accurate, accommodating variations in data availability and regional characteristics. By allowing these adjustments, we aim to provide a robust and dynamic tool for evaluating indicators across different scenarios.

4.4 Weighting methods

Weighting is crucial in indicator frameworks primarily when indicators are aggregated into a composite index or a single score, as it shapes how different components contribute to the final assessment (Gan et al., 2017; Mikulić et al., 2015; OECD, 2008; Hermans et al., 2008; Munda & Nardo, 2005). In our case, the framework follows a hierarchical additive design: indicators within each “value” are weighted and summed, values are then combined at the domain level, and domains ultimately form one overall score. This linear approach explicitly permits substitutions, meaning a higher score in one dimension can compensate for a lower score in another, thereby enabling users to omit irrelevant or infeasible indicators without invalidating the rest of the framework. However, because additive aggregation implies that dimensions can be partially or fully interchangeable, interpreting their weights as measures of absolute “importance” should be done with caution—especially if certain dimensions are intended to be non-substitutable.

A variety of methods can be used to determine these weights. Equal weighting, where each indicator is assigned the same weight, has been applied in well-known indices such as the Human Development Index (UNDP, 1990) and Genuine Savings (World Bank, 1999), offering simplicity and transparency but failing to capture potential differences in indicator relevance or the risk of double-counting. Statistical methods, such as Principal Component Analysis or Factor Analysis used in the 2006 European Business Readiness Index (Pennoni et al., 2006), derive weights from data structures like variance or covariance, thereby helping to reduce double-counting by grouping correlated indicators. However, such approaches may yield weights that do not align with stakeholder priorities or produce unexpected results if the underlying data vary widely. Other data-driven methods include the Benefit of the Doubt (BOD) approach, which uses linear programming to endogenously determine weights that maximize each unit’s composite score under its most favorable conditions (Cherchye & Kuosmanen, 2004), a feature that can limit direct comparability among different units or regions. Regression-based weighting, such as that employed by Porter and Stern (2001) in their National

Innovative Capacity framework, leverages coefficients to represent indicator weights but may be vulnerable to issues like multi-collinearity if indicators are strongly correlated. Unobserved-component models, as illustrated by Kaufmann et al. (1999) in the construction of aggregate governance indicators, statistically integrate weighting and index construction in a single procedure yet may be sensitive to outliers or inadequate data structures.

Public or expert opinion-based methods, such as Budget Allocation, Public Opinion Polling, Analytic Hierarchy Process (AHP), or Conjoint Analysis (CA), increase transparency by directly engaging stakeholders. Budget Allocation underpins measures like the Eco-indicator 99 (Goedkoop, 1999) and Overall Health System Attainment (Murray et al., 2000), requiring participants to distribute a fixed "budget" of points across indicators. Public Opinion Polling captures the attitudes and perceptions of a broader population. AHP has been utilized in creating a composite sustainability performance index (Singh et al., 2007). Conjoint Analysis, exemplified by Ülengin et al. (2001) in measuring quality of life in Istanbul, estimates how shifts in each indicator affect overall preferences. While these methods often resonate well with local contexts, they can measure "perceived urgency" more than inherent importance, and they typically maintain an additive aggregation function that permits trade-offs. Consequently, even if stakeholders assign a high weight to one dimension, strong results in another can overshadow it if the final composite is additive.

All of these weighting approaches have strengths and limitations. Equal weighting is straightforward but may fail to reflect meaningful differences among indicators. Statistical methods offer a systematic treatment of large datasets but can emphasize indicators that vary strongly rather than those deemed most relevant by local priorities. Public and expert opinion-based methods promote stakeholder engagement and acceptance yet can be biased or inconsistent if different groups hold divergent views, and they generally do not eliminate the trade-offs implied by a linear model. In every case, additive aggregation means that a dimension with a higher weight can still be offset by robust performance in other dimensions.

Given the broad variance among rural settlements across Europe and our goal of creating a framework that local communities can adapt to their own contexts, a classical additive weighting method offers a pragmatic balance. It is transparent, easy to implement, and allows users to omit indicators that do not apply to their situation, thereby retaining the framework's coherence. We acknowledge that linear aggregation permits partial or full substitutability, so these weights should not be interpreted as reflecting intrinsic importance. Instead, they indicate how communities choose to allocate attention or resources among potentially overlapping indicators, reflecting realistic trade-offs while still accommodating wide-ranging local conditions. Where strong correlations exist or certain dimensions must be non-negotiable, a non-additive approach could be preferred. Otherwise, this flexible and inclusive model supports the development of a coherent yet context-sensitive measure of sustainability or climate neutrality in diverse European rural areas.

4.4.1 Internet search volume-based weighting method

The internet search volume-based weighting method leverages public opinion as reflected in internet search volumes to assign weighting factors to various impacts. This approach ensures the weighting factors are aligned with societal preferences, making them more representative and potentially more accurate than traditional methods that often rely on expert panels or specific stakeholder groups. This method allows a user to generate weights for indicators/values/domains without any biases and based on the popularity of search terms (Ji and Hong 2016).

The provided python script (refer to Annex 8.10) demonstrates a method to gather and analyze internet search data for specific indicators. This script begins by loading an Excel file containing search terms, which are organized by different indicators. Each indicator has several synonymous terms (e.g., GHG emissions, greenhouse gas emissions, carbon pollution, etc.), therefore, to avoid missing any relevant terms, an AI language model (Chatgpt) was used (OpenAI, 2024) to generate at least ten variations for each indicator. After checking for duplicates, these terms were uploaded to the script.

Next, the script extracts these terms and initializes the `pytrends` API with specified parameters for language and time zone. The script includes a function to fetch Google Trends data for each search term, implementing retries with exponential backoff to handle potential request limits and timeouts. The main part of the script involves iterating through each indicator and its associated search terms. The data is then compiled into a single DataFrame for each indicator. The next step was to sum the values received for each indicator grouped under the same Value-Domain and assign each indicator a weight by dividing its Google Trends result by the group's total. The methodology described in the script provides a systematic approach to collecting and organizing Google Trends data, facilitating the analysis of public interest in various environmental impacts.

For a complete methodology using this method, an additional script is attached, which performs the same process for terms including values and domains (e.g., Energy sustainability, Industry reliability, etc.) and another script for domains (refer to Annex 8.8-8.9). This ensures a comprehensive analysis across different levels of specificity in the search terms, allowing for a more detailed understanding of public interest in various environmental impact categories. The full methodology and validation of this approach can be found in Ji and Hong (2016).

4.5 Policy measures, implementation criteria and process and impact indicators

To collect policy measures relevant to the topic of the framework, we utilized two key databases: the European Environmental Agency (EEA) policy database and the Covenant of Mayors (CoM) database. The collection process adhered to several stringent rules to ensure the relevance and applicability of the measures. Firstly, the policy measure had to relate to climate neutrality in some capacity. Secondly, it had to be within the control of the local community rather than governed at the regional or national level. For the EEA, the database itself tags measures according to the entity responsible for implementation, ensuring only local-level actions are included. In the CoM database, all action plans are drawn up and implemented by local governments, so any measure listed falls under local jurisdiction. Finally, each policy measure needed to be specific, including concrete actions rather than general approaches.

For the EEA database, we screened the measures based on the responsible entity for implementation, focusing on those managed by local governments, which yielded 133 measures. In the CoM database, we restricted our search to local plans from settlements with populations under 10,000 inhabitants and submitted during 2024, resulting in 493 measures. This threshold was chosen because it was the smallest population filter offered by the CoM database search options. After removing duplicates, we identified a final number of 104 policy measures. Each of these measures was further examined to ensure relevance to rural settings. To do this, we examined the purpose, scale, and means required to implement each policy measure, ensuring it was not exclusively designed for urban environments. Because we aim to accommodate diverse rural settlements, we retained measures that appeared adaptable to smaller populations, excluding only those clearly intended for dense, urban infrastructure. For example, a policy measure proposing the creation of an extensive metro rail network was omitted, as it requires high population density and sophisticated transit systems typically not feasible in rural areas. The measures were then classified according to the relevant domain or value and each measure was categorized by type for easy user screening.

Next, we assigned an implementation criterion to each policy measure. This implementation criterion takes into account preconditions such as local infrastructure, resources, and support needed to implement the measure effectively. For instance, a policy promoting “Renewable Energy Land Allocation” might require access to unused or underutilized land suitable for renewable projects, plus strong local government and community backing aligned with renewable energy objectives. This implementation criterion is a qualitative assessment designed to give users an idea of the basis for implementing the measure and the appropriate timing for its implementation. These criteria were developed by examining each policy measure. We deliberately kept these criteria at a qualitative level to avoid creating rigid guidelines that might hinder implementation in certain communities.

The final step involved creating two types of indicators: process and impact indicators. The choice of indicators for policy measures includes two types: implementation (process) indicators and outcome (impact) indicators.

Implementation indicators, also known as process indicators, measure the progress of the activities or processes outlined in the policy. They help assess whether the policy measures are being carried out as planned. These indicators are chosen based on the specific actions outlined in the policy measure. For instance, if the policy involves constructing new facilities such as train station parking or pedestrian sidewalks, the implementation indicator would track the number or extent of these constructions. These indicators provide immediate or short-term insights, essential for monitoring the policy’s deployment and enabling timely adjustments if necessary. This dual approach ensures that both the actions taken and the end results are monitored.

On the other hand, outcome indicators, or impact indicators, measure the effectiveness of the policy in achieving its overall goals. They focus on the long-term impacts and assess how well the policy contributes to broader objectives like environmental sustainability, public health, or economic development. These indicators are chosen based on the ultimate goals the policy aims to achieve, such as reducing carbon emissions, improving public health, or enhancing biodiversity. For example, in policies targeting reduced vehicle use or enhanced energy efficiency, outcome indicators could include a decrease in individual car usage or a reduction in energy consumption. While these indicators may not show immediate results, they are critical for evaluating the long-term success and efficacy of the policy. However, these outcome indicators are often challenged by the attribution problem, as it can be difficult to isolate the extent to which observed improvements (e.g., in energy efficiency or reduced vehicle use) are directly caused by the policy, rather than by external factors.

By examining each policy measure, we assigned one impact and one process indicator to each. This "one-to-one" pairing was chosen for practical feasibility, simplicity, and clarity. Including a single implementation indicator alongside a single outcome indicator for each measure ensures transparency in tracking and avoids an overly complex monitoring framework. Process indicators allow for real-time monitoring of the implementation, ensuring the actions are on track, while impact indicators assess the ultimate success of the policy in achieving its long-term objectives. This combined approach provides a comprehensive framework for both immediate tracking and long-term evaluation, offering a full picture of each policy's performance.

4.6 Tailoring sustainability frameworks for local communities

As stated before, broad sustainability challenges often have local expressions, varying significantly between communities—even those geographically close to each other. Therefore, we built our framework to be modular and adaptable to fit different settings and communities. To achieve this flexibility, our framework allows users to provide their input at three different points, which will help customize the framework to their community's specific needs:

Indicators/Value/Domain Weights: By setting different weights for various indicators, values, or domains, users can determine the importance of each for their local community. For instance, a community without industries can assign a weight of zero to the entire industry domain, effectively excluding it from the framework. This ensures that the framework focuses only on what is relevant to the community. If users are unsure about which weights to assign or how to rank the importance of different domains, they can use the default Google Trend search volume method or any other method provided in this document that seems fitting.

Normalization Values: While many normalization values used to standardize indicator data into a unified scale should remain unchanged as they are specific to that data (e.g., current levels of GHG emissions measured against historic levels), some indicators require values that are hard to benchmark and should be tailored to the community's nature and geographical settings. For example, the indicator for soil organic carbon (SOC) measures local data against ideal SOC values for agricultural land. This ideal value should be adjusted based on the region's climate, as colder regions tend to retain more carbon in the soil than warmer regions. Therefore, the benchmark for cold regions should be higher.

Policy Measures: Not all policy measures collected and analyzed for this framework are relevant to every community. Instead, they should be viewed as a policy toolbox from which decision-makers and policymakers can draw ideas and guidance to promote specific topics. It is expected that users will select appropriate policy measures based on their scores in the objective indicators section and what they can and want to implement, bearing in mind that national regulations or funding schemes may also affect local feasibility and timing. This ability to choose relevant policy measures ensures that the policies promoted align with the community's perspective.

By incorporating these points of customization, our framework is designed to be adaptable, ensuring it meets the unique needs and priorities of different communities, particularly those in rural areas, which often have distinctive infrastructure, demographic, and economic characteristics compared to urban settings. By enabling local stakeholders to fine-tune indicators, exclude irrelevant domains, and select context-appropriate policy measures, the framework adds value to smaller, dispersed communities seeking to address sustainability challenges at a local scale. This modularity allows the acknowledgement of the diversity of local issues and contexts.

5. Results and interpretation

5.1 Chosen domains

The next section presents the domains which were chosen after the literature review. Figure 2 presents the final domains and values found for this framework. Figure 3 presents the mentions per domain as captured by the literature review. This figure provides a visual representation of the prominence of each domain in the context of three key terms: climate neutrality, carbon neutrality, and zero carbon. It is important to note that (D) indicates a sectorial domain, while (V) denotes a value domain.

The analysis reveals several key insights. As expected, given that these terms relate to environmental sustainability above all others, the domain of 'Environment' consistently receives the highest number of mentions across all three terms, totaling 82 mentions. This reflects the critical role of environmental sustainability in achieving climate neutrality. The Environment Domain encompasses the natural systems and ecological processes essential for achieving climate neutrality. It focuses on preserving biodiversity, managing ecosystems, and enhancing natural carbon sinks such as forests and wetlands. The domain measures indicators related to land use, conservation efforts, and ecosystem health, all of which contribute to reducing emissions and promoting resilience to climate change. For instance, Ciambra et al. (2023) highlight the integration of environmental indicators, such as biodiversity conservation and natural resource management, within the Sustainable Development Goals (SDGs). Similarly, Brodny and Tutak (2023) explore the role of sustainable energy systems and their intersection with ecosystem preservation, emphasizing the importance of balancing energy production with ecological resilience through policies that prioritize renewable energy and minimize habitat disruption.

The 'Energy' domain follows closely with 73 mentions, highlighting the significant attention given to energy factors in these contexts. The Energy Domain addresses the production, consumption, and efficiency of energy systems, which are critical components of climate neutrality strategies. It includes transitioning to renewable energy sources, optimizing energy use, and implementing energy-saving technologies across industries, buildings, and transportation sectors. This domain emphasizes the reduction of greenhouse gas emissions through decarbonization and energy efficiency improvements. For instance, Arens et al. (2021) explore the transition from coal-based to electricity-based energy systems in the steel industry, identifying the importance of renewable electricity in decarbonizing energy-intensive industries. Similarly, Bohvalovs et al. (2023) demonstrate the impact of energy efficiency measures in educational buildings, showing that targeted interventions can reduce primary energy consumption by up to 39% and greenhouse gas emissions by 34% through retrofitting, renewable energy integration, and behavioral changes among stakeholders

In the 'Economic' domain (V), there are 58 mentions, underscoring the considerable importance placed on economic factors in achieving climate and carbon neutrality. The Economic Domain focuses on the financial, market, and policy mechanisms necessary for enabling a sustainable transition to climate neutrality. This includes investment in renewable technologies, fiscal reforms to phase out fossil fuel subsidies, and the promotion of circular economy principles. Filipovic et al. (2022) explore how the European Green Deal's decarbonization roadmap integrates substantial investments in renewable energy and innovation, while also addressing concerns about economic stability during the transition. Similarly, Bleischwitz et al. (2022) discuss the importance of creating circular industrial systems, emphasizing that resource efficiency and material reuse are critical for reducing economic reliance on unsustainable practices and aligning growth with climate goals .

The 'Social' domain (V) has 49 mentions, indicating a moderate level of attention to social implications and considerations. The Social Domain encompasses the societal impacts of climate neutrality policies, including equity, inclusiveness, and the potential for improving public well-being. For instance, Tzeiranaki et al. (2023) highlight the role of energy efficiency programs in reducing energy poverty, particularly for vulnerable households, and their capacity to promote social fairness alongside environmental benefits. Linkevicius et al. (2023) discuss the potential for sustainable construction practices, such as using wood-based materials, to generate positive social impacts, including job creation and improved community engagement through local resource utilization. This domain was not included in the framework. The exclusion of the social domain was guided by practical considerations. Social aspects often require qualitative and community-specific data, which can vary significantly and detract from the quantitative comparability needed in this framework.

The 'Waste' domain (D) has a lower overall mention count of 10, suggesting that waste management is less frequently discussed in the context of these terms. The Waste Domain focuses on managing and reducing waste through sustainable practices such as recycling, reuse, and energy recovery. Loizia et al. (2021) emphasize the integration of circular economy principles in food waste management, particularly the optimization of energy production through technologies like UASB reactors, which convert organic waste into biogas. Additionally, Myszograj and Płuciennik-Koropczuk (2022) highlight the importance of sustainable wastewater treatment and resource recovery systems, underscoring the role of waste management in reducing environmental pollution and supporting resource efficiency.

The 'Buildings' domain (D), with 14 mentions, reflects its role but to a lesser extent. The Buildings Domain addresses the energy consumption, emissions, and resource efficiency of the built environment, focusing on both new construction and retrofitting of existing structures. Satola et al. (2022) emphasize that nearly 40% of global greenhouse gas emissions are attributed to the construction sector, highlighting the critical need for decarbonizing building operations and reducing embodied carbon in materials like steel and concrete. Strategies such as adopting zero-energy building designs, integrating renewable energy systems, and optimizing insulation and ventilation are central to reducing operational emissions. Civiero et al. (2022) explore Positive Energy District models, which aim to achieve energy self-sufficiency at the community level by combining building retrofits with smart energy management technologies.

The 'Agri-Food' domain (D), with 12 mentions, shows its relevance but is not a primary focus in the literature. The Agri-Food Domain encompasses agricultural practices, food production, and supply chain systems, focusing on their environmental impacts and contributions to climate neutrality. Cuadros-Casanova et al. (2022) highlight the importance of sustainable irrigation systems and soil management techniques in reducing emissions from intensive agriculture while preserving biodiversity and soil fertility. Tortorella et al. (2020) discuss how integrating circular economy principles into food supply chains—such as minimizing waste and enhancing resource efficiency—can significantly lower the carbon footprint of food systems.

Technology (V) garners 37 mentions, showing a significant interest in technological solutions and advancements. The Technology Domain encompasses innovative tools, processes, and systems designed to enable and accelerate sustainability transitions. Labenko et al. (2022) explore the integration of digital technologies into the European Green Deal, emphasizing their role in optimizing resource efficiency and enhancing renewable energy systems through smart grids and IoT-enabled devices. Beggs et al. (2022) highlight the importance of advanced materials in energy storage and the development of decentralized energy systems, demonstrating how technology can bridge gaps in rural and urban infrastructure.

The 'Transport' domain (D), with 25 mentions, emphasizes the role of transportation in achieving these goals. The Transportation Domain addresses the decarbonization of mobility systems, focusing on improving energy efficiency, reducing emissions, and integrating renewable energy into logistics and public transportation networks. Ren and Long (2021) emphasize the need for electric vehicle (EV) adoption and the role of smart infrastructure, such as charging networks, in reducing the carbon footprint of urban mobility. Palander et al. (2020) highlight the significance of optimizing freight logistics and transitioning to low-carbon fuels, particularly in sectors like forestry, where road transportation plays a critical role in supply chains.

Finally, the 'Industry' domain (D), with 20 mentions, highlights the industrial sector's involvement and challenges in the pursuit of climate and carbon neutrality. The Industry Domain focuses on the decarbonization of manufacturing and production systems, emphasizing resource efficiency, emissions reductions, and the adoption of circular economy principles. Guzowska and Kryk (2021) examine the efficiency of implementing climate and energy targets in the EU, highlighting the varying success of member states in aligning industrial policies with the goals of the Europe 2020 Strategy. Loizia et al. (2021) discuss industrial applications of advanced waste treatment technologies, such as anaerobic digestion and pyrolysis, which not only mitigate emissions but also recover valuable resources like biogas and biochar.

Overall, the literature review suggests that while environmental and energy domains dominate the discourse, economic, social, and technological aspects also play crucial roles. The relatively lower mentions of waste, buildings, agri-food, transport, and industry indicate potential areas for further exploration and integration in future research and policy discussions. For further details and cited papers, see Annex 8.1. We began our literature review by focusing on sectoral domains such as energy, transport, and waste, as described in this section. However, during our analysis, we identified certain overarching values—such as technology and environmental sustainability—that are relevant across all sectoral domains. This realization prompted a subsequent literature review, which is discussed in the next subsection, focusing on the identification of values specific to each domain.

Figure 2 - Domains and values of the framework

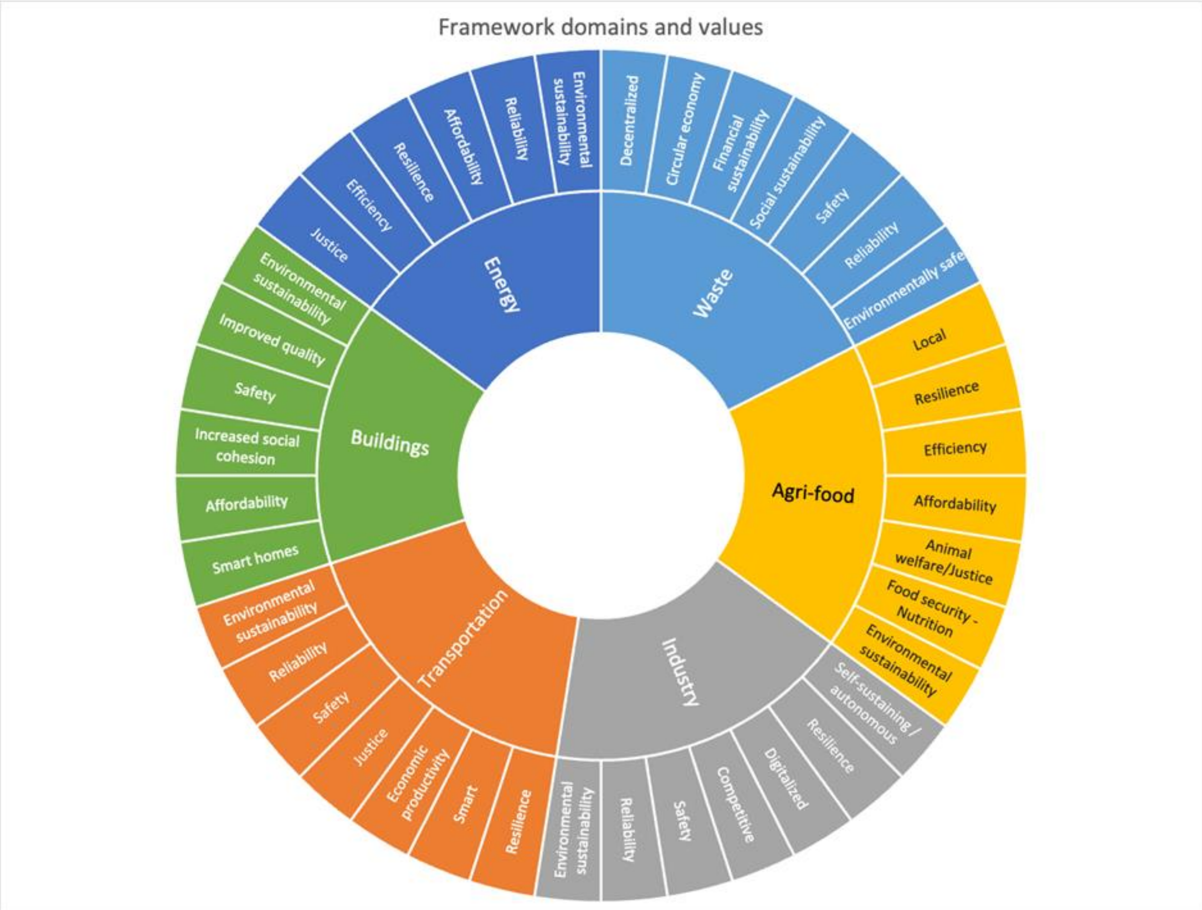
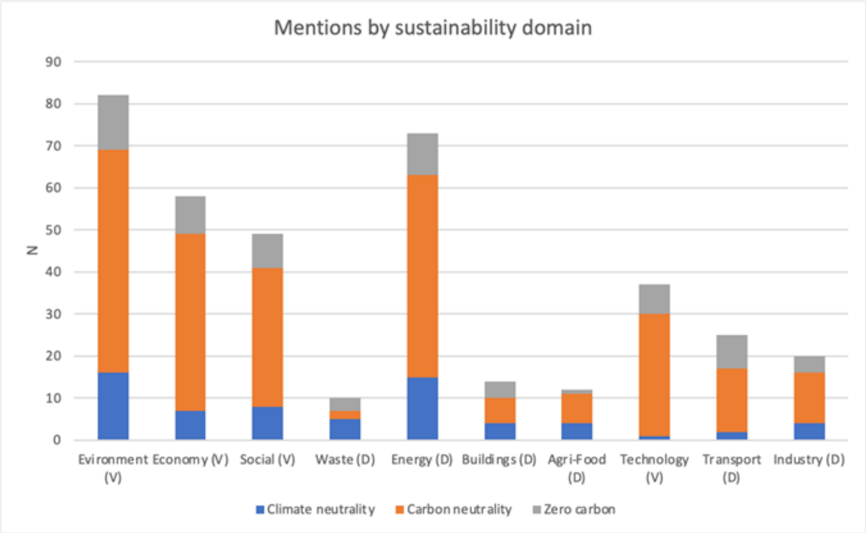


Figure 3 - Results of literature review for domains



5.2 Chosen values

After the initial literature review, which identified domains and values related to climate neutrality, a second, targeted review was conducted. The values associated with each domain were systematically determined through individual literature reviews focused on specific areas. Here, 'values' refer to desirable qualities or principles that guide actions and decisions toward achieving climate neutrality. These values help determine the priorities and trade-offs necessary for balanced and sustainable outcomes. To ensure a thorough understanding of the relevant factors and emerging trends within each domain, these reviews examined both policy papers and academic literature. By integrating insights from diverse sources, the resulting assessment provides a well-rounded perspective on values that are both theoretically grounded and practically relevant. For a complete overview of the references and the full table detailing these values, please refer to Annex 8.2.

Climate neutrality is a multifaceted goal that integrates various values to achieve a balanced and sustainable approach at the local level. *Environmental sustainability* lies at the core of climate neutrality by ensuring that actions taken to reduce emissions and environmental impact do not compromise future ecological stability. By preserving ecosystems and biodiversity, this value helps communities transition toward sustainable practices that do not exhaust natural resources or lead to long-term environmental degradation. This value was mentioned 32 times in the literature review. Key studies include Niet et al. (2021), which discuss integrating environmental performance into circular economy strategies for sustainable industrial development, and Mechri et al. (2023), which emphasize the role of strong sustainability paradigms in balancing social, ecological, and economic systems to respect planetary boundaries

Reliability and *safety* work together to build systems that can consistently meet climate neutrality goals while ensuring that these systems do not pose threats to human health or the environment. Reliable energy sources and infrastructure ensure continuity and dependability in transitioning to low-carbon options, while safety ensures that technologies, policies, and processes safeguard public health and minimize risks, fostering local trust in climate strategies.

Reliability received 11 mentions in the literature. Lowe et al. (2018) emphasize the role of robust energy systems in grid stability, particularly through the integration of flexible resources like demand response and distributed generation, which ensure reliability even under variable renewable energy conditions. Stefanovic et al. (2020) highlight how resilient infrastructure, designed to withstand both normal and extreme conditions, is a cornerstone for achieving reliability in energy transitions. Safety received 8 mentions in the literature. Valente et al. (2018) discuss the importance of safety protocols in renewable energy installations, focusing on mitigating risks in offshore wind and large-scale solar systems. Marinagi et al. (2023) explore how Industry 4.0 technologies, such as IoT-based monitoring systems, enhance safety by detecting and preventing operational failures across supply chains

Justice and *accessibility/affordability* emphasize the social dimension of climate neutrality by ensuring equitable access to resources and opportunities for all communities. Justice addresses inequalities by ensuring marginalized groups are not disproportionately affected by the transition, while accessibility and affordability make low-carbon technologies, renewable energy, and sustainable practices available to all, reducing barriers to adoption at the local level. Justice received 16 mentions in the literature. Demski et al. (2015) highlight the importance of public engagement in energy transitions, emphasizing that trust and fairness in decision-making processes are critical for social acceptance of climate policies. Zimdahl and Holtzer (2016) examine the ethical responsibilities of agricultural systems, arguing that equitable resource allocation is essential for addressing global climate challenges.

While the concept of climate justice encompasses multiple dimensions—including procedural, recognitional, restorative, inter-generational, and spatial justice—this framework focuses on distributional justice. This decision reflects the framework's emphasis on addressing tangible inequalities in resource allocation, access to sustainable technologies, and economic opportunities at the local level. Future iterations could expand to include procedural or inter-generational justice for a more comprehensive approach.

Accessibility and affordability received 14 mentions in the literature. Diu et al. (2022) explore the economic barriers to adopting renewable energy technologies in rural areas, advocating for targeted subsidies and community-driven initiatives to enhance accessibility. Bartolacci et al. (2018) discuss strategies for lowering the cost of sustainable infrastructure, including leveraging public-private partnerships to make low-carbon options affordable for underprivileged communities.

Finally, *efficiency* and *resilience* focus on optimizing resource use and preparing for future uncertainties. Efficiency in energy, transportation, and resource management reduces waste and enhances the effectiveness of climate actions. Efficiency received 20 mentions in the literature. Matheri et al. (2023) discuss the implementation of decentralized hybrid renewable energy systems, which enhance energy efficiency and reduce greenhouse gas emissions by integrating solar and bioenergy technologies. Kontopanou and Tsoulfas (2021) highlight the role of life-cycle approaches in agri-food supply chains to optimize resource use and reduce environmental impacts, demonstrating how technical and managerial solutions can significantly improve efficiency across sectors.

Resilience ensures that communities can adapt to changing environmental conditions, such as extreme weather events, reinforcing local capacities to cope with climate-related challenges while maintaining progress toward neutrality. Resilience received 14 mentions in the literature. Monirul Alam et al. (2023) explore how integrating local knowledge and adaptive governance strengthens resilience in riparian communities facing climate change impacts. Kaasinen et al. (2022) emphasize the development of climate-resilient infrastructure, focusing on incorporating predictive modeling and risk assessment tools to improve urban and rural adaptation strategies.

5.3 Chosen indicators with calculation types, comments and normalization values

The chosen indicators presented in this section were selected through a comprehensive literature review process, ensuring they accurately reflect the diverse dimensions necessary for assessing climate neutrality. The complete list of indicators can be found in Annex 8.3. The ideal scenario envisioned for this framework is one where users can gather bottom-up data for all indicators, allowing for real-time assessment of the climate neutrality condition.

However, recognizing the practical challenges in achieving this level of data collection in the near future, we have developed alternative methods that allow for the calculation of climate neutrality scores even when only minimal data is available. Specifically, the minimal required data includes the population size of the community being investigated and the average income, with the national average income serving as a substitute if community-specific data is unavailable.

The dataset comprises 111 indicators spread across six major domains. The Transportation domain is the most represented, constituting 23% (25) of the total indicators, followed by Agri-food with 18% (20), and Industry with 17% (19). Both Energy and Buildings domains contribute 15% (18) each, while Waste makes up 12% (13) of the indicators. This distribution reflects a balanced emphasis on transportation and agri-food sectors, which are crucial in understanding climate neutrality, as well as energy, industry, and buildings, which are key sectors in achieving sustainability goals.

The time period associated with each indicator relates to the range of available data, acknowledging that complete data coverage may not be consistent across all member states. The term 'Data reflecting current state' is used to describe data that is sourced from open databases, which offer real-time insights but may not provide historical data. Consequently, for some indicators, data is only available to represent the current state without the ability to track changes over time. To assess changes over time, users will need to measure the same indicators at multiple time points and compare the results. This approach ensures that temporal dynamics and progress toward climate neutrality can be monitored even when the framework relies on snapshot data.

Different types of data are provided to users through this framework, categorized into three main types: Score, Intensities, and Methodology (for scores and intensities see attached Excel file “GRANULAR_D4.1_Indicators_Data_File”, for methodologies see Annex 8.4). A "Score" refers to a final, calculated indicator that can be directly used by the user without the need for further input. This score is typically based on the most recent data point available. Figures 4-5 illustrates an example of a score presented at two levels: national (Figure 4) and NUTS2 (Figure 5), showing how indicator values can be scaled to reflect broader or more regional contexts.

"Intensities" represent the 'T' in the IPAT (Impact = Population x Affluence x Technology) formula and are expressed per capita and per Euro of income. These intensities are calculated using the IPAT downscaling method, requiring users to input the population size and average income of the studied community to derive the relevant scores. The intensities are provided across all time points in the original dataset, allowing users to adjust their calculations as needed. To exemplify the application of intensities, we used data from Mikou et al., 2024, which provides population and income data at the local administrative unit (LAU) level. This granularity allowed us to calculate greenhouse gas emissions scores from energy and transportation domains at the LAU level (Figures 6-7). By combining these intensities with population and income data from the reference paper, we were able to demonstrate how the framework can adapt existing datasets to derive emissions scores at a more localized scale.

Lastly, the "Methodology" type provides users with scripts, primarily in Python, to collect and calculate the indicator. Most of these scripts require the user only to input the name of the settlement, with the data reflecting the most recent available information (see Annex 8.4).

The scope of each indicator can vary, covering national levels (64%), more granular NUTS 2 (5%) and NUTS 3 (1%) levels, or even local levels achieved through downscaling (21%) or direct grid-level data (9%). National-level indicators are primarily used to assign consumer responsibility for nationwide infrastructures, such as imported fuels or electricity that support the entire distribution system. Local-level data, which accounts for 21% through the IPAT framework and an additional 9% labeled as local without IPAT, allow for the assignment of responsibility for various impacts, such as GHG emissions, based on population size and affluence levels. This local data is often extracted from open geographic databases like OpenStreetMap, providing highly detailed, grid-level information.

Finally, the normalization process for the scores is defined in the Normalizing column, which details the minimum and maximum values used to standardize the scores across different indicators. The normalization formula applied is:

$$Score = \left(\frac{Value - Baseline\ value}{Goal\ value - Baseline\ value}\right) * 100$$

the normalized score, where:

- Value = The actual measured value of the indicator.
- Baseline Value = The starting or reference point for comparison.
- Goal Value = The target value that is intended to be achieved.

Several goal values are closely tied to geographic and social conditions and have been estimated by the authors to provide an initial example or default value. However, users are encouraged to adjust these values to better reflect their specific contexts. In some cases, goal values may represent ideal situations that are challenging to achieve, such as zero fatalities from traffic accidents or zero GHG emissions. While these values can be adapted to align with EU goals, it is essential that such adjustments be agreed upon by all users of the framework to ensure consistency and avoid unequal comparisons.

Figure 4 - National level score: Percentage of renewable energy in energy production

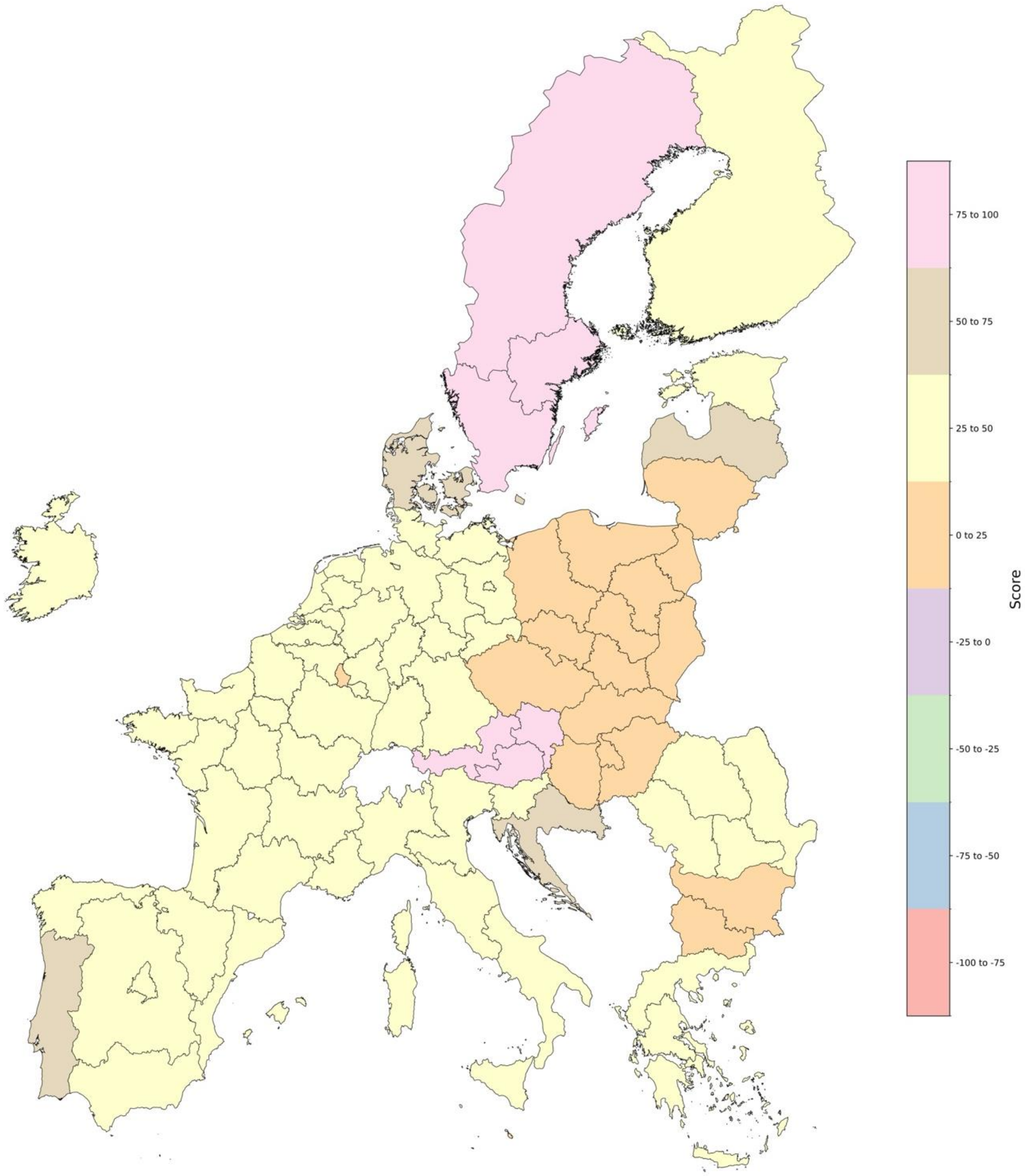


Figure 5 - NUTS2 level score: Percentage of arable land needed for Biodiesel and Bioethanol crops

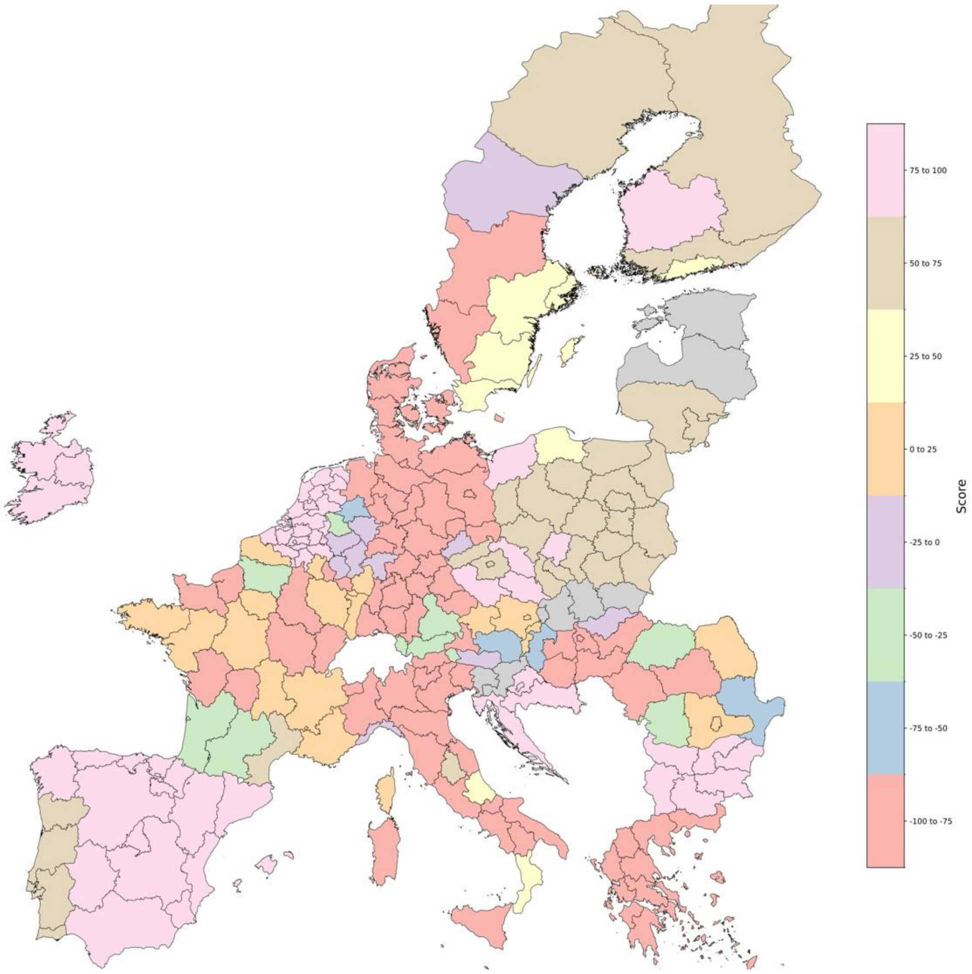


Figure 6 - Scores for GHG from energy LAU level

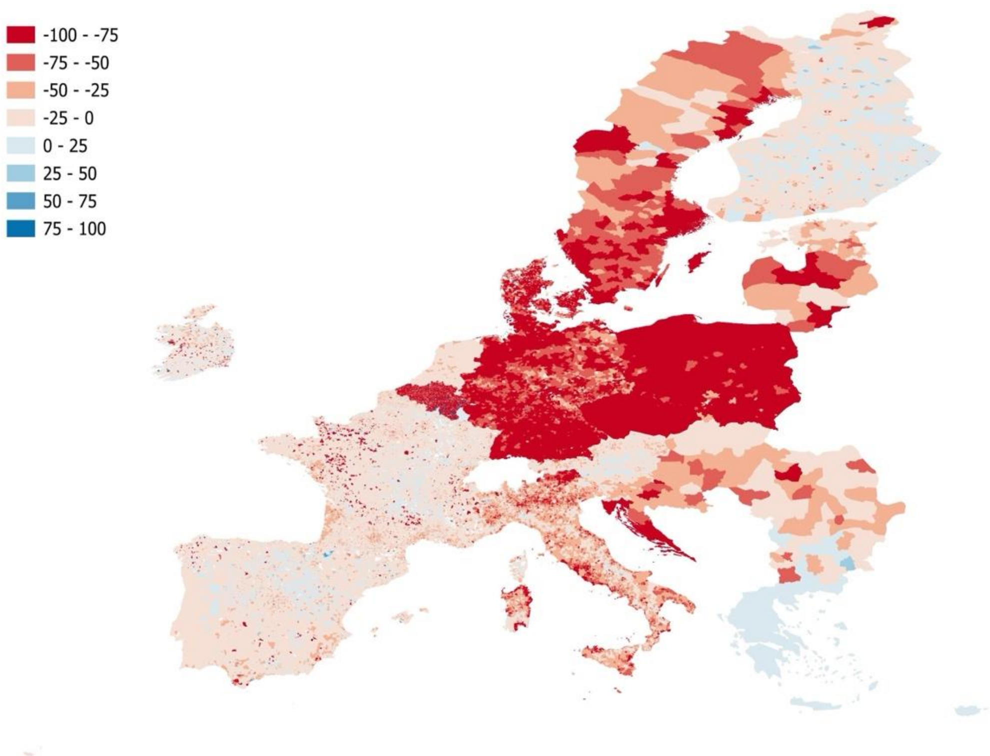
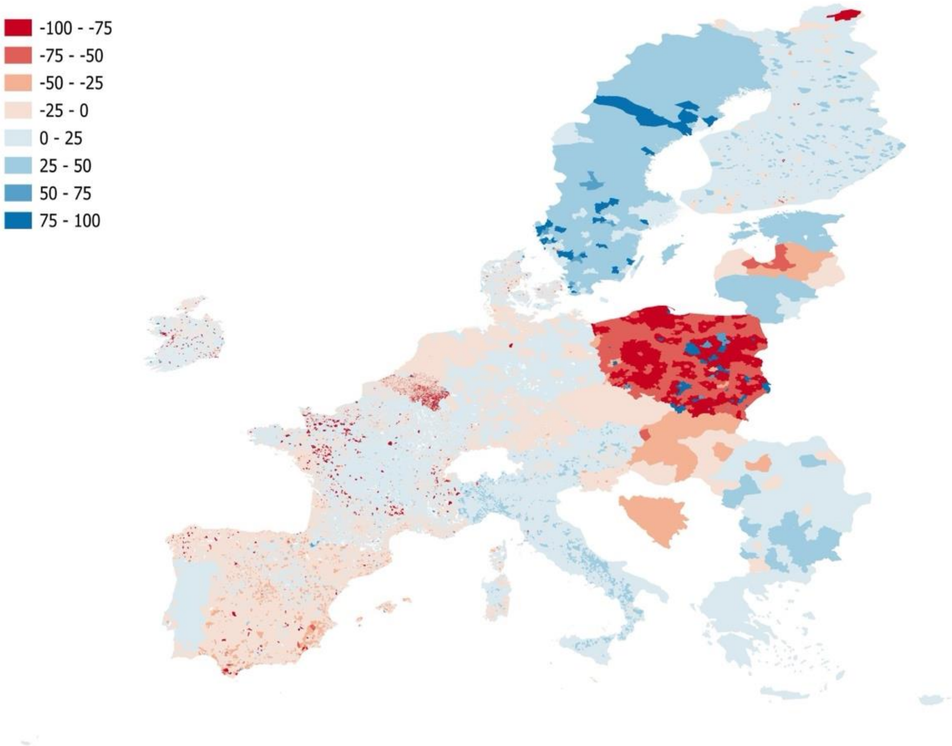


Figure 7 - Scores for GHG from transportation LAU level



5.4 Weighting method results

This section provides an analysis of public interest in various environmental domains, using Google search volumes to gauge the relative importance of different values and indicators and to provide users with default weights for the index. The analysis is based on weights calculated for each domain, value, and indicator, offering insight into the public's environmental concerns. Below is a detailed comparison of the domains and their values and indicators (Table 1, Figure 8). The Google Trends analysis is configured to retrieve weekly search volume data over a five-year period, ensuring that the results capture long-term public interest trends rather than short-term spikes or seasonal fluctuations. By aggregating weekly data across this extended timeframe, the weighting method provides a stable and representative measure of public interest for each domain, value, and indicator.

The analysis reveals that Energy commands the greatest attention, accounting for 20% of total interest. Within this domain, Environmental Sustainability (28.49%) holds the largest share, followed by Efficiency (26.28%) and Affordability (16.05%). Other values, such as Reliability (14.63%), Resilience (8.33%), and Justice (6.22%), receive less attention. Notably, under Environmental Sustainability, the focus is on GHG emissions from energy consumption (29.50%) and waste generation from energy production (28.05%), indicating strong public concern over the environmental impact of energy production. In the Reliability category, the reserve-production ratio dominates (80.22%), showing that public interest centers on long-term energy security rather than issues like power outages or self-sufficiency. For Affordability, the energy supply-demand ratio (55.95%) takes a significant share, highlighting the importance of maintaining a stable energy supply over other factors like price stability (3.89%).

In Agri-food, which accounts for 19% of public interest, Environmental Sustainability (30.71%) is the dominant value, with Local (18.92%) ranking second. Food Security-Nutrition (16.68%) and Efficiency (16.88%) also receive significant attention, while Animal Welfare/Justice (6.16%) and Resilience (2.25%) are less prominent. The most significant concern within Environmental Sustainability is the efficiency of water usage for irrigation (39.08%), reflecting public concern about sustainable water management in agriculture. However, there is comparatively little focus on organic agricultural land (0.96%). Under Food Security-Nutrition, food-related outbreaks per capita (47.16%) are the top indicator, indicating that food safety is a critical issue for the public, with more emphasis than on undernourishment (29.96%).

Industry, which captures 17% of public interest, sees Environmental Sustainability (22.99%) as the leading value, followed by Digitalization (20.83%) and Competitive (17.85%). Other values, like Resilience (4.53%) and Self-Sustaining (6.30%), receive less focus. Within Environmental Sustainability, air pollution from industry (31.44%) is the most prominent concern, reflecting heightened public awareness of industrial pollution's environmental impact. Meanwhile, Digitalization is almost entirely focused on the percentage of business operations using digital tools (94.10%), indicating strong public interest in the digital transformation of industry.

In the Waste domain, which also captures 17% of public interest, Environmental Safety (32.56%) commands the most attention, followed by Social sustainability (24.21%), Financial Sustainability (21.98%) and Circular Economy (18.88%). Safety (0%) and Reliability (1.26%) receive minimal interest. Within Environmental Safety, air pollution from waste management (51.17%) is the top concern, emphasizing the public's awareness of the environmental damage caused by improper waste handling. In the Circular Economy category, recycling rates (44.62%) and material recovery rates (46.63%) are nearly equally weighted, indicating a balanced public interest in promoting recycling and resource recovery.

For Buildings, which accounts for 16% of public interest, Environmental Sustainability (28.12%) is the leading value, with Improved Quality (26.09%) ranking second. Affordability (22.93%) and Safety (13.11%) follow closely behind, while smart homes (9.49%) and Social Cohesion (0.27%) receives the least attention. In Improved Quality, thermal comfort within buildings (54.04%) takes priority, reflecting the importance of comfortable living conditions.

Transportation, which receives the least public attention at 12%, has Smart (22.33%) as the most dominant value, followed by Safety (21.06%). In Smart Transportation, energy intensity per capita (50.28%) is the dominant indicator, revealing concerns about the energy efficiency of transportation systems.

In conclusion, Energy and Agri-food receive the highest levels of public interest, driven by concerns around environmental sustainability, resource efficiency, and reliability. Industry and Waste also capture significant attention, particularly regarding pollution and circular economy practices. Buildings and Transportation, while receiving less overall focus, show concentrated public concern around affordability, safety, and efficiency. This distribution of attention reveals how public interest shapes priorities across different environmental sectors.

Interestingly, the domains receiving the highest levels of public interest—Energy and Agri-food—do not align directly with their prominence in the literature review. Energy, while commanding the greatest attention in both cases, represents 73 mentions in the literature, whereas Agri-food, which accounts for 19% of public interest, was mentioned only 12 times in the literature review. Conversely, Waste, which captured significant public interest at 17%, had relatively low representation in the literature with 10 mentions.

These discrepancies may reflect differences in immediate public concerns, as gauged by search trends, versus long-term research priorities highlighted in academic and policy discourse. Notably, findings from a stakeholder survey conducted as part of the GRANULAR project further validate the emphasis on Energy as a top priority, with respondents ranking it as the most important domain (mean rank: 2.2). Similarly, Waste (4.62) and Buildings (4.50) were deprioritized in the survey, aligning with their lower weighting in the public interest analysis. The convergence of both the survey and search trend data reinforces the robustness of these findings, suggesting that stakeholder perceptions and online interest are consistent indicators of public priorities. This underscores the importance of integrating multiple perspectives—both public opinion and academic insights—when developing frameworks for climate neutrality. Full details of the survey, including methodology and participant breakdown, can be found in Annex 8.5.

Table 1 - Results for weights by Google Trends

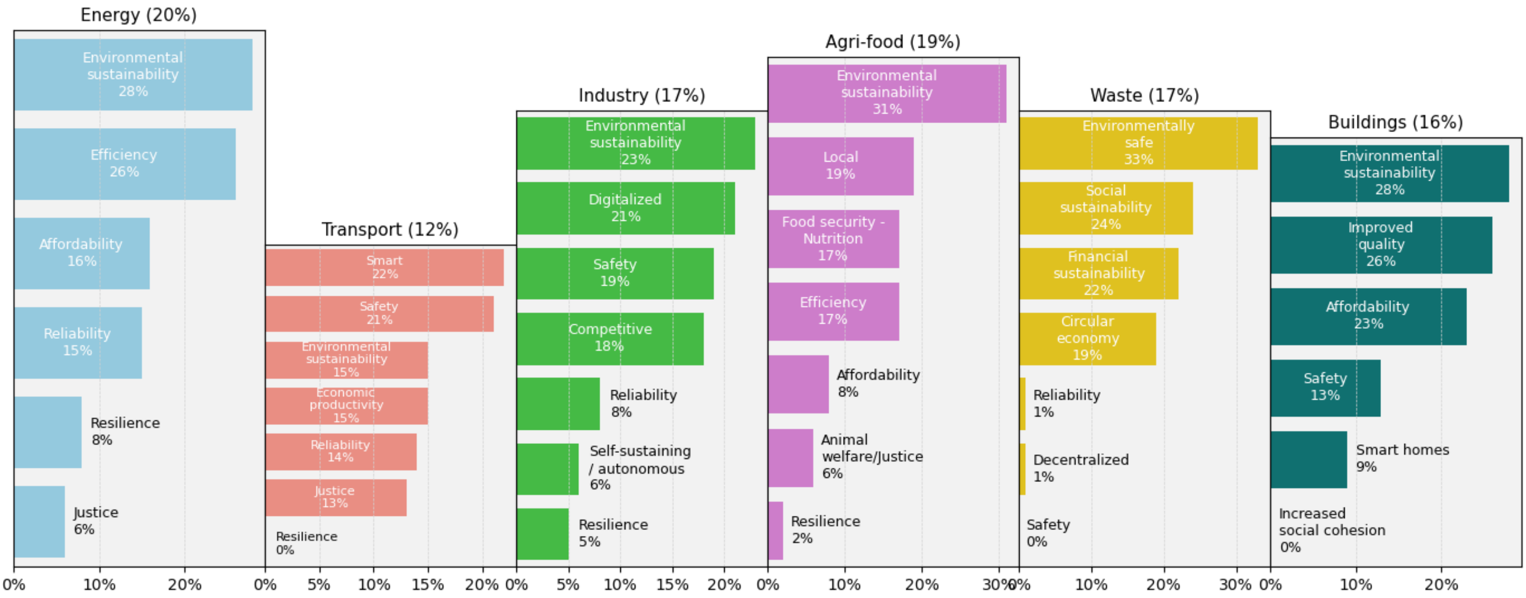
Domain	Relative Search Volume for domains	Percentage	Value	Relative Search Volume for values	Percentage	Objective Indicator	Relative Search Volume for indicators	Percentage
Energy	16175	20%	Environmental sustainability	71856	28.49%	GHG emissions from energy consumption	71033	29.50%
						Air pollutants from energy consumption	42242	17.54%
						Waste generation from energy production	67551	28.05%
						Percentage of renewable energy in energy production	59963	24.90%
			Reliability	36899	14.63%	Hours with power outage	3545	15.69%
						Reserve-Production ratio	18120	80.22%
						Self-sufficiency: Percentage of imported energy (fuel or electricity)	924	4.09%
			Affordability	40487	16.05%	Energy price stability	3676	3.89%
						Energy supply-demand ratio	52808	55.95%
						Share of energy expenditure from income	37902	40.16%
			Resilience	21009	8.33%	Energy diversification index	14589	11.87%
						Decentralization of energy sources	39341	32.01%
						Energy storage capacity	68987	56.12%
			Efficiency	66288	26.28%	Energy intensity (consumption per GDP)	40243	46.58%
						Electricity transmission and distribution losses	46150	53.42%
			Justice	15681	6.22%	Percentage of population with inability to keep the house warm	1280	17.95%
						Disparity in electricity distribution	5852	82.05%
Transportation	9559	12%	Environmental sustainability	34861	14.63%	Air pollution from transportation: passenger cars	39457	60.49%
						Air pollution from transportation: light duty vehicles	980	1.50%
						Air pollution from transportation: heavy duty vehicles and buses cars	7219	11.07%
						GHG emissions from transport sector	16961	26.00%
						Level of noise from transport in rural areas	613	0.94%
			Reliability	32680	13.71%	Delays due to traffic congestion/Dwell time	8841	48.86%
						Public transport punctuality (measured with an average of delay times)	981	5.42%
						Accessibility to essential services by public transport	8273	45.72%

			Safety	50176	21.06%	Number of traffic accidents	92900	54.56%
						Number of fatalities and injuries (per km) from traffic	53878	31.64%
						Number of crimes committed on or while waiting for public transport	20973	12.32%
						Hazardous materials incidents while transporting	2527	1.48%
			Justice	31147	13.07%	Seat-kilometers offered by public transport	16213	37.72%
						Length of cycling and walking paths compared to roads	26270	61.12%
						Portion of low-income households that spend more than 20% of their budgets on transport	500	1.16%
			Economic productivity	35362	14.84%	Affordability index: Transportation Costs as percentage household Income	13176	79.21%
						Average commuting	3075	18.49%
						Total cost of public transport per capita	384	2.31%
			Smart	53212	22.33%	Energy intensity per capita for transport	2359	50.28%
						Energy intensity per VKM for transport	921	19.63%
						Ratio of non-fossil fuel consumption to fossil fuel consumption	921	19.63%
						Zero emission vehicles stock compared to conventional vehicles	491	10.46%
			Resilience	844	0.35%	Public transport system diversity (number of modes)	15937	33.11%
						Smart and Flexible transport modes	20287	42.15%
						Number of public transport stations/stops per sqkm	11906	24.74%
Industry	13646	17%	Environmental sustainability	79051	22.99%	Air pollution from Industry	67638	31.44%
						GHG emissions from Industry sector	33093	15.38%
						Industry water demand	26155	12.16%
						Industry energy demand	19841	9.22%
						Share of renewable energy in Industry	7415	3.45%
						Total materials used by industry	11819	5.49%
						Waste generation by industrial processes	49164	22.85%
			Reliability	28757	8.36%	Industry downtime due to failures	4164	100.00%
			Safety	65786	19.13%	Frequency/No. of accidents in industry	20739	45.04%
						Health and security expenses by industry	25303	54.96%
			Competitive	61362	17.85%	Industry profit	52822	100.00%
			Digitalized	71631	20.83%	Percentage of business operations using digital tools	45500	94.10%
						Digital skills training and adoption rates	2855	5.90%

			Resilience	15589	4.53%	Industrial supply chain diversification	42012	55.41%
						Disruptions in industrial production	11242	14.83%
						Business financial reserves	22561	29.76%
			Self-sustaining / autonomous	21646	6.30%	Self-produced energy at industry	15075	65.20%
						Percentage of employees from the region	6129	26.51%
						Percentage of local supply chain	1918	8.30%
Agri-food	15957	19%	Environmental sustainability	61917	30.71%	Organic agricultural land	1444	0.96%
						GHG emissions from agricultural activities	26891	17.91%
						Efficiency of water usage for irrigation in agriculture	58674	39.08%
						Waste from agriculture	26336	17.54%
						Soil Organic Carbon (SOC) content	36805	24.51%
			Food security - Nutrition	33623	16.68%	Total of crops for Biodiesel and Bioethanol production as a percentage of the arable land	2410	2.24%
						Prevalence of undernourishment in total population	32224	29.96%
						Average dietary energy supply adequacy	22190	20.63%
						Food related outbrakes per capita	50723	47.16%
			Animal welfare/Justice	12419	6.16%	Share of population unable to afford a healthy diet.	593	1.77%
						Level of animal diseases in agri-food system	32996	98.23%
			Affordability	16925	8.40%	Food affordability index	14653	100.00%
			Efficiency	34036	16.88%	Intensity of total pesticides use	5991	10.41%
						Intensity of the total fertilizer use	19771	34.34%
						Direct energy use in agriculture and food industry	9239	16.05%
						Food crop efficiency	22576	39.21%
			Resilience	4538	2.25%	Production ratios per capita: Cereals, Meat, Fruit, Vegetables, Fish	2088	10.79%
						Dependency on imported agricultural products	1505	7.78%
						Species variation (number of species per farm)	15759	81.43%
			Local	38133	18.92%	Food miles (km/kg)	20655	100.00%
Waste	13776	17%	Environmentally safe	39615	32.56%	GHG emissions from waste management	15318	18.18%
						Air pollution from waste management	43127	51.17%
						Per capita waste generation	25835	30.65%
			Reliability	1531	1.26%	Frequency of waste collection	24144	100.00%
			Safety	0	0	Hazardous waste per capita	2492	14.73%

						Proportion of hazardous waste recycled or processed through waste-to-energy (WTE) methods	14430	85.27%
			Social sustainability	29455	24.21%	Accessibility to waste collection and disposal services	30080	100.00%
			Financial sustainability	26752	21.98%	Taxes on landfill and incineration	1337	6.90%
						Costs of waste management	18053	93.10%
			Circular economy	22980	18.88%	The volume of waste sent to landfill via WTE processes per capita	4690	8.75%
						Recycling rates	23912	44.62%
						Material recovery rates	24993	46.63%
			Decentralized	1352	1.11%	Variety of waste treatment methods utilized	25491	100.00%
Buildings	12888	16%	Environmental sustainability	66427	28.12%	GHG emission from buildings	28411	41.15%
						Construction waste recycled	40634	58.85%
			Improved quality	61631	26.09%	Acoustic performance of buildings	1873	31.93%
						Thermal comfort within buildings	3170	54.04%
						Rates of building renovation	823	14.03%
			Safety	30972	13.11%	Indoor air quality within buildings	28238	94.73%
						Compliance with building codes and regulations	1570	5.27%
			Increased social cohesion	638	0.27%	Access to public transport from residential buildings	1196	2.73%
						Locally sourced materials	16293	37.22%
						Mixed uses	1604	3.66%
						Buildings vacancy rate	24681	56.38%
			Affordability	54175	22.93%	Housing cost overburden	16854	100.00%
			Smart homes	22412	9.49%	Energy efficiency in buildings	48036	39.81%
						Share of renewable energy from total consumption	32135	26.63%
						Water efficiency in buildings	23180	19.21%
						Waste generation from residential buildings	12153	10.07%
						Smart meter installation rate in residential buildings	5158	4.27%

Figure 8 - Domain and value weights distribution



5.5 Policy measures and application criteria

A total of 104 distinct policy measures were identified following the screening of data from the European Environmental Agency (EEA) and Covenant of Mayors (CoM) databases, with the full table along with indicator calculation steps available in Annex 8.6. These policies spanned a variety of domains crucial for achieving climate neutrality (Figure 9.1, Table 2), including energy (25%), transportation (24%), industry (7%), agri-food (6%), waste (8%), buildings (14%), governance (8%), and environmental policy (8%).

The measures were classified into different policy types (Figure 9.2), policy types were identified based on existing classifications in the EEA database, where the type of each policy is already specified. For the CoM database, we examined each policy measure individually and classified it according to the policy types outlined in the EEA framework. This approach ensured consistency in categorization and alignment with established methodologies for assessing climate-related policies. The largest proportion was economic measures (34%), which involved subsidies, grants, and financial incentives aimed at fostering action in areas such as renewable energy adoption and energy efficiency. Regulatory measures (26%) also played a prominent role, highlighting local governments' focus on enforcing legal standards to ensure compliance with climate and environmental goals. Planning measures constituted 21% of the total, reflecting efforts to integrate sustainable development into urban and rural planning strategies. Education and information measures, which made up 7% of the policies, focused on raising awareness and knowledge sharing to drive behavioral changes in communities. Voluntary or negotiated agreements accounted for 6%, showcasing efforts to engage stakeholders and communities through non-compulsory initiatives aimed at fostering collaboration. Lastly, research-based measures represented 6% of the policies, focusing on developing innovative solutions and gathering data to support long-term sustainability objectives.

Energy was the most represented domain, making up 25% of the policies. Key measures in this domain included policies promoting renewable energy through land allocation, financial incentives for wind energy, and subsidies for energy efficiency in public and residential buildings. These policies focused on increasing the share of renewable energy in the overall energy mix while reducing fossil fuel consumption. Transportation, accounting for 24% of the policies, had a strong focus on reducing emissions through electric vehicle incentives, public transport upgrades, and the introduction of low-emission zones in urban areas. These measures aimed to improve urban mobility while cutting transportation-related greenhouse gas emissions.

In the buildings domain, which comprised 14% of the policies, measures were aimed at improving energy efficiency through renovations, such as retrofitting residential buildings to meet Net Zero Energy Building standards and installing photovoltaic panels on municipal buildings. These policies targeted reductions in energy consumption and the promotion of sustainable construction practices. Waste management policies, representing 8%, focused on increasing recycling rates, improving waste separation, and reducing landfill usage through measures like biowaste separation and the establishment of recycling centers.

Industry-related policies (7%) emphasized improving energy efficiency in industrial processes, with measures such as mandatory energy audits and funding for renewable energy projects within the sector. In the agri-food domain (6%), policies addressed the environmental impacts of agriculture, with measures focused on reducing emissions from livestock, promoting sustainable farming practices, and supporting the use of drought-resistant crops. Governance and environmental policy measures, both making up 8% of the total, centered on improving public engagement and governance structures to support sustainability. These included training for elected officials, enhancing public alert systems, and developing water scarcity management plans.

When examining the distribution across policy types, economic measures were the most common, accounting for 34%. These included financial incentives, subsidies, and grants aimed at encouraging the adoption of renewable energy and energy-efficient practices. Regulatory measures (26%) were also heavily utilized, focusing on enforcing standards for energy efficiency, pollution control, and sustainable construction practices. Planning measures, which made up 21%, emphasized the integration of sustainable development goals into urban planning, such as limiting land use for new developments and promoting compact urban growth. Education and information measures (7%) focused on raising public awareness of climate change, waste management, and energy-saving practices, while research-based policies (6%) sought to innovate through studies on food loss reduction and renewable energy production.

To ensure the effective monitoring and evaluation of each policy, two types of indicators were assigned: process and impact indicators (Annex 8.6). Process indicators tracked the implementation of the policies in real time, providing insight into immediate progress. For example, they measured the number of renewable energy projects initiated, the amount of funding allocated, or the number of kilometers of pedestrian sidewalks constructed. These indicators were crucial for ensuring that the policies were being implemented as planned and for identifying any necessary adjustments early on.

Impact indicators, on the other hand, assessed the long-term effectiveness of the policies in achieving broader objectives. They tracked outcomes such as reductions in energy consumption, decreases in greenhouse gas emissions, and improvements in air quality. By focusing on the ultimate goals of the policies, impact indicators provided a comprehensive view of whether the measures were successful in contributing to climate neutrality. Together, process and impact indicators offered a complete framework for both immediate tracking and long-term evaluation, allowing policymakers to ensure that the actions taken were not only implemented correctly but also achieved their desired results over time.

Figure 9.1 - Distribution of policy measures by domain

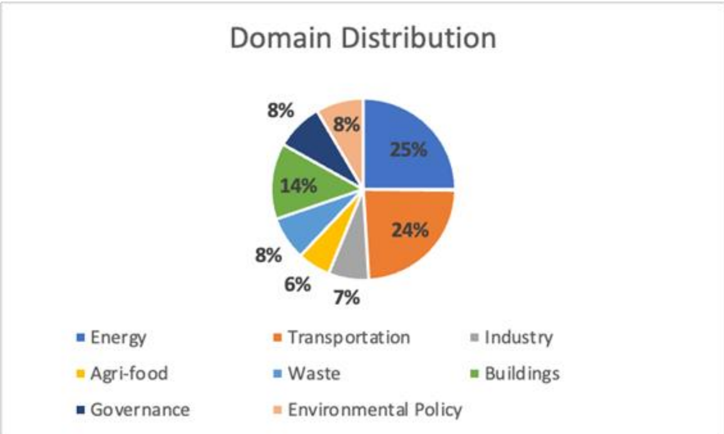


Figure 9.2 - Distribution of policy measures by type

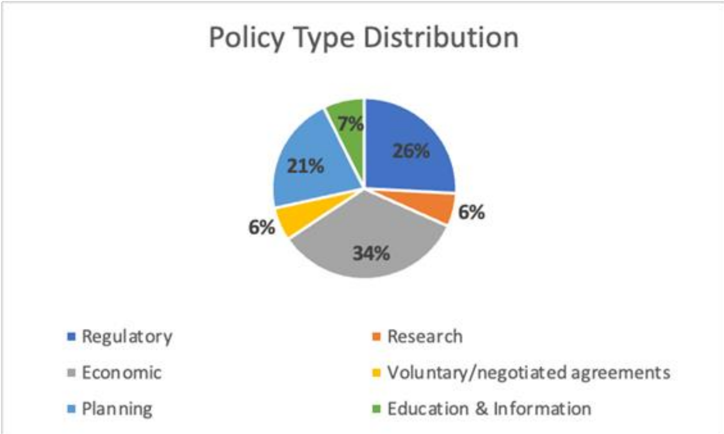


Table 2 - Policy measures by type and domain

Domain/Policy measure	Regulatory	Research	Economic	Voluntary/ negotiated agreements	Planning	Education & Information
Energy	11	2	12	0	5	0
Transportation	6	2	12	1	12	2
Industry	1	0	3	2	0	0
Agri-food	2	2	2	1	1	1
Waste	6	0	3	1	1	1
Buildings	5	0	8	0	3	1

5.6 Domains and values correlations

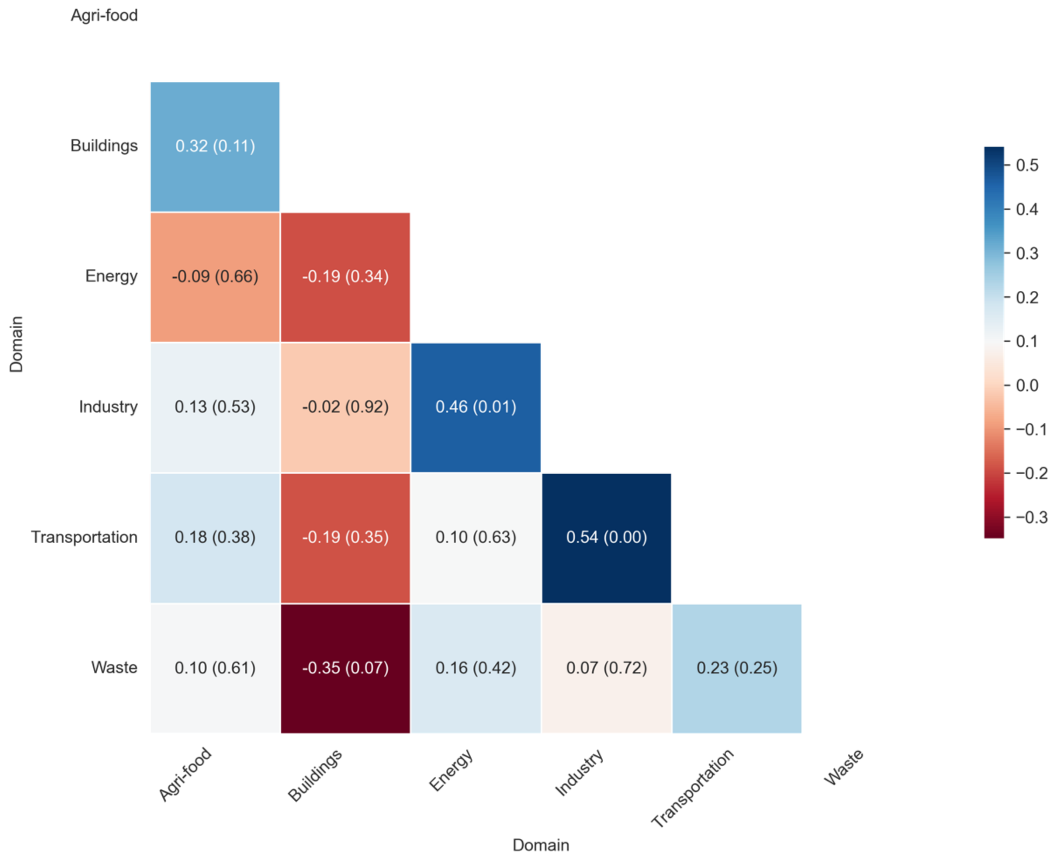
A correlation analysis was performed at two levels—domains (Figure 10) and domain–value pairs (for example, Agri-food–Affordability or Energy–Environmental sustainability). At the domain level, there were two statistically significant results: Energy correlated positively with Industry ($r = 0.46$, $p = 0.01$) and Industry correlated positively with Transportation ($r = 0.54$, $p < 0.01$). Although it remains speculative why these links appear, one possibility is that countries with strong industrial performance may also have more advanced energy systems and transport networks, reflecting complementary policies or infrastructures. These interpretations are only tentative indications of where synergies could exist within our framework.

When looking at domain–value pairs (for full table see annex 8.7), the Agri-food domain showed several notable correlations. Efficiency was negatively linked with Food security–Nutrition ($r = -0.54$, $p < 0.01$), suggesting that efforts to optimize production might undermine equitable access to nutritious food. A similar negative relationship emerged between Affordability and Food security–Nutrition ($r = -0.42$, $p = 0.03$), hinting that cheap food may come at the cost of nutritional outcomes. Agri-food Efficiency, on the other hand, was positively associated with Industry Environmental sustainability ($r = 0.58$, $p < 0.01$) and Transportation Environmental sustainability ($r = 0.51$, $p = 0.01$), implying that resource-efficient practices in the Agri-food sector could align with broader ecological goals across industries and transport. However, tensions arose between Agri-food Animal welfare/Justice and certain Energy dimensions, as seen in negative correlations with Energy Affordability ($r = -0.42$, $p = 0.03$) and Energy Reliability ($r = -0.49$, $p = 0.01$). Meanwhile, Agri-food Food security–Nutrition showed a mixed pattern regarding Energy performance, correlating positively with Energy Efficiency ($r = 0.46$, $p = 0.02$) but negatively with Energy Environmental sustainability ($r = -0.49$, $p = 0.01$).

Two additional cross-domain correlations underscore the complexity of these interactions: Agri-food Efficiency was negatively associated with Energy Efficiency ($r = -0.52$, $p = 0.01$), while Energy Efficiency was negatively associated with Transportation Environmental sustainability ($r = -0.50$, $p = 0.01$). Both relationships indicate that pursuing efficiency in one area may complicate efforts to enhance environmental or efficiency goals elsewhere. These observations, taken together, highlight not only possible synergies—where improvements in one domain–value pair may contribute to another—but also potential trade-offs, where gains in certain areas could inadvertently hinder progress in others.

Overall, the positive correlations often point to opportunities for integrated strategies aimed at simultaneously improving multiple dimensions, while the negative correlations caution that bolstering one priority (for example, efficiency or affordability) may sometimes compromise another (for instance, food security, animal welfare, or environmental sustainability). It is crucial to remember that these explanations are presumptive rather than definitive, serving as a way to spotlight promising avenues and cautionary notes within our framework. They are best viewed as starting points for deeper investigation and nuanced policymaking.

Figure 10 - Domain correlations



5.7 Sensitivity analysis

5.7.1 Domain and Domain–Value Pair Removals

To evaluate the robustness of our framework, we utilized national-level data to calculate scores and perform sensitivity analysis, even though the framework is intended for rural settlements. We began by removing entire domains one at a time to determine their impact on country rankings. The removal of the Transportation domain resulted in the largest average absolute rank shift of 3.11, followed by Waste with 2.81 and Buildings with 2.59. This indicates that these domains are crucial in differentiating country performances, as their exclusion leads to significant reshuffling in rankings. In contrast, removing Industry, Agri-food, or Energy caused smaller average changes of 2.22, 1.26, and 1.19 respectively, suggesting these domains have a more moderate influence on overall standings.

Further refining our analysis, we removed specific domain–value pairs to pinpoint which aspects within each domain are most influential (Table 3). Pairs such as Waste–Safety and Transportation–Environmental sustainability each caused an average absolute rank difference of 2.22, making them the most impactful in altering rankings. Buildings–Environmental sustainability followed with 2.07, and Waste–Environmentally safe contributed an average change of 2.00. Conversely, domain–value pairs within the Energy domain, including Affordability, Resilience, and Efficiency, exhibited minimal impacts of around 0.22. These findings highlight that certain values within key domains like Transportation and Waste are pivotal in shaping country rankings, whereas aspects of Energy and Industry tend to have a lesser effect. Overall, Transportation, Waste, and Buildings—especially their environmental and safety-related values—are key drivers of ranking variability, while elements of Energy and Industry contribute more modestly to rank shifts.

Table 3 - Average rank difference for Domain-Value pairs

Domain	Value	Average rank difference
Waste	Safety	2.22
Transportation	Environmental sustainability	2.22
Buildings	Environmental sustainability	2.07
Waste	Environmentally safe	2.00
Buildings	Affordability	1.78
Waste	Circular economy	1.63
Industry	Safety	1.33
Transportation	Economic productivity	1.11
Buildings	Improved quality	1.04
Transportation	Safety	1.04
Agri-food	Food security - Nutrition	0.96
Buildings	Smart homes	0.96
Agri-food	Environmental sustainability	0.89
Agri-food	Efficiency	0.89
Transportation	Smart	0.81
Agri-food	Affordability	0.81
Energy	Environmental sustainability	0.67
Agri-food	Resilience	0.67
Industry	Competitive	0.59
Industry	Digitalized	0.59
Industry	Resilience	0.59
Agri-food	Animal welfare/Justice	0.59
Energy	Reliability	0.52
Energy	Justice	0.44
Energy	Affordability	0.22
Energy	Resilience	0.22
Energy	Efficiency	0.22
Industry	Environmental sustainability	0.22

5.7.2 Policy-Weighted Scenarios

Hainsch et al. (2022) provide a detailed exploration of Europe's energy transition, illustrating how policy action, technology innovation, and societal engagement can each drive or hinder decarbonization outcomes. Drawing on that framework, we develop four scenario narratives—Societal Commitment, Directed Transition, Techno-Friendly, and Gradual Development—that illustrate how different emphases on policy, technology, or grassroots action can profoundly shape an energy transition's pathway and outcomes (Table 4 describes the complete change domains and values weights, Figure 11 shows average scores and change and for full scenario results see annex 8.11).

Societal Commitment envisions a shift guided by vibrant grassroots movements, cooperative communities, and sustainable local practices. To reflect these social dynamics, this scenario slightly reduces the weight of industrial and large-scale Energy domains, while boosting Agri-food and Waste. Values that signal local empowerment (justice, environmental sustainability) receive greater emphasis, whereas efficiency and reliability diminish. Because nearly all countries see a drop in their scores under Societal Commitment, it yields moderate rank movements (average absolute difference of about 1.52) compared to the baseline which assumes equal weights across domains and values.

Directed Transition instead spotlights far-reaching government policies that steer large-scale renewable infrastructure, industrial decarbonization, and strong efficiency improvements. Energy is raised to 25% of the total weight, and Industry to 20%, reflecting major policy efforts in these areas. Values such as efficiency and reliability receive extra emphasis, while affordability and justice lose some weight to illustrate equity trade-offs under top-down reforms. In this scenario, every country's score increases, often substantially, driving an average absolute rank change of 3.69.

Techno-Friendly highlights a market-driven quest for breakthroughs in smart energy, advanced renewables, and digitalization. Energy's weight rises to 30%, Transportation to 20%, and values such as "smart" and "efficiency" are prioritized, while environmental sustainability and justice each drop by 10%. This re-prioritization creates the largest average absolute rank change—4.78—and, as in Directed Transition, all countries improve their raw scores relative to baseline.

Gradual Development offers a balanced approach, distributing equal domain weights (16.67%) and shifting certain values only slightly. Environmental sustainability sees a small rise, while "smart" or "efficiency" is nudged down. This measured departure from the baseline yields the smallest average absolute rank difference—just 0.28—and most countries show negative or only marginally positive changes in score. A handful, such as Austria and Greece, do experience small gains, but overall the majority see slight reductions, confirming that modest weight adjustments preserve much of the baseline's scoring pattern with minimal reshuffling of ranks.

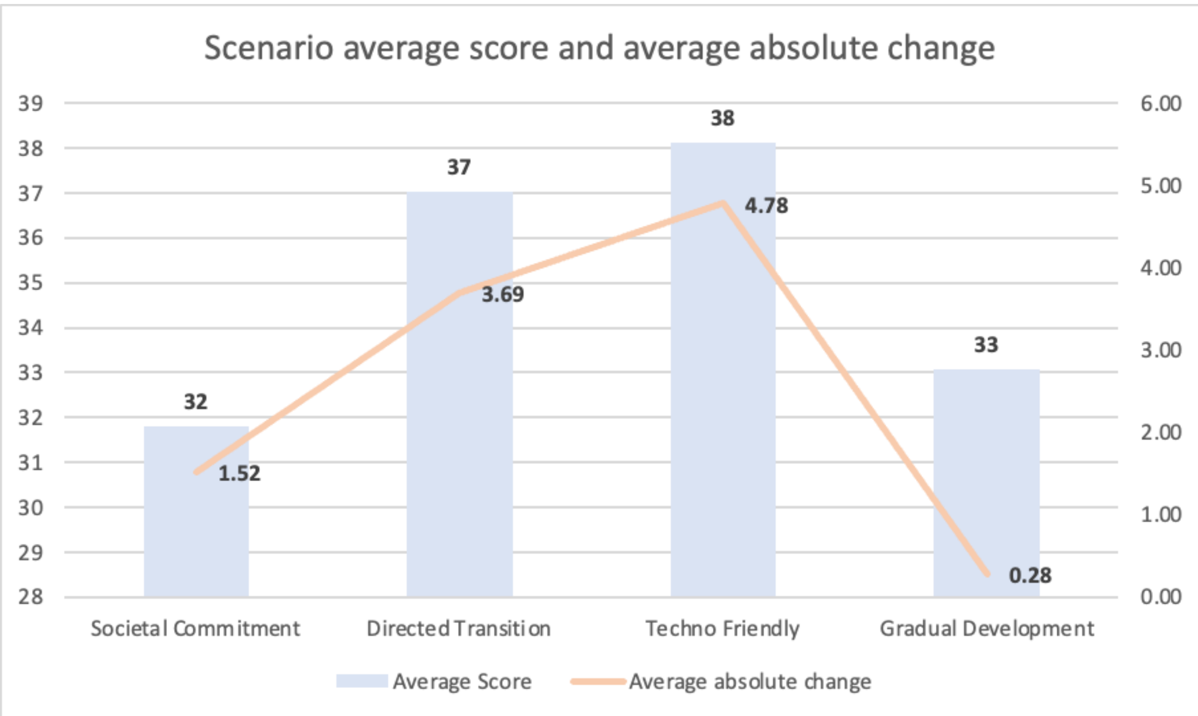
Each scenario captures a distinct pathway to decarbonization and leads to unique shifts in the overall ranking structure. Societal Commitment, which emphasizes social engagement and equity, results in moderate changes across the board. Directed Transition, underpinned by top-down policy measures and large-scale infrastructure, produces greater fluctuations in the standings. Techno-Friendly, fueled by market-driven technological innovation, leads to the largest reshuffling of positions. Gradual Development, oriented toward balanced efforts across all areas, most closely preserves the baseline hierarchy, indicating that small, widely distributed alterations to priorities have a comparatively mild impact on the final outcomes.

Table 4 - Changes in domain and value weights to create the scenarios

Scenario Name	Description	Domain Changes	Value Changes
Societal Commitment	A grassroots-driven transition focusing on social justice, sustainability, and local solutions. Behavioral changes dominate, minimizing reliance on centralized infrastructure.	- **Energy:** Reduced (from 16.67% → 14%) as decentralized, small-scale energy solutions like solar panels are emphasized over large-scale energy infrastructure.	- **Environmental Sustainability:** Increased by +10% across all domains, reflecting its central role in societal initiatives.
		- **Transportation & Buildings:** Maintained at 16.67% to balance societal demands for mobility and retrofitting.	- **Justice:** Increased by +5% in Transportation, Energy, and Agri-food to ensure equity.
		- **Industry:** Reduced (16.67% → 14%) due to less focus on heavy industrial decarbonization, aligning with societal preference for reduced consumption.	- **Efficiency & Reliability:** Decreased by -5% in Energy and Industry, deprioritizing traditional performance metrics in favor of community priorities.
		- **Agri-food:** Increased (16.67% → 20%) as sustainable, local food production becomes a societal priority.	
		- **Waste:** Increased (16.67% → 18%) to reflect societal interest in waste reduction and circular economy initiatives.	
Directed Transition	A top-down policy-led approach, emphasizing large-scale industrial and energy solutions supported by strong government incentives.	- **Energy:** Increased (16.67% → 25%) as centralized policies heavily target renewable energy infrastructure and grid systems.	- **Efficiency:** Increased by +15% in Energy and Industry to prioritize performance and reduction of waste.
		- **Industry:** Increased (16.67% → 22%) with heavy focus on decarbonizing steel, cement, and other key industries.	- **Reliability:** Increased by +10% in Energy, Transportation, and Waste to ensure stable systems.
		- **Transportation & Buildings:** Balanced at 15% each, reflecting government support for electrification and retrofitting.	- **Justice & Affordability:** Decreased by -10% in all domains to reflect the trade-offs in equity and inclusivity under centralized approaches.
		- **Agri-food:** Decreased (16.67% → 13%) as it receives less focus compared to industry and energy.	
		- **Waste:** Decreased (16.67% → 10%) as waste management becomes a secondary focus.	

Techno-Friendly	A market-driven scenario emphasizing rapid technological innovation, where breakthroughs and industry leadership dominate.	- **Energy:** Increased (16.67% → 30%) as technology-driven solutions like advanced renewables, grids, and storage dominate.	- **Smart Solutions:** Increased by +20% in Transportation and Buildings to reflect prioritization of IoT and smart systems.
		- **Transportation:** Increased (16.67% → 20%) with significant focus on autonomous vehicles and electrification.	- **Efficiency:** Increased by +10% across domains due to technological optimization.
		- **Buildings:** Reduced (16.67% → 10%) as retrofitting and smart homes become secondary compared to broader technological innovations.	- **Environmental Sustainability & Justice:** Decreased by -10% across all domains as technological adoption takes precedence over ecological and social concerns.
		- **Waste:** Reduced (16.67% → 10%) with less emphasis on waste management.	
		- **Industry & Agri-food:** Balanced at 15% each, reflecting moderate importance of technological advances in these sectors.	
Gradual Development	A balanced approach distributing responsibilities equally among policy, society, and industry. Incremental progress is key.	- **All Domains:** Maintained at equal weights (16.67%) to reflect shared responsibility and balanced contributions across Energy, Transportation, Industry, Agri-food, Waste, and Buildings.	- **Environmental Sustainability:** Slightly increased by +5% across domains to reflect universal recognition of its importance.
			- **Smart & Efficiency:** Slightly decreased by -5% across domains to reflect trade-offs for balanced development.
			- **Justice & Affordability:** Maintained as moderate priorities without significant trade-offs.

Figure 11 - Scenario average score and average absolute change



6. Limitations

6.1 Lack of Local Data: A Challenge for Climate Neutrality

One of the key limitations identified in this report is the lack of comprehensive data available at the local level. Climate neutrality issues, such as greenhouse gas emissions, energy consumption, and waste management, often manifest in highly localized ways, influenced by factors like geography, population density, local industries, and specific socio-economic conditions. Yet, despite the local nature of these challenges, data collection and analysis often occur at broader national or regional levels, leaving significant gaps in the understanding of local dynamics.

This lack of localized data creates a barrier to designing and implementing effective climate neutrality strategies. Local-level data is essential for identifying the most significant sources of emissions, understanding energy use patterns, and determining the specific interventions that will be most effective in each area. For example, different rural contexts, as identified in EU-wide rural typologies, may each require tailored strategies due to variations in transportation needs, building infrastructure, and local industries. One rural area might focus on sustainable agriculture and improving access to public transport, while another might prioritize renewable energy development and circular economy initiatives. These distinctions highlight the importance of localized data for developing interventions that address specific conditions within different types of rural communities.

Moreover, localized data is crucial for monitoring the progress of climate initiatives. Without accurate and detailed information, it becomes difficult to track emissions reductions or the effectiveness of policies at a community level. Local governments and organizations, which are often the entities responsible for implementing climate strategies, are left without the critical insights they need to adapt and refine their efforts.

The importance of local data also extends to public engagement and accountability. Communities need to see data that reflects their unique circumstances to foster a sense of ownership and urgency around climate action. When local data is unavailable, it can hinder efforts to build support for necessary policies and behaviors, as the impacts and benefits of climate actions may not be immediately apparent to those on the ground.

In summary, the absence of detailed local-level data is a significant limitation for achieving climate neutrality. Effective climate action is inherently local, and without the necessary data to understand and respond to community-specific needs and challenges, strategies risk being too generalized or misaligned with the reality of local conditions. To address this gap, our research incorporates a downscaling step that refines broader datasets to local contexts, allowing us to identify specific needs, set more accurate baselines, and monitor progress more effectively. This approach is essential for designing more precise, effective, and equitable climate neutrality interventions.

6.2 Disconnection Between Local Indicators and Global Impact

Another limitation encountered in this report is the challenge of connecting local indicators to the international scale, largely due to the broad and complex scope of issues such as greenhouse gas (GHG) emissions. For instance, GHG emissions related to food consumption should account not only for local production but also for emissions embedded in imports, transportation, and supply chains that span across borders.

This disconnect makes it difficult to develop a holistic picture of a region's true environmental impact and its contribution to global emissions. Since many sectors, such as agriculture, manufacturing, and energy, are part of international systems, limiting indicators to local data without considering these broader factors can provide an incomplete or skewed view of progress toward climate neutrality. The absence of a comprehensive framework that integrates both local actions and their international implications creates gaps in accountability and strategic planning, as critical components like imported goods and services are often overlooked.

Thus, while local data is crucial, there is also a need to connect these indicators to the international scale to ensure a complete assessment of a region's environmental footprint. Our current framework does not fully integrate these global complexities due to the substantial methodological and data-related challenges involved. Future research could address this gap by incorporating more advanced modeling and multi-level governance perspectives to better capture the interplay between local actions and their global implications. Without this connection, efforts to achieve climate neutrality risk falling short, as they may neglect key drivers of emissions that originate outside local borders but have significant local and global impacts.

6.3 Balancing Local Adaptation with Standardized Climate Metrics

Another limitation faced in this report is the challenge of maintaining a balance between local relevance and standardization within the climate neutrality framework. On one hand, it is essential to adapt the indicators and the weights of indicators for different users, as different communities may prioritize specific issues based on local conditions and needs. For example, coastal regions may place more emphasis on sea-level rise, while urban areas might focus on air quality or transportation emissions. This flexibility allows for the framework to be more meaningful and actionable at the local level.

On the other hand, the need to maintain a standardized scale that ensures comparability across different communities presents a conflicting challenge. A standardized benchmark helps to normalize indicators to a unified score, making it possible to compare progress toward climate neutrality between regions. However, this approach can be difficult to reconcile with the need for customization, as too much flexibility in indicator weighting or benchmarking can undermine the consistency and comparability of results.

Further work is required to refine and formalize this balance between flexibility and standardization. One potential entry point is to use methods such as Google Trends to identify key indicators of public interest or concern across different regions, which can guide adaptive weighting while still maintaining core, standardized metrics. Decisions need to be made on which values or indicators will remain constant across all communities, and which can be adjusted to reflect local priorities without compromising the overall goal of climate neutrality. This balance is critical for ensuring that the framework remains both relevant at the local level and useful for broader comparisons and policy assessments.

6.4 Challenges in Choosing Weighting Methods

A further limitation in this report involves the choice of weighting methods, particularly the trade-offs between statistical-based methods and public opinion-based methods.

Statistical-based weighting methods provide a more objective and data-driven approach to determining the importance of different indicators. These methods can offer consistency and transparency, relying on quantitative data to establish the weights of various factors, such as emissions or resource use. However, a key limitation is that they may not fully capture local priorities, as they focus on aggregate data rather than community-specific concerns. Additionally, statistical methods can be inflexible, limiting their ability to adjust to changing conditions or emerging issues at the local level.

In contrast, public opinion-based weighting methods allow for greater input from the communities that are directly impacted by climate neutrality initiatives. These methods can better reflect the priorities and values of local populations, ensuring that the indicators most relevant to the public are given appropriate weight. However, relying on public opinion introduces challenges such as subjectivity, potential biases and lack of stability. Opinions can be influenced by short-term trends, misinformation, or limited understanding of long-term environmental impacts. Moreover, public opinion may vary widely across different regions, making it difficult to establish a unified, comparable framework.

The limitation here lies in finding a balance between the objectivity of statistical-based methods and the local relevance of public opinion-based methods. Neither approach alone fully captures the complexity of weighting climate neutrality indicators in a way that is both fair and effective. Our framework seeks to address some of these limitations by combining local opinion data with external reference points such as Google Trends, a method described in the previous section. This hybrid approach retains elements of local relevance while mitigating some of the volatility and bias inherent in purely opinion-driven methods. Still, more work is needed to refine these techniques, and ongoing research will focus on how to optimize the interplay between public opinion, trend-based insights, and statistical reliability. Ultimately, leveraging the strengths of both approaches will help create more robust, adaptable, and meaningful climate neutrality metrics.

7. Conclusions

The climate neutrality framework developed in this report goes beyond a technical guide for emissions reduction; it represents a transformative tool that positions rural areas at the heart of Europe's sustainability transition. By aligning with both the Long-Term Vision for Rural Areas (LTVRA) and the broader EU vision, this framework reflects the intricate relationship between local action and global sustainability goals, offering a path where rural areas can act as catalysts for systemic change.

7.1 The Intersection of Local Resilience and Global Sustainability

A core contribution of this framework is its ability to bridge local and global concerns. The LTVRA's vision of fostering resilient, dynamic, and prosperous rural communities is fundamentally linked to the EU's global ambitions under the Green Deal. The framework addresses this intersection by incorporating indicators that focus on local-level resilience, such as soil health, renewable energy adoption, and community well-being, while connecting these to larger climate neutrality goals. By doing so, When adapted and applied, the framework can help enhance the sustainability of rural communities and may also support broader efforts to reduce greenhouse gas emissions, aligning with global climate goals.

The report also highlights a significant limitation—the challenge of balancing local specificity with global comparability, particularly in terms of emissions related to food production and resource use. This underscores the complex but critical role rural areas must play in contributing to global sustainability while maintaining local relevance. While further work is needed to refine these aspects, the framework opens new possibilities for rural areas to participate in global climate efforts, not merely as sites for mitigation but as active contributors to sustainability innovations that could be scaled across Europe.

7.2 Reimagining Rural Prosperity and Inclusion

One of the more profound implications of this framework is its contribution to reimagining rural prosperity, as highlighted in the LTVRA. Traditionally, rural development has been framed through an economic lens, but this framework advances a more holistic view, in line with the LTVRA's emphasis on well-being, fairness, and inclusivity. By embedding principles of climate neutrality, it redefines prosperity not just in terms of economic growth but also in terms of environmental sustainability and equitable access to resources.

The EU's vision for prosperous and resilient rural areas is reflected in the framework's focus on inclusivity, especially for vulnerable groups, and its emphasis on renewable energy and bio-based materials as pillars of future rural economies. The framework can guide rural communities in identifying strategic opportunities that might benefit young people, entrepreneurs, and women, thereby supporting a more just and equitable transition to climate neutrality.

7.3 Policy and Governance Implications

The alignment of the framework with both the LTVRA and EU vision has profound policy implications. It suggests that for rural areas to thrive in the context of climate neutrality, policy frameworks must evolve to be more flexible, responsive, and locally driven. The participatory nature of the framework—where communities have the ability to tailor indicator weights and prioritize local solutions—calls for a shift in governance that allows rural areas to co-create their sustainability pathways. This echoes the LTVRA's vision of rural areas as places of interdependence, where local, regional, and national governance systems must work in harmony to achieve shared goals.

Future policy directions should thus focus on creating environments that support the autonomy and capacity-building of rural areas, ensuring they have access to the necessary resources, data, and technological tools and skills to drive their climate neutrality efforts. A key takeaway here is the recognition that rural areas are not passive recipients of policy but active co-creators of solutions, requiring governance models that encourage local leadership and innovation.

7.4 Toward a Sustainable and Resilient Rural Future

This climate neutrality framework offers more than a technical tool; it presents a paradigm shift in how rural areas are perceived and how they can engage with the EU's broader sustainability objectives. It aligns deeply with the LTVRA's vision of rural areas as dynamic, resilient, and inclusive spaces that actively contribute to solving global challenges. By empowering rural communities to take ownership of their climate neutrality journey, this framework contributes to a future where rural areas are not just surviving but thriving—economically, socially, and environmentally.

While challenges remain, particularly in data availability and balancing local adaptation with global comparability, the framework stands as a critical step forward. It underscores the central role of rural areas in Europe's transition to climate neutrality, positioning them as vital contributors to the EU's Green Deal and beyond. In doing so, it offers a hopeful vision of a future where rural communities are empowered to lead in sustainability, driving both local and global progress toward a more just, equitable, and resilient Europe.

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8. Annexes

Annex 8.1 - Domain literature table

Source	Term related	Paper	Environment	Economic	Social	Waste	Energy	Buildings	Agri-Food	Technology	Transport	Industry
WoS	Carbon neutrality	Adjei et al. 2022	•	•	•		•					
WoS	Carbon neutrality	Ahmad et al. 2022	•	•			•					
WoS	Carbon neutrality	Ahmed 2023	•	•			•			•		
WoS	Zero carbon	Alshuwaikhat et al. 2023	•			•	•	•			•	
WoS	Climate neutrality	Arens et al. 2021					•					
WoS	Carbon neutrality	Aziz et al. 2023	•	•	•		•					
WoS	Zero carbon	Beggs et al. 2022	•	•	•		•		•	•	•	
WoS	Climate neutrality	Bleischwitz et al. 2022		•								
WoS	Climate neutrality	Bohvalovs et al. 2023					•					
WoS	Climate neutrality	Borysiak and Brych 2022					•					
WoS	Climate neutrality	Borysiak et al. 2022a					•					
WoS	Climate neutrality	Borysiak et al. 2022b					•					
WoS	Climate neutrality	Brodny and Tutak 2023	•	•	•		•					
WoS	Carbon neutrality	Chen and Lin 2021	•	•	•		•					
Scopus	Carbon neutrality	Chen et al. 2023	•	•	•		•			•		
WoS	Carbon neutrality	Cherepovitsyna et al. 2023	•									
WoS	Carbon neutrality	Chun et al. 2023	•	•			•					
WoS	Climate neutrality	Ciambra et al. 2023	•			•	•				•	
WoS	Climate neutrality	Civiero et al. 2022						•				
WoS	Climate neutrality	Cuadros-Casanova et al. 2022	•						•			
Scopus	Climate neutrality	Dabkiene et al. 2021							•			
WoS	Carbon neutrality	Dong et al. 2022	•	•	•		•			•		

WoS	Zero carbon	Fan et al. 2022	•		•							
WoS	Zero carbon	Fankhauser et al. 2020								•		
WoS	Carbon neutrality	Feng 2022	•				•			•		
Scopus	Carbon neutrality	Feng and Pi 2023	•	•	•							
WoS	Climate neutrality	Filipovic et al. 2022	•	•	•							
WoS	Carbon neutrality	Forsius et al. 2021	•									
WoS	Zero carbon	Gambhir et al. 2017	•							•		
WoS	Zero carbon	Garvey et al. 2023	•	•	•							
WoS	Zero carbon	Guivarch and Monjon 2017					•					
WoS	Climate neutrality	Guzowska and Kryk et al. 2021	•				•					•
Scopus	Carbon neutrality	Hao and Chen 2023	•	•	•		•			•		•
Scopus	Carbon neutrality	Hashmi et al. 2023	•	•	•		•					
WoS	Carbon neutrality	Ibrahim 2022	•	•	•		•			•		•
WoS	Carbon neutrality	Immonen and Kopsakangas-Savolainen 2022			•		•					
WoS	Zero carbon	Isaksson and Rosvall 2020						•				
WoS	Carbon neutrality	Jain et al. 2017	•	•	•							
WoS	Climate neutrality	Janik et al. 2020	•				•					
WoS	Climate neutrality	Jelenski et al. 2021	•				•					
WoS	Carbon neutrality	Ji et al. 2023	•		•			•				
WoS	Carbon neutrality	Jia et al. 2022	•				•	•				
Scopus	Climate neutrality	Jiang and Kurnitskia 2023	•			•	•				•	
WoS	Carbon neutrality	Kong et al. 2023					•			•		•
WoS	Climate neutrality	Labenko et al. 2022								•		
WoS	Carbon neutrality	Lee and Jung 2023		•	•		•				•	
Scopus	Carbon neutrality	Li and Wang 2023							•	•		
WoS	Carbon neutrality	Li et al. 2022	•									
WoS	Carbon neutrality	Li et al. 2022b	•	•	•		•					•
WoS	Carbon neutrality	Li et al. 2022c	•								•	•

Scopus	Carbon neutrality	Li et al. 2023	•				•					
WoS	Carbon neutrality	Liang and Luo 2023	•	•	•							
WoS	Carbon neutrality	Liang et al. 2023		•	•		•			•		
WoS	Carbon neutrality	Liao et al. 2021	•	•	•		•			•		
Scopus	Carbon neutrality	Liao et al. 2023	•				•			•		
WoS	Carbon neutrality	Lin and Guan 2023		•								
Scopus	Carbon neutrality	Lin et al. 2022		•	•					•		
WoS	Climate neutrality	Linkevicius et al. 2023	•		•			•				
WoS	Carbon neutrality	Liu et al. 2023	•	•	•		•			•		
WoS	Carbon neutrality	Liu et al. 2023b	•	•			•			•		
WoS	Carbon neutrality	Liu et al. 2023c	•	•								
WoS	Climate neutrality	Loizia et al. 2021	•	•	•	•						•
WoS	Carbon neutrality	Luo et al. 2022	•	•			•					•
WoS	Carbon neutrality	Lyu et al. 2023										
Scopus	Carbon neutrality	Ma et al. 2023	•	•						•		
WoS	Climate neutrality	Martin et al. 2023	•		•		•					
WoS	Carbon neutrality	Mathur et al. 2022	•						•			•
Scopus	Carbon neutrality	Meng et al. 2022	•	•								•
WoS	Carbon neutrality	Moucheng and Lun 2021	•	•			•		•	•		
WoS	Climate neutrality	Myszograj and Pluciennik-Koropczuk 2022	•	•	•	•			•			•
WoS	Carbon neutrality	Niu et al. 2021	•	•			•			•	•	
WoS	Carbon neutrality	Ofori et al. 2023	•	•			•					
WoS	Climate neutrality	Oreggioni et al. 2017	•				•					
WoS	Zero carbon	Pakina and Mukhamedina 2021	•	•	•		•	•		•	•	
WoS	Carbon neutrality	Palander et al. 2020					•				•	
Scopus	Carbon neutrality	Pata et al. 2023	•				•					
WoS	Carbon neutrality	Ren and Long 2021	•	•	•		•				•	•
Scopus	Carbon neutrality	Ren et al. 2023	•	•								

WoS	Zero carbon	Rey-Hernandez et al. 2018					•	•				
WoS	Zero carbon	Saedi and Ahmadi 2023					•				•	
WoS	Climate neutrality	Sahimaa et al. 2017	•			•						
WoS	Carbon neutrality	Sarwar et al. 2022	•				•		•	•		
WoS	Climate neutrality	Satola et al. 2022						•				
WoS	Zero carbon	Shaffer et al. 2018					•			•	•	
WoS	Carbon neutrality	Shang and Lv 2023	•	•	•		•	•		•	•	
WoS	Carbon neutrality	Song et al. 2022		•	•		•			•	•	
WoS	Carbon neutrality	Su et al. 2021	•								•	
WoS	Zero carbon	Tamoor et al. 2023	•			•						
Scopus	Carbon neutrality	Tariq et al. 2023	•	•	•		•			•		
WoS	Carbon neutrality	Tian et al. 2022	•		•		•					
WoS	Climate neutrality	Topor et al. 2022	•	•								
WoS	Climate neutrality	Tortorella et al. 2020							•			•
WoS	Climate neutrality	Tutak and Brondy 2022	•	•	•		•					
WoS	Climate neutrality	Tzeiranaki et al. 2023			•		•					
WoS	Zero carbon	Uchehara et al. 2022	•	•	•						•	•
WoS	Carbon neutrality	Udemba 2021	•	•	•		•					
WoS	Zero carbon	Urrutia-Azcona et al. 2018	•	•	•	•	•			•	•	
WoS	Zero carbon	Vogt-Schilb and Hallegatte 2017		•								•
Scopus	Climate neutrality	Vollmer et al. 2023						•				
WoS	Carbon neutrality	Wang et al. 2022		•	•		•	•	•	•	•	
Scopus	Carbon neutrality	Wang et al. 2023		•						•		
WoS	Zero carbon	Xing et al. 2022	•	•			•					•
WoS	Carbon neutrality	Xu et al. 2022	•	•	•		•			•	•	
Scopus	Carbon neutrality	Xu et al. 2023	•	•	•	•	•		•	•	•	
Scopus	Carbon neutrality	Yang and Liu 2023		•	•		•			•		
WoS	Carbon neutrality	Yang and Shi 2022										

WoS	Zero carbon	Yang and Zhao 2023	•		•							
WoS	Carbon neutrality	Yang et al. 2022	•				•	•			•	•
WoS	Zero carbon	Yang et al. 2022	•	•							•	
Scopus	Carbon neutrality	Yang et al. 2023									•	•
Scopus	Carbon neutrality	Yin et al. 2023										
Scopus	Carbon neutrality	You et al. 2023	•	•	•	•	•			•		
Scopus	Carbon neutrality	Yu et al. 2023					•					
WoS	Zero carbon	Zaidan et al. 2022	•	•	•		•			•		•
Scopus	Carbon neutrality	Zhai et al. 2023	•									•
WoS	Carbon neutrality	Zhang 2023	•		•		•			•		
Scopus	Carbon neutrality	Zhang et al. 2023					•					
WoS	Carbon neutrality	Zhang et al. 2023	•		•		•				•	
Scopus	Carbon neutrality	Zhao et al. 2023	•				•					
WoS	Carbon neutrality	Zhu et al. 2022	•	•	•		•	•	•	•	•	

Annex 8.2 - Value literature table

Domain	Paper	Environmental sustainability	Reliability	Safety	Just	Accessibility/Affordability	Efficient	Resilient	Local
Energy	Niet et al. 2021	•	•	•	•				
Energy	Demski et al. 2015	•	•	•	•	•	•		
Energy	Milchram et al. 2018	•	•						
Energy	Sovacool and Brown 2010	•							
Energy	Sovacool and Mukherjee 2011					•			
Energy	Royakkers et al. 2018			•					
Energy	Christen, Gordijn and Loi 2020			•					
Energy	Jenkins et al. 2016				•				
Energy	van Summeren et al. 2020				•			•	
Energy	Bolton and Hannon 2016	•							•
Energy	Matheri et al., 2023	•					•		•
Energy	Gladkykh et al., 2021	•			•			•	•
Transportation	Green deal	•		•	•	•	•	•	
Transportation	Lowe et al., 2018	•			•	•			
Transportation	Lodovici and Torichio, 2015				•	•			
Transportation	Diu et al., 2022		•						
Transportation	Gu et al., 2020		•						
Agri-Food	Green deal	•	•		•	•		•	•
Agri-Food	Zimdahl and Holtzer 2016	•	•		•				
Agri-Food	Mechri et al., 2023	•	•			•		•	•
Agri-Food	Stefanovic et al., 2020	•	•			•		•	•
Agri-Food	Meyer 2020							•	
Agri-Food	Monirul Alam et al., 2023							•	
Agri-Food	Bisoffi et al., 2021	•	•			•			•

Agri-Food	Kontopanou and Tsoulfas 2021	•					•		
Agri-Food	Priyadarshini and Abhilash 2023	•					•	•	•
Industry	Industry 5.0	•				•	•	•	•
Industry	Valente et al., 2018	•		•					
Industry	Harsanto et al., 2023	•					•		
Industry	Olah et al., 2020	•					•		
Industry	Latif et al., 2017	•					•		
Industry	Marinagi et al., 2023			•				•	•
Industry	Riegler and Sametinger 2021						•	•	
Industry	Kaasinen et al., 2022						•	•	
Industry	Franciosi et al., 2018	•					•	•	
Waste	Waste Framework Directive	•		•			•		
Waste	Taelman et al., 2018	•					•		
Waste	Bartolacci et al., 2018					•			
Waste	Chong et al., 2016	•			•	•	•		
Waste	Avilés-Palacios and Rodríguez-Olalla 2021	•			•		•		
Waste	Rybaczewska-błażejowska et al., 2022	•					•		•
Waste	Kuznetsova et al., 2019	•					•		•
Waste	Pleissner 2016	•			•		•		•
Buildings	Renovation Wave - Green deal	•	•		•		•		
Buildings	Rodrigues et al., 2023	•			•	•			
Buildings	Karimi et al., 2022	•			•	•			

Annex 8.3 - Objective indicators table

Domain	Value	Objective Indicator	Description	Time period	Type of data provided	Scope	Data base	Downscaling	Normalizing	Comments	References
Energy	Environmental sustainability	GHG emissions from energy consumption	Quantifies greenhouse gas emissions produced through energy consumption.	2008-2021	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2008 value as the baseline, with the goal value set to 0		Ren and Sovacool 2014; Klemm and Wiese 2022; Patlitzianas et al., 2008; Ivan and Langlois 2007; Mainali et al., 2014; Sharma and Balachandra 2015; Fonseca et al., 2021
Energy	Environmental sustainability	Air pollutants from energy consumption	Quantifies air pollutants emissions produced through energy consumption.	2008-2020	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2008 value as the baseline, with the goal value set to 0		Klemm and Wiese 2022; Ivan and Langlois 2007; Mainali et al., 2014; Sharma and Balachandra 2015; Liu et al., 2013
Energy	Environmental sustainability	Waste generation from energy production	Assesses amount of waste generated during energy production processes.	2004-2020 Biannual	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Ivan and Langlois 2007
Energy	Environmental sustainability	Percentage of renewable energy in energy production	Indicates proportion of energy derived from renewable sources in overall energy mix.	2012-2021	Score	National	Euro stat		Final score is the same as the percentage value from the original data		Kruyt et al., 2009; Ren and Sovacool 2014; Klemm and Wiese 2022; Patlitzianas et al., 2008; Ivan and Langlois 2007; Mainali et al., 2014; Sharma and Balachandra 2015; Liu et al., 2013
Energy	Reliability	Hours with power outage	Measures duration of power outages within given timeframe.	No data available							Amin et al., 2023; Sharma and Balachandra 2015
Energy	Reliability	Reserve-Production ratio	Evaluates adequacy of energy reserves relative to production capacity.	1990-2022	Score	National	Euro stat		Reserve goal of 20% and baseline value of 0	Reserve goal should be adapted to local standards.	Purwanto et al., 2015; Sharma and Balachandra 2015; Carrera and Mack 2010

										Reserve calculated as Production+imports-exports-losses-final consumption	
Energy	Reliability	Self-sufficiency: Percentage of imported energy (fuel or electricity)	Determines percentage of energy sourced domestically compared to imported energy.	1990-2022	Score	National	Euro stat		Final scores are normalized between a goal value of 0 and a baseline value set at 1	Self sufficiency is calculated by imports/production	Kruyt et al., 2009; Ren and Sovacool 2014; Ivan and Langlois 2007; Mainali et al., 2014; Sharma and Balachandra 2015; Fonseca et al., 2021
Energy	Affordability	Energy price stability	Indicates stability of energy prices over time, adjusted for inflation.	2011-2022	Score	National	Euro stat		Final scores are calculated as 100 minus the original index value	Price stability index: After correcting for inflation (European inflation rate), the standard deviation was calculated for Electricity and Natural Gas prices (for households and commercial users), and devided by the period mean.	Kruyt et al., 2009; Ren and Sovacool 2014; Klemm and Wiese 2022; Sharma and Balachandra 2015; Carrera and Mack 2010; Liu et al., 2013; Fonseca et al., 2021
Energy	Affordability	Energy supply-demand ratio	Assesses balance between energy supply and demand.	1990-2022	Score	National	IEA		Final scores are calculated with ratio goal at 75%	Ratio goal was set at 75%	Kruyt et al., 2009; Ren and Sovacool 2014; Sharma and Balachandra 2015
Energy	Affordability	Share of energy expenditure from income	Calculates portion of household income spent on energy expenses.	No data available							Klemm and Wiese 2022; Ivan and Langlois 2007; Mainali et al., 2014; Sharma and Balachandra 2015

Energy	Resilience	Energy diversification index	Uses the Shannon-Weiner index to measure variety of energy sources used for supply to mitigate risks associated with overdependence.	1990-2022	Score	National	Euro stat		Final scores are normalized based on the minimum and maximum values observed across all member states		Ren and Sovacool 2014; Klemm and Wiese 2022; Sharma and Balachandra 2015; Carrera and Mack 2010
Energy	Resilience	Decentralization of energy sources	Evaluates level of renewable energy production as share of consumption.	1990-2021	Score	National	Euro stat		Final score is the same as the percentage value from the original data		Ren and Sovacool 2014; Maja et al., 2020; Sharma and Balachandra 2015
Energy	Resilience	Energy storage capacity	Assesses ability to store energy for future use at the community level.	1970-2020	Score	National	data.euro pa.e u		The European goal for storage at 2030 was used as the target value	European goal for storage was calculated by taking 2030 goals and dividing by current european population	Maja et al., 2020
Energy	Efficiency	Energy intensity (consumption per GDP)	Measures energy usage relative to economic output.	1995-2021	Score	National	Euro stat		Results are scaled using the 1995 value as the baseline, with the goal value set to 0		Ren and Sovacool 2014; Klemm and Wiese 2022; Patlitzianas et al., 2008; Ivan and Langlois 2007; Mainali et al., 2014; Sharma and Balachandra 2015
Energy	Efficiency	Electricity transmission and distribution losses	Evaluates efficiency of energy transmission and distribution systems.	1990-2022	Score	National	Euro stat		Final scores are normalized between a goal value of 0 and a baseline value set at 1		Mainali et al., 2014; Sharma and Balachandra 2015; Liu et al., 2013
Energy	Justice	Percentage of population with inability to keep the house warm	Determines percentage of population unable to maintain adequate heating in their homes.	2013-2022	Score	National	Euro stat		Final score is the same as the percentage value from the original data		Kruyt et al., 2009; Klemm and Wiese 2022; Ivan and Langlois 2007; Mainali et al., 2014; Maja et

											al., 2020; Sharma and Balachandra 2015
Energy	Justice	Disparity in electricity distribution	Assesses inequality in electricity distribution by measuring the ratio of electricity use of lower quintile to electricity use of upper quintile.	No data available							Mainali et al., 2014; Carrera and Mack 2010
Transportation	Environmental sustainability	Air pollution from transportation: passenger cars	Measures pollutants emitted by passenger cars.	1995-2021	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 1995 value as the baseline, with the goal value set to 0	Averages between three types of transport	Danielis et al., 2018; Hussain et al., 2023; Zito and Salvo 2011; Karjalainen and Juhola 2021; Kraus and Proff 2021; Yang et al., 2020
Transportation	Environmental sustainability	Air pollution from transportation:light duty vehicles	Measures pollutants emitted by light-duty vehicles.								
Transportation	Environmental sustainability	Air pollution from transportation: heavy duty vehicles and buses	Measures pollutants emitted by heavy-duty vehicles and buses.								
Transportation	Environmental sustainability	GHG emissions from transport sector	Quantifies greenhouse gas emissions from transportation sector.	2008-2021	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2008 value as the baseline, with the goal value set to 0		Danielis et al., 2018; Hussain et al., 2023; Zito and Salvo 2011; Karjalainen and Juhola 2021; Kraus and Proff 2021; Yang et al., 2020
Transportation	Environmental sustainability	Level of noise from transport in rural areas	Assesses noise pollution generated by transportation activities in rural regions.	No data available							Hussain et al., 2023; Karjalainen and Juhola 2021; Kraus and Proff 2021; Yang et al., 2020
Transportation	Reliability	Delays due to traffic congestion/Dwell time	Measures delays caused by traffic congestion or waiting times.	No data available							Hussain et al., 2023; Karjalainen and Juhola 2021; Kraus and Proff 2021
Transportation	Reliability	Public transport punctuality (measured with an average of delay times)	Evaluates reliability of transportation services based on average delay times.	No data available							Hussain et al., 2023; Karjalainen and Juhola 2021; Maja et al., 2020

Transportation	Reliability	Accessibility to essential services by public transport	Measures proximity of public transport stations to essential amenities.	Data reflecting current state	Methodology	Local	OSM		Averages distances to hospitals, schools, and shops/supermarkets. If the average distance exceeds 400 m, the category scores 0; otherwise, it scores 100. The final score is the average of the category scores	Averages distances across three different types of amenties (hospitales, schools, shops and supermarkets). If average distance is larget than 400, category recives 0 ,otherwise 100. Then score is averaged across the three categories to receive final score.	Hussain et al., 2023; Karjalainen and Juhola 2021; Yang et al., 2022; Yang et al., 2020
Transportation	Safety	Number of traffic accidents	Quantifies total number of traffic accidents within specified area and timeframe.	1999-2021	Intensities	Local (through IPAT)	Eurostat	IPAT (POP)	Results are scaled using the 1999 value as the baseline, with the goal value set to 0		Danielis et al., 2018; Hussain et al., 2023; Yang et al., 2020
Transportation	Safety	Number of fatalities and injuries (per km) from traffic	Calculates rate of fatalities and injuries per kilometer traveled.	1999-2021	Intensities	Local (through IPAT)	Eurostat	IPAT (POP)	Results are scaled using the 1999 value as the baseline, with the goal value set to 0		Danielis et al., 2018; Hussain et al., 2023; Zito and Salvo 2011; Karjalainen and Juhola 2021; Kraus and Proff 2021
Transportation	Safety	Number of crimes committed on or while waiting for public transport	Assesses safety of public transport users in terms of criminal incidents.	No data available							Hussain et al., 2023; Kraus and Proff 2021; Yang et al., 2020
Transportation	Safety	Hazardous materials incidents while transporting	Measures frequency of incidents involving hazardous materials during transportation.	No data available							Hussain et al., 2023

Transportation	Justice	Public-to-Private Transport Stock Ratio	Compares between busses and cars stocks per capita.	1990-2021	Score	NUTS 2	Euro stat		Results are scaled using the 2004 value as the baseline, with the goal value set to 0	Compared to 2004 value as it the earliest value avaulable for most regions	Danielis et al., 2018; Karjalainen and Juhola 2021; Yang et al., 2022; Yang et al., 2020
Transportation	Justice	Length of cycling and walking paths compared to roads	Measures infrastructure dedicated to non-motorized transportation modes.	Data reflecting current state	Methodology	Local	OSM		Final score is calculated as the ratio of pedestrian and cycling paths to total roads		Hussain et al., 2023; Karjalainen and Juhola 2021; Yang et al., 2020
Transportation	Justice	Portion of low-income households that spend more than 20% of their budgets on transport	Assesses financial burden of transportation costs on low-income households.	No data available							Hussain et al., 2023; Karjalainen and Juhola 2021; Yang et al., 2020
Transportation	Economic productivity	Affordability index: Transportation Costs as percentage household Income	Evaluates affordability of transportation based on household income.	2015	Score	National	Euro stat		Final scores are normalized between a goal value of 2% and a baseline value set at 30%		Zito and Salvo 2011; Karjalainen and Juhola 2021
Transportation	Economic productivity	Average commuting	Commuters as percentage of population	1999-2022	Score	NUTS 2	Euro stat		Results are scaled using the 2004 value as the baseline, with the goal value set to 0	Compared to 2004 value as it the earliest value avaulable for most regions	Danielis et al., 2018; Hussain et al., 2023; Yang et al., 2020
Transportation	Economic productivity	Total cost of public transport	Calculates expenditure on public transportation.	1995-2021	Score	National	Euro stat		Final scores are normalized with a goal of 2.6% set according to the highest percentage found in the data and a baseline of 0		Hussain et al., 2023; Karjalainen and Juhola 2021; Kraus and Proff 2021; Yang et al., 2022; Yang et al., 2020

Transportation	Smart	Energy intensity per capita for transport	Measures energy consumption per capita for transportation purposes.	1990-2021	Score	National	Eurostat		Results are scaled using the 1990 value as the baseline, with the goal value set to 0		Danielis et al., 2018; Hussain et al., 2023; Zito and Salvo 2011; Karjalainen and Juhola 2021
Transportation	Smart	Energy intensity per VKM for transport	Assesses energy consumption per vehicle-kilometer traveled.	2013-2021	Score	National	Eurostat		Results are scaled using the 2013 value as the baseline, with the goal value set to 0		Kraus and Proff 2021; Corlu et al., 2020; Jiao et al., 2022; Yang et al., 2020
Transportation	Smart	Ratio of non-fossil fuel consumption to fossil fuel consumption	Evaluates proportion of non-fossil fuel consumption relative to fossil fuel consumption.	1990-2021	Score	National	Eurostat		Results are scaled using 0 as the baseline, with the goal value set to 14% (EU goal)		Hussain et al., 2023; Karjalainen and Juhola 2021; Yang et al., 2020
Transportation	Smart	Zero emission vehicles stock compared to conventional vehicles	Compares prevalence of zero-emission vehicles to conventional vehicles.	2013-2022	Score	National	Eurostat		Final score is the same as the percentage value from the original data		Jia and Chen 2022; Axsen et al., 2022
Transportation	Resilience	Public transport system diversity (number of modes)	Assesses variety of conventional public transportation modes available.	Data reflecting current state	Methodology	Local	Google maps, Rome2Rio		Final score is the same as the percentage value from the original data	Checks the frequency of busses, trains and ferries to closest regional capital per day, then divides by 24 and averaged across the three modes (40%, 40%, 20% respectively).	Hussain et al., 2023; Karjalainen and Juhola 2021; Maja et al., 2020; Yang et al., 2020
Transportation	Resilience	Smart and Flexible transport modes	Measures availability of flexible transportation	No data available							Yang et al., 2020

			options (e.g., ride share options).								
Transportation	Resilience	Number of public transport stations/stops per sqkm	Evaluates density of public transportation infrastructure.	Data reflecting current state	Methodology	Local	OSM		Results are scaled using 0 as the baseline, with the goal value set to 1 stop per sqkm		Hussain et al., 2023; Yang et al., 2022; Yang et al., 2020
Industry	Environmental sustainability	Air pollution from Industry	Quantifies pollutants emitted by industrial activities.	2008-2021	Intensities	Local (through IPAT)	Eurostat	IPAT (POP+INCOME)	Results are scaled using the 2008 value as the baseline, with the goal value set to 0		Valente et al., 2018; Mengistu and Panizzolo 2023
Industry	Environmental sustainability	GHG emissions from Industry sector	Measures greenhouse gas emissions from industrial processes.	2008-2021	Intensities	Local (through IPAT)	Eurostat	IPAT (POP+INCOME)	Results are scaled using the 2008 value as the baseline, with the goal value set to 0		Valente et al., 2018; Abdul Shukor and Ng 2022; Yadav et al., 2017; Mengistu and Panizzolo 2023
Industry	Environmental sustainability	Industry water demand	Assesses volume of water used for industrial purposes.	No data available							Valente et al., 2018; Abdul Shukor and Ng 2022; Yadav et al., 2017; Mengistu and Panizzolo 2023
Industry	Environmental sustainability	Industry energy demand	Measures energy used industrial processes.	2010-2021	Intensities	Local (through IPAT)	Eurostat	IPAT (POP+INCOME)	Results are scaled using the 2010 value as the baseline, with the goal value set to 0		Valente et al., 2018; Abdul Shukor and Ng 2022; Yadav et al., 2017; Mengistu and Panizzolo 2023
Industry	Environmental sustainability	Share of renewables energy in Industry	Indicates proportion of renewable energy used in industrial processes.	2010-2021	Score	National	Eurostat		Results are scaled using the 2010 value as the baseline, with the goal value set to 0		Valente et al., 2018; Abdul Shukor and Ng 2022; Mengistu and Panizzolo 2023
Industry	Environmental sustainability	Total materials used by industry	Assesses amount of materials used in industrial activities.	2008-2020	Score	National	Eurostat		Results are scaled using the 2008 value as the baseline, with	Many counries values are missing	Abdul Shukor and Ng 2022; Mengistu and Panizzolo 2023

									the goal value set to 0		
Industry	Environmental sustainability	Waste generation by industrial processes	Assesses amount of waste generated within industrial sector.	2004-2020 Biannual	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Abdul Shukor and Ng 2022; Mengistu and Panizzolo 2023
Industry	Reliability	Industry downtime due to failures	Measures duration of production stoppages due to failures.	No data available							Werner et al., 2021; Sambowo and Hidayatno 2021
Industry	Safety	Frequency/No. of accidents in industry	Quantifies days lost due to accidents within industrial settings.	2008-2021	Intensities	National	Euro stat	IPAT (POP)	Results are scaled using the 2008 value as the baseline, with the goal value set to 0		Valente et al., 2018
Industry	Safety	Health and security expenses by industry	Evaluates expenditures related to health and safety measures in industrial workplaces.	No data available							Valente et al., 2018
Industry	Competitive	Industry profit	Assesses profitability as percentage of Gross Value Added.	1995-2022	Score	National	Euro stat		Final scores are normalized between a goal value of 30% and a baseline value set at 0	source for 30% value: https://www.cfajournal.org/average-profit-margin-by-industry-explanation-and-examples/	Valente et al., 2018; Mengistu and Panizzolo 2023; Sambowo and Hidayatno 2021
Industry	Digitalized	Percentage of business operations using digital tools	Measures adoption of digital technologies in business operations.	2022	Score	National	Euro stat		Final score is the same as the percentage value from the original data		Ziółkowska 2021; Kolobov and Varfolomeev 2020; Kasych et al., 2019

Industry	Digitalized	Digital skills training and adoption rates	Enterprise provided training to their personnel to develop their ICT skills	2012-2022	Score	National	Euro stat		Final score is the same as the percentage value from the original data		Yaacob et al., 2023
Industry	Resilience	Industrial supply chain diversification	Assesses diversity of import sources for raw materials.	No data available							Morage et al., 2019; Werner et al., 2021
Industry	Resilience	Disruptions in industrial production	Measures frequency of significant disruptions in production processes.	2001-2022	Score	National	Euro stat		Final scores are normalized between a goal value of 0 and a baseline value set at 1	Counts the number of times in 10 years the production has fallen (-4%) from previous year production. Value of -4% should be adjusted.	Werner et al., 2021
Industry	Resilience	Business financial reserves	Evaluates financial stability of business based on asset reserves.	1995-2022	Score	National	Euro stat		Results are scaled using the value 0 as the baseline, with the goal value set to EU average		Sambowo and Hidayatno 2021
Industry	Self-sustaining / autonomous	Self produced energy at industry	Measures percentage of energy produced internally by industry.	No data available							Franco et al., 2023
Industry	Self-sustaining / autonomous	Percentage of employees from the region	Indicates proportion of employees from the territory.	No data available							Aletdinova et al., 2021
Industry	Self-sustaining / autonomous	Percentage of local supply chain	Assesses reliance on local suppliers within industry's supply chain.	No data available							Bag et al., 2018; Li et al., 2015
Agri-food	Environmental sustainability	Organic agricultural land	Measures the share of organic agricultural land.	2012-2022	Score	National	Agri data		Final score is the same as the percentage value from the original data		Ruiz-Almeida and Rivera-Ferre 2019; van Assel et al., 2014; de Carvalho et al., 2022; Orou Sannou et al., 2023; Latruffe et al., 2016

Agri-food	Environmental sustainability	GHG emissions from agricultural activities	Quantifies greenhouse gas emissions from agricultural activities.	1995-2021	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 1995 value as the baseline, with the goal value set to 0		van Assel et al., 2014; Castillo-Díaz et al., 2023; Ruggieri et al., 2022; de Carvalho et al., 2022; Poponi et al., 2022; Latruffe et al., 2016
Agri-food	Environmental sustainability	Efficency of water usage for irrigation in agriculture	Indicates volume of water used for irrigation per ton of crops.	2017-2022	Score	National	Agri data		Final scores are normalized based on the minimum and maximum values observed across all member states		van Assel et al., 2014; Castillo-Díaz et al., 2023; Ruggieri et al., 2022; de Carvalho et al., 2022; Poponi et al., 2022
Agri-food	Environmental sustainability	Waste from agriculture	Assesses amount of waste generated within agri-food sector.	2004-2020 Biannual	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Ruggieri et al., 2022; de Carvalho et al., 2022; Poponi et al., 2022
Agri-food	Environmental sustainability	Soil Organic Carbon (SOC) content	Measures soil health in agri-food systems through the Soil Organic Carbon (SOC) content.	Data reflecting current state	Methodology	Local	https://soilgrids.org/		Results are scaled using the value of 20 (ton/ha) as the baseline, with the goal value set to 60 (ton/ha)	Values were taken for all pixels around the destination and averaged (source: https://soilgrids.org/)	Mirchooli et al., 2020; Lord and Sakrabani 2019; Lal 2016
Agri-food	Food security - Nutrition	Total of crops for Biodiesel and Bioethanol production as a percentage of the arable land	Measures proportion of arable land used for biofuel production.	2010, 2020	Score	NUTS 2	Euro stat		Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Ruiz-Almeida and Rivera-Ferre 2019; Cai et al., 2011; Fargione et al., 2008; Wiens et al., 2011
Agri-food	Food security - Nutrition	Prevalence of undernourishment in total population	Evaluates percentage of population experiencing undernourishment.	2001-2021	Score	National	FAO		Final score is the same as the percentage value from the		Ruiz-Almeida and Rivera-Ferre 2019; Nicholson et al., 2021

									original data (100-value)		
Agri-food	Food security - Nutrition	Average dietary energy supply adequacy	Measures energy intake compared to dietary recommendations.	2000-2022	Score	National	FAO		Final scores are based on a goal value of 2300 kcal, with any deviation above or below this value resulting in a lower score		Ruiz-Almeida and Rivera-Ferre 2019; de Carvalho et al., 2022; Nicholson et al., 2021
Agri-food	Food security - Nutrition	Food related outbrakes per capita	Indicates prevalence of foodborne pathogens.	2018-2022	Score	National	EFSA		Results are scaled using the 2018 value as the baseline, with the goal value set to 0		van Assel et al., 2014; Nyachuba 2010
Agri-food	Animal welfare/Justice	Share of population unable to afford a healthy diet.	Measures percentage of population unable to afford a healthy diet.	2017-2022	Score	National	FAO		Results are scaled using the 2017 value as the baseline, with the goal value set to 0		Ruiz-Almeida and Rivera-Ferre 2019; Nicholson et al., 2021
Agri-food	Animal welfare/Justice	Level of animal diseases in agri-food system	Estimated by the sale of antimicrobials for food producing animal	2010-2021	Score	National	EFSA		Results are scaled using the 2017 value as the baseline, with the goal value set to 0	Compared to value of 2017 because it is the last available value for all member state	van Assel et al., 2014; de Carvalho et al., 2022
Agri-food	Affordability	Food affordability index	Measures the difference between food CPI and genral CPI.	2000-2023	Score	National	FAO		Final scores are normalized based on the minimum and maximum values observed		van Assel et al., 2014; Nicholson et al., 2021

									across all member states		
Agri-food	Efficiency	Intensity of total pesticides use	Measures pesticide usage per value of agricultural production.	2000-2022	Score	National	EFSA		Results are scaled using the 2000 value as the baseline, with the goal value set to 0		Ruiz-Almeida and Rivera-Ferre 2019; van Assel et al., 2014; Castillo-Díaz et al., 2023; Ruggieri et al., 2022; Poponi et al., 2022
Agri-food	Efficiency	Intensity of the total fertilizer use	Measures fertilizer usage per value of agricultural production.	2000-2022	Score	National	FAO		Results are scaled using the 2000 value as the baseline, with the goal value set to 0	Final score averaged over three types of fertilizers (Nitrogen, Phosphate, Potash)	Ruiz-Almeida and Rivera-Ferre 2019; van Assel et al., 2014; Castillo-Díaz et al., 2023; Ruggieri et al., 2022; Poponi et al., 2022
Agri-food	Efficiency	Direct energy use in agriculture and food industry	Measures direct energy consumption within agri-food sector.	2010-2022	Score	National	Agri data		Results are scaled using the 2010 value as the baseline, with the goal value set to 0	Measures percentage of total energy consumption both agriculture and food industry	Ruiz-Almeida and Rivera-Ferre 2019; van Assel et al., 2014; Castillo-Díaz et al., 2023; Ruggieri et al., 2022; de Carvalho et al., 2022; Poponi et al., 2022
Agri-food	Efficiency	Food crop efficiency	Measures crop yields relative to best yields in Europe.	2000-2023	Score	National	Agri data		Final score is the same as the percentage value from the original data		Nicholson et al., 2021; Ray et al., 2013
Agri-food	Resilience	Production ratios per capita: Cereals, Meat, Fruit, Vegetables, Fish	Calculates Shannon-Weiner index of production rates for various agricultural products per capita to represent self-sufficiency.	2000-2022	Score	National	Euro stat		Results are scaled using the 2010 value as the baseline, with the goal value set to 0	Goal was set at SW value of 2	Ruiz-Almeida and Rivera-Ferre 2019; Orou Sannou et al., 2023; Nicholson et al., 2021

Agri-food	Resilience	Dependency on imported agricultural products	Measures reliance on imports relative to domestic production.	2010-2022	Score	National	FAO		Final scores are normalized between a goal value of 0 and a baseline value set at 1		Ruiz-Almeida and Rivera-Ferre 2019; van Assel et al., 2014
Agri-food	Resilience	Species variation	Estimated by farmlands birds biodiversity	1995-2020	Score	National	Agri data		Final score is the same as the percentage value from the original data		van Assel et al., 2014; Nicholson et al., 2021
Agri-food	Local	Food miles (km/kg)	Measures distance traveled per unit of food transported.	No data available							van Assel et al., 2014; Cleveland et al., 2015
Waste	Environmentally safe	GHG emissions from waste management	Quantifies greenhouse gas emissions from waste management activities.	1990-2021	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Chong et al., 2016; Wilson et al., 2015; Milutinovic et al., 2014
Waste	Environmentally safe	Air pollution from waste management	Measures air pollutants emitted from waste management processes.	1990-2021	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Chong et al., 2016; Milutinovic et al., 2014
Waste	Environmentally safe	Per capita waste generation	Assesses amount of waste generated per person.	2004-2020 Biannual	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Morage et al., 2019; Wilson et al., 2015; da Silva et al., 2019; Milutinovic et al., 2014
Waste	Reliability	Frequency of waste collection	Measures frequency of waste collection services.	No data available							Wilson et al., 2015; da Silva et al., 2019; Olay-Romero et al., 2020
Waste	Safety	Hazardous waste per capita	Quantifies amount of hazardous waste generated per person.	2004-2020 Biannual	Intensities	National	Euro stat	IPAT (POP+INCOME)	Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Wilson et al., 2015; Polaz and Teixeira 2009; Veiga et al., 2016

Waste	Safety	Proportion of hazardous waste recycled or processed through waste-to-energy (WTE) methods	Indicates proportion of hazardous waste treated or recycled.	2004-2020 Biannual	Score	National	Euro stat		Final scores are normalized between a goal value of 1 and a baseline value set at 0		Zhao et al., 2021; Chen 2018
Waste	Social sustainability	Accessibility to waste collection and disposal services	Assesses availability of waste disposal facilities, including recycling sites.	Data reflectin g current state	Methodolo gy	Local	OSM		If a recycling center exists, the indicator is scored at 100; otherwise, it is scored at 0		Wilson et al., 2015; da Silva et al., 2019; Olay-Romero et al., 2020
Waste	Financial sustainability	Taxes on landfill and incineration	Taxes levied on landfill and incineration activities.	No data available							Wilson et al., 2015; da Silva et al., 2019
Waste	Financial sustainability	Costs of waste management	Measures cost of managing one ton of municipal solid waste.	No data available							Rigamonti et al., 2016; Wilson et al., 2015; da Silva et al., 2019; Polaz and Teixeira 2009; Milutinovic et al., 2014
Waste	Circular economy	The volume of waste sent to landfill via WTE processes per capita	Measures the capacity of WTE (Waste-to-Energy).	2004-2020 Biannual	Score	NUTS 2	Euro stat		Results are scaled using the 2004 value as the baseline, with the goal value set to 0		Chong et al., 2016; Wilson et al., 2015; da Silva et al., 2019; Olay-Romero et al., 2020
Waste	Circular economy	Recycling rates	Measures proportion of materials recycled from generated waste.	2010-2020 Biannual	Score	National	Euro stat		Final score is the same as the percentage value from the original data		Rigamonti et al., 2016; Morage et al., 2019; Wilson et al., 2015; da Silva et al., 2019
Waste	Circular economy	Material recovery rates	Evaluates share of materials recycled and reintroduced into economy.	2010-2022	Score	National	Euro stat		Final score is the same as the percentage value from the original data		Rigamonti et al., 2016; Morage et al., 2019; da Silva et al., 2019; Polaz and Teixeira 2009
Waste	Decentralized	Variety of waste treatment methods utilized	Assesses diversity of waste treatment options available.	2004-2020 Biannual	Score	NUTS 2	Euro stat		Final scores are normalized between a goal value of 1	Checks for the existence of a variety	Soltanian et al., 2022; Wilson et al., 2015; da Silva et al., 2019; Olay-Romero et al., 2020

									and a baseline value set at 0	treatment methods	
Buildings	Environmental sustainability	GHG emission from buildings	Quantifies greenhouse gas emissions from construction and building activities.	2008-2022	Intensities	Local (through IPAT)	Euro stat	IPAT (POP+INCOM E)	Results are scaled using the 2008 value as the baseline, with the goal value set to 0		Felicioni et al., 2023; Foster and Kreinin 2020; Mosca and Perini 2022; Kylili et al., 2016; Rodrigues et al., 2023; Cordero et al., 2019; Bragança et al., 2010; Kamali and Hewage 2015
Buildings	Environmental sustainability	Construction waste recycled	Measures amount of construction waste recycled.	2010-2020 Biannual	Score	National	Euro stat		Results are scaled using the 2010 value as the baseline, with the goal value set to 0		Felicioni et al., 2023; Foster and Kreinin 2020; Kylili et al., 2016; Rodrigues et al., 2023; Cordero et al., 2019; Bragança et al., 2010; Sameer and Bringezu 2019; Kamali and Hewage 2015; Kono et al., 2018
Buildings	Improved quality	Acoustic performance of buildings	Assesses sound insulation capabilities of buildings.	No data available							Kylili et al., 2016; Rodrigues et al., 2023; Bragança et al., 2010; Kamali and Hewage 2015
Buildings	Improved quality	Thermal comfort within buildings	Measures indoor temperature comfort levels.	No data available							Felicioni et al., 2023; Mosca and Perini 2022; Rodrigues et al., 2023; Cordero et al., 2019; Bragança et al., 2010; Kamali and Hewage 2015
Buildings	Improved quality	Rates of building renovation	Percentage of residential buildings renovation.	2016	Score	National	BSO		Final score is the same as the percentage value from the original data		Rodrigues et al., 2023
Buildings	Safety	Indoor air quality within buildings	Evaluates air quality within buildings.	No data available							Mosca and Perini 2022; Kylili et al., 2016; Rodrigues et al., 2023; Cordero et al.,

											2019; Kamali and Hewage 2015
Buildings	Safety	Compliance with building codes and regulations	Evaluate adherence to local building codes and regulations	No data available							Rodrigues et al., 2023; Cordero et al., 2019; Kamali and Hewage 2015
Buildings	Increased social cohesion	Access to public transport from residential buildings	Assesses variety of conventional public transportation modes available.							Taken from the transportation domain: Public transport system diversity (number of modes)	Felicioni et al., 2023; Mosca and Perini 2022; Rodrigues et al., 2023; Kamali and Hewage 2015; Kono et al., 2018
Buildings	Increased social cohesion	Locally sourced materials	Assesses use of locally available materials in construction.	No data available							Felicioni et al., 2023; Cordero et al., 2019; Kamali and Hewage 2015; Kono et al., 2018
Buildings	Increased social cohesion	Mixed uses	Evaluates integration of various functions (banks, schools, restaurants, city hall and libraries) within building environments.	Data reflecting current state	Methodology	Local	OSM		Checks for the existence of amenities at the area, if exists the indicator is scored at 100; otherwise, it is scored at 0		Mosca and Perini 2022; Rodrigues et al., 2023
Buildings	Increased social cohesion	Buildings vacancy rate	Percentage of vacant buildings of total buildings stock.	No data available							Armstrong et al., 2023; Song et al., 2020; Rahman et al., 2017; Burkholder 2012
Buildings	Affordability	Housing cost overburden	Measures proportion of income spent on housing costs.	2010-2022	Score	National	Eurostat		Results are scaled using the 2010 value as the baseline, with the goal value set to 0		Cordero et al., 2019; Bragança et al., 2010; Kamali and Hewage 2015

Buildings	Smart homes	Energy efficiency in buildings	Measures energy consumption per unit area (m2).	2016-2020	Score	National	BSO		Results are scaled using the 2016 value as the baseline, with the goal value set to 0		Felicioni et al., 2023; Foster and Kreinin 2020; Mosca and Perini 2022; Kylili et al., 2016; Rodrigues et al., 2023; Cordero et al., 2019; Sameer and Bringezu 2019; Kamali and Hewage 2015; Kono et al., 2018
Buildings	Smart homes	Share of renewable energy from total consumption	Indicates proportion of renewable energy used for space and water heating	2010-2021	Score	National	Euro stat		Final score is the same as the percentage value from the original data	Ratio between space and water heating used to determine the ratio between scores	Felicioni et al., 2023; Foster and Kreinin 2020; Mosca and Perini 2022; Kylili et al., 2016; Rodrigues et al., 2023; Sameer and Bringezu 2019; Kamali and Hewage 2015
Buildings	Smart homes	Water efficiency in buildings	Measures water consumption per capita.	1990-2022	Score	National	Euro stat		Results are scaled using the 2010 value as the baseline, with the goal value set to 0		Felicioni et al., 2023; Foster and Kreinin 2020; Kylili et al., 2016; Rodrigues et al., 2023; Cordero et al., 2019; Bragança et al., 2010; Kamali and Hewage 2015; Kono et al., 2018
Buildings	Smart homes	Waste generation from residential buildings	Quantifies waste generation within households.							Taken from waste domain: Per capita waste generation	Felicioni et al., 2023; Mosca and Perini 2022; Kylili et al., 2016; Rodrigues et al., 2023; Cordero et al., 2019; Bragança et al., 2010; Kamali and Hewage 2015; Kono et al., 2018
Buildings	Smart homes	Smart meter installation rate in residential buildings	Assesses adoption rate of smart meters for monitoring energy usage.	No data available							Rodrigues et al., 2023

Instructions for Using the Accessibility to essential services by public transport indicator

1. Purpose

- This script analyzes the proximity of key amenities (hospitals, schools, supermarkets) to the nearest public transport in a specified settlement.
- It calculates distances and provides a score based on how well-connected the amenities are to public transport.

2. Running the Script

- Ensure you have Python installed on your computer along with the necessary libraries (`requests`, `geopy`, and `numpy`). If not, you can install them using pip:

pip install requests geopy numpy

- Save the script provided below to a file named `amenity_analysis.py`.

3. How to Use

- Open a terminal or command prompt and navigate to the directory where the `amenity_analysis.py` file is saved.
- Run the script by typing:

python amenity_analysis.py

- The script will prompt you to enter the name of your settlement:

Enter your settlement name:

- **Enter the name of the settlement you want to analyze. Make sure the name matches how it is listed in OpenStreetMap.

4. Understanding the Output

- The script will process the data and output:
  - **Distances**: The distances of each hospital, school, and supermarket to the nearest public transport stop.
  - **Average Distances**: The average distance for each type of amenity.
  - **Scores**: A score based on whether the average distance is within 400 meters (100 points if yes, 0 if not).
  - **Final Score**: An overall average score combining all the scores for hospitals, schools, and supermarkets.

5. Python code

```
import json
import requests
from geopy.distance import geodesic
import numpy as np

# Function to fetch data from Overpass API with error handling
def fetch_data_from_overpass(settlement_name):
    overpass_url = "http://overpass-api.de/api/interpreter"
    overpass_query = f"""
    [out:json];
    area["name"="{settlement_name}"][admin_level=8]->.searchArea;

    (
      // Fetching all types of shops
      node["shop"](area.searchArea);
      way["shop"](area.searchArea);
      relation["shop"](area.searchArea);

      // Fetching supermarkets
      node["shop"="supermarket"](area.searchArea);
      way["shop"="supermarket"](area.searchArea);
      relation["shop"="supermarket"](area.searchArea);
```

```
// Fetching schools
node["amenity"="school"](area.searchArea);
way["amenity"="school"](area.searchArea);
relation["amenity"="school"](area.searchArea);

// Fetching hospitals
node["amenity"="hospital"](area.searchArea);
way["amenity"="hospital"](area.searchArea);
relation["amenity"="hospital"](area.searchArea);

// Fetching public transport stops
node["public_transport"="platform"](area.searchArea);
way["public_transport"="platform"](area.searchArea);
relation["public_transport"="platform"](area.searchArea);

node["highway"="bus_stop"](area.searchArea);
way["highway"="bus_stop"](area.searchArea);
relation["highway"="bus_stop"](area.searchArea);

node["railway"="station"](area.searchArea);
way["railway"="station"](area.searchArea);
relation["railway"="station"](area.searchArea);

node["railway"="tram_stop"](area.searchArea);
way["railway"="tram_stop"](area.searchArea);
relation["railway"="tram_stop"](area.searchArea);

node["railway"="halt"](area.searchArea);
way["railway"="halt"](area.searchArea);
relation["railway"="halt"](area.searchArea);
```

```
  node["railway"="subway_entrance"](area.searchArea);
  way["railway"="subway_entrance"](area.searchArea);
  relation["railway"="subway_entrance"](area.searchArea);
);

out body geom;
>;
out skel qt;
"""

try:
    response = requests.get(overpass_url, params={'data': overpass_query})
    response.raise_for_status()  # Raises an HTTPError for bad responses
except requests.exceptions.HTTPError as http_err:
    print(f"HTTP error occurred: {http_err}")
    return None
except Exception as err:
    print(f"An error occurred: {err}")
    return None

# Check if the response is empty or not JSON
if response.text.strip() == "":
    print("Error: Received an empty response from the API.")
    return None

try:
    data = response.json()
except json.JSONDecodeError as json_err:
    print(f"Error decoding JSON: {json_err}")
    return None

return data
```

```
# Function to convert Overpass data to GeoJSON format
def overpass_to_geojson(overpass_data):
    elements = overpass_data.get('elements', [])
    features = []

    for element in elements:
        if 'type' in element and element['type'] in ['node', 'way', 'relation']:
            feature = {
                "type": "Feature",
                "id": element["id"],
                "properties": element.get("tags", {}),
                "geometry": {
                    "type": "Point" if element["type"] == "node" else "Polygon",
                    "coordinates": []
                }
            }
            if element["type"] == "node":
                feature["geometry"]["coordinates"] = [element["lon"], element["lat"]]
            elif element["type"] == "way":
                if "geometry" in element:
                    feature["geometry"]["coordinates"] = [[
                        [node["lon"], node["lat"]] for node in element["geometry"]
                    ]]
            features.append(feature)

    geojson_data = {
        "type": "FeatureCollection",
        "features": features
    }
    return geojson_data
```

```
# Functions to process the GeoJSON data
def filter_amenities(features, amenity_types):
   return [feature for feature in features if 'properties' in feature and 'amenity' in feature['properties'] and any(amenity_type in
feature['properties']['amenity'] for amenity_type in amenity_types)]

def filter_supermarkets(features):
   return [feature for feature in features if 'properties' in feature and 'shop' in feature['properties'] and 'supermarket' in
feature['properties']['shop']]

def get_centroid(coordinates):
   if not coordinates or len(coordinates[0]) == 0:
      return None
   coords = np.array(coordinates[0])  # assuming coordinates[0] is the outer ring of the polygon
   length = coords.shape[0]
   sum_lat = np.sum(coords[:, 1])
   sum_lon = np.sum(coords[:, 0])
   return [sum_lon / length, sum_lat / length]

def extract_point(geometry):
   if geometry['type'] == 'Point':
      return geometry['coordinates']
   elif geometry['type'] == 'Polygon':
      centroid = get_centroid(geometry['coordinates'])
      if centroid is not None:
         return centroid
      else:
         raise ValueError(f"Invalid geometry coordinates for Polygon: {geometry['coordinates']}")
   elif geometry['type'] == 'LineString':
      coords = geometry['coordinates']
      if coords:
         mid_idx = len(coords) // 2
         return coords[mid_idx]
```

```
        else:
            raise ValueError(f"Invalid geometry coordinates for LineString: {geometry['coordinates']}")
    else:
        raise ValueError(f"Unsupported geometry type: {geometry['type']}")

def find_closest_transport(amenity, transport_features):
    amenity_coords = extract_point(amenity['geometry'])  # Use extracted point
    if amenity_coords is None:
        raise ValueError(f"Invalid geometry for amenity: {amenity}")

    closest_transport = None
    min_distance = float('inf')

    for transport_feature in transport_features:
        transport_coords = extract_point(transport_feature['geometry'])  # Use extracted point

        try:
            distance = geodesic(amenity_coords, transport_coords).meters
        except ValueError as e:
            print(f"Error calculating distance between {amenity_coords} and {transport_coords}: {e}")
            continue

        if distance < min_distance:
            min_distance = distance
            closest_transport = transport_feature

    return closest_transport, min_distance

def calculate_average_distance(distances):
    if len(distances) == 0:
        return None
    return sum(distances) / len(distances)
```

```
def calculate_score(average_distance):
    if average_distance is None:
        return 0
    return 100 if average_distance <= 400 else 0

def main():
    # Prompt the user to enter their settlement name
    settlement_name = input("Enter your settlement name: ")

    # Fetch data from Overpass API
    data = fetch_data_from_overpass(settlement_name)
    if data is None:
        print("Failed to fetch data from Overpass API.")
        return

    # Convert Overpass data to GeoJSON format
    geojson_data = overpass_to_geojson(data)

    # Directly process the GeoJSON data
    features = geojson_data['features']

    hospital_features = filter_amenities(features, ['hospital'])
    shop_and_supermarket_features = filter_supermarkets(features)
    school_features = filter_amenities(features, ['school'])
    transport_features = [feature for feature in features if 'public_transport' in feature['properties'] or 'highway' in feature['properties']]

    amenity_distances = {
        'Hospitals': [],
        'Shops and Supermarkets': [],
        'Schools': []
    }
```

```
    for amenity_type, amenity_features in [('Hospitals', hospital_features), ('Shops and Supermarkets',
shop_and_supermarket_features), ('Schools', school_features)]:
        print(f"{amenity_type}:")
        for amenity in amenity_features:
            try:
                closest_transport, distance = find_closest_transport(amenity, transport_features)
                amenity_name = amenity['properties'].get('name', 'Unknown')
                amenity_type_value = amenity['properties'].get('amenity', amenity['properties'].get('shop', 'Unknown'))
                print(f"Name: {amenity_name}, Type: {amenity_type_value}, Distance to closest public transport: {distance:.2f} meters")
                amenity_distances[amenity_type].append(distance)
            except ValueError as e:
                print(f"Skipping amenity due to error: {e}")

    # Calculate average distances
    avg_hospital_distance = calculate_average_distance(amenity_distances['Hospitals'])
    avg_shop_supermarket_distance = calculate_average_distance(amenity_distances['Shops and Supermarkets'])
    avg_school_distance = calculate_average_distance(amenity_distances['Schools'])

    # Calculate scores
    hospital_score = calculate_score(avg_hospital_distance)
    shop_supermarket_score = calculate_score(avg_shop_supermarket_distance)
    school_score = calculate_score(avg_school_distance)

    # Print average distances and scores
    print("\nAverage Distances:")
    if avg_hospital_distance is not None:
        print(f"Hospitals: {avg_hospital_distance:.2f} meters")
    else:
        print("Hospitals: No data available")

    if avg_shop_supermarket_distance is not None:
```

```
        print(f"Shops and Supermarkets: {avg_shop_supermarket_distance:.2f} meters")
    else:
        print("Shops and Supermarkets: No data available")

    if avg_school_distance is not None:
        print(f"Schools: {avg_school_distance:.2f} meters")
    else:
        print("Schools: No data available")

    print("\nScores:")
    print(f"Hospitals: {hospital_score}")
    print(f"Shops and Supermarkets: {shop_supermarket_score}")
    print(f"Schools: {school_score}")

    # Calculate and print final score
    final_score = (hospital_score + shop_supermarket_score + school_score) / 3
    print(f"\nFinal Score: {final_score:.2f}")

if __name__ == "__main__":
    main()
```

Instructions for Using the Length of cycling and walking paths compared to roads indicator

1. Purpose

This script calculates the total lengths of walking paths, cycling paths, and roads within a specified settlement. Additionally, it computes a final score based on the ratio of walking and cycling paths to roads using the formula `((cycling + walking) / road) * 100`.

2. Running the Script

Ensure you have Python installed on your computer along with the necessary libraries (`requests` and `geopy`). If not, you can install them using pip:

    pip install requests geopy

Save the script provided above to a file named `path_length_calculator.py`.

3. How to Use

Open a terminal or command prompt and navigate to the directory where the `path_length_calculator.py` file is saved.
Run the script by typing:

    python path_length_calculator.py

The script will prompt you to enter the name of your settlement:

    Please enter the name of the settlement:

Enter the name of the settlement you want to analyze (e.g., `Céret`, `New York`, `Berlin`). Ensure the name matches how it is listed in OpenStreetMap.

4. Understanding the Output

The script will process the data and output:
- Total Walk Length: The total length of all footways in meters.
- Total Cycle Length: The total length of all cycleways in meters.
- Total Road Length: The total length of all roads, including primary, secondary, tertiary, residential, unclassified, service, and general roads, in meters.
- Final Score: A score calculated using the formula `((cycling + walking) / road) * 100`. This score reflects the balance between walkability/cyclability and road infrastructure in the settlement.

The output will look something like this:

    Total Walk Length: 1234.56 meters
    Total Cycle Length: 789.10 meters
    Total Road Length: 4567.89 meters
    Final Score: 44.14

5. Interpreting the Final Score

A higher score indicates a greater proportion of walking and cycling paths relative to roads, suggesting a more walkable and bike-friendly environment.
A lower score indicates a greater proportion of roads relative to walking and cycling paths.

6. Full Python Code

Below is the full Python code that you can use to calculate the path lengths and final score:

```
import requests
import json
from geopy.distance import geodesic

def calculate_length(coordinates):
    total_length = 0.0
    for i in range(1, len(coordinates)):
        point1 = (coordinates[i-1][1], coordinates[i-1][0])
        point2 = (coordinates[i][1], coordinates[i][0])
        total_length += geodesic(point1, point2).meters
    return total_length

def get_path_lengths(settlement_name):
    query = f"""
    [out:json];
    area["name"="{settlement_name}"][admin_level=8]->.searchArea;
    (
      way(area.searchArea)[highway=footway];
      way(area.searchArea)[highway=cycleway];
      way(area.searchArea)[highway~"^(primary|secondary|tertiary|residential|unclassified|service|road)$"];
    );
    out body geom;
    """
    url = "http://overpass-api.de/api/interpreter"
```

```
    response = requests.post(url, data={'data': query})

    if response.status_code == 200:
        geojson = response.json()

        total_walk_length = 0.0
        total_cycle_length = 0.0
        total_road_length = 0.0

        for element in geojson['elements']:
            if element['type'] == 'way':
                coordinates = [(node['lon'], node['lat']) for node in element['geometry']]
                length = calculate_length(coordinates)
                highway_type = element['tags'].get('highway')

                if highway_type == 'footway':
                    total_walk_length += length
                elif highway_type == 'cycleway':
                    total_cycle_length += length
                elif highway_type in ['primary', 'secondary', 'tertiary', 'residential', 'unclassified', 'service', 'road']:
                    total_road_length += length

        return {
            'total_walk_length_meters': total_walk_length,
            'total_cycle_length_meters': total_cycle_length,
            'total_road_length_meters': total_road_length
        }
    else:
        raise Exception(f"Error: {response.status_code}")

def calculate_final_score(lengths):
    total_walk_and_cycle = lengths['total_walk_length_meters'] + lengths['total_cycle_length_meters']
```

```
    total_road_length = lengths['total_road_length_meters']

    if total_road_length > 0:
        final_score = (total_walk_and_cycle / total_road_length) * 100
    else:
        final_score = 0  # If there's no road length, the score is set to 0

    return final_score

settlement_name = input("Please enter the name of the settlement: ")
lengths = get_path_lengths(settlement_name)

final_score = calculate_final_score(lengths)

print(f"Total Walk Length: {lengths['total_walk_length_meters']} meters")
print(f"Total Cycle Length: {lengths['total_cycle_length_meters']} meters")
print(f"Total Road Length: {lengths['total_road_length_meters']} meters")
print(f"Final Score: {final_score:.2f}")
```

Instructions for Using the Public transport system diversity indicator

1. Purpose

This indicator assesses the variety of conventional public transportation modes available in a given area. The goal is to provide an understanding of how diverse the local public transport system is, which may include buses, trains, and ferries. A more diverse system often indicates greater accessibility and sustainability in transport options.

2. Data Requirements
Data reflecting the current state of public transportation, including the total number of buses, trains, and ferries per day.

3. Data Sources
- Primary Sources: Google Maps, Rome2Rio, or any local transportation website. These sources will provide up-to-date information on the transportation options available for analysis.

4. Methodology Overview

1. Geographic Scope:
The analysis is performed at the local level. It focuses on the availability and frequency of public transport to the closest regional capital. This ensures the system diversity reflects connections to significant urban centers.

2. Transport Modes Considered:
The modes of public transport considered (e.g., buses, trains, ferries) depend on the availability of these modes in your region.

3. Customizing the Calculation:
- Step 1: Identify the public transportation modes available in your region. If other relevant modes such as trams or subways are present, include them in your analysis.

- Step 2: For each identified mode, determine the total number of trips per day to the nearest regional capital.

- Step 3: Assign weights to each mode based on its relative importance in your region. The total weights should sum to 1. For example:
  - If buses and trains are the primary modes of transport, you might assign them weights of 0.4 each.
  - If ferries play a smaller role, you might assign them a weight of 0.2.

- Step 4: Adjust the formula accordingly based on the modes you include and the assigned weights.

4. Formula Example (Adjustable):

Score = ((Total buses per day / 24 * 0.40) + (Total trains per day / 24 * 0.40) + (Total ferries per day / 24 * 0.20)) / 3

Adapt the formula by replacing the transportation modes and weights based on your region's available services. You can use a 7-day average to smooth out any variations between weekdays and weekends.

5. Interpretation of Results

- Higher Scores indicate a more diverse and accessible public transport system with multiple transportation options and frequent services.
- Lower Scores reflect limited diversity in public transport modes and lower frequency of services, which may highlight gaps in accessibility and sustainability.

6. Key Considerations

- Data Accuracy:
  Ensure that the data gathered from platforms like Google Maps and Rome2Rio are current, as public transport schedules can change frequently.

- Local Context:
  Adjustments may be necessary if certain public transport modes (e.g., ferries, trams) are important in your region but are not covered by this example.

Instructions for Using the Number of public transport stations/stops per square km indicator

1. Purpose

This script calculates the number of public transport stations (bus stops, tram stops, railway stations, etc.) within a specified settlement. It also computes a final score that reflects the density of public transport stations per square kilometer using the formula ((number of stations / area in sqkm) * 100).

2. Running the Script

Ensure you have Python installed on your computer along with the necessary libraries (requests). If not, you can install them using pip:

pip install requests

Save the script provided below to a file named public_transport_density.py.

3. How to Use

1. Open a terminal or command prompt and navigate to the directory where the public_transport_density.py file is saved.
2. Run the script by typing:

python public_transport_density.py

3. The script will prompt you to enter:

- The name of your settlement: e.g., Céret, New York, Berlin.
- The area of the settlement in square kilometers: Input the area of the settlement manually.

4. Ensure the settlement name matches how it is listed in OpenStreetMap.

4. Understanding the Output

The script will process the data and output:

- Total Number of Public Transport Stations: This includes bus stops, tram stops, railway stations, ferry terminals, subway entrances, and public transport platforms within the settlement.
- Total Area: The area of the settlement provided by the user.
- Final Score: This is calculated using the formula ((number of stations / area in sqkm) * 100), reflecting the density of public transport stations in the settlement.

The output will look something like this:

Total Number of Public Transport Stations: 6
Please enter the area of Céret in square kilometers: 5.23
Final Score: 114.71

5. Interpreting the Final Score

- Higher Score: A higher score indicates a denser network of public transport stations, which suggests better access to public transport options within the settlement.

- Lower Score: A lower score indicates fewer public transport stations relative to the area, which may suggest limited public transport options.

6. Full Python Code

Below is the full Python code that you can use to calculate the number of public transport stations and their density score:

```
import requests
import json

# Function to retrieve the public transport stations in the settlement area
def get_public_transport_stations(settlement_name):
    query = f"""
    [out:json];
    area["name"="{settlement_name}"][admin_level=8]->.searchArea;
    (
      node["amenity"="bus_stop"](area.searchArea);
      way["highway"="bus_stop"](area.searchArea);
      node["railway"="tram_stop"](area.searchArea);
      way["railway"="tram_stop"](area.searchArea);
      node["railway"="station"](area.searchArea);
      way["railway"="station"](area.searchArea);
      node["public_transport"="platform"](area.searchArea);
      way["public_transport"="platform"](area.searchArea);
      node["amenity"="tram_stop"](area.searchArea);
      way["amenity"="tram_stop"](area.searchArea);
      node["amenity"="subway_entrance"](area.searchArea);
      way["amenity"="subway_entrance"](area.searchArea);
      node["harbour"="ferry_terminal"](area.searchArea);
      way["harbour"="ferry_terminal"](area.searchArea);
      node["amenity"="ferry_terminal"](area.searchArea);
      way["amenity"="ferry_terminal"](area.searchArea);
    );
```

```
    out body geom;
    '''

    url = "http://overpass-api.de/api/interpreter"
    response = requests.post(url, data={'data': query})

    if response.status_code == 200:
        geojson = response.json()
        return len(geojson['elements'])
    else:
        raise Exception(f"Error: {response.status_code}")

# Function to calculate the final score based on number of stations and area
def calculate_final_score(stations_count, area_sqkm):
    if area_sqkm > 0:
        return (stations_count / area_sqkm) * 100
    else:
        return 0  # Avoid division by zero

# Main function
def main():
    settlement_name = input("Please enter the name of the settlement: ")

    # Retrieve the number of public transport stations
    stations_count = get_public_transport_stations(settlement_name)
    print(f"Total Number of Public Transport Stations: {stations_count}")

    # Ask the user to provide the area in sqkm manually
    try:
        area_sqkm = float(input(f"Please enter the area of {settlement_name} in square kilometers: "))
    except ValueError:
        print("Invalid input for area. Please enter a valid number.")
```

```
        return

    # Calculate the final score
    final_score = calculate_final_score(stations_count, area_sqkm)
    print(f"Final Score: {final_score:.2f}")

# Run the main function
if __name__ == "__main__":
    main()
```

Instructions for Using Soil Organic Carbon (SOC) Content indicator

1. Purpose

This indicator measures soil health in agri-food systems by assessing the Soil Organic Carbon (SOC) content. SOC plays a crucial role in maintaining soil fertility, supporting plant growth, and contributing to climate change mitigation through carbon sequestration.

2. Data Requirements

- Data Sources:
  - Primary Source: SoilGrids (https://soilgrids.org/), an open-access global soil information system providing up-to-date predictions of soil properties at various depths.

3. Methodology Overview

1. SOC Values Collection:
   - Step 1: Obtain SOC values for the area of interest from SoilGrids (https://soilgrids.org/).
   - Step 2: Collect SOC data for all the pixels around the destination. A pixel-based method ensures that the indicator captures the spatial variability of soil organic carbon in the study area.
   - Step 3: Average the values to get a representative SOC content for the area. Averaging across all pixels provides a reliable

reflection of the overall soil health in the region.

2. Scaling the Results:
- SOC values are scaled using the following baseline and goal:
  - Baseline value: 20 tons per hectare (ton/ha) – This represents a typical or minimum soil health level.
  - Goal value: 60 tons per hectare (ton/ha) – This reflects the target SOC content for healthy, carbon-rich soils.

4. Scale the measured SOC values by comparing them to these benchmarks, providing an indication of how close the region is to achieving optimal soil health.

Formula for Scaling (Example):
If the average SOC value for the area is 35 tons/ha:
Scaled SOC value = (Measured SOC value - Baseline value) / (Goal value - Baseline value) * 100

For example:
Scaled SOC value = (35 - 20) / (60 - 20) * 100 = 37.5%
The region would be at 37.5% of the goal SOC content.

4. Interpretation of Results

- Higher Scaled Values (closer to 100%) indicate soils with high organic carbon content, reflecting healthy soils that support sustainable agriculture and contribute to climate mitigation.
- Lower Scaled Values indicate areas where soil health may be poor, and interventions to improve soil organic matter are needed.

5. Key Considerations

- Local Context:
SOC content varies across different soil types, climates, and agricultural practices. It is important to interpret results within the context of local soil management and environmental conditions.

- Baseline and Goal Values:

The baseline (20 tons/ha) and goal (60 tons/ha) may be adjusted based on region-specific targets, agricultural policies, or natural soil conditions in the area.

Instructions for Using the Accessibility to waste collection and disposal services indicator

1. Purpose

This script is designed to help users identify and locate waste collection points and recycling stations in a specific area. It retrieves locations tagged with waste management amenities (such as recycling centers) from OpenStreetMap using the Overpass Turbo API. Additionally, it provides a final score indicating whether a recycling center exists in the settlement: a score of 100 if a recycling center is found, and 0 if not.

2. Running the Query

To use this query, follow these steps:

1. 1. Open Overpass Turbo:
   - Go to [Overpass Turbo](https://overpass-turbo.eu/).
2. 2. Paste the Query:
   - Copy and paste the provided query code (see below) into the Overpass Turbo editor.
3. 3. Enter Your Settlement Name:
   - In the query, replace the placeholder "ENTER YOUR SETTLEMENT NAME HERE" with the name of the area you're interested in.
   - Make sure the settlement name is spelled exactly as it appears in OpenStreetMap (e.g., "Paris" or "New York").
4. 4. Run the Query:
   - Click the "Run" button to execute the query and fetch results.

3. Query Code

Below is the full query code that you will need to paste into Overpass Turbo:

```
[out:json];
area["name"="ENTER YOUR SETTLEMENT NAME HERE"]["admin_level"="8"]->.searchArea;

(
  node["amenity"~"waste|recycling"]["name"](area.searchArea);
  way["amenity"~"waste|recycling"]["name"](area.searchArea);
  relation["amenity"~"waste|recycling"]["name"](area.searchArea);
  node["waste"~"collection_point"]["name"](area.searchArea);
  way["waste"~"collection_point"]["name"](area.searchArea);
  relation["waste"~"collection_point"]["name"](area.searchArea);
);
out body;
>;
out skel qt;
out tags;
```

4. How to Use

1. Choose Your Area of Interest: Replace the placeholder "ENTER YOUR SETTLEMENT NAME HERE" with the name of the settlement you're investigating.
   Example:
   - To search for recycling centers and waste points in Barcelona, change it to: area["name"="Barcelona"]["admin_level"="8"]->.searchArea;
2. Run the Query: Click the "Run" button to process the query and view the results, which will be displayed on a map.

5. Understanding the Output

The results will display all nodes, ways, and relations that correspond to waste collection points and recycling centers within the selected settlement. Specifically, the output will include:
- Waste Collection Nodes: Individual points like waste bins or smaller collection points.

- Recycling Nodes and Ways: Points or areas indicating recycling centers.
- Relations: Grouped data for complex features like larger recycling centers or waste management areas.

6. Final Score Calculation

The script includes a final indicator that reflects whether a recycling center exists in the selected area:
- Final Score:
  - If any recycling center is found within the settlement, the score is 100.
  - If no recycling center is found, the score is 0.

Instructions for Using the Mixed uses indicator

1. Purpose

This script calculates the presence of specific amenities (bank, school, townhall, library, and supermarket) within a specified settlement using OpenStreetMap (OSM) data. It assigns a score of 100 for each amenity that exists and computes a final average score based on the presence of these amenities.

2. Running the Script

Ensure you have Python installed on your computer along with the necessary libraries (osmnx, geopandas). If not, you can install them using pip:

pip install osmnx geopandas

Save the script provided below to a file named amenity_presence_score.py.

3. How to Use

1. Open a terminal or command prompt and navigate to the directory where the amenity_presence_score.py file is saved.

2. Run the script by typing:

python amenity_presence_score.py

3. The script will prompt you to enter:
- The name of your settlement (e.g., Paris, Berlin, New York).
4. The script will automatically fetch data from OpenStreetMap, so ensure the settlement name matches how it is listed in OpenStreetMap.

4. Understanding the Output

The script will process the OSM data and output:
- Amenity Counts by Type: This shows the number of occurrences of different amenities found in the specified settlement.
- Presence of Key Amenities: The script will check for the presence of five key amenities (bank, school, townhall, library, and supermarket). For each amenity that exists, it will assign a score of 100 points.
- Final Score: The average score will be calculated based on the presence of these five amenities. If all five exist, the final score will be 100.

The output will look something like this:

```
Amenity Counts by Type:
bank        5
school      3
library     2
townhall    1

Shop Counts by Type:
supermarket 4

bank exists, assigning 100 points.
school exists, assigning 100 points.
townhall exists, assigning 100 points.
library exists, assigning 100 points.
supermarket exists, assigning 100 points.
```

Average Score for Paris: 100.00

5. Interpreting the Final Score

- Higher Score: A higher score (closer to 100) indicates the presence of all key amenities, suggesting that the settlement is well-equipped in terms of these essential services.
- Lower Score: A lower score indicates the absence of some key amenities, which may suggest limited access to important services within the settlement.

6. Full Python Code

```
import osmnx as ox
import geopandas as gpd

def classify_data(settlement_name):
    # Get the OSM data for the specified settlement
    try:
        # Get the boundary of the settlement using its name
        gdf = ox.geocode_to_gdf(settlement_name)

        # Get amenities and shops within the settlement boundary
        tags = {'amenity': True, 'shop': True}
        gdf_osm = ox.geometries_from_place(settlement_name, tags)

    except Exception as e:
        print(f"Error fetching data for settlement '{settlement_name}': {e}")
        return None, None, 0

    if gdf_osm.empty:
        print(f"No OSM data found for settlement: {settlement_name}")
```

```
    return None, None, 0

# Create separate DataFrames for "amenity" and "shop" types
amenity_df = gdf_osm[gdf_osm['amenity'].notnull()][['amenity', 'geometry']]
shop_df = gdf_osm[gdf_osm['shop'].notnull()][['shop', 'geometry']]

# Count the number of amenities and shops by type
amenity_counts = amenity_df['amenity'].value_counts()
shop_counts = shop_df['shop'].value_counts()

# Display counts of amenities and shops
print("\nAmenity Counts by Type:")
print(amenity_counts)

print("\nShop Counts by Type:")
print(shop_counts)

# Check for the existence of specific amenities and assign scores
categories = ['bank', 'school', 'townhall', 'library', 'supermarket']
scores = []

for category in categories:
    # Check if the category exists in either amenity or shop DataFrames
    if category in amenity_counts.index or category in shop_counts.index:
        print(f"{category} exists, assigning 100 points.")
        scores.append(100)
    else:
        print(f"{category} does not exist, assigning 0 points.")
        scores.append(0)

# Calculate the average score
average_score = sum(scores) / len(scores)
```

```
    print(f"\nAverage Score for {settlement_name}: {average_score}")

    return amenity_df, shop_df, average_score, amenity_counts, shop_counts

if __name__ == "__main__":
    # User input for settlement name
    settlement_name = input("Enter the settlement name: ")

    # Call the classify_data function with the user-provided settlement name
    amenity_df, shop_df, final_score, amenity_counts, shop_counts = classify_data(settlement_name)

    # Return or print the final score
    if final_score is not None:
        print(f"\nFinal Score: {final_score}")

    # Display counts of amenities by type
    print("\nDetailed Amenity Counts:")
    print(amenity_counts)

    print("\nDetailed Shop Counts:")
    print(shop_counts)
```

Annex 8.5 - Survey on Public Values and Priorities for Achieving Climate Neutrality

Purpose of the Survey

This survey was conducted as part of the GRANULAR project to understand public perceptions, values, and priorities related to climate neutrality. The goal was to assess how different climate-related domains (e.g., Energy, Transportation, Industry, Waste, Agri-Food System, Buildings) are prioritized by various stakeholders across Europe. The results help inform policy development and climate neutrality strategies that align with stakeholder perspectives.

Survey Methodology

The survey consisted of 16 questions, covering:

- Demographic Information: Respondents provided details about their organization type, position, and country.
- Domain Prioritization: Participants ranked six climate neutrality domains by importance to their community.
- Additional Feedback: Open-ended responses allowed for qualitative insights.

The survey was distributed through GRANULAR consortium partners, targeting relevant stakeholders across Europe. Participation required agreement to data protection terms in accordance with the General Data Protection Regulation (GDPR).

Participants

A total of 34 respondents participated in the survey. They represented a variety of organization types, including:

Organization type	Count
Government	10
Academia	15
Private	3
NGO	6

Respondents were geographically diverse, with participation from multiple countries across Europe:

Country	Count
France	8
Italy	7
Spain	4
Greece	2
Poland	2
Netherlands	2
Tunisia	2
Sweden	1
Lithuania	1
Latvia	1
United Kingdom	1
Moldova	1
Serbia	1
Belgium	1

Key Findings

- Energy emerged as the top priority, with an average rank of 2.2.
- Waste (4.62) and Buildings (4.50) were ranked lowest.
- Agri-Food (3.03), Transportation (3.06), and Industry (3.59) occupied middle positions.
- Clustering analysis indicated that Energy was consistently ranked highest, while Waste and Buildings were deprioritized.

Annex 8.6 - Policy measures, process and impact indicators

ID	Policy Measure	Description	Current Assessment and Feasibility Conditions for Policy Implementation	Domain	Type of Policy	EEA References *	CoM References *	Indicator	Type of Indicator	Calculation Formula
1	Renewable Energy Land Allocation	Promote renewable energy through structured land allocation to ensure efficient, equitable, and environmentally responsible energy project integration.	Unused or underutilized land suitable for renewable projects, alongside local government and community's support aligned with renewable energy objectives.	Energy; Governance	Regulatory; Economic; Voluntary/ negotiated agreements; Planning	16, 74	168,196,210,223,229,232,235,2,39,82,89,102,114,139,155,243,308,148,255,263,291,323,336,353,354	Total area of land allocated for renewable energy projects annually.	Process	(Total allocated area annually (ha) / Total area under jurisdiction (ha)) * 100
								Increase in the percentage of renewable energy in the total energy mix.	Impact	(Current annual renewable energy in the total energy mix % - Previous annual renewable energy in the total energy mix %) / Previous annual renewable energy in the total energy mix % * 100
2	Renewable Gases Production Potential	Assessing and projecting the theoretical production potential of renewable gases like biogas, biomethane, and 100% renewable hydrogen to support energy sustainability efforts.	Local resources and waste management systems providing sufficient raw materials for renewable gas production, accessible and affordable technology for gas conversion.	Energy	Research	113, 122		Funds allocated for gas production research.	Process	(Total allocated funds this year ($) / Total annual budget ($)) * 100
								Total renewable gas production (e.g., biogas, biomethane) annually.	Impact	(Total production volume this year (m^3) / Total production volume last year (m^3)) * 100
3	Renewable Gases Regulations	Developing regulations to allow the injection of renewable gases into the natural gas grid, thereby enhancing energy sustainability and reducing dependency on fossil fuels.	Existing natural gas infrastructure adaptable for renewable gases, supported by political and regulatory energy transition initiatives.	Energy	Regulatory	113		Number of regulations developed and implemented.	Process	(Count of new regulations implemented this year / Count of regulations implemented last year) * 100
								Increase in renewable gas injection into the natural gas grid.	Impact	(Current year volume injected - Previous year volume injected) / Previous year volume injected * 100
4	Wind Power Feed-in Tariff	Implementation of a feed-in tariff system for wind power to incentivize and boost the production of wind energy by providing financial compensation to wind energy producers.	Abundant and untapped wind resources, financial mechanisms in place supporting investments, and the majority of community backing for wind projects.	Energy	Economic	16		Number of wind power projects initiated after implementation.	Process	(Count of new wind power projects after implementation / Total existing wind power projects before implementation) * 100

								Increase in wind energy production (MWh).	Impact	(Current production - Previous production) / Previous production * 100
5	Wind Power Tax Subsidies	Implementing tax subsidies for wind power to reduce the cost and encourage the installation and utilization of wind energy technologies.	Cost of wind technology as a barrier to its adoption, with a clear path through subsidies to reducing these costs and influencing faster market adoption.	Energy	Economic	16		Number of wind power projects benefiting from tax subsidies.	Process	(Count of subsidized wind projects this year / Total projects subsidized this year) * 100
								Reduction in average cost of wind energy production.	Impact	(Current annual average cost - Previous annual average cost) / Current annual average cost * 100
6	Wind Power Investment Subsidies	Offering investment subsidies for the establishment and operation of wind power plants, aimed at accelerating the adoption of wind energy solutions.	Recognized demand for wind power but insufficient investment due to high initial costs, where subsidies can bridge the financial gap.	Energy	Economic	16		Total investment in wind power projects subsidized.	Process	(Total subsidized investment this year ($) / Total annual energy sector investment ($)) * 100
								Increase in installed wind power capacity (MW).	Impact	(Current capacity MW - Previous capacity MW) / Previous capacity MW * 100
7	Household Heating Fuel Replacement	Encouraging the transition from traditional heating fuels such as wood and coal to more sustainable alternatives like pellets and gas.	High dependency on non-renewable heating sources, availability of more sustainable alternatives, and public willingness to transition.	Energy; Buildings	Economic	2, 12		Number of households switching from traditional to sustainable heating fuels.	Process	(Count of households transitioned this year / Total number of households in jurisdiction) * 100
								Reduction in emissions from household heating.	Impact	(Current emissions - Previous emissions) / Current emissions * 100
8	Refinery Electrolyzers Deployment	Deploying electrolyzers in refineries to enhance the production of green hydrogen, contributing to the reduction of carbon emissions and the advancement of clean energy technologies.	Refinery infrastructure capable of technologically supporting electrolyzers, clear environmental benefits, and availability of funding for green upgrades.	Energy; Buildings; Industry	Regulatory	34		Number of electrolyzers deployed in refineries.	Process	(Count of deployed electrolyzers this year / Total number of refineries) * 100
								Increase in green hydrogen production.	Impact	(Current production kg - Previous production kg) / Previous production kg * 100
9	Energy Efficiency Improvement Funding	Providing funding to enhance energy efficiency in the public sector, enabling organizations to adopt more energy-efficient practices and technologies, thereby reducing overall energy consumption.	Significant potential for energy savings within public buildings and systems.	Energy; Buildings; Industry	Economic	64, 110		Amount of funding allocated to energy efficiency projects.	Process	(Total allocated funding this year ($) / Total annual budget ($)) * 100
								Reduction in energy consumption in public sector buildings.	Impact	(Previous consumption - Current consumption) / Previous consumption * 100

10	Energy Consultancy Funding	Allocating funds for energy consultancy services for Small and Medium-sized Enterprises and local governments, as well as establishing energy advice points for all citizens to promote energy conservation and efficiency.	SMEs and local governments lacking information or resources for energy efficiency, with significant energy savings and cost reductions potential.	Energy; Buildings; Industry; Governance	Economic; Education & Information	66, 133	7,25,29,45,66,87,94,107,160,172,180,187,201,215,278,285,295,302,312,119,128,341,344,8,12,14,20,60,153,246,250,272,274,277,327,346,382,398,426	Number of households receiving consultancy services.	Process	(Count of households serviced this year / Total number of households in jurisdiction) * 100
								Increase in energy efficiency measures implemented.	Impact	(Current measures implemented - Previous measures implemented) / Previous measures implemented * 100
11	Public Lighting Efficiency System	Creating a Public Lighting Consumption Management System to replace outdated lighting with LED technology and low energy consumption lights, enhancing energy efficiency and reducing electricity costs.	Outdated lighting systems significantly contributing to municipal energy consumption, with available technology for efficient alternatives.	Energy; Buildings	Regulatory; Economic; Planning	107	288,305,306,286,303,28,46,48,53,55,67,71,72,74,120,130,136,193,202,205,206,208,216,237,239,257,258,358,360,364,365,372,376,379,387,390,400,402,409,411,428,432,440,441,443	Percentage of public lighting converted to LED.	Process	(Number of LED lights installed / Total number of public lights) * 100
								Reduction in public lighting energy consumption.	Impact	(Previous energy consumption - Current energy consumption) / Previous energy consumption * 100
12	Renewable Energy Utilization	Promote the use of renewable energy sources for electricity and heat, including biogas and small-scale biomass, through targeted funding.	Viable renewable resources and funding avenues.	Energy	Regulatory; Economic	10, 83, 84		Total capacity of renewable energy sources installed annually (MW).	Process	(Annual installed capacity MW / Total energy capacity MW) * 100
								Increase in the percentage of renewable energy in total energy consumption.	Impact	(Current % of renewable energy - Previous % of renewable energy) / Previous % of renewable energy * 100
13	Island Energy Storage Promotion	Encouraging the development of energy storage capacities on islands with isolated electrical grids to improve grid stability and integrate intermittent renewable energy sources.	Island grids isolated and benefiting significantly from energy storage to improve stability and integrate renewables, especially if funding and technical expertise are available.	Energy	Economic	108		Increase in the percentage of energy storage capacity.	Process	(Increased storage capacity MW / Total storage capacity MW) * 100
								Storage capacity as a percentage of production capacity.	Impact	(Storage capacity MW / Production capacity MW) * 100
14	Energy Construction Administrative Simplification	Simplifying administrative procedures for the construction of energy infrastructure to facilitate the development of	Bureaucratic processes significantly delaying energy project deployments, with a majority consensus to	Energy	Regulatory	3,4		Reduction in processing time for energy project approvals.	Process	(Previous processing time - Current processing time) / Previous processing time * 100

		renewable energy projects and reduce bureaucratic barriers.	streamline for efficiency and environmental gain.					Increase in the number of renewable energy projects developed.	Impact	(Number of projects this year - Number of projects last year) / Number of projects last year * 100
15	Electricity Grid Expansion Monitoring	Monitoring and controlling electricity grid expansion projects to ensure that they are developed in a sustainable and efficient manner, minimizing environmental impact and enhancing energy accessibility.	Grid infrastructure expanding, and availability of resources for monitoring and management.	Energy	Planning	78		Number of grid expansion projects monitored and controlled.	Process	(Number of projects monitored / Total number of projects) * 100
								The number of new households and businesses connected to the grid as a result of expansion.	Impact	(Number new households and businesses connected / Total number of existing connections) * 100
16	Grid Expansion Legal Acceleration	Implementing legal measures to accelerate grid expansion in approval procedures and construction phases, facilitating the integration of renewable energy sources and improving energy infrastructure.	Recognized delays in grid expansion due to legal issues, with governmental will to accelerate processes for energy infrastructure improvement.	Energy	Regulatory	79		Decrease in time required for legal approval and construction of grid expansion.	Process	(Previous time for approval and construction - Current time) / Previous time * 100
								Increase in renewable energy integration into the grid.	Impact	(Current MW of renewable energy integrated - Previous MW) / Previous MW * 100
17	Low-Emission Zones Introduction	Introducing low-emission zones in urban areas to reduce air pollution, encourage the use of cleaner transportation options, and promote environmental health and sustainability.	Urban areas suffering from high pollution levels, with public support for initiatives to improve air quality and promote healthier living conditions.	Transportation	Regulatory	5, 23, 87, 111		Number of low-emission zones implemented in urban areas.	Process	(Low-emission zones (sqkm) / Total area in jurisdiction (sqkm)) * 100
								Reduction in air pollution levels.	Impact	(Previous air pollution levels - Current air pollution levels) / Previous air pollution levels * 100
18	Vehicle Tax CO2 Component Enhancement	Strengthening the CO2 component weighting of the vehicle tax to encourage the use of low-emission vehicles and reduce greenhouse gas emissions.	Need to reduce vehicle emissions, with the government ready to implement tax measures to incentivize cleaner vehicles.	Transportation	Economic	37		Increase in the vehicle tax CO2 component.	Process	(Added tax CO2 component / tax CO2 component) * 100
								Increase in the number of low-emission vehicles registered.	Impact	(Number of low-emission vehicles this year / Total number of vehicles registered) * 100
19	Port Shore-Side Power Expansion	Expanding shore-side power supply in ports to enable ships to plug into the local electricity grid while docked, reducing emissions from idling engines and improving air quality in port areas.	Ports contributing significantly to local pollution, infrastructure capacity for shore-side power, and regulatory and industry support.	Transportation ; Energy	Planning	44		Number of ports with shore-side power facilities.	Process	(Number of ports with facilities / Total number of ports) * 100
								Reduction in emissions from ships while docked.	Impact	(Previous emissions while docked - Current emissions while docked) / Previous emissions * 100

20	Commercial Vehicle CO2 Standards	Setting European Union CO2 standards for heavy commercial vehicles and passenger cars to reduce carbon emissions, improve air quality, and encourage the adoption of more efficient, cleaner vehicles.	Need to align vehicle emissions with stricter environmental standards, EU-wide or national agreement on emission reduction targets.	Transportation	Regulatory	45, 46		Compliance rate with EU CO2 standards for commercial vehicles.	Process	(Number of vehicles compliant with standards / Total number of commercial vehicles) * 100
								Reduction in carbon emissions from commercial vehicles.	Impact	(Previous carbon emissions - Current carbon emissions) / Previous emissions * 100
21	Zero Emissions Maritime Program	Launching a maritime research program aimed at developing and promoting zero-emission ships, contributing to the reduction of maritime transport emissions and advancing sustainable shipping practices.	Maritime emissions a significant concern, strong support for research and development, and industry readiness to adopt new technologies.	Transportation	Research	56		Number of zero-emission ships developed or converted.	Process	(Number of zero-emission ships / Total number of ships) * 100
								Reduction in maritime transport emissions.	Impact	(Previous maritime emissions - Current maritime emissions) / Previous maritime emissions * 100
22	Electric Buses Integration	Integrating electric buses into public transportation networks to reduce emissions, improve air quality, and promote the use of clean, renewable energy sources in urban transit.	Urban air quality concerns and fossil fuel dependency, electric bus technology viable, and infrastructure and political support for integration into transit networks.	Transportation ; Energy	Regulatory	59		Number of electric buses integrated into public transportation networks.	Process	(Number of electric buses / Total number of buses in network) * 100
								Reduction in public transport system emissions.	Impact	(Previous transport emissions - Current transport emissions) / Previous transport emissions * 100
23	Ferry Landing Places Improvement	Upgrading ferry landing sites in Islands to enhance the efficiency and accessibility of waterborne transport, contributing to a more integrated and sustainable transportation network.	Waterborne transport infrastructure outdated, push towards enhancing efficiency and integration into the wider transport network.	Transportation	Planning	94		Number of ferry landing sites upgraded for efficiency and accessibility.	Process	(Upgraded ferry landing sites / Total number of ferry landing sites) * 100
								Increase in usage of waterborne transport and overall network efficiency.	Impact	(Current year waterborne passengers / Previous year waterborne passengers) * 100 - 100
24	Cycling Infrastructure Development	Investing in the development and maintenance of cycle paths for better connectivity, promoting cycling and reducing traffic congestion and emissions.	Growing urban congestion and demand for healthier transport alternatives, municipal planning supports cycling infrastructure.	Transportation	Planning; Economic	5, 41, 109	16	Kilometers of cycle paths developed or maintained.	Process	(Kilometers of paths developed or maintained / Total kilometers of planned paths) * 100
								Increase in cycling as a mode of transport and reduction in traffic congestion.	Impact	(Current year cycling traffic count / Previous year cycling traffic count) * 100 - 100

25	Public Transport Accessibility Enhancement	Offering free public transport to specific populations and those receiving social assistance and improving the affordability of public transport to encourage its use over private vehicles, thereby reducing traffic and emissions.	Cost as a barrier to public transport usage, and funding available to subsidize access.	Transportation	Economic	1, 40		Number of beneficiaries of free public transport and improved transport services.	Process	(Number of beneficiaries / Total population of service area) * 100
								Increase in public transport ridership.	Impact	(Current year public transport ridership / Previous year public transport ridership) * 100 - 100
26	Electric Car Purchase Incentives	Providing a buyers premium for electric cars to incentivize the purchase and use of electric vehicles, thereby reducing greenhouse gas emissions and promoting cleaner transportation.	Market for electric vehicles developing but requiring incentives for adoption, governmental and public support for cleaner transport solutions.	Transportation	Economic	35, 103		Number of electric cars sold under the incentive program.	Process	(Number of electric cars sold / Total number of cars sold) * 100
								Reduction in greenhouse gas emissions from the transport sector.	Impact	(Previous sector emissions - Current sector emissions) / Previous sector emissions * 100
27	Electric Company Car Tax Reduction	Reducing the company car tax for electric vehicles to encourage businesses to transition to cleaner, more sustainable vehicle options.	Corporate vehicle fleets significantly contributing to emissions, tax reduction supplying a sufficient motivation for businesses towards sustainable transport options.	Transportation	Economic	36		Increase in electric company cars due to tax reductions.	Process	(Number of electric company cars / Total number of company cars) * 100
								Decrease in average emissions of company car fleets.	Impact	(Previous average emissions - Current average emissions) / Previous average emissions * 100
28	Resident Parking Permit Fees	Implementing fees for residents' parking permits to regulate parking within cities, encourage the use of alternative transport modes, and reduce vehicle congestion and emissions.	Urban parking contributing to congestion and emissions, community and political support for managing vehicle use through permit fees.	Transportation	Economic; Regulatory	58		Number of resident parking permits issued with fees.	Process	(Number of permits issued / Total number of eligible residents) * 100
								Increase in alternative transport use.	Impact	(Previous year public transport tickets purchased - Current year public transport tickets purchased) / Previous year public transport tickets purchased * 100
29	Urban Entry Charges	Setting charges for entering certain city areas to reduce traffic congestion and emissions, encourage public transport use,	City centers facing severe congestion and pollution, sufficient social move towards encouraging public	Transportation	Economic; Regulatory	111		Implementation of urban entry charge systems and areas covered.	Process	(Areas covered by urban entry charges / Total urban areas) * 100

		and promote urban mobility sustainability.	transport and reducing private vehicle entries.					Reduction in number of car entries to urban areas.	Impact	((Previous year car entries - Current year car entries) / Previous year car entries) * 100
30	Vehicle Emission Labeling	Implementing a distinctive labeling system for vehicles to identify their emission categories, enabling municipalities to develop targeted environmental policies and promote the use of lower-emission vehicles.	Vehicle emissions poorly regulated, societal and political drive for transparency and sustainable choices through vehicle labeling.	Transportation	Regulatory	121		Number of vehicles labeled with emission categories compared to total vehicle stock.	Process	(Number of vehicles labeled / Total number of vehicles) * 100
								Increase in the use of lower-emission vehicles based on labeling awareness.	Impact	(Current year low-emission vehicle registrations / Previous year registrations) * 100 - 100
31	Electric Car Surcharge Reduction	Decreasing the surcharge imposed on electric car users to make electric vehicles more financially attractive and encourage their adoption over traditional fuel-powered cars.	Electric vehicles seen as too expensive compared to traditional vehicles, reduced surcharges would help to accelerate their adoption.	Transportation	Economic	38, 125		Reduction in the surcharge rate for electric cars.	Process	(Previous surcharge rate - Current surcharge rate) / Previous surcharge rate * 100
								Increase in electric car registrations post-surcharge reduction.	Impact	(Registrations post-reduction / Registrations pre-reduction) * 100 - 100
32	Long-Distance Commuter Allowance Change	Changing the commuting allowance for long-distance commuters to incentivize the use of public transport and reduce individual private transport, thus decreasing traffic and emissions.	Long-distance commuting exacerbating traffic and emissions, support for incentivizing the shift towards public transport.	Transportation	Economic	39		Change in commuter allowance.	Process	(Allowance post-change / Allowance pre-change) * 100 - 100
								Reduction in private vehicle use for long-distance commuting.	Impact	(Private vehicle use pre-change - Use post-change) / Use pre-change * 100
33	Low-Carbon Commercial Vehicle Subsidy	Encouraging the purchase of low CO2 emission vehicles, particularly heavy commercial vehicles, through subsidies, promoting cleaner transportation and reducing environmental impact.	Recognition that commercial vehicles are major polluters, political will supporting transition to lower-emission vehicles through subsidies and industry support.	Transportation ; Industry	Economic; Voluntary/negotiated agreements	42	37,76,96,129,135,220,225,289,366,367,368,371,380,417,436,442,445	Increase in low-CO2 commercial vehicles purchased with subsidies.	Process	(Subsidized low-CO2 vehicle purchases / Total commercial vehicle purchases) * 100
								Reduction in average CO2 emissions from commercial vehicles.	Impact	(Previous average emissions - Current average emissions) / Previous average emissions * 100
34	Low-Carbon Commercial Vehicle Toll Exemption	Providing toll exemptions for commercial vehicles with low-carbon drive systems to incentivize the use of cleaner, more sustainable transport	Commercial transport sector slow in adopting sustainable practices, toll exemptions providing sufficient incentive to switch to greener alternatives.	Transportation ; Industry	Economic	43		Share of toll exemptions granted for low-carbon vehicles.	Process	(Number of low-carbon vehicles receiving toll exemptions / Total number of vehicles granted toll exemptions) * 100

		options in the commercial sector.						Increase in usage of low-carbon commercial vehicles in toll areas.	Impact	(Low-carbon vehicle toll area crossings post-exemption / Pre-exemption crossings) * 100 - 100
35	Car-Sharing Scheme Introduction	Activating informal shared mobility services to improve access to remote areas and reduce individual car usage, promoting community-oriented and environmentally friendly transportation alternatives.	Limited transportation access in remote areas, community initiatives supporting car-sharing, demand for sustainable transport options.	Transportation	Voluntary/negotiated agreements; Planning	5, 26, 96	77,97,111,227,331,407	Population using car-sharing services in communities.	Process	(Population using car-sharing services / Total population in the community) * 100
								Reduction in individual car usage in areas with car-sharing services.	Impact	(Individual car ownership pre-introduction - Individual car ownership Post-introduction) / Individual car ownership Pre-introduction * 100
36	Car-Sharing Incentives	Offering tax exemptions and subsidies for car-sharing initiatives to encourage the sharing of vehicles, reduce the number of cars on the road, and lower greenhouse gas emissions.	Low uptake of car-sharing due to lack of incentives, community and governmental interest in reducing number of private vehicles on the road.	Transportation	Economic	26		Number of car-sharing programs receiving incentives.	Process	(Number of car-sharing programs receiving incentives / Total car-sharing programs) * 100
								Increase in memberships and usage rates of car-sharing programs.	Impact	(Post-incentive program memberships / Pre-incentive memberships) * 100 - 100
37	Car-Sharing Dedicated Lanes	Establishing dedicated lanes for car-sharing to enhance the efficiency and appeal of shared transportation options, reducing traffic congestion and promoting more sustainable urban travel habits.	Cities gridlocked, potential to improve traffic flow and reduce pollution through dedicated car-sharing lanes, sufficient demand and infrastructure.	Transportation	Planning	26		Number of dedicated car-sharing lanes established.	Process	(Dedicated car-sharing lanes / Total lanes in city) * 100
								Increase in efficiency and usage of car-sharing services in dedicated lanes.	Impact	(Usage of car-sharing services in dedicated lanes post-establishment / Pre-establishment) * 100 - 100
38	Smart Mobility Campaigns	Launching information and educational campaigns to promote smart mobility solutions, encouraging the adoption of more sustainable transportation practices and technologies.	Need for cultural shift towards sustainable mobility, resources available for public education and incentives for smarter travel habits.	Transportation	Education & Information	5, 86		Number of smart mobility campaigns conducted.	Process	(Smart mobility campaigns conducted / Total campaigns planned) * 100
								Increase in the usage of smart mobility solutions.	Impact	(Smart mobility users pre-campaigns / Smart mobility users post-campaigns) * 100
39	Intelligent Traffic Management	Upgrading and adapting traffic signaling devices and equipment to include advanced traffic management technologies and intelligent traffic lights powered by renewable sources, thereby	Traffic management outdated and inefficient, leading to high congestion, accessibility to advanced, energy-efficient technologies.	Transportation	Economic	5, 85		Implementation of advanced traffic management technologies.	Process	(Traffic management technologies implemented / Total planned implementations) * 100
								Reduction in traffic congestion in controlled areas.	Impact	(Congestion Levels pre-implementation - Post-

		enhancing traffic flow efficiency and reducing emissions.								implementation) / Pre-implementation * 100
40	Vehicle Emissions Remote Monitoring	Implementing a remote monitoring system for vehicle emissions to track and reduce air pollution levels, encouraging the maintenance of vehicles in eco-friendly condition.	Availability of technology for remote monitoring of vehicle emissions, and community and legislative support for environmental health initiatives.	Transportation	Regulatory	88		Number of vehicles monitored for emissions remotely.	Process	(Vehicles monitored remotely / Total vehicles eligible for monitoring) * 100
								Reduction in average emissions levels from monitored vehicles.	Impact	(Average emissions pre-monitoring - Post-monitoring) / Average emissions pre-monitoring * 100
41	Public City Bicycles System Introduction	Introducing a public city bicycle-sharing system to encourage cycling as a sustainable transportation option, reducing traffic congestion and emissions in urban areas.	Urban areas with suitable infrastructure for cycling, and community interest in sustainable transportation alternatives.	Transportation	Planning	5		Number of public city bicycles available for sharing.	Process	(Number of public bicycles available / Total population) * 100
								Increase in usage of public bicycle-sharing systems.	Impact	(Current year shared bicycle rides / Previous year shared bicycle rides - 1) * 100
42	Collective and Shared Transportation Enhancement	Enhancing the accessibility of multimodal transportation information, especially in rural areas, to promote the use of carpooling, on-demand services, and shared vehicle availability, contributing to reduced personal vehicle usage and emissions.	Availability of diverse transportation modes and technological infrastructure.	Transportation	Education & Information	25		Increase in access to multimodal transportation information.	Process	(Transport modes covered by information systems / Total transport modes) * 100
								Reduction in personal vehicle usage due to enhanced shared transportation options.	Impact	(Previous personal vehicle trips - Current personal vehicle trips) / Previous personal vehicle trips * 100
43	Electric Vehicle Refueling Infrastructure Development	Developing a comprehensive electric vehicle recharging network and refueling infrastructure for electric passenger cars, light commercial, and heavy vehicles to support the transition to electric mobility and reduce fossil fuel dependence.	Existence of a growing electric vehicle market, availability of funding, and technological capability for developing widespread refueling infrastructure.	Transportation ; Energy	Planning; Economic; Regulatory	49, 50	240,328,369,370	Number of electric vehicle charging stations installed.	Process	(Number of EV charging stations / Total planned EV charging stations) * 100
								Increase in electric vehicle usage due to improved refueling infrastructure.	Impact	(Current EV registrations / Previous EV registrations - 1) * 100
44	Inland Waterway Transport Promotion	Promoting the use of inland waterway transport to reduce road traffic congestion and emissions, leveraging waterborne transport as a more	Suitable waterway networks available, and regional interest in reducing road traffic and emissions through	Transportation	Planning; Economic	55		Increase in cargo and passenger transport via inland waterways.	Process	(Current tonnage or passengers via waterways / Previous tonnage or passengers - 1) * 100

		sustainable and efficient alternative.	alternative transport methods.					Reduction in road traffic congestion and emissions due to increased waterborne transport.	Impact	(Previous road traffic volume - Current road traffic volume) / Previous road traffic volume * 100
45	Livestock Pollution Restrictions	Implementing restrictions to reduce ammonia emissions from livestock farms, including buffer zones around sensitive areas, mandatory covers for manure containers, and reduced livestock density in nitrate-vulnerable areas, aiming to decrease agricultural pollution and protect natural habitats.	Presence of significant livestock farming activities impacting local environments, availability of sustainable farming technologies, and regulatory support.	Agri-food	Regulatory	14, 101		Implementation of livestock pollution control measures.	Process	(Measures implemented / Total planned measures) * 100
								Reduction in ammonia and other emissions from livestock farms.	Impact	(Previous emissions from farms - Current emissions from farms) / Previous emissions from farms * 100
46	Calf Barns Investment	Introducing a subsidy scheme for investments in calf barns equipped with welfare-friendly floors and ammonia-reducing systems, aimed at improving animal welfare and reducing agricultural emissions.	Government or private funding available for farm upgrades, along with an interest to move towards improving animal welfare and reducing environmental impacts of farming.	Agri-food	Economic	102		Number of calf barns upgraded with welfare-friendly and emission-reducing systems.	Process	(Upgraded calf barns / Total calf barns) * 100
								Reduction in agricultural emissions from enhanced calf barns.	Impact	(Previous agricultural emissions - Current agricultural emissions) / Previous agricultural emissions * 100
47	Food Loss Reduction Research	Conducting research activities to identify effective strategies for reducing food losses, aiming to minimize waste and improve food system sustainability.	Research institutions and funding available for studying food loss, with a goal towards enhancing food system sustainability and reducing waste.	Agri-food	Research	104		Number of research projects conducted on food loss reduction.	Process	(Research projects conducted / Total planned research projects) * 100
								Identification and implementation of strategies to reduce food loss.	Impact	(Strategies implemented / Total identified strategies) * 100
48	Food Loss Reduction Measures	Implementing regulatory activities to manage the handling of unsold, edible food, aiming to reduce food waste and encourage food redistribution or repurposing.	Legal framework allowing for the regulation of food distribution and waste, community and business willingness to engage in food redistribution or repurposing.	Agri-food	Regulatory	104		Implementation of measures to handle unsold, edible food.	Process	(Measures implemented / Total planned measures) * 100
								Reduction in food waste and increase in food redistribution or repurposing.	Impact	(Previous food waste - Current food waste) / Previous food waste * 100
49	Food Loss Consumer Education	Conducting educational activities targeted at consumers to raise awareness about food loss and	Lack of public awareness of food loss issues, availability of platforms for educational	Agri-food	Education & Information	104		Number of educational campaigns on	Process	(Educational campaigns conducted / Total planned campaigns) * 100

		waste, encouraging more sustainable food consumption and waste reduction practices.	outreach, and societal willingness to adopt more sustainable food practices.					food loss and waste.		
								Increase in consumer awareness and actions taken to reduce food waste.	Impact	(Current year campaign participants / Previous year campaign participants - 1) * 100
50	Waste Disposal Deadline Implementatio n	Setting deadlines for reducing the amount of waste disposed in non-compliant landfills, aiming to encourage waste reduction, recycling, and more sustainable waste management practices.	Legislative framework for setting and enforcing waste disposal deadlines, public awareness and support for improved waste management practices.	Waste	Regulatory	6		Deadlines set for reducing waste in non-compliant landfills.	Process	(Deadlines met / Total deadlines set) * 100
								Reduction in the amount of waste disposed in non-compliant landfills.	Impact	(Previous landfill waste volumes - Current landfill waste volumes) / Previous landfill waste volumes * 100
51	Biodegradable Waste Reduction	Setting a goal for households to separate biowaste from other municipal waste, facilitating the disposal of biodegradable materials in dedicated containers and promoting composting and other sustainable waste treatment methods.	Public acceptance and support for waste separation initiatives, availability of infrastructure for biowaste treatment, and local government policies promoting composting and recycling.	Waste	Regulatory	8		Increase in biowaste separation at the household level.	Process	(Number of households separating biowaste / Total households) * 100
								Reduction in landfill biodegradable waste due to effective separation and treatment.	Impact	(Previous landfill biodegradable waste - Current landfill biodegradable waste) / Previous landfill biodegradable waste * 100
52	Landfill Gas Management Regulations	Implementing regulations for landfills to ensure the collection and treatment of landfill gas, thereby reducing methane emissions and exploiting the gas for energy production or flaring it safely.	Regulatory capability to enforce landfill gas management, technological solutions for gas collection and treatment, and a push for reducing greenhouse gas emissions from landfills.	Waste	Regulatory	8, 15		Implementation of landfill gas collection systems.	Process	(Landfills with gas collection systems / Total landfills) * 100
								Reduction in methane emissions from landfills.	Impact	(Previous methane emissions - Current methane emissions) / Previous methane emissions * 100
53	Waste Reduction Educational Activities	Conducting educational activities focused on waste reduction, informing the public about sustainable waste management practices and encouraging reduced consumption and increased recycling.	Existence of platforms for public education on waste management, societal interest in sustainability, and governmental or organizational support for educational campaigns.	Waste	Education & Information	6		Increase in public participation in waste reduction activities.	Process	(Participants in waste reduction activities / Total community members) * 100
								Increase in recycling rates and decrease in waste production.	Impact	(Current recycling rate / Previous recycling rate - 1) * 100

54	Recycling Cost Reduction for Waste Sorters	Offering lower recycling costs to waste holders who reduce their waste volume or sort their waste properly, incentivizing waste reduction and proper waste segregation.	Financial mechanisms to reduce recycling costs for participants, public engagement in waste reduction efforts, and infrastructure to support waste sorting and recycling.	Waste	Economic	81		Cost reduction for sorters.	Process	(Previous recycling cost rate - Current recycling cost rate) / Previous recycling cost rate * 100
								Increase in waste sorting due to reduced costs for sorters.	Impact	(Current year sorted waste volume / Previous year sorted waste volume - 1) * 100
55	Waste Treatment Taxation	Implementing taxation policies for waste treatment based on the amount of waste created, encouraging households and local authorities to reduce waste generation and promote more sustainable waste management strategies.	Governmental capability to implement and enforce waste treatment taxes, public acceptance of the tax as an incentive to reduce waste, and support for sustainable waste management strategies.	Waste	Economic	30, 81		Increase in waste treatment tax per kg of waste.	Process	(Previous cost of waste treatment per kg - Current cost of waste treatment per kg) / Previous cost of waste treatment per kg * 100
								Reduction in total waste generated by households and businesses.	Impact	(Previous total waste - Current total waste) / Previous total waste * 100
56	Recycling Centers Establishment	Establishing recycling centers to enhance municipal waste management, incorporating on-site composting systems for organic waste.	Community demand for improved waste management facilities, availability of space and funding for recycling centers, and commitment to enhancing local recycling efforts.	Waste; Energy	Planning; Regulatory; Research	6	350	Number of new recycling centers established.	Process	(New recycling centers / Total recycling centers) * 100
								Increase in the amount of waste processed through recycling centers.	Impact	(Current year waste processed / Previous year waste processed - 1) * 100
57	Investment in Waste Recovery Technologies	Investing in modern technologies that facilitate material recovery and chemical recycling of waste, promoting circular economy principles and reducing landfill reliance.	Investment in technology and infrastructure for waste recovery, government support for circular economy initiatives, and market demand for recycled materials.	Waste	Economic	6		Investment amount in waste recovery technology.	Process	(Total investment in waste recovery in current year ($) / Total waste disposal budget) * 100
								Increase in material recovery rate.	Impact	(Current year material recovery rate / Previous year rate - 1) * 100
58	Source Waste Separation Increase	Implementing a door-to-door waste collection system to enhance recycling rates by improving the separation of waste at the source, encouraging more efficient recycling practices and reducing contamination in recycling streams.	Availability of infrastructure for door-to-door waste collection, public willingness to participate in source separation, and support for enhancing local recycling rates.	Waste	Regulatory; Economic	7, 28,31	156,176,183,211,224,230,233,236,268,281,298,115,124,140,21,42,90,103,38,149,244,347	Share of households included in door-to-door waste collection system.	Process	(Households included in door-to-door waste collection system / Total households) * 100
								Increase in source-separated waste collection.	Impact	(Current year source-separated waste / Previous year waste - 1) * 100
59	Mandatory Biowaste Sorting	Introducing mandatory biowaste sorting for all sectors, including households, to facilitate the recycling of organic waste and	Legislative backing for mandatory biowaste sorting, public education on the benefits of organic waste	Waste	Regulatory	29,77		Compliance rate with biowaste sorting regulations.	Process	(Compliant households / Total households required to comply) * 100

		support the production of compost and biogas, contributing to a more sustainable waste management system.	recycling, and infrastructure to handle separated biowaste.					Increase in biowaste processing.	Impact	(Current year biowaste processed / Previous year biowaste processed - 1) * 100
60	Producer Recycling Responsibility	Extending producer responsibility to all packaging and many plastic products currently not covered, requiring producers to manage and recycle their products at the end of their life cycle, thus reducing waste and encouraging more sustainable product design and packaging.	Comprehensive legal frameworks for extended producer responsibility, industry readiness to adapt, and consumer demand for sustainable packaging.	Waste	Regulatory	82		Number of producers adhering to extended producer responsibility regulations.	Process	(Compliant producers / Total producers) * 100
								Reduction in packaging and plastic waste due to producer recycling measures.	Impact	(Previous packaging waste - Current packaging waste) / Previous packaging waste * 100
61	Home Composting Equipment Provision	Providing households with the necessary equipment for home composting, encouraging the reduction of organic waste disposal and promoting the conversion of biowaste into valuable compost for gardening and agricultural use.	Availability of resources for providing composting equipment, and community interest in reducing organic waste.	Waste	Voluntary/negotiated agreements	6		Number of composting kits distributed to households.	Process	(Number of composting kits distributed / Total number of households) * 100
								Increase in household organic waste composting rates.	Impact	(Current year composting households / Previous year composting households - 1) * 100
62	Settlement and Road Development Limitation	Limiting land consumption for new settlements and roads by excluding additional areas from development, aiming to reduce habitat fragmentation, protect natural landscapes, and promote sustainable urban planning and development strategies.	Regulatory support for limiting land consumption, community backing for preserving natural landscapes, and integrated urban planning initiatives.	Buildings; Environmental Policy; Governance	Planning; Regulatory	73	52	Reduction in land allocated for new settlements and roads.	Process	(Land allocated previous year - Land allocated current year) / Land allocated previous year * 100
								Preservation of natural landscapes and reduced habitat fragmentation.	Impact	(Previous year fragmented habitats - Current year fragmented habitats) / Previous year fragmented habitats * 100
63	Land Use and Building Act Revision	Revising the Land Use and Building Act to include specific provisions demanding energy and resource efficiency in the renovation of buildings, aiming to improve the energy performance and sustainability of existing infrastructure.	Legal and regulatory willingness to update building acts, societal demand for energy efficiency, and technological solutions for sustainable renovations.	Buildings	Regulatory	17		Revisions made to the Land Use and Building Act for energy and resource efficiency.	Process	(Revisions made / Total potential revisions) * 100
								Improvement in the energy efficiency of renovated buildings.	Impact	(Energy saved from renovated buildings / Total energy previously used by renovated buildings) * 100

64	Residential Energy Renovation Support	Providing financial support for energy renovations of residential buildings to meet Net Zero-Energy Building standards, encouraging homeowners to improve energy efficiency and reduce energy bills through state aid and local community programs.	Availability of funding for residential energy upgrades, public awareness of energy efficiency benefits, and local programs supporting home renovations.	Buildings; Energy	Economic	93, 117	69,355,357,37 3,381,410,418 ,438,444	Amount of financial support provided for energy renovations.	Process	(Total funding for residential energy renovations ($) / Total annual budget for housing and energy ($) * 100)
								Reduction in energy consumption in renovated residential buildings.	Impact	(Previous energy consumption - Current energy consumption) / Previous energy consumption * 100
65	Local Authority Building Standards	Mandating new buildings owned by local authorities to adhere to exemplary energy and environmental standards, serving as a model for sustainable construction practices and energy efficiency in the public sector.	Local authority commitment to high environmental standards, availability of sustainable building technologies, and public sector leadership in energy efficiency.	Buildings; Energy	Regulatory	22, 62, 92		Share of new buildings meeting high energy and environmental standards.	Process	(Number of compliant buildings / Total new buildings) * 100
								Improvement in energy efficiency and environmental sustainability in public buildings.	Impact	(Previous energy consumption - Current energy consumption) / Previous energy consumption * 100
66	Retail Centre Development Regulation	Strengthening regulatory measures to control the development of major retail centers, aiming to prevent disruptive land use changes and reduce the increase in transportation needs and emissions associated with reliance on private car transportation for shopping.	Regulatory frameworks to manage retail development, community resistance to unchecked retail sprawl, and initiatives aimed at reducing car dependency.	Buildings; Transportation	Regulatory	19		Regulation measures implemented to control retail center development.	Process	(Regulation measures implemented / Total possible regulation measures) * 100
								Reduction in new retail center developments in unsuitable areas.	Impact	(Number of developments in unsuitable areas previous year - Current year) / Number of developments in unsuitable areas previous year * 100
67	City Center Revitalization Funds	Allocating funds to revitalize city centers, specifically addressing the containment of urban sprawl and reducing soil artificialization, promoting more compact, sustainable urban development and preserving natural habitats.	Financial resources dedicated to urban revitalization, public support for compact city development, and strategies to combat urban sprawl.	Buildings	Economic	21		Funds allocated for city center revitalization projects.	Process	(Funds allocated for city center projects ($) / Total annual urban development budget ($)) * 100
								Improvement in urban compactness and reduced urban sprawl.	Impact	(Decrease in urban sprawl area / Total urban area) * 100
68	Essential Daily Services Accessibility	Ensuring the provision of essential services needed for daily life within a 15-minute walking or cycling distance from	Urban planning focused on accessible services, commitment to reducing reliance on vehicles, and	Buildings; Transportation	Planning	91		Increase in services accessible within a	Process	(Population living in areas with services accessible within 15 minutes / Total population) * 100

		one's residence, promoting local accessibility and reducing the need for motorized transportation.	support for pedestrian-friendly communities.					15-minute walk or cycle.		
								Reduction in motorized transportation due to improved service accessibility.	Impact	(Previous year motorized trips - Current year motorized trips) / Previous year motorized trips * 100
69	Residential Renewable Energy Funding	Providing funding for the installation of renewable energy systems in residential buildings, encouraging homeowners to adopt solar panels, wind turbines, and other renewable energy sources to reduce reliance on fossil fuels and lower energy bills.	Financial mechanisms for supporting residential renewable energy projects, homeowner interest in sustainable energy, and available renewable technologies.	Buildings; Energy	Economic	117		Share of funding provided for residential renewable energy installations.	Process	(Total funding for residential renewable energy ($) / Total annual energy budget ($)) * 100
								Increase in renewable energy systems installed in residential areas.	Impact	(Renewable energy systems installed current year / Renewable energy systems installed previous year - 1) * 100
70	Renewable Energy Cost Reduction	Exempting industries from renewable energy source levies and energy taxes to reduce the operational costs of renewable energy usage, making sustainable energy solutions more attractive and affordable for businesses.	Policy incentives to make renewable energy more affordable for businesses, industry demand for lower operational costs, and government support for clean energy.	Energy; Industry	Economic	60, 61		Reduction in renewable energy source levies and taxes for industries.	Process	(Reduction in levies and taxes ($) / Total previous levies and taxes ($)) * 100
								Increase in renewable energy usage by businesses due to reduced costs.	Impact	(Current year business renewable energy usage / Previous year business renewable energy usage - 1) * 100
71	Industry Renewable Energy Funding	Allocating funds specifically for the adoption of renewable energy solutions within the industrial sector, supporting businesses in transitioning to cleaner energy sources and reducing industrial carbon footprints.	Targeted funding for industrial renewable energy projects, industrial commitment to reducing carbon footprints, and available clean energy technologies.	Industry; Energy	Economic	72, 119		Amount of funds allocated for renewable energy in the industrial sector.	Process	(Funds allocated for industrial renewable energy ($) / Total annual industrial sector budget ($)) * 100
								Increase in renewable energy usage.	Impact	(Current year renewable energy usage / Previous year usage - 1) * 100
72	Industry Mandatory Energy Audit	Introducing mandatory energy audits for the industry to assess and improve the efficiency of industrial processes, promoting the transition to less energy-intensive operations and encouraging the adoption of energy-saving measures.	Regulatory framework for mandatory energy audits in the industry, technological solutions for energy efficiency, and industry commitment to sustainable practices.	Industry; Energy	Regulatory; Research	70	280,307,10,83,265,322	Number of factories which conducted a mandatory energy audits.	Process	(Factories which conducted energy audits / Total number of factories) * 100
								Reduction in energy consumption	Impact	(Energy consumption in industry before audits - After audits) / Before audits * 100

								following audit recommendations.		
73	Cross-Sector Smart Technology Funding	Providing funding for the development and implementation of cross-cutting and smart process technologies, with a focus on supporting research and development by various industries.	Cross-industry support for smart technology, funding availability, and industry demand for innovative solutions to improve efficiency and sustainability.	Industry; Energy	Economic	62, 95		Investment in cross-sector smart technologies.	Process	(Funds allocated for smart technologies ($) / Total annual budget for tech development ($)) * 100
								Number of industries implementing new smart technologies.	Impact	(Industries implementing smart tech / Total industries) * 100
74	Smart Cooling Technology Funding	Allocating funds for the development and deployment of smart cooling technologies, aimed at improving energy efficiency in cooling systems and reducing the energy consumption and environmental impact of refrigeration and air conditioning.	Investment in cooling technology innovations, industry demand for energy-efficient cooling systems, and environmental goals targeting reduced energy consumption.	Industry; Energy	Economic	62, 95		Funding allocated for smart cooling technology projects.	Process	(Funds allocated for cooling tech ($) / Total budget for energy efficiency ($)) * 100
								Reduction in energy use due to improved cooling efficiencies.	Impact	(Energy use before implementation - After implementation) / Before implementation * 100
75	Industry Energy Efficiency Networks	Establishing Energy Efficiency Networks for industry to bring together groups of industrial companies, often within the same sector or region, to collaboratively identify and implement energy-saving opportunities, aiming to reduce overall energy consumption and enhance sectoral sustainability.	Industry cooperation in energy efficiency, and sector-specific sustainability goals.	Industry; Energy	Voluntary/negotiated agreements	68		Number of industries participating in energy efficiency networks established.	Process	(Number of industries participating in energy efficiency networks / Total industries) * 100
								Energy savings achieved within networked industries.	Impact	(Energy use before implementation - After implementation) / Before implementation * 100
76	Public Alert System Improvements	Improving public alert systems for risks or emergencies to enhance public safety and preparedness, ensuring timely and effective communication of risks and emergency instructions to the public.	Government and community support for improved public alert systems, technological infrastructure for timely alerts, and public education on emergency response.	Governance; Environmental Policy	Education & Information		5,23,33,41,64,85,92,105,158,178,185,199,213,270,283,293,300,310,117,126,151,325,339,342,393	Share of improvements made to public alert systems.	Process	(Improvement measures implemented / Total planned improvements) * 100
								Increase in public awareness and responsiveness during emergencies.	Impact	(Post-improvement response rates / Pre-improvement rates - 1) * 100
77	Environmental Education Program Development	Developing an Environmental Education Program in schools to increase environmental awareness and understanding among students, fostering a generation that is	Commitment to environmental education, availability of educational resources and programs, and support from schools	Governance; Environmental Policy	Education & Information		399	Environmental Education Programs developed and implemented in schools.	Process	(Programs implemented / Total schools) * 100

		knowledgeable and committed to sustainable practices and conservation.	and communities for sustainability education.					Increase in student participation in environmental education programs.	Impact	(Post-program participation rate / Pre-program rate - 1) * 100
78	Water Collection and Reuse Systems	Installing water tanks for water collection and reuse in public spaces and buildings, promoting water conservation and enabling the use of rainwater for non-potable purposes, thereby reducing the demand on municipal water supplies.	Infrastructure for water collection and reuse, public support for water conservation, and local government initiatives promoting sustainable water management.	Buildings	Planning; Economic; Regulatory		4,22,40,63,84,91,104,157,177,184,198,212,269,282,292,299,309,116,125,141,245,150,324,338,348,385,405	Number of water collection and reuse systems installed.	Process	(Systems installed / Total possible installations) * 100
								Reduction in municipal water use due to installed systems.	Impact	(Water use before systems - After systems) / Before systems * 100
79	Local Renewable Energy Community Creation	Creating a local community of renewable energy producers to foster collaborative energy production and sharing, encouraging the adoption of renewable energy sources and promoting community-led sustainable energy initiatives.	Community interest in renewable energy, frameworks for cooperative energy production, and local initiatives supporting sustainable energy practices.	Energy; Governance	Planning; Voluntary/negotiated agreements		175,197,267,110,226,275,297,3,31,62,78,80,95,173,256,317,437	Share of population participating in local renewable energy communities.	Process	(Population participating in local renewable energy communities / Total population) * 100
								Increase in locally produced and shared renewable energy.	Impact	(Energy produced by communities this year / Last year - 1) * 100
80	Municipal Photovoltaic Panel Installation	Installing photovoltaic panels on municipal buildings to generate clean, renewable energy, reducing municipal energy costs and contributing to the community's renewable energy goals.	Availability of suitable municipal buildings for photovoltaic panel installation, budget allocations for renewable energy initiatives, and community support for green energy solutions.	Buildings; Energy	Economic; Regulatory		238,287,304,145,161,36,51,56,68,109,247,248,252,259,261,313,319,320,329,330,356,386,391,395,401,416,431,435	Number of municipal buildings with installed photovoltaic panels.	Process	(Buildings with PV panels / Total municipal buildings) * 100
								Reduction in municipal energy costs due to generated solar power.	Impact	(Energy costs before PV installation - After PV installation) / Before installation * 100
81	Water Scarcity Management Plan	Developing a water management plan to address water scarcity, implementing measures to ensure water savings and conservation, and promoting sustainable water use practices to preserve water resources.	Regions experiencing water scarcity, availability of technical solutions for water management, and community and political will to implement water conservation practices.	Environmental Policy; Governance	Planning; Regulatory		316,318,17,18,57,99,112,134,142,164,188,204,207,251,334,359,384,394,408,415,439	Number of measures developed to address water scarcity.	Process	(Water measures developed / Total needed measures) * 100
								Reduction in water usage.	Impact	(Previous water usage - Current water usage) / Previous water usage * 100
82	Biomass Heating	Creating biomass heating networks in different municipal areas to provide sustainable	Municipal areas with sufficient biomass resources, availability of	Energy	Planning; Economic		32,123,182,241,262,290,337	Biomass heating networks	Process	(Biomass networks developed / Total planned networks) * 100

	Network Development	heating solutions, utilizing organic waste materials for energy production and reducing reliance on fossil fuel heating systems.	technology for biomass energy production, and support for sustainable heating solutions.				,378,383,397,429,430	developed within municipal areas.		
								Reduction in fossil fuel use.	Impact	(Previous fossil fuel usage - Current fossil fuel usage) / Previous fossil fuel usage * 100
83	Climate Change Information Campaigns	Carrying out information and awareness campaigns focused on climate change, aiming to educate the public on the causes, impacts, and solutions to climate change, and encouraging individual and collective actions to mitigate its effects.	Availability of resources for campaign execution, and public and political will to engage in climate action.	Environmental Policy; Governance	Education & Information		26,49,121,191,192,194,253,421,424,434	Share of population exposed to climate change information and awareness campaigns.	Process	(Population exposed to campaigns / Total population) * 100
								Increase in public knowledge and actions taken to mitigate climate change effects as measured by surveys.	Impact	(Post-campaign survey score / Pre-campaign score - 1) * 100
84	Elected Officials Environmental Training	Implementing a training and awareness plan for elected officials on environmental management, equipping them with the knowledge and tools to make informed decisions and implement sustainable policies and practices in their communities.	Training programs available for elected officials, recognition of the need for environmental literacy in governance, and support for policy implementation at local levels.	Governance; Environmental Policy	Education & Information; Planning		271,284,294,301,311,171,186,200,214,118,127,159,179,70,73,79,98,152,260,332,340,343,352,446	Environmental training programs conducted for elected officials.	Process	(Officials trained / Total officials needing training) * 100
								Increase in sustainable policies and practices implemented by trained officials.	Impact	(Policies implemented post-training / Policies before training - 1) * 100
85	Building Insulation Update Encouragement	Encouraging the replacement of obsolete insulation materials in buildings to enhance energy efficiency, reduce heat loss, and lower heating and cooling costs, contributing to improved building sustainability and comfort.	Availability of funding for building upgrades, public awareness of the benefits of insulation, and incentives for homeowners and builders to adopt energy-efficient practices.	Buildings; Energy	Regulatory; Economic		203,221,362,363,388	Number of buildings updated with new insulation materials.	Process	(Buildings updated / Total buildings targeted) * 100
								Reduction in overall energy consumption due to insulation improvements.	Impact	(Previous energy consumption - Current energy consumption) / Previous energy consumption * 100
86	Road Safety and Land Degradation Prevention Maintenance	Conducting maintenance activities for road safety and the prevention of land degradation, aiming to ensure safe and sustainable transportation infrastructure and protect	Commitment to improving road safety and environmental sustainability, availability of maintenance resources, and community support for preserving	Transportation; Environmental Policy	Regulatory; Planning		218,219,403,413,414	Share of funds utilized for road maintenance and land degradation prevention.	Process	(Funds utilized for road maintenance and land degradation prevention / Total budget for road maintenance and land degradation prevention) * 100

		surrounding landscapes and ecosystems.	landscapes and ecosystems.					Reduction in accidents and land degradation incidents.	Impact	(Previous incidents - Current incidents) / Previous incidents * 100
87	Energy-Efficient Appliances Replacement	Encouraging the replacement of old, inefficient appliances with modern, energy-efficient models to reduce energy consumption and environmental impact, supporting households and businesses in transitioning to more sustainable energy use.	Availability of energy-efficient appliances, incentive programs for appliance replacement, and public awareness of energy consumption impacts.	Energy; Buildings	Economic; Regulatory		314,361	Number of energy-efficient appliances replacing old models.	Process	(Appliances replaced / Total appliances targeted for replacement) * 100
								Decrease in energy consumption due to new efficient appliances.	Impact	(Previous energy consumption - Current energy consumption) / Previous energy consumption * 100
88	Eco-Sustainable Tree Planting	Planting trees following eco-sustainable practices to enhance urban green spaces, improve air quality, and contribute to biodiversity and ecosystem resilience, promoting environmental sustainability and community well-being.	Public and private support for urban greening, and availability of spaces for tree planting.	Environmental Policy; Agri-Food	Planning; Voluntary/negotiated agreements		217,406	Number of trees planted following eco-sustainable practices.	Process	(Trees planted / Total planned plantings) * 100
								Improvement in air quality.	Impact	(Current air quality indices / Previous air quality indices - 1) * 100
89	Teleworking Promotion	Promoting teleworking to reduce the need for travel, decrease traffic congestion, and lower transportation emissions, while also improving internet coverage and accessibility to support remote work.	Infrastructure and policies supporting teleworking, societal shift towards remote work, and availability of technological solutions for effective telecommunication.	Transportation; Governance	Planning; Voluntary/negotiated agreements		9	Share of population teleworking.	Process	(Population teleworking / Share of population teleworking goal) * 100
								Reduction in transportation emissions due to teleworking.	Impact	(Previous commute emissions - Current commute emissions) / Previous commute emissions * 100
90	Climate Change Sensitive Areas Identification	Identifying areas sensitive to climate change to inform conservation and adaptation strategies, aiming to reduce biodiversity loss, protect vulnerable ecosystems, and enhance resilience to climate impacts.	Scientific research suitable for identifying climate-sensitive areas, public and political will to protect and adapt vulnerable ecosystems, and resources for implementing conservation strategies.	Environmental Policy; Agri-Food; Governance	Research; Planning		11	Areas identified as sensitive to climate change.	Process	(Total areas assessed / Total areas in jurisdiction) * 100
								Strategies implemented for conservation and adaptation in sensitive areas.	Impact	(Strategies implemented / Total strategies planned) * 100
91	Energy-Saving Street Light Management	Implementing energy-saving measures such as turning off street lights during specified hours to save energy, reduce light pollution, and decrease municipal energy costs, while maintaining public safety and visibility.	Energy-efficient lighting technology availability, municipal commitment to reducing energy costs and pollution, and public acceptance of changes to street lighting practices.	Energy; Buildings	Regulatory		13	Energy-saving measures implemented in street lighting.	Process	(Street lights updated to energy-saving models / Total street lights) * 100
								Reduction in energy usage from street lighting.	Impact	(Previous energy usage by street lighting - Current usage) / Previous usage * 100

92	Elderly Housing Renovation	Renovating municipal dwellings for the elderly to improve energy efficiency and reduce energy bills, enhancing the comfort and sustainability of housing for vulnerable populations.	Programs aimed at improving living conditions for the elderly, availability of funds for renovation, and focus on energy-efficient housing solutions.	Buildings; Energy	Economic; Regulatory		15	Share of elderly housing units renovated for energy efficiency.	Process	(Elderly housing units renovated / Total elderly housing units) * 100
								Decrease in energy consumption in elderly housing.	Impact	(Previous energy consumption - Current energy consumption) / Previous energy consumption * 100
93	Water and Energy Consumption Reduction	Implementing measures to reduce water consumption and associated energy consumption through public awareness campaigns and subsidies for water-saving devices, promoting more sustainable water and energy use practices.	Public campaigns promoting water and energy savings, availability of subsidies and technology for efficient consumption, and community interest in sustainable practices.	Environmental Policy; Energy	Education & Information; Economic		27	Measures implemented to reduce water and energy consumption.	Process	(Measures implemented / Total planned measures) * 100
								Reduction in water and energy bills following the implementation of measures.	Impact	(Previous bills - Current bills) / Previous bills * 100
94	Traffic Calming and Safety Improvements	Implementing traffic calming measures such as reduced speed zones (zones 30), parking improvements, and pedestrian-friendly infrastructure to enhance road safety, reduce emissions, and promote sustainable urban mobility.	Recognition of the need for safer and more sustainable urban transportation, available funding for traffic calming measures, and community support for improved urban mobility.	Transportation	Planning; Regulatory		35	Traffic calming and safety improvements implemented in urban areas.	Process	(Improvements implemented / Total planned improvements) * 100
								Reduction in emissions due to improved traffic management.	Impact	(Previous emission rates - Current rates) / Previous rates * 100
95	Local Dairy Tourism Development	Developing tourism packages that involve local dairy production, accommodation, and activities, promoting local agriculture and sustainable tourism, and offering visitors authentic and environmentally friendly experiences.	Local interest in promoting sustainable tourism, availability of local farms and related businesses, and initiatives to integrate agriculture with sustainable tourism.	Agri-Food; Governance	Economic; Voluntary/negotiated agreements		50	Local dairy tourism packages developed and marketed.	Process	(Tourism packages developed / Total planned packages) * 100
								Share of visitors to local dairy farms and associated businesses.	Impact	(Current visitors / Total visitors) * 100
96	Town Hall Window and Balcony Replacement	Substituting all outdated window and balcony closures in the town hall with energy-efficient alternatives, contributing to reduced energy consumption and enhanced thermal comfort in public buildings.	Energy-efficient alternatives available for public buildings, municipal commitment to energy saving, and support for sustainable building practices.	Buildings; Energy	Economic; Planning		137	Number of windows and balconies replaced in town hall buildings.	Process	(Windows and balconies replaced / Total replacements needed) * 100
								Energy savings in public buildings due to replacements.	Impact	(Previous energy usage in public buildings - Current usage) / Previous usage * 100

97	Water Saving Tax Incentives	Offering tax incentives for actions that save water and promote its reuse, encouraging individuals and businesses to adopt water-efficient practices and technologies, thereby reducing water waste and conserving valuable water resources.	Incentive structures for water conservation, public awareness campaigns, and governmental support for water-saving measures and technologies.	Environmental Policy; Governance	Economic; Regulatory		169	Share of population receiving tax incentives for water-saving actions.	Process	(Population receiving incentives / Total population) * 100
								Increase in adoption of water-efficient appliances and practices.	Impact	(Number of new adoptions post-incentive / Total households or businesses) * 100
98	Watering Facility Efficiency Improvements	Improving the efficiency of watering facilities and adapting agricultural practices to more drought-resistant crops, reducing water consumption in agriculture and promoting more sustainable irrigation methods.	Technological advancements in agricultural efficiency, availability of drought-resistant crops, and initiatives to reduce water use in agriculture.	Agri-Food; Environmental Policy	Research; Planning; Economic		189	Share of watering facilities with efficiency improvements made .	Process	(Facilities improved / Total facilities) * 100
								Reduction in water use in agriculture due to efficiency improvements.	Impact	(Previous water use - Current water use) / Previous water use * 100
99	Mobility Demand and Origin Analysis	Conducting an analysis of mobility demand and travel origins to better understand transportation needs and patterns, informing the development of targeted policies and infrastructure to improve public transit, reduce congestion, and lower emissions.	Data availability for mobility demand and travel patterns, commitment to optimizing public transportation, and efforts to reduce urban congestion and emissions.	Transportation	Research; Planning		273	Mobility demand and origin studies conducted.	Process	(Studies conducted / Total planned studies) * 100
								Policy and infrastructure changes implemented based on analysis outcomes.	Impact	(Changes implemented / Recommendations from studies) * 100
100	Interurban Transport Adaptation	Adapting interurban transport lines in areas with low population density to a service on demand, optimizing scheduling and vehicle size to reduce energy consumption in the bus fleet and decrease individual private transport usage.	Demand-responsive transport systems available, community support for efficient public transit solutions, and resources to adapt existing interurban services.	Transportation	Planning; Economic		349	Interurban transport lines adapted to demand-responsive services.	Process	(Transport lines adapted / Total lines) * 100
								Reduction in energy consumption in public transport.	Impact	(Previous energy consumption by transport - Current consumption) / Previous consumption * 100
101	Train Station Parking Construction	Constructing parking facilities near train stations to encourage the use of combined car and train transportation, supporting a	Resources for constructing parking facilities near train stations, policies encouraging combined	Transportation	Planning; Economic		375	Number of train station parking facilities constructed.	Process	(Parking facilities constructed / Total planned facilities) * 100

		shift towards more sustainable commuting practices and reducing individual car usage.	transportation use, and community interest in reducing car dependency.					Increase in combined car and train transportation usage by commuters.	Impact	(Post-construction combined transportation usage / Pre-construction usage - 1) * 100
102	Swimming Pool Thermal Energy Recovery Installation	Installing a thermal energy recovery system to capture and reuse heat from swimming pool water, improving energy efficiency in recreational facilities and reducing the energy consumption associated with heating pools.	Availability of thermal energy recovery systems for swimming pools, initiatives to improve energy efficiency in recreational facilities, and support for sustainable practices.	Buildings; Energy	Economic; Planning		377	Share of pools with installation of thermal energy recovery systems.	Process	(Pools with thermal energy recovery systems installed / Total pools targeted) * 100
								Reduction in energy consumption for heating swimming pools.	Impact	(Energy consumption before installation - After installation) / Before installation * 100
103	Pedestrian Infrastructure Enhancement	Constructing new pedestrian sidewalks and developing a Sustainable Urban Mobility Plan to encourage walking, enhance urban walkability, and reduce reliance on motorized transportation, promoting healthier and more sustainable urban environments.	Plans and resources for enhancing pedestrian infrastructure, community demand for walkable cities, and support for sustainable urban mobility initiatives.	Transportation	Planning; Education & Information		396	Number of new pedestrian sidewalks constructed.	Process	(New sidewalks constructed (km) / Total planned sidewalks (km)) * 100
								Increase in the number of walking path options available.	Impact	(Number of walking paths after implementation − Number of walking paths before implementation) / Number of walking paths before implementation * 100
104	Green Lawn Replacement	Replacing green lawns with native plant species in public spaces to conserve water and preserve biodiversity, promoting drought-resistant landscaping and contributing to the ecological health of urban areas.	Community support for water-conserving landscaping, and commitment to enhancing urban biodiversity and sustainability.	Environmental Policy	Planning; Research		427	Share of area of green lawns replaced with native plant species.	Process	(Area replaced with native plants / Total area of green lawns) * 100
								Reduction in water usage in public spaces.	Impact	(Water usage before replacement - After replacement) / Before replacement * 100

* *EEA and CoM references can be found in the Excel file "GRANULAR_D4.1_Policy_Measures_File" attached to this report*

Annex 8.7 – Domain-Value Correlation table

	Domain	Agri-food						Buildings				Energy						Industry				Transportation				Waste		
	Value	Affordability	Animal welfare/Justice	Efficiency	Environmental sustainability	Food security - Nutrition	Resilience	Affordability	Environmental sustainability	Improved quality	Smart homes	Affordability	Efficiency	Environmental sustainability	Justice	Reliability	Resilience	Digitalized	Environmental sustainability	Resilience	Safety	Economic productivity	Environmental sustainability	Safety	Smart	Circular economy	Environmentally safe	Safety
Domain	Value																											
Agri-food	Affordability	1.00 (0.00)	-0.14 (0.48)	0.30 (0.13)	-0.12 (0.56)	-0.42 (0.03)	0.03 (0.89)	0.15 (0.46)	-0.36 (0.07)	-0.05 (0.83)	-0.22 (0.28)	0.24 (0.23)	-0.08 (0.70)	0.03 (0.89)	0.23 (0.25)	0.26 (0.21)	0.11 (0.61)	0.32 (0.11)	0.37 (0.06)	0.29 (0.15)	0.05 (0.79)	0.23 (0.25)	0.30 (0.13)	0.22 (0.27)	0.18 (0.37)	-0.06 (0.75)	0.06 (0.79)	-0.25 (0.22)
	Animal welfare/ Justice	-0.14 (0.48)	1.00 (0.00)	-0.31 (0.12)	0.12 (0.56)	0.09 (0.65)	-0.20 (0.33)	0.38 (0.06)	0.02 (0.93)	-0.05 (0.80)	-0.13 (0.53)	-0.42 (0.03)	0.26 (0.19)	-0.25 (0.21)	0.01 (0.95)	-0.49 (0.01)	-0.14 (0.49)	-0.06 (0.78)	-0.32 (0.11)	-0.08 (0.70)	-0.35 (0.08)	-0.35 (0.07)	-0.10 (0.60)	-0.00 (0.99)	-0.26 (0.18)	-0.07 (0.73)	0.14 (0.49)	0.09 (0.64)
	Efficiency	0.30 (0.13)	-0.31 (0.12)	1.00 (0.00)	-0.11 (0.59)	-0.54 (0.00)	-0.23 (0.24)	-0.24 (0.23)	0.16 (0.42)	0.21 (0.30)	0.13 (0.53)	0.11 (0.60)	-0.52 (0.01)	0.36 (0.06)	-0.01 (0.95)	0.23 (0.25)	0.17 (0.40)	0.20 (0.31)	0.58 (0.00)	0.19 (0.34)	0.42 (0.03)	-0.16 (0.43)	0.51 (0.01)	0.03 (0.89)	0.22 (0.28)	0.17 (0.41)	0.05 (0.81)	-0.07 (0.72)
	Environmental sustainability	-0.12 (0.56)	0.12 (0.56)	-0.11 (0.59)	1.00 (0.00)	0.14 (0.50)	0.42 (0.03)	0.12 (0.56)	0.33 (0.10)	0.02 (0.91)	-0.08 (0.71)	-0.03 (0.87)	-0.33 (0.09)	-0.04 (0.84)	-0.22 (0.28)	0.06 (0.78)	0.09 (0.64)	-0.45 (0.02)	0.16 (0.44)	-0.30 (0.13)	0.12 (0.56)	0.34 (0.08)	-0.24 (0.23)	0.29 (0.14)	-0.17 (0.38)	0.16 (0.44)	-0.08 (0.69)	0.41 (0.03)
	Food security - Nutrition	-0.42 (0.03)	0.09 (0.65)	-0.54 (0.00)	0.14 (0.50)	1.00 (0.00)	0.01 (0.98)	-0.17 (0.41)	0.10 (0.62)	-0.20 (0.31)	0.12 (0.56)	-0.33 (0.09)	0.46 (0.02)	-0.49 (0.01)	0.03 (0.87)	-0.41 (0.03)	-0.23 (0.25)	-0.19 (0.34)	-0.45 (0.02)	-0.08 (0.70)	-0.17 (0.40)	0.02 (0.91)	-0.51 (0.01)	-0.15 (0.44)	-0.06 (0.75)	-0.09 (0.64)	0.01 (0.97)	0.05 (0.79)

	Resilience	0.03 (0.89)	-0.20 (0.33)	-0.23 (0.24)	0.42 (0.03)	0.01 (0.98)	1.00 (0.00)	0.20 (0.32)	0.09 (0.66)	-0.08 (0.68)	0.11 (0.60)	0.21 (0.29)	-0.39 (0.04)	0.06 (0.75)	-0.27 (0.17)	0.10 (0.62)	0.17 (0.40)	-0.28 (0.16)	0.39 (0.04)	-0.35 (0.08)	-0.09 (0.65)	0.47 (0.01)	-0.11 (0.57)	0.65 (0.00)	-0.05 (0.82)	-0.13 (0.51)	-0.21 (0.30)	0.12 (0.55)
Buildings	**Affordability**	0.15 (0.46)	0.38 (0.06)	-0.24 (0.23)	0.12 (0.56)	-0.17 (0.41)	0.20 (0.32)	1.00 (0.00)	-0.02 (0.92)	-0.01 (0.95)	-0.10 (0.64)	0.03 (0.88)	0.22 (0.29)	0.16 (0.44)	0.13 (0.51)	-0.14 (0.49)	-0.00 (0.99)	0.13 (0.54)	-0.08 (0.70)	-0.08 (0.68)	-0.15 (0.45)	-0.06 (0.78)	-0.11 (0.60)	0.13 (0.51)	-0.18 (0.37)	0.21 (0.31)	-0.37 (0.06)	0.23 (0.27)
	Environmental sustainability	-0.36 (0.07)	0.02 (0.93)	0.16 (0.42)	0.33 (0.10)	0.10 (0.62)	0.09 (0.66)	-0.02 (0.92)	1.00 (0.00)	0.11 (0.59)	0.30 (0.13)	-0.31 (0.11)	-0.24 (0.22)	-0.10 (0.62)	-0.42 (0.03)	-0.25 (0.21)	-0.11 (0.59)	-0.33 (0.09)	0.18 (0.36)	-0.27 (0.17)	0.08 (0.70)	-0.16 (0.42)	-0.10 (0.62)	-0.06 (0.76)	-0.11 (0.59)	-0.01 (0.96)	-0.45 (0.02)	-0.02 (0.90)
	Improved quality	-0.05 (0.83)	-0.05 (0.80)	0.21 (0.30)	0.02 (0.91)	-0.20 (0.31)	-0.08 (0.68)	-0.01 (0.95)	0.11 (0.59)	1.00 (0.00)	0.23 (0.25)	0.32 (0.10)	0.02 (0.91)	0.07 (0.74)	-0.18 (0.38)	0.18 (0.36)	0.34 (0.08)	-0.25 (0.21)	0.17 (0.41)	-0.30 (0.13)	0.03 (0.89)	0.17 (0.39)	-0.38 (0.05)	-0.06 (0.77)	-0.50 (0.01)	0.01 (0.95)	-0.01 (0.97)	0.07 (0.71)
	Smart homes	-0.22 (0.28)	-0.13 (0.53)	0.13 (0.53)	-0.08 (0.71)	0.12 (0.56)	0.11 (0.60)	-0.10 (0.64)	0.30 (0.13)	0.23 (0.25)	1.00 (0.00)	-0.06 (0.76)	-0.24 (0.23)	-0.17 (0.40)	0.07 (0.71)	-0.21 (0.30)	-0.09 (0.66)	0.10 (0.62)	0.35 (0.07)	-0.33 (0.09)	-0.06 (0.76)	0.03 (0.86)	-0.07 (0.74)	0.06 (0.76)	-0.03 (0.89)	0.17 (0.40)	-0.10 (0.62)	-0.13 (0.53)
Energy	**Affordability**	0.24 (0.23)	-0.42 (0.03)	0.11 (0.60)	-0.03 (0.87)	-0.33 (0.09)	0.21 (0.29)	0.03 (0.88)	-0.31 (0.11)	0.32 (0.10)	-0.06 (0.76)	1.00 (0.00)	-0.14 (0.48)	0.60 (0.00)	-0.05 (0.80)	0.76 (0.00)	0.57 (0.00)	0.15 (0.46)	0.27 (0.17)	-0.01 (0.96)	0.52 (0.01)	0.33 (0.09)	-0.08 (0.71)	0.09 (0.66)	0.07 (0.72)	0.09 (0.66)	0.11 (0.58)	0.23 (0.25)
	Efficiency	-0.08 (0.70)	0.26 (0.19)	-0.52 (0.01)	-0.33 (0.09)	0.46 (0.02)	-0.39 (0.04)	0.22 (0.29)	-0.24 (0.22)	0.02 (0.91)	-0.24 (0.23)	-0.14 (0.48)	1.00 (0.00)	-0.31 (0.11)	0.13 (0.53)	-0.31 (0.12)	-0.35 (0.07)	0.05 (0.81)	-0.65 (0.00)	0.09 (0.67)	-0.22 (0.27)	-0.25 (0.22)	-0.50 (0.01)	-0.51 (0.01)	-0.21 (0.28)	-0.24 (0.23)	-0.21 (0.30)	-0.03 (0.87)
	Environmental sustainability	0.03 (0.89)	-0.25 (0.21)	0.36 (0.06)	-0.04 (0.84)	-0.49 (0.01)	0.06 (0.75)	0.16 (0.44)	-0.10 (0.62)	0.07 (0.74)	-0.17 (0.40)	0.60 (0.00)	-0.31 (0.11)	1.00 (0.00)	-0.09 (0.66)	0.63 (0.00)	0.44 (0.02)	0.23 (0.25)	0.24 (0.22)	-0.03 (0.87)	0.61 (0.00)	-0.13 (0.51)	0.25 (0.21)	-0.09 (0.64)	-0.01 (0.96)	0.08 (0.68)	-0.17 (0.39)	0.24 (0.24)
	Justice	0.23 (0.25)	0.01 (0.95)	-0.01 (0.95)	-0.22 (0.28)	0.03 (0.87)	-0.27 (0.17)	0.13 (0.51)	-0.42 (0.03)	-0.18 (0.38)	0.07 (0.71)	-0.05 (0.80)	0.13 (0.53)	-0.09 (0.66)	1.00 (0.00)	-0.23 (0.24)	-0.03 (0.90)	0.51 (0.01)	-0.06 (0.78)	0.29 (0.14)	0.04 (0.85)	0.24 (0.23)	0.05 (0.80)	-0.01 (0.95)	0.27 (0.17)	0.43 (0.03)	0.18 (0.37)	-0.23 (0.25)
	Reliability	0.26 (0.21)	-0.49 (0.01)	0.23 (0.25)	0.06 (0.78)	-0.41 (0.03)	0.10 (0.62)	-0.14 (0.49)	-0.25 (0.21)	0.18 (0.36)	-0.21	0.76 (0.00)	-0.31 (0.12)	0.63 (0.00)	-0.23 (0.24)	1.00 (0.00)	0.32 (0.11)	0.23 (0.25)	0.22 (0.27)	0.20 (0.31)	0.57 (0.00)	0.08 (0.67)	0.25 (0.20)	-0.10 (0.62)	0.14 (0.48)	0.04 (0.86)	0.15 (0.45)	0.24 (0.23)

											(0.30)																	
	Resilience	0.11 (0.61)	-0.14 (0.49)	0.17 (0.40)	0.09 (0.64)	-0.23 (0.25)	0.17 (0.40)	-0.00 (0.99)	-0.11 (0.59)	0.34 (0.08)	-0.09 (0.66)	0.57 (0.00)	-0.35 (0.07)	0.44 (0.02)	-0.03 (0.90)	0.32 (0.11)	1.00 (0.00)	-0.09 (0.66)	0.14 (0.50)	-0.17 (0.38)	0.11 (0.58)	0.46 (0.01)	0.01 (0.96)	0.34 (0.09)	-0.01 (0.97)	0.00 (0.99)	0.32 (0.10)	-0.03 (0.88)
Industry	**Digitalized**	0.32 (0.11)	-0.06 (0.78)	0.20 (0.31)	-0.45 (0.02)	-0.19 (0.34)	-0.28 (0.16)	0.13 (0.54)	-0.33 (0.09)	-0.25 (0.21)	0.10 (0.62)	0.15 (0.46)	0.05 (0.81)	0.23 (0.25)	0.51 (0.01)	0.23 (0.25)	-0.09 (0.66)	1.00 (0.00)	0.11 (0.57)	0.58 (0.00)	0.17 (0.40)	-0.23 (0.24)	0.53 (0.00)	-0.14 (0.50)	0.60 (0.00)	-0.01 (0.96)	0.22 (0.27)	-0.16 (0.43)
	Environmental sustainability	0.37 (0.06)	-0.32 (0.11)	0.58 (0.00)	0.16 (0.44)	-0.45 (0.02)	0.39 (0.04)	-0.08 (0.70)	0.18 (0.36)	0.17 (0.41)	0.35 (0.07)	0.27 (0.17)	-0.65 (0.00)	0.24 (0.22)	-0.06 (0.78)	0.22 (0.27)	0.14 (0.50)	0.11 (0.57)	1.00 (0.00)	-0.16 (0.42)	0.32 (0.10)	0.16 (0.43)	0.25 (0.21)	0.42 (0.03)	0.16 (0.43)	-0.04 (0.82)	-0.11 (0.59)	-0.01 (0.97)
	Resilience	0.29 (0.15)	-0.08 (0.70)	0.19 (0.34)	-0.30 (0.13)	-0.08 (0.70)	-0.35 (0.08)	-0.08 (0.68)	-0.27 (0.17)	-0.30 (0.13)	-0.33 (0.09)	-0.01 (0.96)	0.09 (0.67)	-0.03 (0.87)	0.29 (0.14)	0.20 (0.31)	-0.17 (0.38)	0.58 (0.00)	-0.16 (0.42)	1.00 (0.00)	0.13 (0.52)	-0.22 (0.28)	0.55 (0.00)	-0.18 (0.38)	0.60 (0.00)	0.07 (0.73)	0.33 (0.09)	0.13 (0.53)
	Safety	0.05 (0.79)	-0.35 (0.08)	0.42 (0.03)	0.12 (0.56)	-0.17 (0.40)	-0.09 (0.65)	-0.15 (0.45)	0.08 (0.70)	0.03 (0.89)	-0.06 (0.76)	0.52 (0.01)	-0.22 (0.27)	0.61 (0.00)	0.04 (0.85)	0.57 (0.00)	0.11 (0.58)	0.17 (0.40)	0.32 (0.10)	0.13 (0.52)	1.00 (0.00)	-0.07 (0.74)	0.09 (0.65)	-0.32 (0.11)	0.19 (0.35)	0.31 (0.12)	-0.21 (0.30)	0.22 (0.26)
Transportation	**Economic productivity**	0.23 (0.25)	-0.35 (0.07)	-0.16 (0.43)	0.34 (0.08)	0.02 (0.91)	0.47 (0.01)	-0.06 (0.78)	-0.16 (0.42)	0.17 (0.39)	0.03 (0.86)	0.33 (0.09)	-0.25 (0.22)	-0.13 (0.51)	0.24 (0.23)	0.08 (0.67)	0.46 (0.01)	-0.23 (0.24)	0.16 (0.43)	-0.22 (0.28)	-0.07 (0.74)	1.00 (0.00)	-0.30 (0.13)	0.62 (0.00)	-0.02 (0.91)	0.27 (0.17)	0.16 (0.43)	-0.16 (0.42)
	Environmental sustainability	0.30 (0.13)	-0.10 (0.60)	0.51 (0.01)	-0.24 (0.23)	-0.51 (0.01)	-0.11 (0.57)	-0.11 (0.60)	-0.10 (0.62)	-0.38 (0.05)	-0.07 (0.74)	-0.08 (0.71)	-0.50 (0.01)	0.25 (0.21)	0.05 (0.80)	0.25 (0.20)	0.01 (0.96)	0.53 (0.00)	0.25 (0.21)	0.55 (0.00)	0.09 (0.65)	-0.30 (0.13)	1.00 (0.00)	0.06 (0.76)	0.52 (0.01)	-0.06 (0.76)	0.29 (0.15)	-0.10 (0.61)
	Safety	0.22 (0.27)	-0.00 (0.99)	0.03 (0.89)	0.29 (0.14)	-0.15 (0.44)	0.65 (0.00)	0.13 (0.51)	-0.06 (0.76)	-0.06 (0.77)	0.06 (0.76)	0.09 (0.66)	-0.51 (0.01)	-0.09 (0.64)	-0.01 (0.95)	-0.10 (0.62)	0.34 (0.09)	-0.14 (0.50)	0.42 (0.03)	-0.18 (0.38)	-0.32 (0.11)	0.62 (0.00)	0.06 (0.76)	1.00 (0.00)	0.02 (0.90)	0.04 (0.83)	0.28 (0.15)	-0.09 (0.65)
	Smart	0.18 (0.37)	-0.26 (0.18)	0.22 (0.28)	-0.17 (0.38)	-0.06 (0.75)	-0.05 (0.82)	-0.18 (0.37)	-0.11 (0.59)	-0.50 (0.01)	-0.03 (0.89)	0.07 (0.72)	-0.21 (0.28)	-0.01 (0.96)	0.27 (0.17)	0.14 (0.48)	-0.01 (0.97)	0.60 (0.00)	0.16 (0.43)	0.60 (0.00)	0.19 (0.35)	-0.02 (0.91)	0.52 (0.01)	0.02 (0.90)	1.00 (0.00)	0.04 (0.85)	0.33 (0.09)	-0.15 (0.45)

Waste	**Circular economy**	-0.06 (0.75)	-0.07 (0.73)	0.17 (0.41)	0.16 (0.44)	-0.09 (0.64)	-0.13 (0.51)	0.21 (0.31)	-0.01 (0.96)	0.01 (0.95)	0.17 (0.40)	0.09 (0.66)	-0.24 (0.23)	0.08 (0.68)	0.43 (0.03)	0.04 (0.86)	0.00 (0.99)	-0.01 (0.96)	-0.04 (0.82)	0.07 (0.73)	0.31 (0.12)	0.27 (0.17)	-0.06 (0.76)	0.04 (0.83)	0.04 (0.85)	1.00 (0.00)	0.09 (0.66)	0.08 (0.70)
	Environmentally safe	0.06 (0.79)	0.14 (0.49)	0.05 (0.81)	-0.08 (0.69)	0.01 (0.97)	-0.21 (0.30)	-0.37 (0.06)	-0.45 (0.02)	-0.01 (0.97)	-0.10 (0.62)	0.11 (0.58)	-0.21 (0.30)	-0.17 (0.39)	0.18 (0.37)	0.15 (0.45)	0.32 (0.10)	0.22 (0.27)	-0.11 (0.59)	0.33 (0.09)	-0.21 (0.30)	0.16 (0.43)	0.29 (0.15)	0.28 (0.15)	0.33 (0.09)	0.09 (0.66)	1.00 (0.00)	-0.07 (0.73)
	Safety	-0.25 (0.22)	0.09 (0.64)	-0.07 (0.72)	0.41 (0.03)	0.05 (0.79)	0.12 (0.55)	0.23 (0.27)	-0.02 (0.90)	0.07 (0.71)	-0.13 (0.53)	0.23 (0.25)	-0.03 (0.87)	0.24 (0.24)	-0.23 (0.25)	0.24 (0.23)	-0.03 (0.88)	-0.16 (0.43)	-0.01 (0.97)	0.13 (0.53)	0.22 (0.26)	-0.16 (0.42)	-0.10 (0.61)	-0.09 (0.65)	-0.15 (0.45)	0.08 (0.70)	-0.07 (0.73)	1.00 (0.00)

User Guide: Python Script for Google Trends Data Analysis and Weight Calculation for Domains

Introduction

This user manual provides instructions for using the Python script that fetches Google Trends data for specified search terms, calculates their weights, and saves the results in an Excel file. The script uses the PyTrends library and offers user interaction to modify search terms and define the output directory.

Prerequisites

To run this script, ensure that Python is installed on your machine. You will also need to install the required libraries such as pytrends and openpyxl. The script includes code to check for these libraries and install them if needed. You should have access to the command line or terminal to execute the script.

Instructions for Using the Script

Step 1: Running the Script

To run the script, save it as a Python file (e.g., trends_analysis.py) on your computer. Open the command line or terminal and navigate to the directory where the script is saved. Run the script using the following command:

```
python trends_analysis.py
```

Step 2: Installing Required Packages

The script will check if the required packages (pytrends, openpyxl) are installed. If not, it will attempt to install them. You may need administrative privileges to install packages.

Step 3: Specifying the Output Directory

Once the script starts running, it will prompt you to enter the path where you'd like to save the output. For example, you can enter a path like:

C:\\Users\\YourName\\Documents

The script will create the necessary folders if they don't already exist.

Step 4: Reviewing and Modifying Search Terms

After specifying the output path, the script will display the default search terms:

Energy, Transportation, Industry, Agriculture, Waste, Buildings

You will be asked if you want to modify these terms. If you enter 'yes', you can input your own search terms separated by commas. If you choose 'no', the default terms will be used. The script will append the word 'sustainable' to each search term and fetch Google Trends data for each.

Step 5: Fetching and Saving Data

The script will fetch Google Trends data for the specified search terms. It uses a retry mechanism in case of temporary issues like too many requests. After gathering the data, it will calculate the sum of values for each term and compute their weight in relation to the total sum of all terms.
The results will be saved in an Excel file named 'Domain_weights.xlsx'. The file will contain two sheets:

- 1. 'Raw values': Raw Google Trends data for the specified terms.
- 2. 'Domain weights': The calculated weights for each domain.

Step 6: Script Output

Once the script finishes running, it will display a confirmation message with the path where the Excel file is saved.

Full Python Script

Below is the full Python script that performs the Google Trends data analysis and saves the results.

```
import os
import time
import pandas as pd
from pytrends.request import TrendReq
from pytrends.exceptions import TooManyRequestsError
import requests
from openpyxl import Workbook

# Ensure all required packages are installed
try:
    import openpyxl
except ImportError:
    os.system('pip install openpyxl')

try:
    import pytrends
except ImportError:
    os.system('pip install pytrends')

# Prompt the user for output directory
output_directory = input(r"Please enter the path where you'd like to save the output (e.g., C:\Users\YourName\Documents): ")
```

```
if not os.path.exists(output_directory):
    os.makedirs(output_directory)

# Define the default search terms
default_search_terms = ['Energy', 'Transportation', 'Industry', 'Agriculture', 'Waste', 'Buildings']
print(f"Default search terms: {', '.join(default_search_terms)}")
modify_terms = input("Would you like to modify these terms? (yes/no): ").strip().lower()

if modify_terms == 'yes':
    search_terms = input("Please enter the new search terms, separated by commas: ").split(',')
    search_terms = [term.strip() for term in search_terms]
else:
    search_terms = default_search_terms

# Initialize pytrends with an increased timeout duration
pytrends = TrendReq(hl='en-US', tz=360, timeout=(10, 25))

# Function to fetch data with retries and exponential backoff
def fetch_data_with_retries(term, retries=10, backoff_factor=1):
    for i in range(retries):
        try:
            pytrends.build_payload([term], cat=0, timeframe='today 5-y', geo='', gprop='')
            data = pytrends.interest_over_time()
            return data
        except (TooManyRequestsError, requests.exceptions.Timeout) as e:
            wait = backoff_factor * (2 ** i)
            print(f"Error {str(e)}. Waiting for {wait} seconds before retrying...")
            time.sleep(wait)
        except Exception as e:
            print(f"Unexpected error {str(e)}. Skipping term: {term}")
            return None
```

```
    return None

# Initialize an empty DataFrame to combine all data
combined_data = pd.DataFrame()

# Loop through each term and fetch data
for term in search_terms:
    search_term = f"{term} sustainable"
    data = fetch_data_with_retries(search_term)

    if data is None:
        print(f"Failed to fetch data for term: {search_term}")
        continue

    if 'isPartial' in data.columns:
        data = data.drop(columns=['isPartial'])

    # Rename the interest column to the search term
    data = data.rename(columns={search_term: search_term})

    # Debugging: Print the data to check the fetched data
    print(f"Fetched data for term '{search_term}':")
    print(data.head())

    # If combined_data is empty, initialize it with the current data
    if combined_data.empty:
        combined_data = data
    else:
        # Otherwise, join the new data on the date index
        try:
            combined_data = combined_data.join(data[search_term], how='outer')
        except KeyError as e:
```

```
            print(f"KeyError: {e}. Data columns: {data.columns}")
            continue

    # Wait for a delay between each request
    time.sleep(5)

# Remove any duplicate columns if there are overlapping search terms
combined_data = combined_data.loc[:, ~combined_data.columns.duplicated()]

# Sum values for each domain and calculate weights
domain_sums = combined_data.sum(axis=0)
total_sum = domain_sums.sum()
domain_weights = domain_sums / total_sum

# Prepare the output Excel file
output_xlsx_path = os.path.join(output_directory, 'Domain_weights.xlsx')
with pd.ExcelWriter(output_xlsx_path, engine='openpyxl') as writer:
    # Save raw values in the first sheet
    combined_data.to_excel(writer, sheet_name='Raw values')

    # Save calculated domain weights in the second sheet
    domain_weights_df = pd.DataFrame(domain_weights, columns=['Weight'])
    domain_weights_df.to_excel(writer, sheet_name='Domain weights')

print(f"Data saved to '{output_xlsx_path}'")
```

User Guide: Python Script for Google Trends Data Analysis and Weight Calculation for Values

Introduction

This guide explains how to use a Python script that fetches Google Trends data for specified search terms, calculates domain-specific weights, and outputs the results in an Excel file. The script requires an Excel file to define the search terms, domains, and variations of each term, and this guide outlines how to create that file.

Prerequisites

Required Software:
1. Python (version 3.6 or higher).
2. Required Python Libraries:
   - pandas
   - pytrends
   - openpyxl
   - requests

To install the required Python libraries, use the following commands in your terminal:

pip install pandas pytrends openpyxl requests

Building the Excel File

The script requires an Excel file that defines Domains, Original Terms, and Variations. This file will guide the script in fetching Google Trends data for each original term and its variations. Here's how to create the Excel file:

1. File Name: Name the file appropriately (e.g., Values variations.xlsx).
2. Sheet Name: The sheet within the Excel file should be named 'Values variations'.
3. Columns:
   - Column 1: 'Domain' – This column defines the broad categories such as 'Energy', 'Transportation', etc. Each 'Domain' can have multiple 'Original Terms' associated with it.
   - Column 2: 'Original Term' – This column contains specific search terms related to each domain (e.g., 'Energy sustainability', 'Energy reliability').
   - Subsequent Columns: These contain Variations or synonyms of each 'Original Term' (e.g., 'Green energy', 'Clean energy'). You can include up to 7 variations for each term.

Example of Required Excel Structure:

Domain	Original Term	Variation 1	Variation 2	Variation 3
Energy	Energy sustainability	Green energy	Clean energy	Renewable energy
Energy	Energy reliability	Energy security	Reliable energy	Dependable energy
Transportation	Transportation sustainability	Eco-friendly transport	Green transport	Sustainable transportation
Transportation	Transportation reliability	Public transport reliability	Reliable commuting	Safe transport

Explanation:
- Domain: The broad category (e.g., 'Energy', 'Transportation').
- Original Term: The specific term within each domain that you want to search on Google Trends (e.g., 'Energy sustainability', 'Energy reliability').
- Variations: Synonyms or related terms for the 'Original Term' (e.g., 'Green energy', 'Clean energy').

Once you have completed the table:
1. Save the file as an .xlsx file (Excel Workbook).
2. Ensure the sheet name is 'Values variations'.
   - Example file name: Values_variations_with_domain.xlsx.

Script Overview

1. Extract Search Terms: The script extracts 'Original Terms' and their variations from the Excel file.
2. Fetch Google Trends Data: The script uses the PyTrends API to fetch data for each term and its variations.
3. Calculate Weights: After fetching the data, the script calculates the total sum for each domain and computes the percentage weight for each search term relative to the total domain sum.
4. Save Results: The results are saved in an Excel file with two sheets:
   - Sheet 1: 'Raw values' – Contains the raw Google Trends data.
   - Sheet 2: 'Value weights' – Contains the calculated weights and percentages.

Step-by-Step Instructions

1. Running the Script
   - Save the provided Python script as a .py file (e.g., trends_weights_script.py) on your computer.
   - Open a command line or terminal window and navigate to the directory where the script is located.
   - Run the script using the following command:

```
python trends_weights_script.py
```

2. Input File Paths
   - When prompted, enter the path to the Excel file you created with search terms and domains.

   Example input for the Excel file:
   C:\path\to\your\Values_variations_with_domain.xlsx

   - Next, you will be asked to enter the path where you'd like to save the output files (CSV and Excel).
3. Google Trends Fetching and Weight Calculation
   - The script will extract search terms from the Excel file and begin fetching Google Trends data for each term and its variations.
   - Once data is fetched, the script calculates the sum for each search term and the percentage weight relative to the total sum within its domain.
4. Output Files
   - Raw Data CSV Files: The script saves individual CSV files for each search term in the output directory you specified.

- Excel File: The results are saved in an Excel file named 'Value_weights.xlsx' in the output directory. The Excel file contains:
  - Sheet 1: Raw values – Contains the raw Google Trends data for all terms.
  - Sheet 2: Value weights – Contains the sum of values for each search term and the calculated percentage relative to the total sum for the domain.

Full Python Script

```
import os
import time
import pandas as pd
from pytrends.request import TrendReq
from pytrends.exceptions import TooManyRequestsError
import requests

# Function to extract search terms from Excel file
def extract_search_terms(df):
    search_terms = {}
    for index, row in df.iterrows():
        indicator = row['Original Term']
        terms = [row['Original Term']] + [row[f'Variation {i}'] for i in range(1, 8) if pd.notna(row[f'Variation {i}'])]
        search_terms[indicator] = terms
    return search_terms

# Function to fetch data with retries and exponential backoff
def fetch_data_with_retries(term, retries=10, backoff_factor=1):
    for i in range(retries):
        try:
            pytrends.build_payload([term], cat=0, timeframe='today 5-y', geo='', gprop='')
            data = pytrends.interest_over_time()
            return data
        except (TooManyRequestsError, requests.exceptions.Timeout) as e:
```

```
            wait = backoff_factor * (2 ** i)
            print(f"Error {str(e)}. Waiting for {wait} seconds before retrying...")
            time.sleep(wait)
        except Exception as e:
            print(f"Unexpected error {str(e)}. Skipping term: {term}")
            return None
    return None

# Ask the user for input and output paths
input_file_path = input("Please enter the path to the Excel file containing the search terms: ")
output_directory = input("Please enter the path where you'd like to save the output files: ")

# Load the Excel file
energy_data = pd.read_excel(input_file_path, sheet_name='Values variations')

# Extract search terms from the Excel sheet
search_terms = extract_search_terms(energy_data)

# Initialize pytrends
pytrends = TrendReq(hl='en-US', tz=360, timeout=(10, 25))

# Create the directory if it doesn't exist
if not os.path.exists(output_directory):
    os.makedirs(output_directory)

# Initialize an empty DataFrame to combine all data
combined_data = pd.DataFrame()

# Loop through each indicator and their respective terms
for indicator, terms in search_terms.items():
    indicator_data = pd.DataFrame()
```

```
for term in terms:
    data = fetch_data_with_retries(term)

    if data is None:
        print(f"Failed to fetch data for term: {term}")
        continue

    if 'isPartial' in data.columns:
        data = data.drop(columns=['isPartial'])

    # Rename the interest column to the search term
    data = data.rename(columns={term: term})

    # Debugging: Print the data to check the fetched data
    print(f"Fetched data for term '{term}':")
    print(data.head())

    # If indicator_data is empty, initialize it with the current data
    if indicator_data.empty:
        indicator_data = data
    else:
        # Otherwise, join the new data on the date index with suffixes to avoid column name conflicts
        indicator_data = indicator_data.join(data, how='outer', lsuffix='_left', rsuffix='_right')

    # Wait for a delay between each request
    time.sleep(5)

# Save each indicator data as a CSV file
if not indicator_data.empty:
    indicator_csv_path = os.path.join(output_directory, f'{indicator}.csv')
    indicator_data.to_csv(indicator_csv_path, index=True)
    print(f"Data for indicator '{indicator}' saved to '{indicator_csv_path}'")
```

```
        # Add the data to combined DataFrame
        if combined_data.empty:
            combined_data = indicator_data
        else:
            # Join combined data with the new indicator data, adding suffixes to avoid overlap
            combined_data = combined_data.join(indicator_data, how='outer', lsuffix='_left', rsuffix='_right')

# Second part: Calculating weights and saving to an Excel file
# Dictionary to store the sums from CSV files
csv_sums = {}

# Traverse the directory for the saved CSV files
for root, dirs, files in os.walk(output_directory):
    for file in files:
        if file.endswith('.csv'):
            file_path = os.path.join(root, file)
            csv_df = pd.read_csv(file_path)

            # Exclude column A (assuming it is the first column)
            numeric_cols = csv_df.select_dtypes(include='number').iloc[:, 1:]
            csv_sum = numeric_cols.sum().sum()

            # Store the sum with the file name (without extension) as the key
            file_name = os.path.splitext(file)[0]
            csv_sums[file_name] = csv_sum

# Match sums with the Excel file
energy_data['Matched Sum'] = energy_data['Original Term'].map(csv_sums)

# Sum the Matched Sum per unique Domain
grouped_sums = energy_data.groupby(['Domain'])['Matched Sum'].transform('sum')
```

```
# Calculate the percentage of each Matched Sum relative to the grouped sum
energy_data['Percentage'] = (energy_data['Matched Sum'] / grouped_sums) * 100

# Prepare output Excel file path
output_xlsx_path = os.path.join(output_directory, 'Value_weights.xlsx')

# Save results to Excel with two sheets: "Raw values" and "Value weights"
with pd.ExcelWriter(output_xlsx_path, engine='openpyxl') as writer:
    # Save raw values (combined_data) in the first sheet
    combined_data.to_excel(writer, sheet_name='Raw values')

    # Save the calculated percentages and sums in the second sheet
    energy_data[['Original Term', 'Matched Sum', 'Percentage']].to_excel(writer, sheet_name='Value weights', index=False)

print(f"Results saved to '{output_xlsx_path}'")
```

User Guide: Python Script for Google Trends Data Analysis and Weight Calculation for Indicators

Step 1: Prepare the Excel File

To successfully run the Python script, you must create and format an Excel file as described below. Each sheet (or tab) in the Excel file represents a different domain (e.g., Energy, Transportation). The columns in the file should contain the following data:
1. Domain: The domain of the indicators (e.g., Energy, Transportation).
2. Value: Specific values for the domain.
3. Indicator Name: Name of the indicators.
4. Keyword 1 to Keyword 10: Search terms (keywords) to be used for each indicator. Each row can have up to 10 keywords. If there are fewer than 10 keywords for a given indicator, leave the remaining columns blank.
For each sheet, fill in the data accordingly for each domain. For example, the 'Energy' sheet would contain all indicators related to energy, and so on.

Step 2: Set Up the Python Environment

1. Install the Required Libraries:
Install the necessary Python libraries before running the script:

pip install pandas pytrends openpyxl requests

2. Save the Script:
Save the provided Python code in a file named `fetch_trend_data.py`. Make sure this file is in a working directory where you have access to the necessary input files.

Step 3: Running the Script

1. Input and Output Paths:
When you run the script, it will prompt you for two paths:
- Input file path: This is the path to the Excel file you have prepared in Step 1. For example: `/path/to/your/excel_file.xlsx`
- Output directory: The directory where you want the script to save the results. For example: `/path/to/output_directory/`

2. Processing the Excel File:
After providing the input file path, the script will list all the sheet names in the Excel file, which represent the different domains. It will then prompt you to select which domain (sheet) to process. You can select domains one by one, and the script will extract the search terms for each domain and fetch the corresponding Google Trends data.

Step 4: Data Collection and Error Handling

1. Search Terms Extraction:
The script will extract search terms from the selected domain and search for them using the Google Trends API.
2. Handling Errors:
If the Google Trends API encounters an error, the script uses exponential backoff to retry the request. If the request fails after several retries, the script will move on to the next search term.
3. Data Fetching and Joining:
For each indicator, the script fetches data for the search terms and sums the values. It then aggregates all the data into a combined DataFrame.
4. Waiting Between Requests:
To avoid being blocked by the Google Trends API, the script waits 5 seconds between each request.

Step 5: Storing the Results

1. Saving Results:
After processing all the selected domains, the script saves the results in an Excel file with two sheets:
- Raw values: Contains all the Google Trends data fetched for each search term.

- Indicator weights: Contains the weights for each indicator based on the ratio of its raw sum to the total sum for its domain and value.
2. Output File:
The output file is saved in the directory you specified when the script was run. It will be named `Indicator_weights.xlsx`.

Step 6: Review the Results

1. Check Raw Values:
Open the Excel file and navigate to the `Raw values` sheet to review the raw data for each search term.
2. Check Indicator Weights:
In the `Indicator weights` sheet, check the calculated weights for each indicator, based on the trends data.

Python Code

```
import os
import time
import pandas as pd
from pytrends.request import TrendReq
from pytrends.exceptions import TooManyRequestsError
import requests

# Function to extract search terms from Excel file
def extract_search_terms(df):
    search_terms = {}
    for index, row in df.iterrows():
        domain = row['Domain']
        value = row['Value']
        indicator = row['Indicator Name']
        terms = [row[f'Keyword {i}'] for i in range(1, 11) if pd.notna(row[f'Keyword {i}'])]
        search_terms[(domain, value, indicator)] = terms
    return search_terms
```

```
# Function to fetch data with retries and exponential backoff
def fetch_data_with_retries(term, retries=10, backoff_factor=1):
    for i in range(retries):
        try:
            pytrends.build_payload([term], cat=0, timeframe='today 5-y', geo='', gprop='')
            data = pytrends.interest_over_time()
            return data
        except (TooManyRequestsError, requests.exceptions.Timeout) as e:
            wait = backoff_factor * (2 ** i)
            print(f"Error {str(e)}. Waiting for {wait} seconds before retrying...")
            time.sleep(wait)
        except Exception as e:
            print(f"Unexpected error {str(e)}. Skipping term: {term}")
            return None
    return None

# Ask the user for input and output paths
input_file_path = input("Please enter the path to the Excel file containing the search terms: ")
output_directory = input("Please enter the path where you'd like to save the output files: ")

# Load the Excel file and get all sheet names (tabs)
excel_file = pd.ExcelFile(input_file_path)
sheet_names = excel_file.sheet_names

# Initialize an empty DataFrame to store combined data for all domains
all_combined_data = pd.DataFrame()

# Initialize an empty list to store the raw values and sums for each indicator
indicator_sums = []

# Process each tab selected by the user until all are done
```

```
while sheet_names:
    print("\nAvailable Domains (tabs) to process:")
    for i, name in enumerate(sheet_names):
        print(f"{i + 1}. {name}")

    try:
        selected_index = int(input("\nSelect the Domain to process (enter the number): ")) - 1
        if selected_index < 0 or selected_index >= len(sheet_names):
            print("Invalid selection. Please try again.")
            continue
    except ValueError:
        print("Invalid input. Please enter a number.")
        continue

    selected_sheet = sheet_names[selected_index]
    print(f"\nProcessing Domain: {selected_sheet}")

    # Load the selected sheet
    energy_data = pd.read_excel(input_file_path, sheet_name=selected_sheet)

    # Extract search terms from the selected sheet
    search_terms = extract_search_terms(energy_data)

    # Initialize pytrends
    pytrends = TrendReq(hl='en-US', tz=360, timeout=(10, 25))

    # Initialize an empty DataFrame to combine all data for the current domain
    combined_data = pd.DataFrame()

    # Loop through each indicator and their respective terms
    for (domain, value, indicator), terms in search_terms.items():
        indicator_data = pd.DataFrame()
```

```
for term in terms:
    data = fetch_data_with_retries(term)

    if data is None:
        print(f"Failed to fetch data for term: {term}")
        continue

    if 'isPartial' in data.columns:
        data = data.drop(columns=['isPartial'])

    # Rename the interest column to the search term
    data = data.rename(columns={term: term})

    # Debugging: Print the data to check the fetched data
    print(f"Fetched data for term '{term}':")
    print(data.head())

    # If indicator_data is empty, initialize it with the current data
    if indicator_data.empty:
        indicator_data = data
    else:
        # Otherwise, join the new data on the date index with suffixes to avoid column name conflicts
        indicator_data = indicator_data.join(data, how='outer', lsuffix='_left', rsuffix='_right')

    # Wait for a delay between each request
    time.sleep(5)

# Sum up the values for the indicator and store in indicator_sums along with domain and value
if not indicator_data.empty:
    total_sum = indicator_data.sum().sum()
    indicator_sums.append([domain, value, indicator, total_sum])
```

```
        # Add the data to combined DataFrame for the current domain
        if combined_data.empty:
            combined_data = indicator_data
        else:
            # Join combined data with the new indicator data
            combined_data = combined_data.join(indicator_data, how='outer', lsuffix='_left', rsuffix='_right')

    # Add the data from the current domain to the overall combined DataFrame
    if not combined_data.empty:
        if all_combined_data.empty:
            all_combined_data = combined_data
        else:
            all_combined_data = all_combined_data.join(combined_data, how='outer')

    # Remove the processed sheet from the list
    sheet_names.pop(selected_index)

# Create a DataFrame from the collected indicator sums
indicator_sums_df = pd.DataFrame(indicator_sums, columns=['Domain', 'Value', 'Indicator', 'Raw Sum'])

# Calculate the sum of indicators for each Domain-Value pair
domain_value_sums = indicator_sums_df.groupby(['Domain', 'Value'])['Raw Sum'].transform('sum')

# Calculate the weight for each indicator as the ratio of its sum to the total sum for its Domain-Value pair
indicator_sums_df['Weight'] = (indicator_sums_df['Raw Sum'] / domain_value_sums) * 100

# Prepare the DataFrame for the Indicator weights sheet with Domain, Value, Indicator, and Weight
indicator_weights_df = indicator_sums_df[['Domain', 'Value', 'Indicator', 'Weight']]

# Save the raw values and indicator weights to an Excel file
output_xlsx_path = os.path.join(output_directory, 'Indicator_weights.xlsx')
```

```
with pd.ExcelWriter(output_xlsx_path, engine='openpyxl') as writer:
    # Save the raw values in the first sheet
    all_combined_data.to_excel(writer, sheet_name='Raw values')

    # Save the indicator weights in the second sheet
    indicator_weights_df.to_excel(writer, sheet_name='Indicator weights', index=False)

print(f"Results saved to '{output_xlsx_path}'")
```

Annex 8.11 – *Scenario scores by scenario and country*

Scenario	Country	Baseline Score	Scenario Score	Baseline Rank	Scenario Rank	Rank Difference	Score Difference
SocietalCommitment	Austria	35.3762662	34.1129335	10	10	0	-1.2633327
SocietalCommitment	Belgium	45.2027863	44.1250206	1	1	0	-1.0777657
SocietalCommitment	Bulgaria	21.4286691	19.3938791	27	26	-1	-2.03479
SocietalCommitment	Croatia	30.944331	29.4957532	20	19	-1	-1.4485778
SocietalCommitment	Cyprus	40.3170963	37.6552442	2	3	1	-2.6618521
SocietalCommitment	Czechia	34.1506091	31.8251363	14	15	1	-2.3254728
SocietalCommitment	Denmark	37.2594132	34.9284407	7	8	1	-2.3309724
SocietalCommitment	Estonia	32.8980197	31.7957597	17	16	-1	-1.1022601
SocietalCommitment	Finland	38.2419036	36.610885	5	5	0	-1.6310186
SocietalCommitment	France	34.7931617	33.1508556	13	13	0	-1.6423061
SocietalCommitment	Germany	38.389562	37.2003602	4	4	0	-1.1892018
SocietalCommitment	Greece	35.8135324	34.2768904	9	9	0	-1.536642
SocietalCommitment	Hungary	33.3508348	32.4449276	15	14	-1	-0.9059072
SocietalCommitment	Ireland	30.4616622	28.7058975	22	22	0	-1.7557646
SocietalCommitment	Italy	35.2985045	33.9356007	11	11	0	-1.3629038
SocietalCommitment	Latvia	26.0170617	25.6191964	24	25	1	-0.3978654
SocietalCommitment	Lithuania	25.7354107	25.7136361	25	24	-1	-0.0217746
SocietalCommitment	Luxembourg	26.707672	26.0397402	23	23	0	-0.6679318
SocietalCommitment	Malta	21.5450594	18.7115778	26	27	1	-2.8334816
SocietalCommitment	Netherlands	37.5630855	35.6097302	6	7	1	-1.9533554
SocietalCommitment	Poland	31.5969472	30.0193315	18	18	0	-1.5776158
SocietalCommitment	Portugal	35.0378772	33.9263609	12	12	0	-1.1115163

SocietalCommitment	Romania	33.2518278	31.3338562	16	17	1	-1.9179716
SocietalCommitment	Slovakia	30.7690124	28.8253178	21	21	0	-1.9436946
SocietalCommitment	Slovenia	36.7485561	35.7692437	8	6	-2	-0.9793124
SocietalCommitment	Spain	39.7229133	38.3690008	3	2	-1	-1.3539125
SocietalCommitment	Sweden	31.522359	29.4483111	19	20	1	-2.074048
DirectedTransition	Austria	35.3762662	39.2638222	10	12	2	3.88755599
DirectedTransition	Belgium	45.2027863	47.5458399	1	1	0	2.34305356
DirectedTransition	Bulgaria	21.4286691	25.3145532	27	27	0	3.88588406
DirectedTransition	Croatia	30.944331	34.8032746	20	20	0	3.85894363
DirectedTransition	Cyprus	40.3170963	41.9927693	2	6	4	1.67567302
DirectedTransition	Czechia	34.1506091	40.0830499	14	9	-5	5.93244084
DirectedTransition	Denmark	37.2594132	42.7020991	7	4	-3	5.44268593
DirectedTransition	Estonia	32.8980197	34.7071914	17	21	4	1.80917161
DirectedTransition	Finland	38.2419036	43.7280685	5	2	-3	5.48616494
DirectedTransition	France	34.7931617	38.613015	13	13	0	3.81985325
DirectedTransition	Germany	38.389562	40.8960947	4	8	4	2.5065327
DirectedTransition	Greece	35.8135324	41.611352	9	7	-2	5.79781966
DirectedTransition	Hungary	33.3508348	35.6392295	15	16	1	2.28839469
DirectedTransition	Ireland	30.4616622	35.1636159	22	19	-3	4.70195371
DirectedTransition	Italy	35.2985045	39.3878291	11	11	0	4.08932461
DirectedTransition	Latvia	26.0170617	27.3509903	24	26	2	1.33392851
DirectedTransition	Lithuania	25.7354107	27.4990827	25	24	-1	1.76367205
DirectedTransition	Luxembourg	26.707672	29.3940669	23	23	0	2.68639487
DirectedTransition	Malta	21.5450594	27.4118598	26	25	-1	5.86680037
DirectedTransition	Netherlands	37.5630855	42.2267621	6	5	-1	4.66367657
DirectedTransition	Poland	31.5969472	35.4538418	18	18	0	3.85689454
DirectedTransition	Portugal	35.0378772	38.6041986	12	14	2	3.5663214

DirectedTransition	Romania	33.2518278	34.5557583	16	22	6	1.30393057
DirectedTransition	Slovakia	30.7690124	35.4766707	21	17	-4	4.70765835
DirectedTransition	Slovenia	36.7485561	39.5651504	8	10	2	2.81659427
DirectedTransition	Spain	39.7229133	43.650967	3	3	0	3.92805374
DirectedTransition	Sweden	31.522359	37.2431899	19	15	-4	5.72083088
TechnoFriendly	Austria	35.3762662	41.2545204	10	8	-2	5.87825419
TechnoFriendly	Belgium	45.2027863	47.7363588	1	1	0	2.53357251
TechnoFriendly	Bulgaria	21.4286691	27.6907756	27	26	-1	6.26210649
TechnoFriendly	Croatia	30.944331	34.1932051	20	22	2	3.24887415
TechnoFriendly	Cyprus	40.3170963	40.8323542	2	9	7	0.5152579
TechnoFriendly	Czechia	34.1506091	40.1599836	14	12	-2	6.00937452
TechnoFriendly	Denmark	37.2594132	43.3709945	7	6	-1	6.11158132
TechnoFriendly	Estonia	32.8980197	37.1414941	17	17	0	4.24347434
TechnoFriendly	Finland	38.2419036	44.7016457	5	3	-2	6.45974212
TechnoFriendly	France	34.7931617	40.6748209	13	11	-2	5.88165921
TechnoFriendly	Germany	38.389562	43.97774	4	4	0	5.588178
TechnoFriendly	Greece	35.8135324	42.6448322	9	7	-2	6.83129979
TechnoFriendly	Hungary	33.3508348	36.2844809	15	19	4	2.93364606
TechnoFriendly	Ireland	30.4616622	38.7627856	22	16	-6	8.30112347
TechnoFriendly	Italy	35.2985045	40.7645031	11	10	-1	5.46599858
TechnoFriendly	Latvia	26.0170617	28.291558	24	25	1	2.27449626
TechnoFriendly	Lithuania	25.7354107	28.4885999	25	24	-1	2.75318917
TechnoFriendly	Luxembourg	26.707672	30.2575802	23	23	0	3.54990818
TechnoFriendly	Malta	21.5450594	25.6661767	26	27	1	4.12111729
TechnoFriendly	Netherlands	37.5630855	43.3796466	6	5	-1	5.81656111
TechnoFriendly	Poland	31.5969472	37.0352895	18	18	0	5.43834228
TechnoFriendly	Portugal	35.0378772	39.697399	12	15	3	4.65952174

TechnoFriendly	Romania	33.2518278	35.9194458	16	20	4	2.66761806
TechnoFriendly	Slovakia	30.7690124	35.6030348	21	21	0	4.83402239
TechnoFriendly	Slovenia	36.7485561	39.9897225	8	14	6	3.24116637
TechnoFriendly	Spain	39.7229133	44.8089225	3	2	-1	5.08600918
TechnoFriendly	Sweden	31.522359	40.0047128	19	13	-6	8.48235381
GradualDevelopment	Austria	35.3762662	35.386369	10	10	0	0.01010272
GradualDevelopment	Belgium	45.2027863	45.1980207	1	1	0	-0.0047657
GradualDevelopment	Bulgaria	21.4286691	20.2906815	27	27	0	-1.1379877
GradualDevelopment	Croatia	30.944331	30.8745142	20	20	0	-0.0698168
GradualDevelopment	Cyprus	40.3170963	38.9460189	2	3	1	-1.3710774
GradualDevelopment	Czechia	34.1506091	33.9793572	14	14	0	-0.1712519
GradualDevelopment	Denmark	37.2594132	37.0898232	7	7	0	-0.16959
GradualDevelopment	Estonia	32.8980197	32.5502701	17	16	-1	-0.3477496
GradualDevelopment	Finland	38.2419036	38.1411742	5	5	0	-0.1007294
GradualDevelopment	France	34.7931617	34.5929229	13	13	0	-0.2002389
GradualDevelopment	Germany	38.389562	38.2322452	4	4	0	-0.1573167
GradualDevelopment	Greece	35.8135324	35.9398384	9	9	0	0.12630603
GradualDevelopment	Hungary	33.3508348	33.3158642	15	15	0	-0.0349706
GradualDevelopment	Ireland	30.4616622	30.291616	22	22	0	-0.1700462
GradualDevelopment	Italy	35.2985045	35.2417186	11	11	0	-0.056786
GradualDevelopment	Latvia	26.0170617	25.8854948	24	24	0	-0.1315669
GradualDevelopment	Lithuania	25.7354107	25.7828396	25	25	0	0.04742889
GradualDevelopment	Luxembourg	26.707672	26.5415009	23	23	0	-0.1661711
GradualDevelopment	Malta	21.5450594	20.6613049	26	26	0	-0.8837545
GradualDevelopment	Netherlands	37.5630855	37.4886824	6	6	0	-0.0744031
GradualDevelopment	Poland	31.5969472	31.3368334	18	19	1	-0.2601138
GradualDevelopment	Portugal	35.0378772	35.0769687	12	12	0	0.0390915

GradualDevelopment	Romania	33.2518278	31.9092007	16	17	1	-1.3426271
GradualDevelopment	Slovakia	30.7690124	30.4854333	21	21	0	-0.2835791
GradualDevelopment	Slovenia	36.7485561	36.6583522	8	8	0	-0.0902039
GradualDevelopment	Spain	39.7229133	39.7505758	3	2	-1	0.02766249
GradualDevelopment	Sweden	31.522359	31.4001629	19	18	-1	-0.1221961