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ŽIVOTOPIS DOKTORANDA/DOKTORANDICE

Mia Dragović Matosović, rođena 23. srpnja 1986. u Osijeku, završila je prirodoslovno matematičku gimnaziju u Osijeku te studirala Service Management na Rochester Institute of Technology u Dubrovniku. Već na fakultetu zanima se za održive teme i kao završni rad bira „pametne" kuće. Karijeru počinje radom *za Program Ujedinjenih naroda za razvoj* na projektima uvođenja energetske učinkovitosti u sve javne zgrade u Hrvatskoj. Uz posao završava prvi međunarodni MBA orijentiran na energetsku učinkovitost i obnovljive izvore – *MBA Renewables and Energy Efficiency* – na tehničkom sveučilištu Beuth u Berlinu. Kasnije radi na kreiranju politika energetske učinkovitosti u Hrvatskoj; razvoj lokalnog planiranja energetske učinkovitosti u Zakonu energetske učinkovitosti, jedan od vodećih ekspertnih autora 3. Nacionalnog akcijskog plana energetske učinkovitosti, Pravilnika za mjerenje i verifikaciju energetske učinkovitosti i drugih akata vezanih uz prijenos obveza iz Europske direktive o energetskoj učinkovitosti. Potom dvije godine radi u Energetskom institutu Hrvoje Požar kao viši istraživač na održivim projektima gdje je sudjelovala na tri Europska projekta te konzultantskim projektima vezanim uz razvoj energetski učinkovitih politika susjednih zemalja.

2017. se zapošljava u mladom *Nizozemskom Institutu za Europske energetske i klimatske politike* (IEECP Stichting) sa svega troje kolega. Do 2023. institut izrasta u prepoznati Europski istraživački i ekspertni centar s 40-ak zaposlenih koji inicira glavne EU projekte na temu energetske tranzicije i održive budućnosti. Mia je sama sudjelovala na pisanju i provođenju petnaestak EU projekata, od čega ja bila koordinator dva projekta (PROSPECT+ i ENSMOV) na temu energetske učinkovitosti u gradovima i regijama. Uz temu mitigacije ili smanjenja potrošnje energije bavi se i temom adaptacije ili prilagodbe klimatskim promjenama te je pomogla kreirati planove prilagodbe u pet Istarskih gradova kroz projekt LifeSecAdapt.

Dok je živjela u Hrvatskoj bila je član nadzornog odbora udruge Društvo za oblikovanje održivog razvoja - DOOR, a od 2022. živi u Abu Dhabiju.

Do sada ima dva objavljena znanstvena rada:

Spyridaki, N.-A.; Kleanthis, N.; Tzani, D.; Matosović, M.D.; Flamos, A. A City Capability Assessment Framework Focusing on Planning, Financing, and Implementing Sustainable Energy Projects. Sustainability 2020, 12, 8447. DOI: https://doi.org/10.3390/su12208447

Matosović M.D., Matosović M. (2020) Economic Appraisal of Introducing Energy Efficiency in the Public Sector: Overview of Existing Economic Methods with Ex-post Application to Sustainable Energy Management Program in Croatia. In: Bertoldi P. (eds) Improving Energy Efficiency in Commercial Buildings and Smart Communities. Springer Proceedings in Energy. Springer, Cham. DOI: https://doi.org/10.1007/978-3-030-31459-0_5

1. NASLOV PREDLOŽENE TEME

Optimizacija urbane održivosti: Sinergijski okvir odlučivanja za planiranje i ulaganje u mjere iz lokalnih energetskih i klimatskih planova

**Optimizing Urban Sustainability:
A Synergistic Decision-making Framework for Tailored Energy and Climate Planning and Investment**

Društvene znanosti / ekonomija

Lokalna održiva politika, energetske politike, mjere ublažavanja i prilagodbe, metode odlučivanja, metode prioritizacije
Local sustainable policy, energy policy, energy efficiency, mitigation and adaptation measures, decision-making methods

2. PREDLOŽENI ILI POTENCIJALNI MENTOR/MENTORI

2.1. Mentor/i

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2.2. Komentor

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3. OBRAZLOŽENJE TEME

3.1. Sažetak na hrvatskom jeziku
(maksimalno 4000 znakova s praznim mjestima)

Rad je planiran u obliku monografije na engleskom jeziku.

Održivost je već desetljećima u političkom fokusu, a potreba za promjenom postala je očigledna svim akterima – od vlada do građana – kroz svjedočenje sve slabijim klimatskim promjenama i katastrofama. Međutim, ono što je manje očito je koje radnje poduzeti kako bi se postigla najveća promjena na bolje? Postoje brojne aktivnosti koje treba provesti, s ograničenim proračunom i vremenom. Ili, točnije, percepcija je da su nepoznanice preskupe ili ih je nemoguće izmjeriti, tako da trošak i vrijednost odluka ostaju neizvjesni, što dovodi do lošeg određivanja prioriteta održivih ulaganja.

Gradovi, mjesta i lokalne zajednice općenito najbolje su pozicionirane za provedbu održivih mjera, blisko surađujući s građanima, potrošačima i energetskim zajednicama i osiguravajući da odabrane akcije odražavaju lokalnu stvarnost, čime se osigurava da će one doista biti provedene. Međutim, nedostatak podataka i često ograničeni financijski, tehnički i ekspertni kapaciteti, kao i *mentalitet silosa*, sprječavaju gradove, regije i druge lokalne zajednice u osmišljavanju ozbiljnih planova prilagodbe i ublažavanja, a energetska učinkovitost često se ne razmatra u drugim postojećim prostornim i razvojnim planovima osim ako to nije propisano zakonom. U tom kontekstu, ne postoji samo potreba da se relevantni podaci učine dostupnima, već i da se osigura jednostavan proces analize informacija i podataka dostupnih onima koji će ih koristiti. Izgradnja kapaciteta u donošenju odluka stoga je ključno područje kojim se treba pozabaviti.

Postojeća literatura o donošenju odluka primjenjivih na održivost i klimatske promjene je ili previše specifična ili previše preskriptivna, što znači da ne nudi smjernice gradovima kako personalizirati svoje izbore kako bi najbolje odgovarali njihovoj situaciji ili preferencijama. Također, postoje opsežni vodiči o tome kako izraditi održive planove, ali se ne spominje određivanje prioriteta ulaganja ili poboljšanje informiranog donošenja odluka za usporedbu različitih odabranih mjera i određivanje prioriteta za ulaganja. Konačni rezultat su nedovoljno realizirani akcijski planovi, ne samo zbog često okrivljavanog „nedostatka resursa", već i zbog potencijalne dodatne vrijednosti mjera koja ostaje podcijenjena ili neizmjerena te neizvjesnost predvodi donošenje odluka. Ova inverzija mjerenja, gdje promatrani kriteriji za donošenje odluke uključuju mahom one aspekte za koje se smatra da ih je lako izmjeriti, umjesto mjerenja onoga što bi donijelo veću vrijednost (ili štetu), dovodi do lošeg donošenja odluka i sprječava korištenje sinergija između mjera prilagodbe i ublažavanja što bi dovelo do većih ušteda i vjerojatnije implementacije mjera.

Postoji mnogo istraživanja u području donošenja odluka, generalno kao i specifično za mjere prilagodbe. Međutim, istraživanju nedostaje taj suradnički pristup razmatranja planiranja mjera prilagodbe i ublažavanja kao dijela istog procesa i razumijevanja da investicija za oba tipa mjera često dolazi iz istog izvora ili gradskog odjela. Stoga je važno osigurati da modeli za donošenje odluka uključuju kriterije koji omogućju kreatorima lokalne politike da procijene rizik koji je izbjegnut ulaganjem u mjere prilagodbe kako bi ga mogli pripojiti dobrobitima uštede energetske učinkovitosti. Model bi trebao sadržavati kriterije koji potiču one mjere koje imaju sinergije oba aspekta ublažavanja i prilagodbe. Jedno ne isključuje drugo, ali kada postoji hitna potreba za implementacijom, popraćena ograničenim vremenom i proračunom, ključno je osigurati ulaganja koja će izvući najveću korist u smislu ušteda i otpornosti.

Krajnji cilj ovog istraživanja je razviti metodologiju koja bi unaprijedila održivo donošenje odluka u urbanim sredinama koje imaju planove prilagodbe i ublažavanja. Konkretno, metodologija bi se usredotočila na prioritizaciju ulaganja u planirane održive mjere, na prepoznavanje sinergija između mjera prilagodbe i mjera smanjenja potrošnje, te na kriterije za optimalno prepoznavanje koristi i troškova/rizika.

Disertacija se bavi kritičnim nedostatkom u literaturi o održivom urbanom planiranju predlažući novi okvir za donošenje odluka. Ovaj okvir integrira višekriterijsku analizu odlučivanja (MCDA) unutar konteksta donošenja odluka s više atributa (MADM), posebno dizajniranog za prioritetizaciju mjera održivog urbanog planiranja povezanih sa strategijama ublažavanja i prilagodbe. Jedinstveno kombinira empirijske podatke i teorijske koncepte kako bi se optimiziralo planiranje održivosti u urbanim područjima uzimajući u obzir mjere u području energije i klime, iskorištavajući sinergije i promičući zajedničke koristi između mjera ublažavanja i prilagodbe.

Istraživanje koristi dvostruki pristup kombinirajući opsežan pregled literature i empirijske podatke iz raznih izvora, uključujući bazu podataka Saveza gradonačelnika (*Covenant of Mayors*), projekte *Obzor 2020* i izravan doprinos predstavnika preko 100 gradova. Cjelovita analiza jaza u trenutnom planiranju održivosti i procesima donošenja odluka služi za identifikaciju potreba za lokalnom primjenom održivih inicijativa. Značajan doprinos je razvoj sveobuhvatnog indeksa kriterija i podkriterija za učinkovito donošenje održivih odluka, uključujući povratne informacije od značajnih europskih institucija za održivost. Robusnost predloženog okvira testira se kroz stvarne podatke o održivim mjerama europskih gradova, uspoređujući rezultate s drugim postojećim indeksima održivosti kako bi se potvrdila njegova točnost i učinkovitost.

Ovo istraživanje je spremno pružiti značajne empirijske, metodološke i konceptualne doprinose održivom urbanom planiranju pružanjem prilagođenog, akcijskog okvira za gradove za učinkovitiju implementaciju održivih akcija, uzimajući u obzir lokalne preferencije, političku podršku i potencijal za sinergije među akcijama.

3.2. Sažetak na engleskom jeziku
(maksimalno 4000 znakova s praznim mjestima)

Sustainability has now been in political focus for decades and the need for change has become obvious to all actors – from governments to citizens – through witnessing withering climate change and disasters. What is less apparent, however, is which actions to take to obtain the greatest change for the better? There are numerous actions to be implemented, with constrained budget and time. **Or, more accurately, the perception is that the unknowns are too costly or impossible to measure, so the cost and value of decisions remain uncertain, leading to poor prioritization of sustainable investments.**

Cities, towns and local communities in general are best placed to implement sustainable measures, working closely with citizens, consumers and energy communities and ensure that the chosen actions reflect the local reality, thus ascertaining that they will indeed be implemented. However, the lack of data and the often limited financial, technical and skills capacity, as well as silos mentality, prevents cities, towns, and local communities from designing robust adaptation and mitigation plans and energy efficiency is often not considered in other existing spatial and development planning process unless it is mandated by law. In this context, there is not only the need to make the relevant data available, but also to ensure a straightforward process to analyze the

information and data available by those who will use it. Capacity building in decision making is, therefore, an essential area to be addressed.

The existing body of literature in decision making applicable to sustainability and climate change is either too specific or too prescriptive, meaning it does not offer guidance to cities to personalize their choices to best fit their situation or preferences. Also, there are extensive guides on how to create sustainable plans, such as the SECAP guide, but there is no mention of prioritization of investment or improving informed decision making to compare the different chosen measures and prioritize measures for investment. The end result is plans and actions that are underrealized not only because of the always glooming "lack of resources", but because of potential value that remains underestimated and thus uncertainty guides decision making. This measurement inversion, where criteria observed to reach a decision includes those aspects that are deemed easy to measure, as opposed to measuring what will bring about more value (or damage) leads to poor decision-making and prevents using synergies among adaptation and mitigation measures which could lead to higher savings and easier implementation.

There is already plenty of research in the arena of decision-making, as well as decision-making specifically for adaptation measures. However, the research lacks this collaborative approach of considering planning of adaptation and mitigation measures as a part of the same process and understanding that investment budget often comes from the same source or local department. Thus, it is important to ensure that the decision-making models include criteria that will enable the local policy makers to value risk avoided of investing in adaptation measures, and be able to compare it with the benefit of energy efficiency savings. The model should include criteria that encourages those measures which have both mitigation and adaptation aspect. One does not exclude the other, but when there is an urgent need for action, accompanied with limited time and budget, it is crucial to ensure that investments are made which will reap the greatest benefits in terms of both savings and resilience.

The dissertation aims to provide local and regional policymakers with a robust decision-making framework to prioritize sustainable urban planning and investment measures. It addresses a critical gap in the literature on sustainable urban planning by proposing a novel decision-making framework. This framework integrates Multi-Criteria Decision Analysis (MCDA) within a Multi-Attribute Decision Making (MADM) context, specifically designed for the prioritization of sustainable urban planning measures related to mitigation and adaptation strategies. It uniquely combines empirical data and theoretical concepts to optimize urban sustainability planning by accounting for energy and climate-related actions, leveraging synergies, and promoting co-benefits between mitigation and adaptation measures.

The research uses a dual approach combining extensive literature review and empirical data from various sources, including the Covenant of Mayors database, Horizon 2020 projects, and direct input from over 100 cities. A comprehensive gap analysis on current sustainability planning and decision-making processes serves to identify the needs for local application of sustainable initiatives. A significant contribution is the development of a comprehensive index of criteria and sub-criteria for effective sustainable decision-making, incorporating feedback from significant European sustainability institutions. The proposed framework's robustness is tested through real data on sustainable actions by European cities, comparing the results with other sustainability indices to validate its effectiveness.

This research is poised to make significant empirical, methodological, and conceptual contributions to sustainable urban planning by providing a tailored, actionable framework for cities to implement sustainable actions more effectively, considering local preferences, political support, and the potential for synergies among actions.

3.3. Uvod i pregled dosadašnjih istraživanja
(preporučeno 7000 znakova s praznim mjestima)

City opportunities and challenges

Significance of cities lies in the fact that, while they only cover only 2% of Earth's surface, they are already significant polluters contributing to 60% of global GHG emissions and are thus focal points for combating energy and climate issues (United Nations Development Programme et al., 2020). United Nations Department of Economic and Social Affairs (2018) further reports that as of 2022, 55% of global population lives in cities, and this number is expected to rise to 68% by 2050.

Cities and other local authorities are especially important in Europe, where there are around 87.000 municipal level governments, including cities (OECD, 2021). However, only a small number of those local authorities takes part in most prominent European organisations tackling the clean energy transition.

As cities are moving from reactive politics to active hubs for *green* and resilient future, they must anticipate various potential risks and incorporate many unknowns. The old approach to sustainability in any system, but cities especially, was oriented towards economic efficiency, simply viewing profits and losses without considering other risks and non-economic benefits. As sustainable development theory took its course, there was a shift in thinking with realizing that risks and vulnerabilities need to be considered and reflected in local planning, as well as the fact that what might seem like elusive benefits in this moment (i.e., health or energy independence) might become either actual large costs, or result in great savings, depending on the course taken by city planning.

In this shift, city planning is in a dire need for more capacities, faster reactions, and smarter ways to make decisions considering long-term consequences. Plans are being drafted most often with a limited budget and question arises in which order should these plans be implemented? To aid this process, decision-methods with relevant and diverse criteria ensure that the reached decisions not only lower costs, but improve life quality and longevity, at the same increasing city resilience and adapting to inevitable climate and societal changes.

Overview of sustainable decision-making methods

A multitude of research covers the benefits of using multi-criteria decision analysis (MCA or MCDA) to improve decision making specifically for sustainable and energy efficiency measures and various MCDA methods have already been applied to rank of climate change mitigation policies and measures at the national level for developed (Streimikiene and Balezentis, 2013; Konidari and Mavrakis, 2007) and less developed countries (Haque, 2016).

The MCDA process involves the following steps, called a *general model* (Jankowski, 1995), which has in its basics stayed the same: defining the problem, searching for alternatives; deriving a set of criteria to evaluate those alternatives; estimating impact of each alternative on every criterion to get criterion scores; formulating the decision table with use of the discrete alternatives, criteria and criterion scores; specifying decision-makers preferences in the form of criterion weights; aggregating the data from the decision table in order to rank the alternatives; making the final recommendation in the form of either one alternative, reduced number of several 'good alternatives', or a ranking of alternatives from best to worst. What has changed throughout the years, is the growing number of fields where MCDA is applied, as well as specific indicators used for different areas, resulting in various MCDA techniques.

Sufficient meta-analyses exist on the different MCDA techniques and the methods for selecting the proper tool. For example, Watróbski et al. (2018) analyse 56 available MCDA methods and they also comment on differences between what literature suggests and what experts use in practice. Some of the widely used MCDA methods for sustainable projects are order of preference by similarity to ideal solution (TOPSIS), a categorical based evaluation technique (MACBETH), simple additive weighting (SAW), and elimination and choice expressing reality III (ELECTRE III) (Cavallaro, 2010; Milakis and Athanasopoulos, 2014; Faria et al., 2018; Tan et al., 2011; Xu et al., 2011).

A broad overview of MCDM methods (Zavadskas, 2018) classifies MCDM into two categories, coinciding with the two schools of thought which differ on what human choice is based on: the French discrete MADM (multi-attribute decision-making) methods and the American continuous MODM (multi-objective decision-making) methods.

A thorough systematic review of MCDM techniques and approaches in sustainable and renewable energy systems problems was covered by Mardani et al. (2015). The techniques were categorized into the following groups: (1) AHP and F-AHP; (2) ANP and VIKOR; (3) TOPSIS and F-TOPSIS; (4) PROMETHEE; (5) integrated methods and (6) other methods. The conclusion was that there is a rising interest for these techniques to *assist stakeholders and decision makers in unravelling some of the uncertainties inherent in environmental decision making* in projects regarding sustainable and renewable energy systems.

Also, a detailed analyses exist on decision-making for adaptation actions, such as Institute for Global Environmental Strategies [IGES] (2014), covering different conditions for selecting the appropriate MCDA techniques. Next, there is an existing body of literature where MCDA is used for technical evaluation of energy efficiency measures Juričić et al. (2020). However, no research yet covers both adaptation and mitigation measures in one single decision-making tool.

Covering either of the two aspects of sustainability, adaptation or mitigation, is already a challenge in itself, as not only are the measures vast and cover many areas, but also city or a region entail different decision-making structures (i.e., budget units or departments) whose criteria need to be respected and consolidated. For example, Carli et al. (2015) demonstrate benefits of MCDA for smart cities' energy management optimisation, also integrating competing decision-units' preferences. However, as noted, **there is yet no such research focusing on prioritization of measures including both adaptation and mitigation goals.**

The often-cited problem of almost any MCDA is that weighted scoring ads further ambiguity and is easily affected by personal preferences and does not add to the credibility of the solutions (i.e. just because a policy maker weighs a certain criteria higher will not make it a more rational decision, but it will make the method rank

it higher). For this reason, many turn to other methods for obtaining a clear unit of measure for which decision is better, such as CBA.

CBA is another important and well-known decision-making process – the cost-benefit analysis (CBA). As opposed to MCDA where the purpose of the analysis is left to stakeholders to decide when shaping the criteria, the CBA has a set rationale – to improve allocation of (scarce) resources for a company, or in this case, a city or a region.

The downside of the traditional CBA, besides this overfocus on economic efficiency which ignores environmental benefits, is that it is focused only on the quantifiable effects and has a single criterion, whereas there are multiple criteria to consider in deciding which sustainable actions to invest in first.

Gaps in literature

Literature review supports the hypothesis that decision-makers benefit from a structured decision-making process (Network for Business Sustainability, 2012). This section presents an overview of prevalent decision-making methods commonly employed in various fields, including (1) Multiple Criteria Decision Analysis (MCDA); (2) Analytic Hierarchy Process (AHP); (3) Cost-Benefit Analysis (CBA); (4) Structured Decision Making (SDM), and (5) Applied Information Economics. A thorough review has been conducted to identify and analyse these methods, each of which plays a pivotal role in addressing complex decision-making challenges. The selection of decision-making methods often depends on the specific context, objectives, and criteria involved in each decision scenario. Therefore, understanding the characteristics and common benefits and downsides of these methods is crucial for informed and effective decision-making. Table 1 presents a summary outlining their approaches, underlying principles, as well as the benefits and downsides associated with each method. Presenting this information is the first step towards understanding the gaps in current models and how each model corresponds with the topic of this research – optimizing sustainability in cities and balancing their energy, climate and resilience goals.

Table 1: Overview of Decision-Making Methods

Method	Approach	Underlying Principles	Key Features	Downsides
Multiple Criteria Decision Analysis (MCDA)[1]	Systematic consideration of multiple criteria for comparing and ranking alternatives based on multiple criteria or attributes	Explicitly consider multiple criteria with different weights; assess trade-offs.	Comprehensive evaluation of alternatives. Transparency in decision-making. Facilitates trade-off analysis. Allows for the consideration of multiple criteria simultaneously. Uses various weighting and ranking techniques. Varied application areas.	Requires substantial data and input. Complex decision framework may be time-consuming. Subjective criteria weighting can introduce bias and add further ambiguity to the solutions.
Cost-Benefit Analysis (CBA)[2]	A method for evaluating decisions by comparing the costs and benefits through monetizing the net present-value or benefit-cost ratio of alternative courses of action.	Economic efficiency, maximizing societal welfare through positive net benefits.	Well-established and widely used. Focuses on economic efficiency. Monetizes outcomes for comparison and Utilizes net present value or benefit-cost ratio for decision-making. Typically used for government policy and project evaluations.	Difficulty in valuing non-monetary factors. Ignores distributional impacts. Sensitive to discount rate and assumptions.
Applied Information Economics (AIE)[3]	A decision analysis method that assesses the value of information and quantifies uncertainties to make decisions that maximize expected value.	Managing risks, quantifying uncertainties, maximizing expected return on investment.	Emphasizes risk management. Focuses on information value and risk analysis through incorporating probability distributions and sensitivity analysis. Accounts for uncertainty and variability. Helps in choosing actions that maximize the expected return on investment.	Requires expertise in risk assessment and information economics. Complexity in handling probabilistic information. May not fully capture qualitative factors.

[1] General overview of MCDA history (Zavadskas & Turskis, 2011)

[2] Overview of CBA in reasoning (Alaoui & Penta, 2022)

[3] Book about the Applied Information Economics (Hubbard, 2014)

Whichever approach in decision-making is used, it should be systematic, multidisciplinary, participative and include as many quantified information as deemed necessary.

Most prevalent MCDA models in sustainability

Various MCDA methods have already been applied to rank of climate change mitigation policies and measures at the national level for developed (Streimikiene and Balezentis, 2013; Konidari and Mavrakis, 2007) and less developed countries (Haque, 2016). Some of the widely used MCDA methods for sustainable urban projects involving multiple criteria are order of preference by similarity to ideal solution (TOPSIS), a categorical based evaluation technique (MACBETH), simple additive weighting (SAW) or weighterd sum method (WSM), and elimination and choice expressing reality III (ELECTRE III) (Cavallaro, 2010; Milakis and Athana- sopoulos, 2014; Faria et al., 2018; Tan et al., 2011; Xu et al., 2011). A thorough systematic review of MCDM techniques and approaches in sustainable and renewable energy systems problems was covered by Mardani et al. (2016). The techniques were categorized into the following groups: (1) analytic hierarchy process (AHP) and fuzzy AHP (F-AHP); (2) analytic network process (ANP) and VIKOR; (3) TOPSIS and F-TOPSIS; (4) preference ranking organization method for enrichment evaluations (PROMETHEE); (5) integrated methods and (6) other methods. The conclusion was that there is a rising interest for these techniques to *assist stakeholders and decision-makers in unravelling some of the uncertainties inherent in environmental decision-making* in projects regarding sustainable and renewable energy systems. In their 2017 comprehensive study of urban energy system planning, Cajot et al. (Cajot, Mirakyan, et al., 2017; Cajot, Peter, et al., 2017) found 89 related articles across 58 journals, confirming that most used methods are AHP/ANP and its variations, WSM, multiple-objective decision-making (MODM), TOPSIS and ELECTRE, which were all found in more than five published studies. To a lesser extent, MODM was also used for some sustainable decisions in cities, such as smart cities' energy management optimisation (Carli et al., 2015), multiobjective optimization by ratio analysis plus full multiplicative form method (MULTIMORA) (Balezentis et al., 2014) or for developing national energy efficiency plans (Haydt et al., 2014).

A multitude of research covers the benefits of using MCDA specifically to improve decision-making for sustainable measures in cities and regions, and the most prevalent method is AHP (Carli et al., 2018; Mirakyan & De Guio, 2013; Moussavi Nadoushani et al., 2017; Stofkova et al., 2022) or hybrid AHP, such as AHP with pairwise comparisons made only to elements of one level of the hierarchy rather than against all levels (Giaccone et al., 2017) , AHP combined with GIS (D'Orso et al., 2023) or combination of NSGA-II MODM method with AHP (Haydt et al., 2014).

Each of these methods brings structured reasoning to complex sustainable decision-making, helping to navigate the trade-offs and synergies inherent in planning for sustainability. All the mentioned MCDA methods are used to evaluate multiple alternatives based on various criteria and aim to simplify complex decision problems by ranking or rating alternatives, however, they have different applications and levels of complexity. Research will summarize benefits and downsides of each technique, indicating their fundamentals and appropriate application. It will be presented as a decision tree for cities to be able to choose the most appropriate method for their specific context.

Although there are many MCDA methods available, they are still being underused in local sustainable planning and implementation due to many challenges. One such challenge, and an important literature gap is that there are no known decision-making frameworks which set out steps on how to account for both adaptation and mitigation measures in the same process, which would assist in exploiting their synergies. Covering either of the aspects of sustainability, adaptation or mitigation, is already a challenge in itself, as not only are the measures vast and cover many areas, but also city or a region entail different decision-making structures (i.e., budget units or departments) whose criteria need to be respected and consolidated. And for the measures to be implemented in practice, the process needs to consider the most important stakehodlers' opinions, including citizens and different city departments.

Key themes and gaps recognized in the literature review related to sustainable decision-making in cities are:
1.   Integration of Mitigation and Adaptation Strategies: Research suggests that there is often a lack of an integrated approach to sustainable decision-making which would consider all climate targets under the same planning process, which leads to inability to utilise synergies from adaptation and mitigation measures (i.e. economic savings and additional benefits that would become evident if the measures were considered as a part of the same planning process).
2.   Decision Support Tools: The literature emphasizes the importance of decision support tools and frameworks to assist any decision-maker in making informed decisions, and the lack of a specific methodology applicable to a multidisciplinary area such as SECAP implementation in cities.
3.   Data and Information Gaps: The availability and quality of data and information are common challenges in sustainable decision-making. Research focuses on addressing data gaps, improving data quality, and

enhancing information sharing among stakeholders. With sustainable decision-making, quantification of non-monetary benefits is of a specific interest: Failure to quantify the additional benefits of sustainable actions, such as social and environmental impacts, is a recurrent gap in the literature. Researchers explore methodologies for valuing these benefits separately, but they are rarely integrated into a streamlined decision process.

4.   Inclusivity and Stakeholder Engagement: Gaps are identified in the level of inclusivity and stakeholder engagement in common decision-making processes. The literature often discusses that the prerequisite for successful initiative implementation is to utilize a participatory approach that involves diverse stakeholders, including marginalized communities.

5.   Long-Term vs. Short-Term Decision Horizons: Prevalent decision-making methods often face challenges related to balancing short-term priorities and long-term sustainability goals. Literature discusses the need for decision frameworks that consider both temporal dimensions.

6.   Policy Implementation and Evaluation: There is often a gap between policy development and effective implementation. Researchers explore strategies to bridge this gap and evaluate the impact of sustainable policies and measures.

7.   Decision Uncertainty and Risk Management: Sustainable decisions are inherently associated with uncertainty and risk. Literature examines methods for assessing, communicating, and managing uncertainty in decision-making processes.

8.   Scale and Contextual Variations: Sustainable decision-making can vary significantly in different geographical, social, and economic contexts. Research explores how decision frameworks can be adapted to suit various scales and contexts.

This research reflects on the above gaps and aims to contribute to the field of urban sustainability by establishing a comprehensive framework designed to guide cities through the selection and application of decision-making methods for their Sustainable Energy and Climate Action Plans (SECAPs) which can be used both in the planning process to choose measures for SECAPs and in the implementation to prioritize measures for investment. The framework will prioritize the accuracy and efficacy of MCDA outcomes, underpinned by an inclusive decision-making process that concurrently addresses adaptation and mitigation as interdependent components that can yield synergistic benefits. This integrative approach aims to provide cities with a robust, methodologically sound pathway for selecting and prioritizing actions that align with their unique sustainability objectives and constraints and ensure better chances for the projects to be implemented.

3.4. Cilj i hipoteze istraživanja
(preporučeno 700 znakova s praznim mjestima)

Goal and hypotheses

The overarching research question of this research is: **How to enable local and regional policymakers to make more informed decisions when prioritizing sustainable measures for planning and investment?**

Specifically, it seeks to address the gap identified in the literature review and the extensive experience of the author in implementing sustainability in urban and regional contexts. The research endeavors to **construct a decision-making framework tailored to the nuances of local policymaking while accounting for pertinent energy, climate, and resilience objectives**. This framework will encompass criteria and processes conducive to rapid, precise, forward-thinking, and pragmatic decision-making that aligns with the unique needs and challenges faced by cities.

Thus, the focus of this research are prescriptive, active MCDA models in MADM context for prioritising actions from sustainable plans, specifically for mitigation and adaptation measures. The specific objectives of this research are as follows:

1. Conduct a comprehensive gap analysis of contemporary sustainability planning and decision-making, with a particular focus on mitigation and adaptation strategies, and assess their suitability for local application;
2. Identify the needs of cities concerning the prioritization and implementation of sustainable initiatives;
    Data input: (1) Covenant of Mayors database with over 11.000 SECAPs and investigating whether they use decision-making methods and which indicators they utilize in decision-making; (2) Results from Horizon 2020 projects PROSPECT, PROSPECT+ and EnergEE Watch which involved participation of over 100 cities and their planning of SECAP measures. Concretely, their inputs on implemented SECAPs will be investigated to discover indicators they deem important in proposing sustainable measures for their sustainable plans.
3. Based on the identified needs of cities, develop a comprehensive index of criteria and subcriteria designed to facilitate effective sustainable decision-making in the prioritization of city-level sustainable initiatives (for both mitigation and adaptation actions)
    Data input: combination of the first two steps.
4. Formulate a methodology for prioritization of sustainable measures that enhances the quality of decision-making and promotes informed choices. The methodology will go beyond the sole choosing of an MCDA

method. It will discuss: (1) all steps necessary to create a comprehensive and sound decision-making process which has better chances of being implemented; (2) indicators that encompass both adaptation and mitigation (3) typology of SECAP actions per sector and per climate impact for adaptation actions, (4) synergies and co-benefits among the chosen list of actions.

Thus, the subsequent research primary hypothesis is:

H_0: A synergistic, value-based decision-making framework can optimize urban sustainability planning by accounting for energy and climate-related actions at once, leveraging mitigation and adaptation co-benefits and synergies.

And the secondary hypotheses or supportive statements are:

H_1: The failure to capitalize on synergies between adaptation and mitigation actions limits the overall effectiveness of sustainability initiatives and inefficient allocation of resources.

H_2: Generic decision-making methods result in suboptimal outcomes for cities, as they fail to consider wider impacts of each action.

H_3: Insufficient tailoring of decision-making approaches to unique local preferences leads to lack of political support and harder implementation.

H_4: The application of a planning framework will facilitate a more comprehensive quantification of benefits associated with sustainable actions and, ultimately, a more efficient allocation of resources, encompassing non-monetary and additional benefits as well as allow for synergistic effects among actions.

Conceptualisation of research model

The research investigates ways to make decisions for local sustainable investment more robust and more likely to be implemented through a dual approach, combining empirical and theoretical elements. Research population involves all local administrations oriented towards sustainable planning, meaning all cities, towns and regions with sustainable energy and climate action plans.

The secondary research for this study will include extensive literature review on the topic of decision-making applicable to local level. This research aims to identify current needs, challenges, and the state of decision-making in EU cities, as well as conceptualizing an appropriate method for a local decision-making framework. Primary research will be sourced from the Covenant of Mayors database of mitigation and adaptation plans database with over 8.000 cities worldwide uploading their SECAPs and the CDP-ICLEI 2023 Full Cities Dataset[4] with over 1.200 city respondents, and the framework will be tested via the Horizon 2020 PROSPECT project which had an outreach on 200+ European cities. By adopting both primary and secondary research approaches, this study aims to encompass cities of varying sizes, levels of development, and experience in sustainable planning and implementation.

Testing the framework

The robustness of the conceptualized framework will be tested by using real data on sustainable actions by European cities, as well as by comparing the results of the created PROSPECT+ index with other sustainable indices. The framework will be tested in three ways:

1. Sample cities and agencies representing European cities through PROSPECT+ project. Seven large EU sustainable institutions and agencies who are project partners will be asked to give comments on the understandability, usefulness and robustness of the framework, testing elements such as: (1) relevance of chosen criteria, (2) extensiveness of the list of alternatives and the applicability of the sector division, (3) usefulness of framework score and its applicability, (4) comprehensibility of score explanations and framework analysis.

The partners are listed in the following table:
Table 1: Horizon 2020 PROSPECT+ partners reviewing the framework

#	Partner name	Acronym	Country	Logo
1	Institute for European Energy and Climate Policy Stichting	IEECP	NL	
2	European Federation of Agencies and Regions for Energy and the Environment	FEDARENE	BE	

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[4] https://data.cdp.net/Governance/2023-Full-Cities-Dataset/7hmg-eagz/about_data

3	EUROCITIES ASBL	EUROCITIES	BE	EURO CITIES
4	Energy Cities/Energie-cites Association	ENC	FR	
5	University of Piraeus Research Center	UPRC	GR	TEESlab
6	OÖ Energiesparverband	ESV	AT	
7	Energy and Climate Agency of Podravje	ENERGAP	SI	energap
8	Tipperary Energy Agency	TEA	IE	energy
9	Ayuntamiento de Valladolid	INNOLID	ES	valladoli+D adelante
10	Association of Energy Managers of Towns and Regions of the Czech Republic	SEMMO	CZ	SEMMO
11	Adelphi research gemeinnützige GmbH	adelphi	DE	adelphi

2. The MCDA methodology and the weight elicitation through pairwise comparison will be tested against an existing method and tool Potentially All Pairwise RanKings of all possible Alternatives (Hansen & Ombler 2008). Both PAPRIKA and the simple pairwise comparison used in this framework use two criteria at a time for comparison, but PAPRIKA uses a software to anticipate some of the answers where there are many combinations of pairs, which means that the number of required pairwise comparisons is significantly reduced. Also, our framework does not test the principle of transitivity, or consistency in expressed preferences. The proposed framework will be tested with a couple of preset decision-makers choices: five scenarios will be set among the 12 subcriteria, through random sampling, and the same pairwise ranking will be performed through PAPRIKA to test the end differences in weight elicitation between PAPRIKA and the PROSPECT+ framework.

3. The framework will be tested on seven sample cities' sustainable action plans available through the Covenant of Mayors Database. The available data on all actions will be transferred to the decision-making matrix. Since there is no way to have an insight into the preferences of each city on the importance of framework criteria and dimensions, the weighting will be performed on three different scenarios for each city; (1) the "status quo" scenario where all weights are equal, (2) the "traditional" scenario where the economic dimension is the most important one, and (3) the "sustainable" scenario where the environmental dimension is the most important one.

Table 2: Three testing scenarios with different weighting for the dimensions (1st level criteria)

	ENVIRONMENTAL IMPACT			ECONOMIC VIABILITY			SOCIAL EQUITY		TECHNICAL FEASIBILITY & COMPETITIVENESS		INSTITUTIONAL FRAMEWORK	
	Emission reduction and resource efficiency	Biodiversity conservation	Risk and resilience	Return on investment	Economic impact	Implementation and management	Equality /equity and accessibility	Quality of life and public health	Technological maturity	Innovation and learning potential	Political and legal framework	Political acceptability
Status quo scenario	20%			20%			20%		20%		20%	
	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Traditional scenario	17%			32%			17%		17%		17%	
	5.7%	5.7%	5.7%	10.7%	10.7%	10.7%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%
Sustainable scenario	32%			17%			17%		17%		17%	
	10.7%	10.7%	10.7%	5.7%	5.7%	5.7%	8.5%	8.5%	8.5%	8.5%	8.5%	8.5%

Sampling

The sampling frame are specifically European cities which are signatories of the Covenant of Mayors network, and the developed framework will be tested on their latest sustainable action strategies and plans dating from 2008 until 2023. The sample of cities will be chosen to represent five categories of cities by Covenant of Mayor standards. This includes:

- Signatories with population < 10,000
- Signatories with population 10,000 - 50,000
- Signatories with population 50,000 - 250,000
- Signatories with population 250,000-500,000
- Signatories with population > 500,000
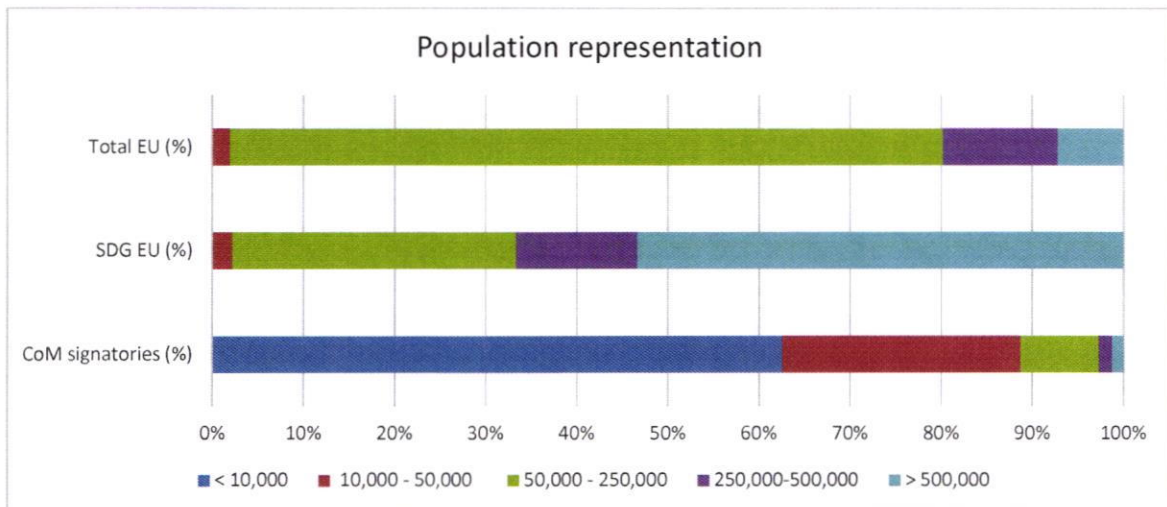
Figure 1: Sample frame population distribution

When deciding which cities to represent it is not intuitive to choose a representative city size because the CoM database and the general EU urban population vary greatly by population distribution. Most of the cities represented in the CoM database are small administrative areas with less than 10,000 people, while 80% of cities in the EU have between 50 and 250 thousand people. Thus, to be representative, the sample will not necessarily follow the population distribution, but rather encompass cities that are in other way representative of European sustainable agendas. List of cities represented in the following indices will be compared and the six cities represented in all categories will be used for testing:

- Sustainable Development Goals European Cities Index (SDG EU Cities) Rank 2024[5]: An index measuring the progress of European cities towards achieving the United Nations' Sustainable Development Goals.
- European Green City Index (EU GCI)[6]: Measures and rates the environmental performance of 30 leading European cities from 30 European countries.
- CDP-ICLEI Cities A-list track 2023[7]. ICLEI – Local Governments for Sustainability and Disclosure Insight Action CDP together formed a CDP – ICLEI Track: The world's leading climate reporting platform and progress accountability mechanism for cities. Tracking over 1,100 cities' climate action on their climate initiatives and actions. The extensive questionnaire unifies different actions, including reporting for both European and Global Covenant of Mayors (CoM) signatories, as well as C40 cities - a global network of mayors of the world's leading cities united in action to confront the climate crisis. CDP ICLEI also publishes an A-list involving cities reporting globally who are demonstrating leadership through concrete climate plans. Out of 939 cities reporting through CDP-ICLEI, in 2023 13% received an A, meaning they report taking four times as many mitigation and adaptation measures as non-A List cities.
- Sustainable Development of Energy, Water and Environment Systems Index (SDEWES Index)[8]: A composite index evaluating sustainability in the areas of energy, water, and environmental systems
- Covenant of Mayors Global Network of Cities with sustainable action plans[9]

[5] https://euro-cities.sdgindex.org/
[6] https://assets.new.siemens.com/siemens/assets/api/uuid:fddc99e7-5907-49aa-92c4-610c0801659e/european-green-city-index.pdf
[7] https://www.cdp.net/en/cities/cities-scores
[8] https://www.sdewes.org/sdewes_index.php
[9] https://www.globalcovenantofmayors.org/

Out of the 45 SDG cities, 19 are represented on both the EU GCI and SDEWES index lists and the comparison of their results can be seen here:
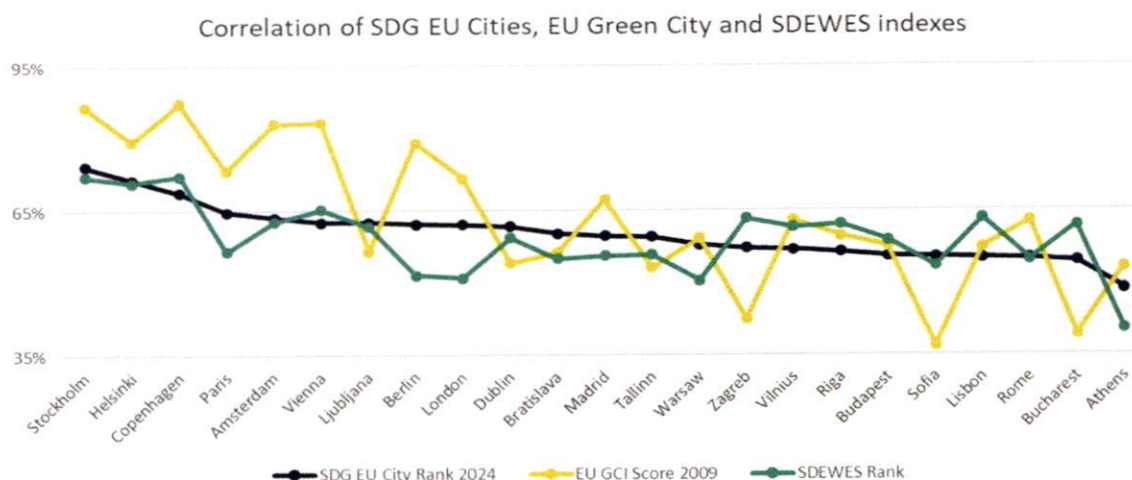
There is a clear correlation between SDG EU and EU GCI of 75%, between EU SDG and SDEWES of 59% and EU GCI and SDEWES 41%.

45 cities are represented by the SDG Index and Dashboards Report for European cities prepared by the Sustainable Development Solutions Network and the Brabant Center for Sustainable Development[10], out of which 29 (65 percent) have population over half a million and fall into the largest CoM Signatory category. Out of all SDG Index Dashboard cities, 6 are present in all prior named initiatives: EU Green City Index from 2009, CDP-ICLEI Cities A-list track 2023[11] published annually to promote global leaders in climate change who publish their climate plans, SDEWES, and Covenant of Mayors Global network and they are: Amsterdam, Copenhagen, London, Madrid, Paris and Stockholm. Since these cities represent the Western, Southern and Northern Europe, Zagreb will be added to the list of testing cities to also represent the Central and Eastern Europe and minimize the undercoverage bias of similar cities being represented in most EU projects and initiatives. Here are the basic facts and index scored of the sample cities:

Table 3: Sample cities chosen for testing the framework

City Name	Country	Region of Europe	Population	SDG EU Rank 2024	SDG EU Score 2024 (max = 100)	EU GCI 2009 (max = 100)	CDP ICLEI track	SDEWES (max = 50.000)
Stockholm	Sweden	Northern	960,031	2	74.2	86.65	Yes	36.007
Copenhagen	Denmark	Northern	528,208	4	68.7	87.31	Yes	36.038
Paris	France	Western	2,265,886	7	64.7	73.21	Yes	28.283
Amsterdam	Netherlands	Western	731,289	11	63.5	83.03	No	31.311
London	United Kingdom	Western	7,800,000	19	62	71.56	Yes	25.477
Madrid	Spain	Southern	3,273,000	28	59.7	67.08	Yes	27.759
Zagreb	Croatia	Central and Eastern	767,131	32	57.1	42.36	No	31.606

The research concept is summarized in the following table:

Table 4: Research matrix

[10] https://euro-cities.sdgindex.org/#/
[11] https://www.cdp.net/en/cities/cities-scores

Overall objective: Leverage local strengths to foster sustainable urban environments equitably and enhance chances for action implementation by guiding cities and municipalities in choosing and implementing sustainable actions.

Goal: Develop a methodological framework for prioritization of local sustainable actions.

The underlying hypothesis:

H_0: A synergistic, value-based, decision-making framework can optimize urban sustainability planning by accounting for energy and climate-related actions at once, leveraging mitigation and adaptation co-benefits and synergies.

Objectives:	1. Identifying state of the art in sustainable planning and decision-making	2. Creating a set of indicators to be used for an effective evaluation of sustainable actions	3. Creating a scoring matrix with a preset catalogue of mitigation and adaptation actions, and their synergies	4. Performing result analysis and testing the framework robustness and usefulness
Relation to hypothesis	H_1: Generic decision-making methods result in suboptimal outcomes for cities, as they fail to consider wider impacts of each action.	H_2: Insufficient tailoring of decision-making approaches to unique local preferences leads to lack of political support and more difficult implementation.	H_3: The failure to capitalize on synergies between adaptation and mitigation actions limits the overall effectiveness of sustainability initiatives and inefficient allocation of resources.	H_4: The application of a planning framework will facilitate a more comprehensive quantification of benefits associated with sustainable actions and, ultimately, a more efficient allocation of resources, encompassing non-monetary and additional benefits as well as allow for synergistic effects among actions.
Variables/ Data sources	Scientific literature review	Indicators: • Sustainable Development Goals European Cities Index (SDG EU Cities) Rank 2024 • CDP-ICLEI Cities A-list track 2023 • Sustainable Development of Energy, Water and Environment Systems Index (SDEWES Index) The source for adaptation actions is the European Climate Adaptation Platform Climate ADAPT, a partnership between the European Commission and the European Environment Agency. The source for mitigation actions is CLIMACT Prio - a Capacity building and Decision Support tool: CLIMate ACTions Prioritization. It was developed by Institute for Housing and Urban Development Studies of Erasmus University Rotterdam (IHS).		Covenant of Mayor Sustainable Energy and Action Plans (SECAPs) database of sustainable Action Plans, input from at least seven cities representing different EU regions (*see sampling method*)
Data collection method	Undertaking a gap analysis of the state of the art in sustainable planning and decision-making, including MCDA method, nominalization method and weight elicitation method. Focus is on applicability to city context, participative methods, and sustainable actions.	Desk research on sustainable initiatives, primary research comparing them with existing sustainable indexes and creating a new index with two-level scoring criteria for evaluating sustainable actions in cities (applicable to both mitigation and adaptation) which will account for all explicit and implicit benefits of common local mitigation and adaptation actions.	Desk research of actions and synergies, primary research and data mining of SECAPs and SECAP databases. .	• Primary research of sample SECAPs and their individual anergy and climate actions • IEECP-led project H2020 PROSPECT+ input from cities and agencies representing the cities.
Type of data analysis	MULTIVARIATE analysis to understand relations between variables such as city size, budget or location and their sustainable indexes rank.	Performing a FACTOR analysis to group scoring criteria into dimensions and its subcriteria and avoid redundancies.	Developing a methodology for the prioritization of adaptation and mitigation measures fitted to local preset goals of adaptation and mitigation of cities	Testing the framework by performing the MCDA techniques formed in previous steps on the chosen set of cities. Statistical and graphical analysis of scores.

	Analysis of five most common nominalization methods (linear sum, linear max-min, linear max, vector, enhanced accuracy and logarithmic)		Listing actions and making easy action category search. Creation of connections between existing synergies and the preset list of actions	Sensitivity analysis of both value preferences (scoring criteria weighting elicitation) and the impact of actions (scoring matrix results).
Scientific results/ outputs	1. Matrix of current decision-making and prioritization methods and choice of applicable method for sustainable planning in cities. 2. Choice of method for weight elicitation to understand local preferences 3. Choice of nominalization technique	1. Ability of framework to "flag" synergies among sustainable actions 2. List of relevant sustainable indexes and the proposition of PROSPECT+ two-level criteria connected with strategic EU climate goals	The results will include a prioritized list of climate mitigation and adaptation actions based on their scores and implementation costs, insights into how each action ranks within specific dimensions like cost-effectiveness and environmental impact, and an understanding of potential synergies among actions. This helps in making informed, value-driven choices for urban sustainability planning.	The analysis will help understand: · Which projects should be implemented first, and why? · What is the ranking of chosen actions, and for which is there enough budget? · Which criteria influenced the rank of the highest scored actions? · What is the relative cost of each action, compared to the highest scored action? · What is the distribution of score per dimension and per mitigation/adaptation actions? · Which criteria or value would need to change to influence the ranking? · Which actions can produce synergies when implemented together?
Final Result	Chosen method for MCDA is simple additive method (SAW) Chosen nominalization method for quantitative data is max linear. Weight elicitation is performed through pairwise comparison of both first (dimensions) and second (subcriteria) level criteria.	Original PROSPECT+ sustainable scoring index with five dimensions (environmental impact, economic viability, social equity, technical feasibility & competitiveness, and institutional framework) and 12 subcriteria.	Mitigation and adaptation database with 174 common actions and their synergies. The actions are divided by action type (mitigation/ adaptation), and climate hazard, with identified potential synergies among all combinations of actions. Scoring matrix with five levels. Possibility of nominalization of quantitative data into the qualitative matrix.	PROSPECT+ Custom SECAP Prioritization Tool for aligning actions with local goals and preferences. The tool results in: • Project prioritisation chart - score vs. cost • Ranking of actions in table form • Bar chart of 10 highest ranked actions per dimension, weighted, and unweighted. • Bubble chart - Value for money, or relative cost of highest ranked actions • Radar chart per dimension mitigation vs. adaptation average score • Sensitivity analysis • Synergies bar chart

3.5. Očekivani znanstveni doprinos predloženog istraživanja
(preporučeno 500 znakova s praznim mjestima)

Scientific contribution and envisaged outputs

The result of this research is a developed methodology for prioritization and optimal selection of measures for investment from local sustainable plans which will achieve preset goals of adaptation and mitigation of cities. The aim is to empower local governments in their planning and implementation of sustainable actions through

covering gaps identified in the existing body of knowledge and making the following scientific contributions to sustainable decision-making in cities:

Conceptual contributions through the identification and conceptual definition of an independent variable to be added to the MCDA model which would account for synergies even when their effect is not quantified. Such a synergies indicator aims to encourage reaching EU and global sustainable policy goals.

Empirical contributions by: (1) Introducing a theoretical linkage between adaptation and mitigation measures to enable their synergies to decrease the cost of implementation; (2) Determining the degree to which introducing synergy recognition in decision making changes the relationship between proposed measures and their ranking; (4) Determining the degree to which using MCDA methods with different weight elicitation techniques (considering local preferences and values), on a real city SECAP example, under same assumptions of preferences and criteria, influences the result.

Methodological contribution to existing frameworks for sustainable decision-making in cities: through field studies of cities' actual interests and needs, construct validity of key criteria to be used in urban decision-making will be enhanced. Further, through sampling of cities whose criteria is considered, undercoverage bias will be removed which usually results in only active and English-speaking cities being represented in EU projects.

Concretely, each of the eight literature gaps listed in chapter 1.4 will be addressed in the following ways:

Table 5: Addressing literature gaps

#	Literature gap	How it will be addressed
1	Integration of Mitigation and Adaptation Strategies	
1a	the adaptation is overlooked	Adaptation and mitigation will be considered as a part of the same process, with criteria used that highlight benefits (and hidden benefits) of both approaches to combating climate change.
1b	inability to utilise adaptation and mitigation synergies	List of synergies from research will be connected with the most common actions from SECAPs in order to flag potential synergies in the decision-making framework and motivate cities to implement synergistic actions together.
1c	having to repeat the stakeholder involvement for both processes	Stakeholder inclusion will be easier, and more complete, through a process that considers an index (two-level criteria) which evaluates both adaptation and mitigation actions.
2	Available Decision Support Models and Tools	Model fit matrix will be developed which will ensure that local and regional decision-makers can choose an appropriate MCDA method outside of the ones utilized in this research.
3	Data and Information Gaps	Although decision-makers are encouraged to enter quantitative data for each action for each of the 12 criteria (i.e. whether the measure has a highly negative, slightly negative, neutral, slightly positive or largely positive contribution to a certain criteria),, the framework is primarily qualitative. The aim is to encourage users to assess even the information they might not have readily available, which can also enable cities to better understand the effect of additional, or sometimes hidden, benefits and to decide whether additional resources for actual measurements of effects would be justified.
4	Inclusivity and Stakeholder Engagement	Pairwise comparisons help in decreasing the cognitive load and avoiding biases through indirect elicitation of criteria. The transitivity and the accuracy of the simple pairwise method will be enabled through PAPRIKA online tool.
5	Long-Term vs. Short-Term Decision Horizons	Combining adaptation and mitigation measures and making the time-horizon a boundary instead of a criterion will help in viewing the benefits of the actions in a comparable manner. Additionally, the decision-maker can view the time horizon, or any other limit, but this will not intervene with the list of optimal measures.
6	Policy Implementation and Evaluation	Having a tool that is easy to reiterate will help decision-makers bridge this gap and evaluate the impact of sustainable policies and measures with up-to-date information.
7	Decision Uncertainty and Risk Management	In this framework, uncertainty and risk will be viewed as a boundary instead of a criterion. This will help in viewing the benefits of adaptation and mitigation actions in a comparable manner.
8	Scale and Contextual Variations	In the ex-ante testing of the tool, urban areas of different size and climate zone will be considered to assess the effect using the tool would have on the implementation of their implemented plans (i.e. how would the adaptation measures rank with the mitigation measures when considered together, instead of separately, and whether

there is any difference when it comes to population size, climate zone, or certain type of measures).

This research incorporates innovative elements and delivers noteworthy contributions:

1. Proposing a Novel Decision-Making Framework: A comprehensive decision-making framework tailored to local and regional policy-making in the context of sustainability will be introduced. Adopting such a constructivist stance that integrates objective factors (e.g., energy or CO_2 savings) with subjective elements (e.g., political will or citizen engagement) within the decision-making framework provides a more holistic methodology for cities. By factoring in political will and risk assessment, the gap between academic theory and real-world application will be bridged, providing policymakers with a tool that is both practical and grounded in research. The framework will be systematic (more structured in scoring and weight elicitation) and effective, yet simple and straightforward, to incentivize its utilization. The framework is applicable at two different stages of the SECAP process: a) planning phase (helping select activities for SECAPs in accordance with their local goals and value preferences) and; b) implementation phase (reducing budget and time constriction through prioritizing best fitting investments).

2. Focus on Synergies: Emphasis will be placed on the exploitation of synergies between adaptation and mitigation actions, which is often overlooked in conventional sustainability planning. This will guide cities in the capitalization of initiatives that offer dual benefits, maximizing their sustainability efforts and resulting in lower cost and greater savings.

3. Indicative Set of Criteria: The methodology will propose a set of two-level criteria within a trade-off system that is both pragmatic and applicable for local policymakers, while giving due consideration to the long-term benefits and risk mitigation associated with adaptation measures, energy conservation and the exploitation of synergies between mitigation and adaptation actions. An original PROSPECT+ value index of five dimensions divided into 12 subcriteria will be developed, based on research on the most popular sustainable indices, such as SDG Cities, EU GCI, CDP ICLEI and considering the local context, ensuring that as many as possible useful categories are included without redundancies.

4. Participatory Approach: Inclusivity will be promoted by emphasizing stakeholder participation. This represents a significant shift from top-down decision-making processes to a more collaborative approach, increasing the potential for successful implementation by garnering political and citizen support for planned measures.

5. Ease of use: a comprehensive list of 58 adaptation and 116 mitigation actions will be offered for both mitigation and adaptation, meaning that with an easy search, all actions from the local SECAP can be chosen. The list also aims to motivate the decision-makers to learn about other actions. Additionally, the determination of weights for each criterion will be performed through a simple process called pairwise comparison, which takes the least time and cognitive effort (only two pairs of alternatives to choose from at a time). Such simplification significantly lowers the facilitation burden of decision-makers and allows for a simple and fast process of understanding one's values to make the right decision for the given time and the context;

6. Perceiving Soft Benefits: One of the challenges in sustainable initiatives is the quantification of less tangible, softer benefits which often get ignored. The framework provides a qualitative matrix which urges users to score different criteria to account for additional benefits, offering a more comprehensive understanding of the impact of sustainable actions.

7. Shift in Paradigm: Emphasis will be placed on the contemporary climate neutrality and clean energy transition goals, including the "Energy Efficiency First" principle and a broader view of sustainability beyond just CO_2 savings, pushing the narrative towards a more holistic understanding of urban sustainability.

3.6. *Popis citirane literature*
(maksimalno 30 referenci)

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3.7. Procjena ukupnih troškova predloženog istraživanja
(u eurima)

30.000 EUR

3.8. Predloženi izvori financiranja istraživanja

Vrsta financiranja	Naziv projekta	Voditelj projekta	Potpis
Nacionalno financiranje			
Međunarodno financiranje	EU project PROSPECT+ - Capacity building for cities and regions - from learning to action!	Mia Dragović Matosović	
Ostale vrste projekata			

Samostalno financiranje	
3.9. Sjednica Etičkog povjerenstva na kojoj je odobren prijedlog istraživanja (po potrebi)	

SUGLASNOST PREDLOŽENOG MENTORA I DOKTORANDA S PRIJAVOM TEME

Izjavljujem da sam suglasan s temom koja se prijavljuje.

Potpis

Prof. dr. sc. Nela Vlahinić Lenz,
Sveučilišni nastavnik i redoviti
profesor na EFRI

Potpis

Professor Stefan Bouzarovski, DPhil
Professor of Human Geography at the
University of Manchester

IZJAVA

Izjavljujem da nisam prijavila/o doktorski rad s istovjetnom temom ni na jednom drugom sveučilištu.

U Rijeci, 18. ožujka 2024.

Potpis

Mia Dragović Matosović

M.P.