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Evaluation Policy Model for Mitigation and Adaptation Policies for Climate Change in Urban Planning

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Abstract Climate change appears as the main threat to all dimensions of sustainable development, namely environment, economy, and society. Policy actions, in this respect, need to be undertaken to target both mitigating Greenhouse Gas (GHG) emissions, but also implementing adaptation measures.

The focus of the present paper is to explore the impact of mitigation and adaptation policies, already undertaken, at various levels, in the urban context. Along this reasoning, a policy-making framework is proposed, in support of decision-making centers, in order to promote an effective resolution of the emerging conflicts between adaptation and mitigation policies, promoting at the same time, social dialogue and citizen interaction.

In the first part of the paper, a short introduction on the concepts of 'mitigation' and 'adaptation' is presented, while in the second, a range of indicative synergies and conflicts of 'adaptation' and 'mitigation' policies are identified. A short description of mitigation and adaptation targets together with their respective policy measures in two Nordic cities follows in the third part. This is accompanied by an identification of the synergies and conflicts between adaptation and mitigation, taking place in the respective urban contexts. Finally, an integrated model is proposed for the selection of an optimal combination of mitigation and adaptation strategies enabling conflict resolution in similar contexts.

Keywords: mitigation, adaptation, evaluation, integrated policy model

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1. INTRODUCTION

In recent years, climate change and the impacts following this rapidly changing environment have become more severe than ever before. Global initiatives and local actions characterize the efforts of humanity to reverse this severe situation.

According to the Kyoto Protocol (Article 10, Paragraph (b), p. 9, United Nations Framework Convention on Climate Change, 1998), all Parties should:

'Formulate, implement, publish and regularly update national and, where appropriate, regional programmes, containing measures to mitigate climate change and measures to facilitate adequate adaptation to climate change.'

In this sense, in Kyoto's provisions, mitigation and adaptation policies constitute the principal efforts to cope with climate change. Later, in the Paris Agreement - adopted at the Climate Change Conference (COP21) - includes, among others, objectives to limit the increase in temperature to below 2 °C, which lies above pre-industrial levels and to increase the ability to adapt to the impacts of climate change. Additionally, for the promotion of greenhouse gas emissions mitigation effectiveness, public participation should be facilitated by undersigning Parties (United Nations Framework Convention on Climate Change [UNFCCC], 2015)

In the following, a range of mitigation and adaptation definitions is presented.

1.1 Mitigation and Adaptation: Definitions

In the Sixth Assessment Report of the Intergovernmental Panel for Climate Change (IPCC), adaptation is defined as follows (IPCC, 2023a, p. 120):

'In human systems, the process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.'

Moreover, mitigation refers to (IPCC, 2023a, p. 126) as:

'An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.'

Several types of adaptation can be noted, such as proactive and reactive adaptation, private or planning adaptation, autonomous or planned adaptation, etc. On the other hand, the main strategies of mitigation are based on the prevention of GHG emissions in the atmosphere, the extraction and containment of GHG from the atmosphere and finally the reduction of future GHG emissions.

1.2 Features of Mitigation and Adaptation Actions

There are many differences between mitigation and adaptation policy actions, primarily based on their different time span (long vs short term) and spatial scale (global vs local), while other aspects shedding light on the differences between mitigation and adaptation relate to their focus, benefits, results, etc. (see Table 1).

Table 1. Mitigation and adaptation characteristics in comparison, Source: Authors, based on IPPC (2007), McEvoy et al. (2006), and IPCC (2023b)

	Mitigation	**Adaptation**	**Reference**
Focus on	Decarbonization (Energy and Transport Sector)	Variety of Sectors (urban planning, agriculture, water supply, infrastructure)	IPCC, 2023b
Benefits	Reduction of global warming	Reduction of local impacts and risks	IPCC, 2007; IPCC, 2023b
Time frame	Long term	Short – medium term	McEvoy et al., 2006
Motivated by	International Agreements and Targets	Mostly on Local – National Initiatives	IPCC, 2007; IPCC, 2023b

Mitigation policy actions are driven by international agreements that mainly focus on decarbonization targets, addressed to sectors such as energy and transport. Obviously, mitigation actions are applied on a global and regional scale, while the expected benefits will appear in the long run, at all scales (global to local). Conversely, adaptation policies have immediate social, environmental and economic benefits, while they are motivated by local or regional initiatives rather than national or global policy actions. Moreover, as climate change conditions affect numerous aspects of human activities, adaptation measures are applied in a variety of sectors, such as the construction sector, etc.

2. SYNERGIES, TRADE-OFFS AND CONFLICTS OF ADAPTATION AND MITIGATION IN THE URBAN CONTEXT

It is widely admitted that the impacts of climate change are becoming increasingly unpredictable, doubting the ability of society and technology to adjust to the rapidly changing conditions.

One of the main sources of GHG release to the atmosphere nowadays is the urban environment (intensive energy consumption, congestion, cities' expansion, etc.). Moreover, urban functions, in many countries worldwide, such as transport, heating, industry, etc., are largely contributing to the greenhouse effect. Provided that the urbanization patterns are increasing, on a global scale, urban systems are nowadays at the heart of policy making, focusing on both mitigation and adaptation policy measures. Mitigation measures will ensure the long-term gradual decrease of cities' contribution to the greenhouse effect, while at the same time, adaptation measures will support cities in the short term to deal with the already established or expected impacts of climate change (e.g. increasing events of flooding, heat waves, etc.). Nowadays, recent advances on city modeling, such as the 'city of 15 minutes', the linear city, etc., have adopted the implementation of mitigation and adaptation policies. A pronounced example is the case of the 'Smart City-Line' in Saudi Arabia (Al-sayed, 2022).

2.1 Inter-relationships between Adaptation and Mitigation

By combining adaptation and mitigation policy measures, certain trade-offs, conflicts and synergies may appear. According to Klein et al. (2007), there are four types of inter-relationships between adaptation and mitigation policy measures, as follows:

- **Adaptation actions that have consequences for mitigation**

An indicative example, where adaptation policy actions may weaken efforts to reduce GHG emissions, refers to the air-conditioning installations that protect people from high temperatures. These imply an increasing demand for electricity consumption. Given the fact that this demand is met by fossil fuels, this adaptation measure results in an increase in GHG emissions.

- **Mitigation actions that have consequences for adaptation**

According to OECD (2010), the promotion of 'compact' cities can be considered as an attempt to reduce transportation needs for individuals, reducing GHG emissions. However, compact cities may lead to the development of the 'heat island effect', which negatively affects local climate conditions and therefore demands further adaptation measures.

- **Decisions that include trade-offs or synergies between adaptation and mitigation**

According to Qi and Terton (2022), Hürlimann et al. (2025), IPCC (2007), trade-offs between adaptation and mitigation concern a balancing of both, in case that fails to be fully implemented, due to a range of prevailing constraints. For example, the target of lowering GHG emissions, in a city environment, can be pursued: Firstly as a result of certain interventions in the land use patterns (mitigation measure), which may reduce the transport volume and therefore the GHG emissions and secondly from additional adaptation measures in the building stock of the city, e.g., green roofs, which would absorb part of the GHG emissions. In this respect, mitigation constraints emerging from the limited intervention potential, in the built space (mitigation potential), can be partly balanced by the adaptation measures.

On the other hand, synergies between mitigation and adaptation measures imply an interaction between the two types of measures, which may lead to considerably higher effects. An indicative example of synergy between adaptation and mitigation measures could be the greening of roofs that is sinking carbon dioxide, but also the reduction of peak water flows during rainfall, the provision of an urban habitat for various species and finally a building cooling system which acts as protection means versus extreme heat waves Miller (2008), Qi and Terton (2022), Hürlimann et al. (2025).

- **Processes that have consequences for both adaptation and mitigation**

The term 'response capacity' of a system refers, after Tompkins and Adger (2003), to 'the ability to manage the generation of greenhouse gases and the consequences of their production'. Several factors of an urban system, such as socio-economic status, technological development, knowledge resources, grassroots movements etc., may reduce or enhance its adaptive and mitigative capacity. In this respect, the socio-economic crisis, cultural aspects or technological maturity of societies may increase or decrease the potential of the system to promote adaptation measures or change behavioral patterns, mitigating thus GHG emissions.

3. CLIMATE CHANGE GOALS IN NORDIC CITIES

Climate change impacts, such as sea level rise, heavy storms, flooding, extremely high temperatures, heat island effects etc., have already been experienced in many countries of the world.

Nordic countries are some of the areas where these extreme situations are heavily threatening their cities. In this respect, Helsinki and Copenhagen are selected as case studies for better presenting the mitigation and adaptation policies likely to be applied in an urban context, but also the conflicts, among synergies and trade-offs that may appear in these policies. Therefore, the resolutions of the conflicts arising during the implementation of such policies would greatly benefit from the introduction of an evaluation policy model addressing these complexities. Towards this end, a short description of mitigation and adaptation targets and measures is presented, as a test case, for the cities of Helsinki and Copenhagen, aiming at reducing their vulnerability to these effects.

3.1 Copenhagen Mitigation Objectives and Adaptation Measures

In 2009, the city of Copenhagen set the goal of becoming the first zero-emission capital in the world. Nowadays, the city is refraining from reaching its goal by the year 2025, thus delaying Copenhagen from being the world’s first carbon-neutral capital. However, Copenhagen succeeded in reducing considerably CO2 emissions in 2021, in comparison to the base year 2005.

- **Mitigation Strategy**

The mitigation agenda of Copenhagen draws upon the following indicative directions (Copenhagen Municipality, 2012);

- *Integration of the climate aspect into the energy supply*: shift from fossil fuels to renewable energy sources.
- *Greener transport: by reducing transportation demand, improving accessibility to public transportation means, promoting bicycle and pedestrian flows, promoting also electrical and hydrogen-powered cars.*
- *Energy efficient buildings: supporting low energy-consumption buildings.*
- *Citizens and climate: engaging Copenhageners to further support environmentally friendly behavioral patterns.*
- *Integration of climate change in urban development: promoting a dense city, less dependent on transport.*

- **Adaptation Measures**

The city of Copenhagen has based its adaptation strategy for climate change on three distinct adaptation levels on its route to tackling flooding risks and heat island effects. The *first level is* focusing on policy actions that prevent the environmental damage (e.g. building dykes, building at positions higher than the sea level); the *second level that* focuses on minimizing the level of damage (e.g. establishing an emergency warning system); and finally, the *third level* that aims at promoting those adaptation measures reducing vulnerability (e.g. equipping the cellars with pumps) (City of Copenhagen, 2011).

Figure 1 presents an explanatory framework for identifying synergies, trade-offs and conflicts between mitigation and adaptation measures in the city of Copenhagen (adapted after Driscoll, 2010).

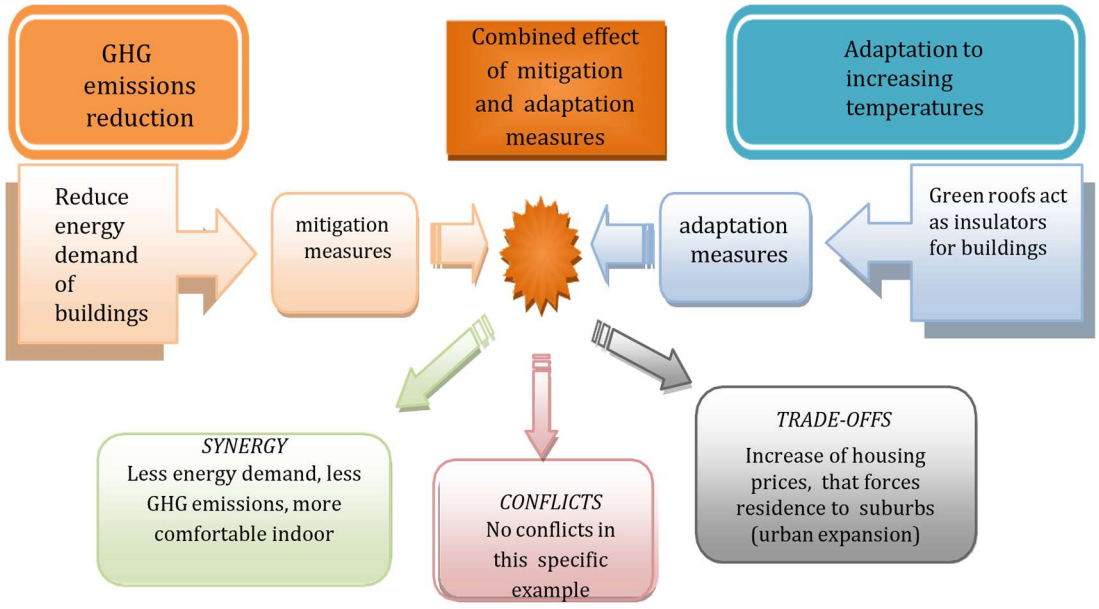

Figure 1. Example of mitigation and adaptation synergies, trade-offs and conflicts in Copenhagen (adapted after Driscoll, 2010)

3.2 Helsinki Mitigation Objectives and Adaptation Measures

Since 2007, the city of Helsinki has established its climate change strategy, targeting the reduction of GHG emissions by 39 percent of the 1990 level by the year 2030 (YTV-Helsinki Metropolitan Area Council, 2007). The city has reset the goal to return to a carbon-neutral city by the year 2030 (Eräranta, 2023).

- **Mitigation Strategy**

For the reduction of GHG emissions in the Helsinki metropolitan area, several mitigation policy measures were adopted targeting several sectors that are considered the main GHG contributors. These are the transportation sector, the land use management sector, the electricity consumption patterns, the heating of buildings, procurement and consumption patterns, and waste management, as well as the energy production sector.

In YTV (2007), the main policy directions for each of the above sectors that involve many agencies are described in detail. For each sector, an indicative list of policy measures and the respective agencies in charge is presented in the following Table 2.

Table 2. Indicative mitigation measures in the city of Helsinki and agencies involved, YTV-Helsinki Metropolitan Area Council (2007)

SECTOR	POLICY MEASURE	CITY AGENCY(IES) ON CHARGE
Transport	Promoting use of low-emission vehicles	Environmental agencies, urban planning agencies
Land use management	Urban development based on rail transportation	Public works departments
Electricity Consumption	Reducing office energy consumption	All agencies
Heating the building stock	Energy saving investments	Authorities responsible for energy use in buildings
Procurement, consumption, and waste	Educate the public to avoid creating solid waste	Education department, social services department
Energy generation and distribution	Promote the use of real-time consumption	Energy companies

- **Adaptation Measures**

Adaptation measures in the city of Helsinki are classified into four categories, namely, a) land use and construction, b) other infrastructure, c) environment, and d) health, rescue operations, and safety. According to the sectors' vulnerability to climate change, higher priority

was given to those that require further effort to adapt to climate change, such as the building sector and other infrastructure sectors. In building the adaptation strategy of the city of Helsinki, it should be noted that citizens' awareness and active participation are mandatory for the successful implementation of adaptation measures (Yrjölä & Viinanen, 2012).

4. OPTIMAL MIX OF ADAPTATION AND MITIGATION MEASURES

To cope with climate change efficiently and effectively, addressing the conflicts between mitigation and adaptation policies, it is necessary to provide an optimal mix of these policy measures. The priority to be set should concern the identification of the *'area'* where this optimal mix has occurred. The second priority reflects the interconnected nature of the three components (impacts, mitigation, adaptation) which are part of a mix of actions and outcomes, that can be either complementary or exhibit trade-offs. The pursued optimal mix may result through the following courses of action which involve a) the reduction of emissions to the level that society can afford by keeping impacts and adaptation costs to the minimum level, over the long run. b) the adaptation of most of the remaining impacts to minimize damage to society and the environment, and (c) the bearing of costs of the unavoidable residual damage occurring by climate change (Parry, 2009).

The schematic representation of the inter-connections among CC impacts, mitigation and adaptation can be seen in Figure 2 below (Parry, 2009).

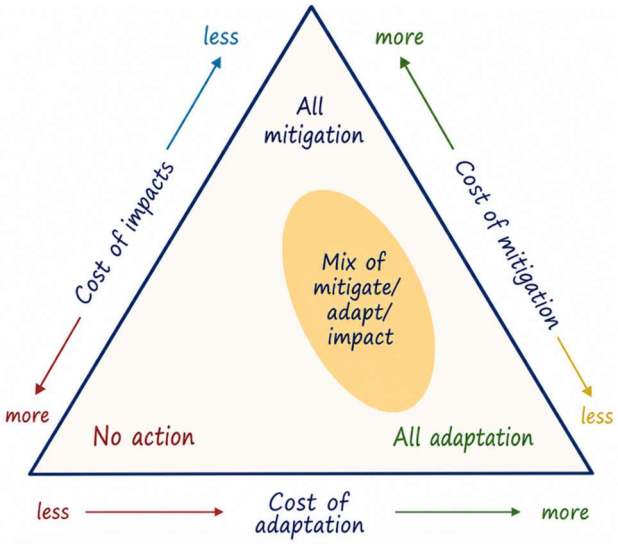

Figure 2. Costs involved in different policy mixes – different combinations of mitigation and adaptation policy measures (adapted by Parry, 2009)

4.1 Structuring of a Policy Analysis Model

During the implementation of a mix of adaptation and mitigation policies, several conflicts may arise. Hence, certain attributes of each mitigation and adaptation measure need to be

identified to deal with these conflicts. In this respect, alternative sets of mitigation and adaptation policy measures are proposed, which are further evaluated as to their effectiveness, based on a multi-criteria evaluation methodology, assessing the direct and indirect effects of these policies (Klein et al., 2005) on environmental, economic, and social dimensions. These alternatives of policy measures should also be evaluated as to their technological feasibility.

The following policy analysis model (see Figure 3), which is proposed for dealing with conflicts between adaptation and mitigation, incorporates the participatory aspect and consists of five distinct steps. The proposed policy analysis tool is an alternative approach to Patton and Sawicki's (1986) six-step policy analysis model, which has the following steps.

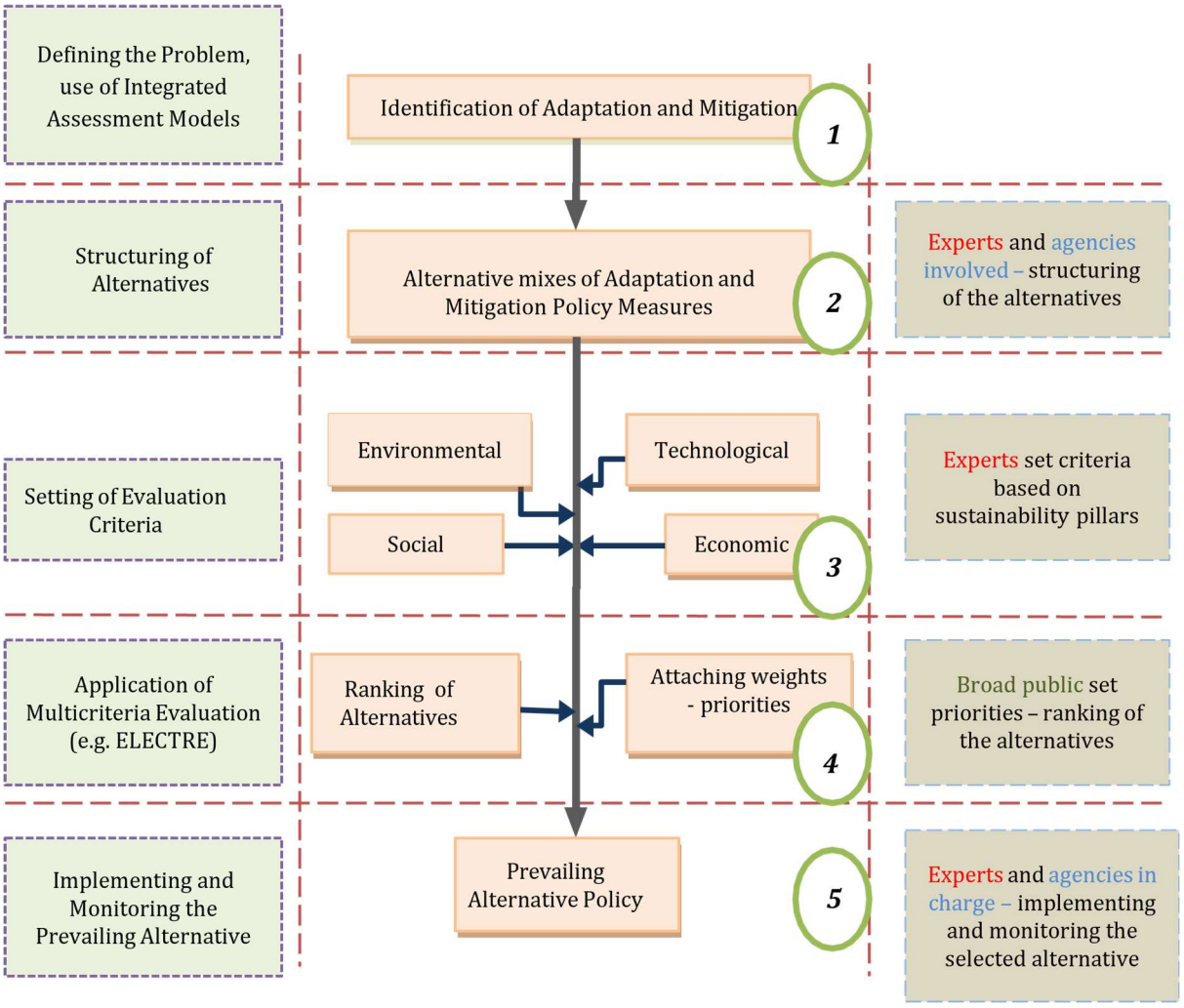

Figure 3. Policy analysis model for managing adaptation and mitigation conflicts (After Patton and Sawicki, 1986)

- **1st Step- problem definition**

In the first step of the proposed system, the study problem, for policy analysis, is defined. Experts and agencies are involved in identifying the conflicts between adaptation and mitigation measures by examining international practices, supported, whenever possible, by Integrated Assessment Models (Grammatikogiannis & Giaoutzi, 2011). In the case, for example, of a compact city environment, a reduction of GHG emissions in the transportation

sector occurs by structuring dense urban areas. However, a mix of mitigation and adaptation policies is necessary to face problems such as the heat island effect, heat waves, and flooding, etc.

- **2nd Step - structuring alternative sets of adaptation and mitigation policies**

The structuring of alternative sets of policy measures for coping effectively with adaptation and mitigation conflicts requires experts' knowledge. Scientists and agencies should also be involved in this process for dealing with the above emerging conflicts. In support of building such alternative solutions a set of participatory methods, such as Brainstorming and Delphi, could be used. Examples of alternative solutions in the case of compact urban areas likely to resolve conflicts could be:

a. Mitigation of the impacts of the heat island effect, could be reached by planting building roofs (*green roofs*) and managing the flood risk, as well as by building water basins on the top of buildings (*blue roofs*),

b. The planting of green rails of grass, the creation of green spaces such as parks and the establishment of heat wave and flood warning systems.

- **3rd Step - setting evaluation criteria**

For the evaluation of alternative sets of policy measures, experts identify indicative pools of evaluation criteria, expressing the environmental, economic, and social aspects of sustainability. (see Table 3).

Table 3. Pool of evaluation criteria

	Environmental	**Economic**	**Social**
Evaluation Criteria	Reduction of GHG	Cost of measures	Legitimacy (Consensus of society)
	Protection for biodiversity	Economic efficiency	Health improvement
	Reduction of energy consumption	Employment generation	Institutional Compatibility

- **4th Step - evaluation**

The evaluation step involves a set of multicriteria approaches, which could be combined with several participatory methods, such as ‘Focus groups’. These may include a representative number of citizens or web platforms for the involvement of citizens and stakeholders. The above selected citizens and stakeholders may attribute weights to the environmental, economic, and social evaluation criteria, based on the priorities set for the alternative sets of mitigation

and adaptation measures. The next step is the ranking of alternatives for all the criteria by applying an appropriate multicriteria method, e.g., ELECTRE[3], REGIME[4].

- **5th Step – implementing and monitoring the prevailing alternative policy mix**

Finally, the output of the evaluation process consists of the prevailing alternative groups of mitigation and adaptation measures which may contribute effectively to the conflict resolution. Experts and agencies oversee the implementation and monitoring of the outcome of the process, which reflects in principle the citizens' and stakeholders' views, ensuring thus the viability and the effectiveness of the prevailing scenario, while ensuring social cohesion.

According to Sapountzaki et al. (2022), as mentioned in (Adger, 2000), '*two major paradigms of the disaster risk reduction are relevant to the development planning context (a) Vulnerability (and exposure to hazard) modification […], and (b) resilience building to foster climate change […]*'. The first is a top-down approach, which could be implemented by international organizations, while the second is a bottom-up approach, motivated by participatory approaches.

The proposed policy analysis model can also be applied in both bottom-up and top-down policy-making processes and can be easily modified as an expert-oriented tool, open for use in the broad public.

Moreover, the policy model manages social and economic complexities while supporting the consumption of natural resources at a sustainable pace. It offers a tool to promote a balance between short- and long-term policies, enabling participatory decision-making to manage trade-offs between these policies (Puig et al., 2025).

5. CONCLUSIONS

The implementation of an optimal mix of mitigation and adaptation measures requires cooperation of different groups of people, such as experts, agencies, decision makers, the broad public, etc. Experts are involved in the structuring of alternative sets of mitigation and adaptation policies by introducing a set of criteria to be used in the evaluation process, which may add to the credibility of the process. Agencies also, at various decision-making levels, may add validity to the outcome of the model, through their involvement in the evaluation process of alternative sets of policies. Finally, the involvement of the broad public in formulating

[3] The ELECTRE family of methods (ELimination Et Choix Traduisant la REalité) were introduced by Roy (1968), and are part of the French School of Multi-Criteria Decision Making (MCDM) methods. ELECTRE I, II, III, IV, Tri and IS are the different versions of the ELECTRE methodology.
[4] Introduced by Hinloopen et al. (1983), the REGIME method is based on pairwise comparison of different sets of alternatives. Its primary advantage is the ability to evaluate both quantitative and qualitative criteria (Grammatikogiannis, 2011; Grammatikogiannis & Giaoutzi,2014).

relevant policy priorities is constantly increasing environmental awareness, ensuring thus the viability of the resulting set of measures.

In this context, though, conflicting parts among mitigation and adaptation measures may prevail and different interests among the different groups of participants may arise, stressing the need for robust evaluation tools, with clear and discrete steps, enabling in turn the smooth resolution of such conflicts among the various actors (Grammatikogiannis & Giaoutzi, 2011).

The proposed framework provides a wide range of methods and techniques, such as multicriteria evaluation methodologies (ELECTRE, PROMETHE, etc.), geovisualization tools, and participatory methodologies, which would enable an effective and smooth functioning of the evaluation process (Grammatikogiannis & Giaoutzi, 2011).

For future research could be of interest, in this context, a creative integration of various multicriteria methodologies and participatory approaches, which could prove to increase the effectiveness of the policy making scene, for the adoption of appropriate adaptation and mitigation mix of measures on the way to 'zero carbon emissions cities'. In this sense, it would be of great importance to explore the challenges emerging of the involvement of different groups of people (decision makers, experts, and broad public) in the proposed framework, as they may serve different priorities in each policy mix and pursue alternative personal interests.

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