



Development of a Novel Framework for the Assessment and Improvement of Climate Adaptation and Mitigation Actions in Europe

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The greenhouse gases (GHG) emissions in the European Union (EU) are mainly caused by human activity from five sectors—power, industry, transport, buildings, and agriculture. To tackle all these challenges, the EU actions and policies have been encouraging initiatives focusing on a holistic approach but these initiatives are not enough coordinated and connected to reach the much needed impact. To strengthen the important role of regions in climate actions, and stimulate wide stakeholders' engagement including citizens, a conceptual framework for enabling rapid and far-reaching climate actions through multi-sectoral regional adaptation pathways is hereby developed. The target audience for this framework is composed by regional policy makers, developers and fellow scientists. The scale of the framework emphasizes the regional function as an important meeting point and delivery arena for European and national climate strategies and objectives both at urban and rural level. The framework is based on transformative and no-regret measures, prioritizing the Key Community Systems (KCS) that most urgently need to be protected from climate impacts and risks.

Keywords: climate change, nature-based solutions, adaptation, systemic approach, rural development

INTRODUCTION

As declared by the President of the European Council Charles Michel on May 13th, 2020:

Climate neutrality should be a driving force for supporting our businesses and our economic and social transformation. The climate agenda will need to be at the heart of our common project.

About 95% of the total greenhouse gases (GHG) emissions due to human activities in the European Union (EU) pertain to five main sectors—power, industry, transport, buildings, and agriculture—all contributing to global warming (Crippa et al., 2019). While there are efforts in GHG emission reductions primarily from the power and industry sectors over the last decades, Europe has been increasingly confronted with the effects of the incumbent climate change. There is an increase in average annual surface temperature of 0.8°C, with an increased rate of warming

over time making the 1990s the warmest decade (Paglia and Parker, 2021; Skea et al., 2021). Warm extremes are more common than cold ones, and the “warmer than normal” episodes occur most often during winter (Basarin et al., 2020) or in the increasing recurrence of heat waves and tropical nights in summer (Teichmann et al., 2018; Pfeifer et al., 2019). In the last century, annual precipitations increased in Northern Europe by 10–40% and decreased in some regions in Southern Europe by up to 20% (Dupuy et al., 2020). There was also an increased precipitation intensity in drier regions (Zhang et al., 2021). Extreme weather events have become common and accelerated “new normal” climatic conditions, which have been causing problems such as heat waves, wildfires, floods, storms (Funk, 2021). These problems threaten biodiversity and the resource base for a healthy human life, such as forests, agriculture, coastal areas, land, sea and cities.

To tackle all these challenges, the EU has focused on developing both mitigation and adaptation actions and policies accordingly, encouraging initiatives focusing on a holistic approach. With the European Green Deal (EUGD), the European Commission (EC) announced various initiatives covering several policy areas, including climate, the environment, energy, transport, industry, agriculture, and sustainable finance, which are strongly interlinked (Fragkos et al., 2021).

Concerning mitigation actions, within the EUGD and the European climate law, the EC proposes to set the EU’s 2050 climate neutrality objective into legislation and to establish the framework needed to reach the reduction target of at least 55% by 2030 (European Commission, 2020).

Concerning adaptation actions, the EU strategy on adaptation to climate change (EC, 2021) sets how countries may adapt to the unavoidable impacts of climate change and define climate resilience targets by 2050.

Furthermore, the 2021 United Nations climate change conference (COP26) ended with all countries agreeing on the Glasgow Climate Pact to keep 1.5°C alive and finalize the outstanding elements of the Paris Agreement by targeting adaptation, mitigation, including targeted finance, technology transfer and capacity building for adaptation and mitigation (Smith, 2021). Moreover, small-scale climate mitigation and adaptation initiatives have been flourishing across Europe. The outcomes of these individual initiatives contribute to overcoming environmental challenges, improving the socioeconomic situation including a restart after the current COVID-19 pandemic, and building a stronger and more competitive Europe.

Relevant examples of these initiatives are represented, among others, by small-scale forestry projects such as that implemented in Emilia Romagna (Italy)—planting 4.5 million trees—to increase the forest heritage up to 10–15,000 hectares (https://www.life-airfresh.eu/project/context_and_background); Besides small-scale forestry, other initiatives include (i) a bunch of nature-based solutions projects (Liu et al., 2021) to enhance the resilience of forest production and the provision of ecosystem services under Climate Change (Lafortezza et al., 2018); (ii) natural resources used in climate smart and sustainable way to enable diverse business (McCarthy et al., 2018); (iii) low

carbon construction and housing (Primasetra et al., 2020); (iv) soil protection (Tepes et al., 2021); (v) adaptation plans for industrial districts to help industries/districts in assessing climate risks and identify main vulnerability and adaptation measures (Ford et al., 2018; Sharifi, 2021); (vi) metropolitan plan of adaptation to climate change (Molinario, 2020); (vii) afforestation of overused areas to reduce the amount of erosion in the soil and enhance soil quality (Cassells et al., 2020); (viii) development of green infrastructures both at metropolitan scale as the case of the city of Turin (Cortinovis et al., 2018) or at micro-scale level as the vertical forest (Boeri and Xu, 2015) to deliver significant environmental, social and economic benefits; and (ix) new farming methods to enhance water retention and water supply to protect sensible areas (Riaz et al., 2020).

Despite their positive contribution to mitigate and to adapt to climate change, these initiatives are usually not integrated nor coordinated enough (Osofsky, 2015) and are independent from each other and do not lead to standardized/generalized frameworks. The initiatives are still driven in silos, and definitely not approached from a systemic point of view. Furthermore, many of these solutions have different objectives, scales, and are designed for either adaptation or mitigation of climate change. Hence, they are difficult to upscale and replicate in a systematic mode to achieve the much-needed impact in timely addressing climate change and building resilience (Kramer et al., 2022). In addition, existing actions have been often focused on countries and cities, while a gap emerge in the role of regions that should be strengthened to make solutions scalable and still related to geographical specificity, being the regional scale an optimal meeting point and delivery arena for European and national climate strategies and objectives (De Gregorio Hurtado et al., 2015; Salvia et al., 2021).

This paper aims to present a conceptual framework to fill such gaps enabling rapid and far-reaching climate actions through multi-sectoral regional adaptation pathways, both at urban and rural level. The framework is based on transformative (Wilson et al., 2020) and no-regret measures (Heltberg et al., 2009), which prioritize the Key Community Systems (KCS)¹ that most urgently need to be protected from climate impacts and risks.

On the basis of a focus group discussion with representatives from regions with a high readiness level for the adoption of such framework (North Karelia – Finland; Szabolcs-Szatmár-Bereg County- Hungary) and key experts in the fields of urban forestry and landscape planning, socioeconomic analyses and production economy, econometrics, policy analysis, environmental science, modeling and climate change, the framework was defined to address the following key questions:

- i. How do we assess and measure the success of climate change actions/solutions?
- ii. How do we identify drivers and barriers for their replication and upscaling?

¹Community systems are defined as community-led organisations and mechanisms through which community members and community-based organizations and groups co-operate, coordinate and deliver their solutions to their key challenges and needs. They can vary from being small-scale or informal to extensive including several organizations and involve various sub-systems.

- iii. How do we institutionalize these individual actions/solutions from a local (urban/rural) level into regional governance?

A CONCEPTUAL FRAMEWORK TO BOOST EFFECTIVENESS AND REPLICABILITY OF URBAN AND REGIONAL CLIMATE ACTIONS

The development of an integrated evaluation framework is motivated by: (1) the rapidly evolving necessity of taking targeted climate action and (2) the lack of a clear roadmap on which actions to take at the local level. Moreover, the Green Deal proposes the development of region-specific portfolios of Research and Innovation (R&I) solutions, mature enough for demonstration. These solutions cover the KCS and comprise the adaptation solutions, pathways deemed essential for climate and social resilience in the specific regional contexts and the set timeline. Furthermore, the Green Deal recommends a massive increase of community resilience and capacities to help coping with unavoidable effects of climate change.

In response to these, this conceptual framework aims to support the need for a growing climate resilience and adaptation by offering a flexible and integrated approach through which planners, policy makers and anyone interested in running an initiative for climate adaptation and mitigation can clarify their own priorities for adapting to and/or mitigating climate change and implement responsive strategies, policies and actions (Figure 1). The framework focuses on building regional networks and solutions, multi-sectoral resilience and adaptation pathways, and knowledge sharing. The framework could also be used to develop a decision support tool (DST) that enable to identify the solutions with the highest efficiency in ensuring the much needed quick and comprehensive change and design the course of actions to improve KCS. The conceptual framework is built around a robust theory of change that supports aspirations of the Green Deal and the 2030 Agenda for Sustainable Development (Desa, 2016).

Key Principles of the Framework

The framework is structured around the principle that any climate initiative must be technically feasible, economically viable, and environmentally sound. Moreover, societies must be able to integrate these novel climate initiatives into their daily lives and therefore the social acceptability becomes vital in achieving systemic change and societal transformation (Fazey et al., 2018; Fedele et al., 2019; Hölscher et al., 2019). It is important that a framework takes into consideration both the technology readiness and societal readiness of any climate initiative (Denmark, 2019; Chan and Meijer, 2020) to be successfully and fully adopted by society and bring the expected systemic and structural change (O'Neill et al., 2020).

The basic economic model of rational decision making (Simon, 1979; Doyle, 1999) can be used to illustrate this conceptual framework. Rational decision making involves detecting the best solutions to achieve the desired output/outcome based on one's preferences as illustrated in

Figure 2. The assumption is that people will make choices that maximize benefits and minimize any costs. In our case, the "choices" pertains to alternative solutions aimed at increasing climate change adaptation and mitigation. The model also assumes that people possess perfect information and are aware of all the relevant information and alternative solutions. This does not always apply in the real world. It is not obvious what the set of alternative solutions (in Figures 2, 3 defined as "alternatives") are, what the preferences of the user look like, and what the relevant benefits and costs are.

The real world approximation of the rational ideal can therefore be illustrated by Figure 3. In the following, we describe in detail the process of (i) establishing a detailed description of possible alternative solutions; and (ii) the process of allowing the users to express preferences and hereby to choose from the initiatives tried in other regions.

To approximate the underlying set of alternative regional initiatives and solutions, a natural starting point are the realized/completed projects in various regions which can be evaluated for their potential relevance to other regions. A series of relevant indicators shall be then established—taking into account the differing preferences in how to achieve climate mitigation and adaptation of each region—to assess the impacts of these alternatives. To make the different alternatives and rate them based on their efficiency, the regions should provide specific information summarized as in Table 1. This information, combined with the detailed plans and reports, provides a useful resource for the development of a decision support tool. It is also important to standardize the description of the resources used (inputs), the measures of the effects (outputs) and the contextual specifics that may facilitate or serve as barriers for the transformation of the inputs into outputs (contextuals).

Why Do We Need a Comprehensive Framework in a Climate Changing Environment? Main Challenges to Address

Despite the growing number of small-scale regional initiatives on climate adaptation and mitigation across Europe, their impact remains much scattered, they are too small and localized, reaching only a very small number of beneficiaries.

Factors to Be Considered in the Analysis of Alternatives Phase Among Existing Initiatives and Solutions

- (i) should be better *integrated across the Community Systems* (Hallsmith, 2003): In order to bring the anticipated benefit, adaptation and mitigation measures must be integrated across specific Key Community Systems (Hedegaard et al., 2020), i.e., (i) health; (ii) primary production, including agriculture, forestry, fisheries and aquaculture; (iii) water; (iv) environment, including biodiversity; and (v) infrastructure, including clean energy and transport (Galarraga et al., 2011). Natural resources and infrastructure, while crucial, are not the only parts that are affected and in need of increased resilience. In a necessary and urgent transition from a linear, fossil-based, make-take-trash economic model toward

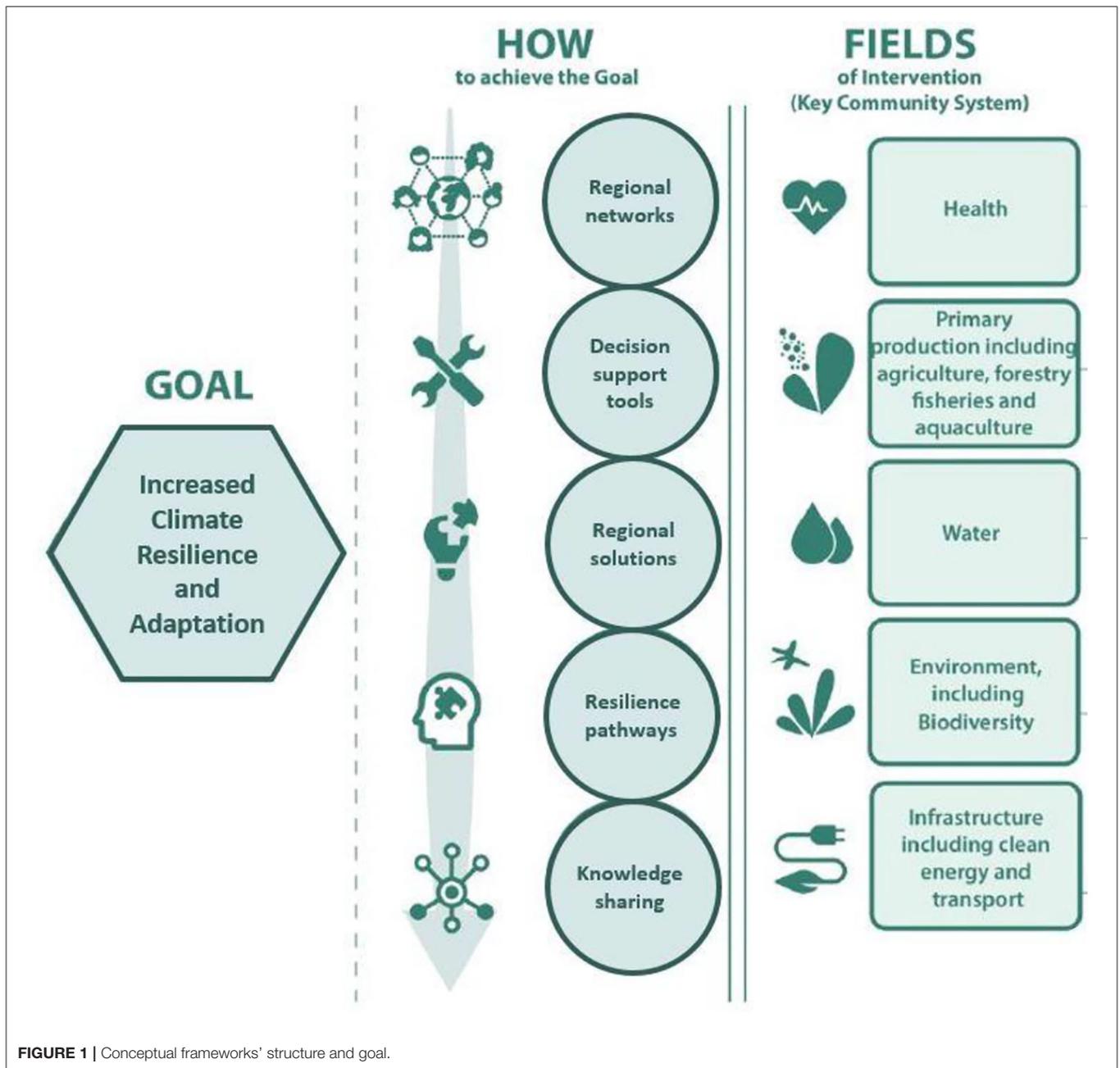


FIGURE 1 | Conceptual frameworks' structure and goal.

a renewable, circular, non-consumerism, bio-based economy, also business, finance and insurance, policy, and citizens are affected. To be successful, sustainable, and resilient, new business and lifestyle models are needed. New measurement scales and values for finance, industry and policy need to be found and accepted.

- (ii) must be better *coordinated among citizens, communities, across regions and Countries*: Lack of coordination represents an obstacle to cohesive and broad climate action that not only incorporates, but also improves upon socioeconomic challenges. Without addressing these issues in tandem, the underlying linkages between the climate, economic, social

and health crises (including COVID-19) go unaddressed and unresolved.

- (iii) *rely on the capability of the different institutions to react quickly with projects and solutions*: There is a much-needed work in building the capacity of the present and future experts to work on complex and interdisciplinary issues. Additionally, it is important to address the rapid increase of risks associated to extreme weather events and the failure of environmental and climate policies.
- (iv) *have different focus on regional climate adaptation and mitigation*: This weakens the role of regions in climate

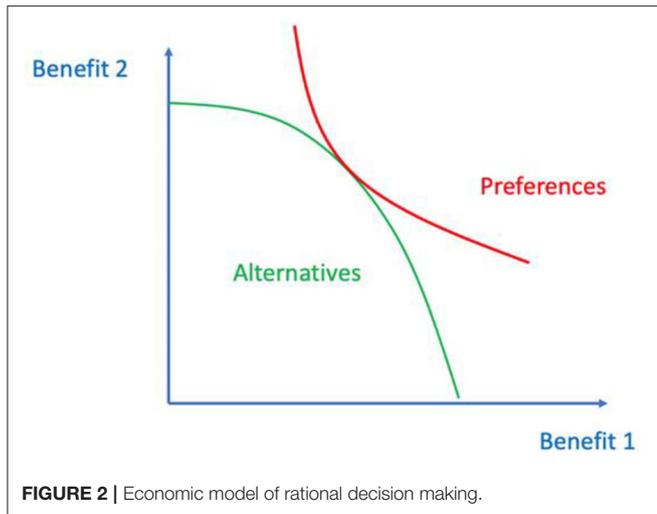


FIGURE 2 | Economic model of rational decision making.

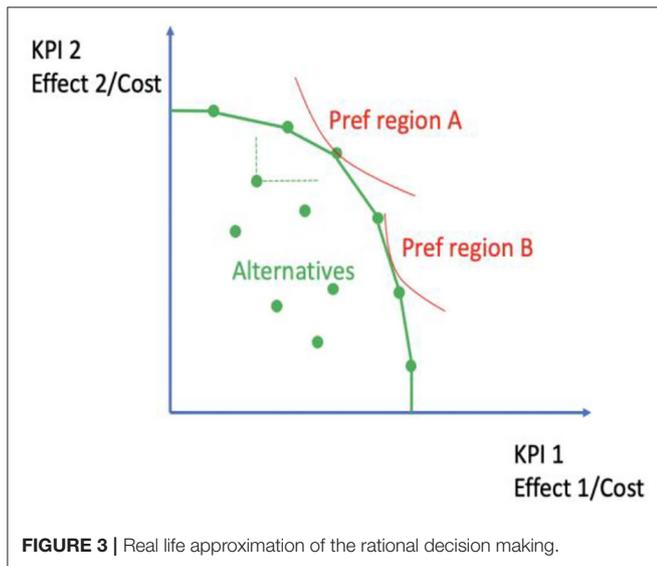


FIGURE 3 | Real life approximation of the rational decision making.

action. Individually, regions are not strong enough to achieve the much-needed impact in addressing climate change and building resilience (De Gregorio Hurtado et al., 2015; Desa, 2016; Salvia et al., 2021).

By using the proposed framework, efficient and sustainable pathways for regional resilience can be developed through:

- *A Paradigm shift.* The framework focuses on the role of regional bio-economies as a foundation for climate action and climate resilience at the regional scale and providing evidence-based policy options and resilience pathways.
- *A systemic approach.* The regional governance and innovation level will be of crucial importance. This framework for sustainability and resilience assessment the 5 capitals (Porritt et al., 2007)—5C—which is a proxy for the most relevant KCS—**Figure 4**) will contribute to increase the knowledge on the benefits of the selected solutions by using the 5C as indicators

TABLE 1 | Summary information on the possible initiatives.

Information required	What should it highlight?
A description of solution	A simple description of the solutions
A brief characteristic	Contextualization – the bigger picture
Adaptation/mitigation	If it is aimed to attain adaptation, mitigation or both
Status	If it is already implemented/ or only planned
The targeted KCS	Which KCS the solutions are aimed to improve
The impact and benefits	Quantification of the impacts and benefits achieved-
The key actors/stakeholders	Description of the clients, beneficiaries, main actors involved
The measurement tools	Which indicators have been/will be used in their impact assessment
The barriers	What has been or will hinder the successful implementation
The resources and time	Financial and human resources used or planned

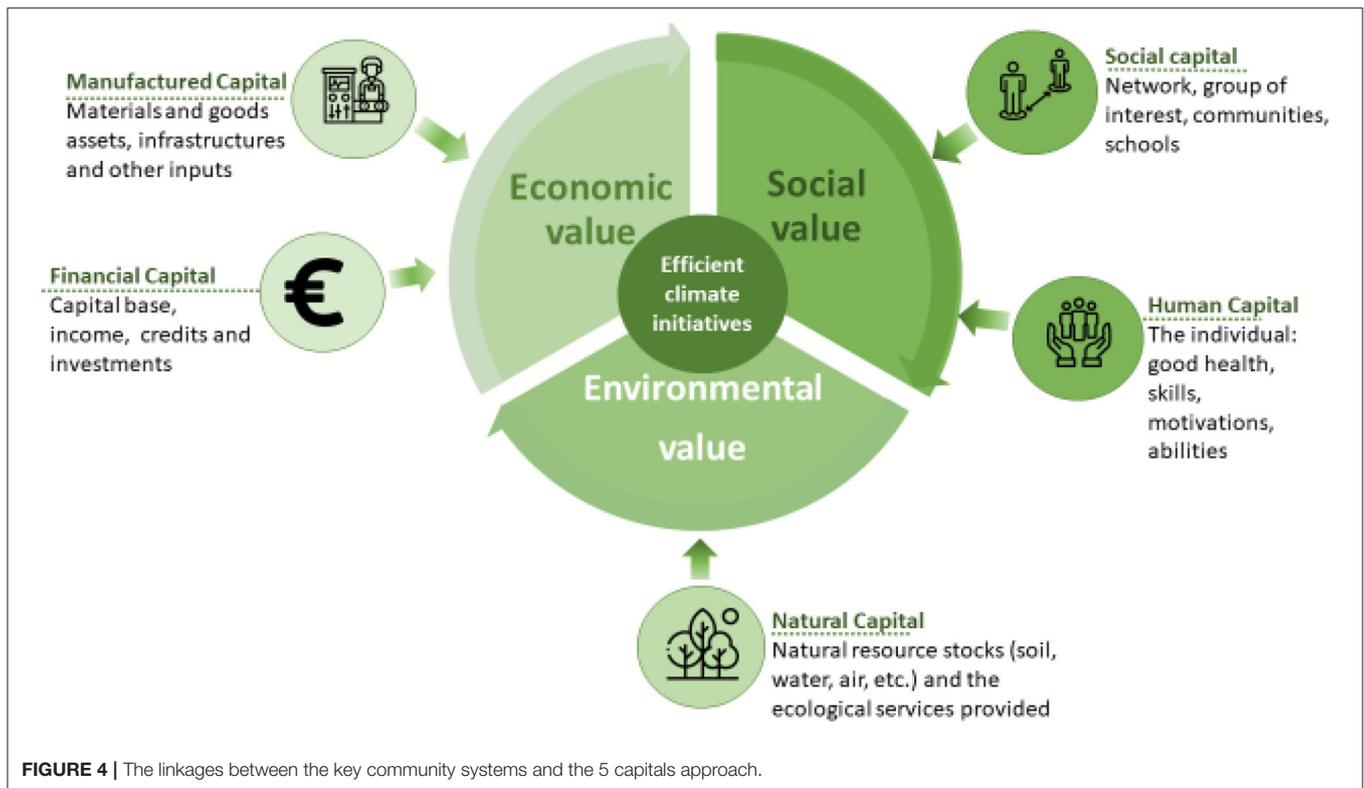
for measuring the benefits and trade-offs of the solutions on the most relevant KCS. This will fill the knowledge gap on the possible impact allowing key decision makers to identify the most sustainable solutions for their region-specific context.

- *Improved cohesion and conflict prevention and mitigation.* Wealth is not evenly distributed across Europe nor is the capacity to respond to macro-economic and unprecedented shocks, e.g., COVID-19 pandemic exacerbated by the effects of climate change such as extreme climate and weather events. The framework will contribute to building a network of regions and cities with the goal to provide fair and equitable solutions empowering less resilient and resourceful actors with means, knowledge and resources, to overcome these challenges. Wealth is not evenly distributed across Europe nor is the capacity to respond to macro-economic and unprecedented shocks, e.g., COVID-19 pandemic exacerbated by the effects of climate change such as extreme climate and weather events. Unless properly addressed, these challenges will increase the divide between east and west within the EU, within societies building new areas of conflict.

Framework Application for Climate Change Actions/Solutions

Based on experience from a large number of benchmarking projects (Bogetoft, 2012b), it is known that, to successfully develop and apply this framework, the following steps are necessary:

- Choice of indicators and standardizations: Initiatives can be described in many different ways, but to make them comparable, relevant variables and standardized way to compare them need to be agreed. Even in a typical benchmarking project, where the compared entities are comparable in relation to each other, there are still many standardizations needed. This includes the choices of accounting standards, cost allocation rules, in/out of scope rules, system boundaries, asset definitions and operating standards which are all necessary to ensure a good data set.



In our framework standardization is simplified because of the possible regional differences allowing for cross-regional comparison. To illustrate, it is useful if resources in the terms of Opex (operating expenditures) and Capex (capital expenditures) can be described at least approximately for all solutions, since it makes little sense to compare only on Opex for example, if some initiatives or solutions require large capital investments while others require few such investments.

- ii) Choice of variable aggregations: Choices of aggregation parameters, such as interest and inflation rates, will be important to compare solutions and initiatives with different time-profiles.
- iii) Data cleaning: Data collection is an iterative process where definitions are likely to be adjusted and refined and where collected data is constantly monitored by comparing simple Key Performance Indicators (KPIs) across initiatives. Outliers shall also be identified and we shall distinguish between outliers that are simple abnormal and difficult to imitate, and outliers that may serve as particularly good examples to imitate. Statistical techniques may in principle facilitate this process, but it is expected that simple comparisons and graphical methods will suffice in this project, where the main challenge is the diversity of the initiatives and not the detailed comparison of one initiative to another very similar initiative.
- iv) Model development: Since there will only be a limited number of discrete initiatives to build on, it is important to establish a model that can extrapolate from these initiatives and be guide to estimation of rescaled and combined initiatives. We suggest using non-parametric

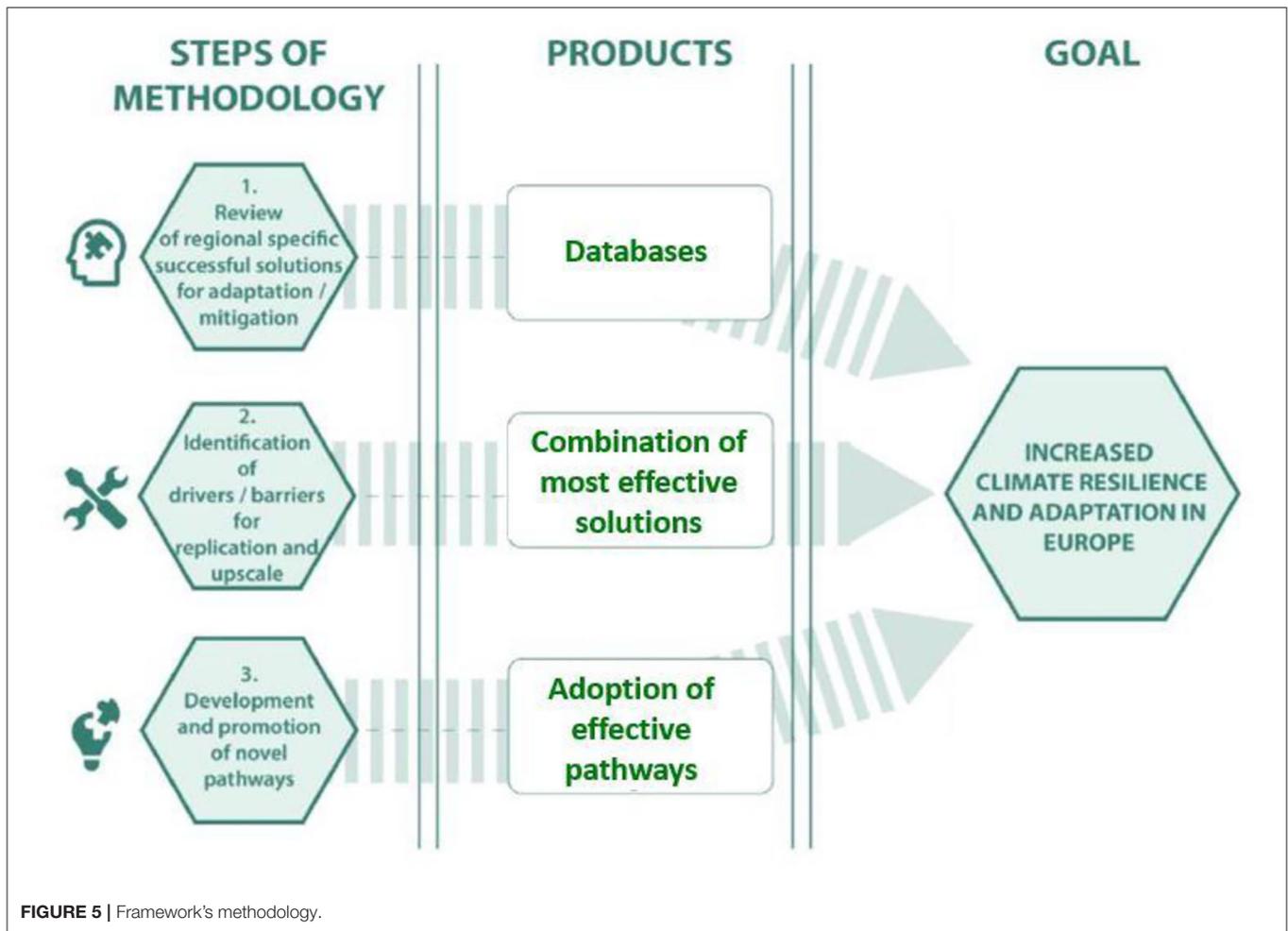
modeling approaches based on a small number of a-priori assumptions, including Data Envelopment Analysis (DEA) (Cooper et al., 2011)-like modeling approaches.

- v) Search methods: To facilitate the search for an interesting initiative for a region to imitate, rescale and perhaps combine with other initiatives, we suggest to use the insights from Multiple Criteria Decision Making and from Interactive Benchmarking (Bogetoft and Prusan, 1997; Bogetoft, 2012a).
- vi) Constraint approaches: Allows the user to put certain minimal constraints on the initiatives of interest. In a practical context, this may correspond to the use of filters.
- vii) Weighted approaches: Allow the user to express the relative importance of saving on different resources (inputs) and on generating the different main effects (outputs).
- viii) Targets approaches: Allow the user to express the feature of an ideal solution that the specific initiatives shall be as close to as possible.

DISCOURSE ANALYSIS: KEY DRIVING ELEMENTS TO ENSURE FRAMEWORK'S SUSTAINABILITY, REPLICATION, AND UPSCALE

The methodology adopted to collect relevant feedback from the focus group was that of discourse analysis.

Discourse is the complex system by which people communicate. It includes both written, verbal and non-verbal communication, as well as the wider social concepts that underpin what language means, and how it changes.



In the context of this study, the discourses analysis was developed as a broader social practice in the case of regions (Tannen et al., 2015) and as a critical analysis of alternatives and choices in the groups of experts. In the latter case, the type of approach used is a problem-centered expert interview (Döringer, 2021) performed in semi-structured collaborative discussion. Revealing the implicit dimensions of expert knowledge was of interest beyond the specific, individual research positioning. Indeed, the experts influence in the whole process brought multiple readings of the research issues and the approach was used to match the need of dealing with multiple conflicts among fields of interest and knowledge.

The discussions involving regions and experts took place in the period June–December 2020 in an online modality and resulted in the following key elements emerging as relevant to ensure the framework's sustainability and success:

1. Regions and cities must engage and commit: focusing on local and regional solutions, best practice and management approaches will ensure uptake, public acceptance and increased awareness. To translate and trickle-down highest-level European climate targets and ambitions to the regional

level, where they are actually being operationalized a firm commitment is needed. Actors ranging to cities to a broad range of European regions should commit own resources. This was also suggested by Bayulken et al. (2021).

2. Increase the number of successful scale-up and uptake of innovation and climate-friendly best practice solutions across Europe. Still too often, innovative, climate friendly innovations, business models and public sector approaches remain confined in smaller-scale, regional environments and unheard of beyond that scope. To scale up and replicate successful initiatives a twinning model could be applied where more advanced cities and regions are showing the path to the less advanced. This was also emphasized in the preliminary results of the project SPARCs funded under H2020-EU.3.3.1.3. SPARCs focuses on solutions based on pioneering business models, tailored on interactions between the citizen, building and urban energy systems, as well as effective governance model to facilitate the transformation process. A comprehensive understanding of complexities and wide acceptance of communication and interaction between citizens, local communities, industries and authorities is

the key securing wider upscaling of sustainable solutions (Melo and Colombo).

3. Mobilization of funds. Europe's climate change challenge is expensive and mobilizing private funding for climate change mitigation and adaptation boost interregional collaboration can ensure the broad implementation of solutions at reduced (shared) risk. An example is given by the relative importance of financial viability in the adoption of NBS as green roofs as elaborated in Rogina and Nukić (2021).

Framework's Sustainability

Today, the speed of adaptation action varies across the EU, with all Member States having adopted national adaptation strategies or plans. The EC was recognized by the Global Commission on Adaptation as a pioneer in integrating considerations of climate risk into decision-making. To this end, small-scale climate mitigation and adaptation initiatives are flourishing across Europe. However, the European Environment Agency (EEA) reported that even if the EU and some countries have started to monitor the implementation of adaptation activities, it is not possible to determine with any certainty whether decisive progress in increased resilience at EU level has been achieved by 2020. The involvement of citizens, communities, regions and nations will be the discriminant for the success of these initiatives as mentioned in the Mission: A Climate Resilient Europe (Hedegaard et al., 2020). Climate resilience can be defined as the ability of all these actors to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate (Vivekananda et al., 2014). In a regional context, resilience can be defined as the regional adaptive capacity to overcome shocks (Gitz and Meybeck, 2012). Regional economic resilience is based on response capacity to shocks and growth performance, as such four general types of regions can be identified in regards to resilience: adaptive regions, rigid resilient, non-resilient regions, and entrepreneurial resilient regions (Simmie and Martin, 2010). While there are numerous studies on regional economic resilience and urban climate resilience, studies on regional climate resilience that address more varied regions are very limited due to the lack of approaches for empirical validation of resilience indicators and data (Feldmeyer et al., 2020). The proposed framework will contribute to the necessary paradigm shift by creating an inclusive and enabling ecosystem for decision makers and other actors to elaborate resilient pathways based on co-creation and fair access to information and resources. In this respect regional alignment and scientific and socio-economic advancement, could be accelerated by adopting the wide ranging three paradigms supported by the European Commission: Open Government Data, Open Science and Open Innovation (Marinelli et al., 2019). It will also advance innovation ecosystems by improving social cohesion within and across cities and regions, facilitating dialogue and communication and learning by example as a basis for incentives to much needed behavioral shift (Figure 5).

Regions are uniquely positioned for testing and advancing climate measures, as they have the operational mandate, structure, legislative power, and size to develop and implement effective strategies and measures, while reaching

all necessary target groups (e.g., policy makers, networks, business, finance/insurance, society) and areas: (i) land-use and city planning which need to rethink (de)centralization, revitalisation, digitalisation and redesigning areas and services; (ii) develop, support and accelerate new business models for the workforce, business and finance sector; (iii) showcase and foster reconsidered lifestyle and workstyle models for citizens.

Framework Replication and Upscale

The described framework because of its multifaceted nature has the potential to be adapted to different sectors and therefore be easily replicated.

Potential applications are related to:

- *Adaptation plans for industrial districts:* While research covers how businesses adjust to changing business conditions—related to new competitors, products or markets or legal framework, there is a lack of analysis on business adjustments to climate change (Linnenluecke et al., 2013). All businesses are affected in different ways according to structures, locations and environment; adverse business outcomes include business interruptions, increased investment or insurance costs, or declining financial measures such as value, return, and growth (Sussman and Freed, 2008). Public policy can help in fostering better climate resilience of businesses and to this aim, a strong risk analysis and risk profile is needed to bring evidence on the urgency to take action. The risks to be considered vary greatly depending on the type of activity carried out, structure that hosts the activity and obviously company's location. The framework could contribute to increase the development of the adaptation strategy of industrial districts, to upgrade the service for a more effective risk analysis at territorial level.
- *Regional innovation for business, governance and society:* Taking resilience, sustainability and circular bioeconomy aspects into account at a systemic level is a prerequisite for policy and lifestyle changes and to open up new business models and opportunities, particularly for remote, rural or disadvantaged regions. This conceptual framework aims at including interregional exchange for policy learning and could contribute to the creation of a governance peer group and capacity building activities, for a business and innovation discovery hub by creating a bioeconomy business accelerator program and for societal awareness by increasing awareness and shaping systemic understanding of consequences from everyday choices.

In relation to the role that the framework could have for different Regions across Europe, several potential applications were defined by the regional representatives during the focus groups meetings. Six regions were part of the focus group i.e., North Karelia (Finland), Emilia Romagna (Italy), Basque Country (Spain), Gornoslasko-Zaglebiowska Metropolia (Poland), Szabolcs-Szatmár-Bereg County (Hungary) and representing one of the Western Balkans Regions was the Ministiria e Turizmit dhe Mjedisit from Albania. Three Regions (North Karelia—FI, Emilia Romagna—IT, Basque Country—ES) were identified and selected on the basis of their climate leadership through strategies and implementation while the remaining three because

of their vulnerabilities and ambitions in adopting a sustainable framework. A short presentation of two representative regions one from each cluster, with their experiences and ambitions in relation to climate objectives and the KPIs that they identified as relevant for assessing a potential success of climate initiatives, are reported below.

North Karelia, Finland

North Karelia is a forested region (89% of land cover) in Eastern Finland with 163,000 inhabitants. The region's industries include the forest, metal, food industries, as well as competence-based growth industries of the future, forest bioeconomy and new technologies and materials. The carbon footprint of North Karelians is 36% smaller than that of an average Finn. Due to the region's remoteness and cold climate, local and renewable energy are important with currently 64% renewable energy consumption, and ~63% of the energy consumed is produced in the region.

North Karelia has an ambitious Climate and Energy program, which aims to achieve at regional level an 80% reduction in greenhouse gas emission and almost 100% renewable energy in total energy consumption by 2030 (compared to 2007 level). In addition, NK is aiming to creating 400–800 new jobs and investments in bioeconomy with a turnover of 2.5 billion euro by 2023 and aims for its regional capital Joensuu to be the first carbon-neutral city in Finland in 2025. In this work the Smart Specialization Strategy with green and digital innovation is in important role.

Being a founding member of the Bioregions Facility is one example of promoting cooperation at regional and international level, while implementing concrete action around bioeconomy-focused policy learning, business and innovation acceleration and social awareness. The role of the Regional Council of North Karelia is to encourage, promote, support, inspire and activate the relevant regional partners to work toward the joint goal of a resilient, innovative and Carbon neutral NK. Success stories—and solutions—are many: in wood construction the 14-story student housing “lighthouse”, pilot production of biofuel (fast pyrolysis bio-oil plant) in Lieksa and piloting biochar production in Joensuu. The district heating in almost all municipalities and cities in the region is based on bioenergy. Also, for electricity production the focus is renewable sources, CHP—plants, solar and water energy. The development of alternative fuel for traffic is the crucial question in the region in the future: the biofuel and biogas from agricultural residuals and side streams from industry are currently under consideration.

The specific challenge is that while some solutions and examples for low-Carbon energy and wood-based construction exist, they are not yet commonplace.

Suggested KPI for these actions: quantified reduction in GHG emission; share of renewable and local energy; number of showcased good practice examples (in projects, buildings, transport solutions, business models, endorsements); number and value of projects (received applications and funded); number of events and recipients of information activities and trainings; number of new business models and registrations focusing on resilient, sustainable, circular or biobased concepts; amount of

funding or turnover/number of regions allocated to relevant funds/projects/bioeconomy acceleration; documented awareness and lifestyle change toward more climate considerations (e.g., survey based).

Szabolcs-Szatmár-Bereg County, (Hungary)

SSBC, situated in the northeastern corner of Hungary, covers an area of close to 6,000 km². It is located in an area that borders with Slovakia, Ukraine, and Romania and has a population of 562,000 people. Agriculture is a major economic activity in the county, but unemployment is high and the local economy is under pressure. This problem is aggravated by climate change which has resulted in extended periods of droughts and an irregular precipitation pattern. Thus, the groundwater level has decreased and the already dry area has issues with water retention, which poses a threat to agriculture and other economic activities.

The county has adopted and is implementing a Sustainable Energy and Climate Action Plan and Climate Strategy. This strategy promotes a number of specific solutions and actions related to e.g., water retention by expanding forest and vegetation cover, promoting more sustainable farming practices and changing farmer behavior, better conservation of protected areas, and promoting use of sustainable energy and materials in construction practices. In the frame of other international projects (e.g., HUSKROUA, GeoSES, MOBI-green corridors), the county's climate strategy is being extended to the border area, the river basin area of the river Tisza and developing a climate strategy for the cross-border area with Slovakia, Ukraine, and Romania. This represents an important governance innovation. Cross-boundary, mutual learning is prioritized as are training and awareness raising activities leading to behavioral changes (e.g., of farmers).

KPIs for these actions included, among other, reviews/monitoring of farming practices, consumption and production; protected area; air quality measurements; water quality; energy consumption; share of renewable energy. Importance of mobilizing international know-how, information exchange, behavioral change approaches. Needed: support from decision makers, key sectors such as agriculture. Also training and awareness raising, funding, knowledge.

CONCLUSIONS AND RECOMMENDATIONS

Existing regional initiatives and solutions focused on climate mitigation and adaptation are often not sufficiently integrated across the relevant KCS, i.e., (i) health; (ii) primary production, including agriculture, forestry, fisheries and aquaculture; (iii) water; (iv) environment, including biodiversity; and (v) infrastructure, including clean energy and transport. These programs have limited coordination among citizens, communities, regions and States, representing an obstacle to cohesive and broad climate action that not only incorporates, but also improves upon socioeconomic challenges. Without addressing these issues in tandem, the underlying linkages

between the climate, economic, social and health crises (including COVID-19) go unaddressed and unresolved.

This framework aims at analyzing and delivering optimal combinations of existing region-specific climate action initiatives and solutions to catalyze their upscaling and replication at the European level and beyond. It also has the potential to represent the stepping stone for developing a comprehensive toolbox for planning, management, monitoring, evaluation, and validation, based on the most relevant KCS.

Climate change, an all-encompassing challenge facing Europe and the world, requires the mobilization of all stakeholders including Europe's regions. It is especially important to focus on the under-prioritized group of subnational governments, who are the decision-makers for most site-dependent adaptation initiatives and solutions (Glemarec, 2009). It is necessary to build a bridge from our current reality of under-coordinated and under-supported communities to a future of strong regional climate resilience and adaptation. This will only be possible through fostering a deeper understanding of the possibilities and impacts of tailored climate initiatives and solutions in order for regions to choose their own climate-neutral futures and start building them today.

As many of the climate initiatives are related to Nature Based Solutions (NBS) the focus group expressed the need for them to be integrated within policies, planning, development and maintenance of the urban ecosystems, comprised by water, soil and atmospheric factors and processes. NBS should be developed as tools to yield high quality and multifunctional environments for urban areas. Types of elements in this contest are multiple and thus, very challenging. The (literally speaking) underlying geology and pedology, together with climate affects the many factors of importance, such as soils, water in ponds, streams and lakes, and their inherent ecosystem services. Habitat types, with microbial associations, plants, and animals form complex and dynamic biological communities, sometimes managed, and always strongly affected by human activity as part of the urban metabolism (Faeth et al., 2011). Although urban and rural areas may be very different, their development and management are most often related to the many human processes and constructed

elements in urban areas. In this framework, the policies and management of the nature capital is demanding and the need for removing silo-thinking is still difficult, even if it is an obvious development.

The above mentioned challenges and perspectives could not do without the people knowledge and awareness, and the increased capacity of the institution to respond to the challenges, with technical solutions. Breaking the silos approach, and working with more transdisciplinary approach is seminal to implement climate adaptation strategies. The pressing need to transition toward a fair, climate neutral and digital Europe, entails among others a change in the way we use, produce and consume things. These environmental, social and economic transformations and consequently in our lifestyles need to be promoted, accepted and institutionalized to become part of the novel policy making process and representing a new-normal for all EU. Policies rewarding specific actions toward adaptation and mitigation will produce the much-needed amplification and harmonization of the actions leading the path toward the EC goals.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

GO, BG, DT, H-YL, MP, PB, and CK contributed to the framework definition and the broadening of the focus group. GO wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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