1. Introduction and Objectives

Rural regions across the European Union are central to achieving the ambitious goal of climate neutrality. While broader EU initiatives target systemic reductions in greenhouse gas emissions, rural communities face unique conditions related to demographics, economic structures, and resource availability. The EU rural vision emphasizes that these regions can lead global climate actions through strategic local policies and practices. Aligning with this perspective, the framework presented here has been designed to evaluate, plan, and track local-level progress toward climate neutrality, with particular attention to rural contexts.

The central objective is to offer a comprehensive monitoring and decision-support tool for rural policymakers and stakeholders. This tool integrates multiple sustainability domains and cross-cutting values that reflect the diverse nature of rural areas. It seeks to capture local realities through a bottom-up approach, maintain alignment with EU-wide sustainability goals, and enable comparability across different regions. By doing so, rural policymakers and other community leaders can identify interventions with the greatest potential impact, track progress over time, and refine strategies to enhance both resilience and well-being.

2. Methods and Data

2.1 Framework Structure and Domains

The framework draws on an extensive review of academic sources, policy documents, and existing measurement methodologies. It focuses on six major domains of relevance to climate neutrality: Energy, Transportation, Agri-food, Waste, Industry, and Buildings. These were identified through recurring emphasis in literature and policy initiatives. A set of cross-cutting values—such as environmental sustainability, affordability, efficiency, reliability, justice, and resilience—further refines the assessment by addressing broader attributes that cut across sectoral lines.

2.2 Indicator Selection and Normalization

Indicators were initially compiled through a structured search using major academic databases. After removing those lacking applicability to rural communities or adequate supporting data, the remaining indicators were evaluated against a standard set of criteria to ensure practicality and alignment with the framework's aims.

For comparability, the framework employs a normalization process that rescores indicator values to a range of -100 to 100. Goal values are set to targets reflecting minimal or zero environmental impact, although these may be aspirational. Where necessary, communities can revise benchmarks and normalization approaches to fit local conditions, such as soil characteristics or resource endowments. This allows standard comparisons across regions, yet also supports region-specific adaptation where needed.

2.3 Weighting Approaches

Aggregating diverse indicators into composite scores relies on assigning weights that capture local or broader priorities. The framework supports various weighting approaches:

One method assigns equal weights for simplicity. Alternatively, some statistical techniques use data distributions to highlight high-variance indicators, although this may not always match local stakeholder views. Another approach draws on public preferences, where internet search volumes can be used as proxies for general interest. This approach can adjust weights according to the prominence of different issues, indicating which topics may be of greatest immediate concern.

Because each rural area can have distinct needs, the framework enables flexible weighting decisions. Some regions may prioritize energy affordability over other considerations, while others may emphasize resilience or justice concerns. The flexibility in assigning weights ensures that the overall tool is adaptable to widely varying local contexts.

2.4 Policy Measures and Monitoring

Alongside objective indicators, the framework includes a policy toolbox containing a wide range of local-level measures. These measures were collected from databases maintained by the European Environment Agency and other initiatives, screened for relevance to rural contexts, and matched with associated process and impact indicators.

Process indicators track real-time implementation progress and can highlight early outcomes of a policy, such as the number of funded projects or the area of land designated for a climate-related purpose. Impact indicators measure longer-term effects, including changes in energy consumption or emissions levels. By combining both types of indicators, stakeholders can assess the effectiveness of actions, identify where policies may need adjustment, and better understand how specific interventions move communities toward climate neutrality.

3. Results

3.1 Domain-Level Insights

Initial testing revealed that certain domains, when removed from the composite index, caused larger shifts in the relative ranking of countries. Among these, Transportation and Waste were especially influential, leading to significant variations. By contrast, excluding domains such as Agri-food or Energy resulted in more moderate changes, suggesting that performance in those areas may be more consistent across different local contexts.

These observations do not imply reduced importance of any domain for climate neutrality. Instead, they highlight the variability of certain sectors in differentiating outcomes. Transportation and Waste showed relatively higher variability, so improvements there can produce noticeable changes in overall assessments.

3.2 Domain–Value Correlations

Analysis of domain–value pairs revealed multiple relationships that can inform policy strategies. In some cases, enhancing efficiency in one domain correlated positively with environmental sustainability efforts elsewhere, indicating potential synergies.

Conversely, some priorities exhibited negative correlations. Pursuing affordability in certain areas could compromise environmental or social goals, indicating a need to consider careful trade-offs.

These interactions underscore the importance of a multifaceted approach. Gains in one domain can simultaneously advance progress in another, but certain objectives may clash, demanding balanced strategies. The identification of such trade-offs allows policymakers to anticipate conflicts among priorities and design interventions that mitigate unintended effects.

3.3 Scenario Analyses

Different scenarios were created by shifting domain and value weights to reflect distinct policy and societal emphasis. One scenario concentrated on community-led initiatives and justice, causing moderate changes in overall rankings. Another scenario emphasized government-driven industrial decarbonization and energy infrastructure, prompting more significant reshuffling. A technology-driven scenario produced the largest differences, showing how innovation-focused policies can rapidly alter outcomes. A final scenario with balanced, incremental approaches deviated the least from the baseline.

By comparing these scenarios, it becomes apparent that varying political and social priorities can shape very different sustainability trajectories. Domains with heavier weights can drive a community's climate neutrality results and rankings in ways that highlight the central role of governance choices, innovation capacity, and social engagement.

3.4 Policy Measures: Distribution and Implementation

The compiled set of 104 policy measures spans multiple domains. A large share focuses on renewable energy promotion, reductions in emissions-intensive sectors, and improvements to waste management and infrastructure. Each measure is linked to one process indicator (tracking immediate implementation) and one outcome indicator (measuring long-term effectiveness).

This structure helps local authorities plan and monitor progress, revealing where policies are on track and where adjustments might be needed. Coordination among different policy instruments emerges as critical, particularly where programs interact across domains and values. Some regions may rely heavily on economic incentives, while others invest more in regulatory approaches or stakeholder engagement.

4. Conclusions

4.1 Placing Rural Communities at the Center

The framework highlights the capacity of rural communities to serve as central actors in climate neutrality. By structuring indicators around local data and conditions, the framework can better reflect rural-specific challenges and opportunities. Policymakers can tailor the emphasis on different domains, addressing the unique needs of smaller or more remote populations.

The approach aligns with broader visions for a resilient, inclusive rural future. Rather than seeing rural areas as peripheral, the framework positions them as key contributors capable of driving sustainability transformations. Tools that accommodate local specificities can strengthen these regions' capacities to adopt climate-friendly practices and help meet overarching emissions targets.

4.2 Synergies and Trade-offs

The results illustrate that no sector or value can be addressed in isolation. Action in one domain often affects progress in another. The correlation analysis confirms that integrating efforts across energy, transportation, agriculture, industry, and waste is crucial. Identifying synergies can help avoid unnecessary resource expenditures, while understanding negative correlations ensures that gains in one domain do not undermine another.

Climate neutrality efforts in rural areas stand to benefit from coordinated strategies that treat these domains collectively. Policy coherence and cross-departmental

collaboration can mitigate conflicts, prevent duplicative measures, and maximize overall outcomes.

4.3 Policy Pathways and Governance

Effective governance structures are vital for implementing the various measures included in the framework. Access to funding, technical expertise, and supportive legislation can help local governments act on key domains like transportation or building retrofits. Multi-level governance emerges as a central theme, where higher-level bodies provide necessary resources, and local authorities retain autonomy in choosing interventions that suit their context.

It becomes evident that consistent policy direction, reinforced by stable funding mechanisms, can enable transformative change, especially in domains that require substantial investment or coordinated regulation. The capacity of rural administrations to handle these tasks depends on institutional support and continued reinforcement of local leadership roles.

4.4 Data Limitations and Future Directions

A persistent challenge is the scarcity of detailed, local-level data on emissions, resource use, and infrastructure. Downscaling methods can estimate these metrics, but more refined approaches would benefit from enhanced local data collection. Another difficulty lies in linking local indicators to global impacts, as cross-border considerations remain complex.

Flexibility in indicator selection and weighting is crucial, yet too much customization can weaken cross-regional comparisons. Identifying a set of core metrics while allowing for local adaptations could balance relevance and comparability. Future developments may include expanded data-sharing platforms, refined models to address transboundary impacts, and additional stakeholder-engagement processes.

4.5 Toward a Sustainable and Resilient Rural Future

This framework illustrates how rural regions can align their local actions with global objectives, advancing climate neutrality through integrated policies, data-driven decision-making, and stakeholder collaboration. The unique combination of adaptability, robust indicator design, and policy guidance underscores the potential for rural communities to become leading examples of sustainability innovation.

Although data availability and methodological complexity remain areas for improvement, the framework offers a valuable starting point. In practice, its adoption can help communities track their progress, prioritize interventions, and engage diverse actors in local decarbonization efforts. This not only aligns rural actions with the EU's overarching climate aims but also reflects a future in which rural regions can thrive economically, socially, and environmentally. By strengthening local governance, refining indicator methodologies, and fostering collaborations, rural communities may become central drivers of Europe's pathway to climate neutrality.