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How do waste climate policies contribute to sustainable development? A case study of North Macedonia

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ABSTRACT

The impact of waste policies and measures from National Determined Contributions (NDCs) on the Sustainable Development Goals (SDGs) is unexamined and creates conditions for policy conflict and incoherence. This participatory case study of North Macedonia quantifies synergies and trade-offs. Our results show twelve times more synergies than trade-offs. The most important synergies concern SDG 8: Decent work and economic growth (score: 10) and SDG 3: Good health and well-being (score: 5) since formalizing the recycling sector is expected to create jobs, economic productivity is expected to improve as a result of increased resource efficiency in industry, and declining pollution is expected to increase health through adequate waste management in landfills. On the other hand, the most important trade-off pertains to SDG 1: No poverty (score: −3) because the incomes of informal workers are expected to decrease, affecting financially vulnerable families. In conclusion, despite being the least emitting sector globally, the waste sector is a promising avenue for mitigating climate change because of its synergistic effects with the SDGs. Circular economy policies in line with the 3Rs: reduce, reuse and recycle hold the most potential for synergies in developing countries. This case study generated momentum for policy implementation by highlighting policy synergies and ideas for the next revision of the NDC. Central to this was the process of fostering dialogue and learning among otherwise siloed policy actors.

1. Introduction

In a momentous year of international cooperation, 2015, the United Nations rolled out the Sustainable Development Goals and, at the same time, facilitated the Paris Agreement. Both initiatives were supported and ratified by most country members of the United Nations, marking significant progress in global cooperation on sustainability issues (Biermann et al., 2017). The Sustainable Development Goals (SDGs) is a wide framework composed of 17 goals and specific goal targets encompassing environmental, social, and economic spheres. The Paris Agreement is an international treaty that concerns climate change mitigation, adaptation, and finance; and is to a certain extent synonymous with SDG 13: Climate Action. According to it, countries submit Nationally Determined Contributions (NDCs) every five years, which outline their mitigation goal and list policies and measures (PAMs) to achieve the goal, thus reaffirming their commitment to the treaty and to global efforts to mitigate climate change.

However, despite sharing the year of adoption, it is not clear how these two initiatives are interconnected. In other words, it is not clear how SDG 13: Climate Action is connected to the rest of the goals, or how NDC PAMs reinforce or hinder other sustainable development issues. For example, carbon pricing may lead to increased consumer energy prices that disproportionately affect those living in poverty. In that case advancement on SDG 13: Climate Action may negate progress on SDG 1: No poverty, i.e., a carbon pricing policy has trade-offs with that particular SDG. Inarguably urgent, as stated in the latest Intergovernmental Panel on Climate Change report (IPCC, 2021), climate action policies and commitments should take place at a fast pace and mandate a certain extent of scrutiny to ensure that they do not contradict

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Abbreviations

SDG	Sustainable Development Goal
NDC	Nationally Determined Contribution
PAMs	Policy and Measures
GHG	Greenhouse Gas

themselves or negate progress in other policy areas considered nationally and internationally important, such as the areas addressed by the SDGs and their targets. Admittedly, there has been some research on the link between SDG 13: Climate action and the rest of the SDGs (Fuso Nerini et al., 2019), but more granular research regarding particular sectors like, for example, the waste sector, has yet to be subject of scholarly analysis.

In response to this invitation for scrutiny and fair criticism, we pose the following research question: How do waste sector NDC PAMs affect SDG progress? We address this question using the Q-SCAN method in a case study with stakeholders in North Macedonia as a continuation of our previous work (Gjorgievski et al., 2021) where we looked at the synergies and trade-off between the SDGs and NDC PAMs in the energy sector. Finally, based on our findings we reflect on implications on SDG interactions theory, the role of waste NDC PAMs for sustainable development and suggest directions for future research.

Section 2 roots this research in theory through a literature review on SDG interconnections, the waste sector and its link to climate action. Section 3 outlines the Q-SCAN method, which was used to quantify the links between waste NDC PAMs and the SDGs in a participatory manner. Next, Section 4 presents the results of applying this method, including additional consensus analysis and expert validation. The discussion presented in Section 5 entails reflections on analyzing NDC-SDG links and the benefits and drawbacks they pose to policy, as well as the most important ways the waste sector impacts sustainable development through NDC PAMs both in the Macedonian context and in general. Last, Section 6 is a concise conclusion.

2. Literature review

This section provides an overview of recent relevant literature that studies the linkages with the SDGs, with a focus on the links between solid waste management and climate action.

2.1. Sustainable development goals interconnections

There are interconnections between the SDGs (Barbier and Burgess, 2017). This becomes especially clear if one adopts a systems thinking lens, which emphasizes a holistic view of issues as a sum of their constitutive elements and their interconnections. These links can be either positive or negative, i.e., progress towards one goal can contribute to progress (regress) toward (away from) another goal. In other words, while positive links describe ways in which sustainable development policies converge, negative links describe ways in which sustainable development policies diverge (Ament et al., 2020). Widely referred to as synergies and trade-offs, studying potential SDG interconnections is useful for maximizing synergistic effects and prioritizing trade-offs (see Anderson et al. (2021) for an example of a model assessing SDG interlinkages).

This line of reasoning has inspired numerous studies (often termed 'nexus studies') on SDG interlinkages (Liu et al., 2018). The most widely studied interlinkages are those between water, energy and agriculture, the so-called 'water-energy-food nexus', especially in the context of climate change (Leck et al., 2015). In addition to this, studies often include economic concepts through industry and socioeconomic equality repercussions (Biggs et al., 2015). However, these studies are criticized for not being interdisciplinary enough or lacking a participatory character (Albrecht et al., 2018). Waste, and subsequently waste management, as a by-product of current socioeconomic practices, has until recently been omitted from these studies as evidenced by the fact that 'waste' is only mentioned in the context of wastewater management and not in the context of solid waste management. Thus, there has been a call to extend research to include waste in 'food-water-energy-waste nexus' studies (Garcia et al., 2019).

Further, despite growing scholarly interest in studying SDG interlinks, scientific methods for evaluating SDG interconnections are lacking in voluntary national reviews for progress on the SDGs. There are, however, indictments that policymaker demand for these types of studies is growing (Allen et al., 2021). One of the reasons for this is that SDG links differ on national and transnational levels (Coenen et al., 2021), which stresses the importance of conducting more granular case studies on both national and cross-national levels.

2.2. Solid waste management and climate action

As a constant accompaniment to human civilization, waste and waste disposal is a universal practice evidenced by archaeological middens. Recently, the definition of waste management has expanded from mere control of disposal to include resource recovery within a circular economy system (Pujara et al., 2019). This shift has also enabled scholars to examine the sustainability of the field since moving from linear to circular thinking has attempted to bridge the gap between waste, at the end, and primary resources, at the beginning of the resource cycle. For example, Piacentino et al. (2019) showcased a sustainable heating solution based on the use of biomass and municipal solid waste to fuel district heating plants. As an interdisciplinary field, solid waste management is not represented by one SDG, but rather encompasses 12 SDGs (Rodić and Wilson, 2017). The cross-cutting nature of the waste sector can arguably lower the political attention given to it, but also emphasizes the need to study the interconnections between the SDGs to examine it in its entirety.

It is important to note that solid waste creation is increasing in most places and is especially worrisome for countries where disposal is open and under-managed, which results in significant greenhouse gas (GHG) emissions from open decay and/or burning, highlighting its importance for SDG 13: Climate Action and NDCs (Ranjbari et al., 2021). Powell, Chertow & Esty (2018) analyze waste sector commitments from 174 submitted NDCs. They find that most countries included waste as part of their NDC commitment, accounting for 91% of global 2010 GHG emissions from waste. Improved landfilling is the most listed measure followed by waste-to-energy, recycling and composting measures.

3. Materials and methods

This study applies a method called Q-SCAN whose output is a single diagram depicting quantified links between NDC PAMs and SDGs. The ability to systematically portray policy effects and interactions in a single diagram is of immense value to both scientists and practitioners of public policy (Cohen et al., 2019). Gjorgievski et al. (2021) developed Q-SCAN and applied it in the energy sector in North Macedonia. In their work, quantification of the links is done by sector experts, but they stress that the methodology is suitable for stakeholder engagement, which ultimately led us to modify Q-SCAN to a participatory approach for the purpose of this study. The strengths of this approach lie not only in systematically ranking and contextualizing NDC-SDG links, but also in providing rich narrative-based insights.

3.1. Method description

The Q-SCAN method, used in this study, consists of three steps (see Fig. 1). Firstly, the links between the PAMs and the SDG are identified at the SDG target level, using the SDG Climate Action Nexus tool (SCAN-

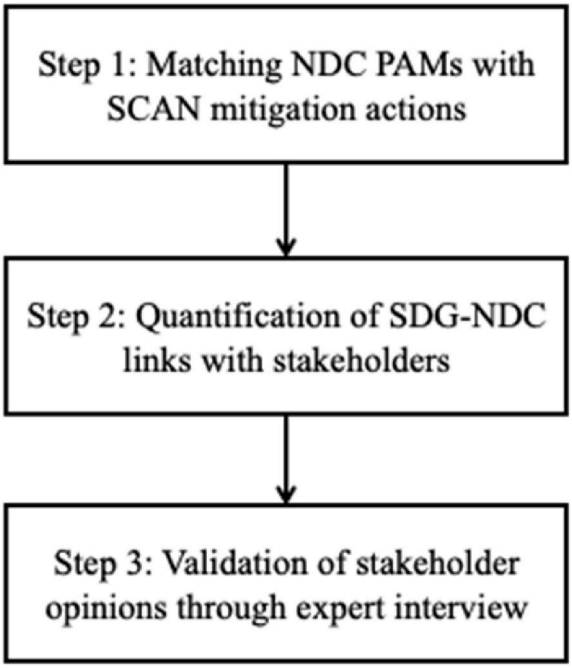

Fig. 1. Modified Q-SCAN method applied in this study.

tool) (Gonzales-Zuñiga et al., 2018). The identified links, chosen from a pool of 982 possible links, are then scored using the scale proposed in Nilsson et al. (2016). As a final step, integral scores are calculated for each SDG and each type of links, respectively (Gjorgievski et al., 2021). Positive scores (+1,+2,+3) are associated with synergies, with +3 being the strongest synergy, while negative scores (−1,-2,-3) are associated with the trade-offs, where −3 indicates the strongest trade-off. These scores quantify the relationship between the PAMs and the SDGs. Because of the fact that quantification was done through a stakeholder workshop, the scores reflect average score voted on by the participants (see Table 1).

Since the motivation behind adopting a participatory approach was to foster inclusivity and dialogue, unlike our past study on the energy sector which aimed to quantify national relevance based on sector expertise (Gjorgievski et al., 2021), an additional step was taken, which validates the results with a sector expert in order to increase the reliability of the results (see Fig. 1). Specifically, expert validation was conducted in the form of a closed-question interview.

3.2. Method justification

Very few SDG interaction studies employ participatory approaches (Bennich et al., 2020) even though the benefits of using a participatory approach to integrate climate change mitigation with sustainable development planning are assumed to be broad. Awareness raising among stakeholders and the general population, as well as abiding by ethics of inclusion are considered to be among the biggest benefits (Gjorgievski et al., 2021). Structured stakeholder engagement, although difficult to facilitate, is considered to give scientific research a stronger base for impact (Cohen et al., 2019). In fact, participatory approaches have been proposed as one of the best ways for creating policy buy-in and policy coherence for the climate change and 2030 Agenda (Caetano et al., 2020). Policy buy-in refers to the acceptance of policy proposals by policy actors and policy coherence refers to the extent a policy conflicts with existing and planned policies, both of which ease the way to successful policy implementation. Examples of this within SDG nexus studies include Cohen et al. (2017) and Antwi-Agyei et al. (2018) as their studies produced and discussed these outcomes. All in all, despite low application, participatory approaches are especially effective for the SDGs because the goals are multisectoral, i.e., they require approval, collaboration and implementation efforts from a variety of stakeholder groups, all of which are common outcomes of participatory research.

Table 1
Scheme for quantifying link importance based on stakeholder votes.

Average score range	Resulting score	Link interpretation
0–0.49	0	No national relevance
0.5–1.49	1	Low importance
1.5–2.49	2	Medium importance
2.49–3	3	High importance

Both participatory and non-participatory past practices have, however, been the subject of criticism as they tend to concentrate on a narrow range of sustainable development sectors and fail to include the entire spread of national development agendas, which may expose new climate-relevant sectors (Atteridge et al., 2020). The authors propose that normative or other biases may be responsible for this missed opportunity. This makes for an even stronger case to extend the Q-SCAN study to include non-conventional climate change sectors such as waste.

Q-SCAN is not the only method attempting to quantify SDG-NDC links. Cohen et al. (2017) exercised rating scales as a means of quantifying co-benefits from an intended NDC in an attempt to combat lack of data. Cohen et al. (2019) went even further by applying a much more complex quantification method: multi-criteria decision analysis. However, they are cautious to recommend it since it is a resource-intensive approach and may frustrate stakeholders who are not convinced of its benefits, which is why this study applies a less detailed approach.

3.3. Data collection

This study engaged stakeholders through a workshop. The goal of the workshop was to foster dialogue and learning among waste and climate change actors in North Macedonia. Hence, a wide range of stakeholders, not all of whom hold the status of experts in their area, were invited. A total of 15 attended the online workshop which took place in June 2021. They were affiliated with the Ministry of Environment and Physical Planning and various non-governmental advocacy groups or were private consultants in the waste sector. The reasoning behind this choice of stakeholders is that they are most actively involved in the creation and implementation of policies.

The expert for step 3 of the method (see Fig. 1) was chosen based on their history of involvement with climate change and waste sector policies in the country, specifically the NDC and national strategic documents and policies for waste management. The interview questions consisted of closed form questions asking for their agreement with and comment on all links quantified during the workshop. Transcripts of the workshop and the expert interview are available from the authors.

3.4. Method limitations

One of the main limitations of our method (Q-SCAN) is that it fails to systematically incorporate feedback from the SDGs to climate change PAMs and to include interlinks among the goals themselves. One way of overcoming this limitation can be to produce causal loop diagrams (Antwi-Agyei et al., 2018) or to use integrative modelling and simulation techniques such as the integrated SDG Model (Collste et al., 2017), which are useful in illuminating policy coherence or incoherence stemming from feedback dynamics. Such modelling can be useful for taking the Q-SCAN method to the next level in the future because it would enable Q-SCAN to engage in what Liu et al. (2018) mention as the fifth and last major step in implementing nexus approaches: simulation of nexus dynamics.

4. Results

The results of this study reveal synergies and trade-offs between four Macedonian enhanced NDC PAMs in the waste sector and the SDGs (see Table 2). Two of these PAMs correspond to "reduce, reuse and recycle" mitigation actions (Gonzales-Zuñiga et al., 2018) as they concern paper waste selection and improved waste and materials management at industrial facilities. And the remaining two have to do with "sustainable waste management systems" mitigation actions (Gonzales-Zuñiga et al., 2018) since they entail landfill gas flaring and mechanical and biological treatment in new landfills with composting.

Overall, there are more synergies than trade-offs in this sector, indicating that enhanced NDC PAMs are likely to have a positive effect on the SDGs (see Fig. 2). Specifically, the synergies of highest importance are with SDG 8: Decent work and economic growth (score: 10) because of new jobs and improved economic productivity and with SDG 3: Good health and well-being (score: 5) because of decreased air, water and soil pollution. Next, there are synergies of medium importance with SDG 11: Sustainable cities and communities (score: 11) and SDG 12: Responsible consumption and production (score: 9) since the formalization of the sector and increase of re-use rates are expected to improve cities, consumption and production, but only to a limited extent with the current PAMs. In terms of negative links, the most significant trade-off is with SDG 1: No poverty (score: −3) because the policies are anticipated to decrease the income of informal workers who often fall below the poverty line.

Taking data variance as a signifier of consensus level, the results portray various levels of consensus regarding the links (see Table 3). In this case study, consensus is understood as the level at which participants agree on the importance and relevance of a link in the national context. It does not refer to agreement on the polarity of the link, i.e., whether a link is a synergy or a trade-off. Specifically, there was most consensus regarding the links to SDG 10: Reduced inequalities and SDG 1: No poverty, which indicates that there is a high level of consensus for all NDC-SDG trade-offs. On the other hand, the lowest levels of consensus relate to SDG 6: Clean water and sanitation and SDG 11: Sustainable cities and communities. The remaining SDG links have medium levels of consensus with an average variance of around 0.55.

Interestingly, there was no discussion among workshop participants regarding the links to SDG 6: Clean water and sanitation even though it showed the highest level of dissensus. However, the expert interview was helpful in shedding light on the issue. Their view was that many mistakenly believe that the NDC PAMs improve sanitation and access to water because they will address liquid discharge from unregulated solid waste disposal sites, however that is not the same as proper wastewater treatment, which is out of the scope of the PAMs. Thus, they agree that the PAMs might improve access to water and sanitation, especially in terms of waste collection, but only to a limited extent, and they state that the effect would not be through wastewater treatment.

There was a discussion among stakeholders regarding links to SDG 11: Sustainable cities and communities. Some agreed that the PAMs will improve access to essential services in poor neighborhoods, while others discerned that only waste collection policies, which are not currently covered by the PAMs, can have that effect. Next, there was dissensus regarding whether the PAMs will improve the sustainability of urbanization and urban planning. The dominant view in the discussion was that waste management is one step behind urbanization and thus cannot affect its sustainability. Rather, it is urbanization that affects waste management. In light of this, some participants expressed that they have changed their views, but not enough to bring up the level of consensus. The expert generally agreed with the idea that the PAMs will not have a significant effect on the availability of essential services or urbanization sustainability. In addition, they emphasized that the biggest effect on SDG 11: Sustainable cities and communities will come from PAMs related to waste collection as they have potential to lower the environmental impact of cities.

Table 2
Matching waste NDC PAMs with corresponding SCAN mitigation actions.

NDC PAM	SCAN mitigation action
Selection of waste - paper	Reduce, reuse and recycle
Improved waste and materials management at industrial facilities	
Landfill gas flaring	Sustainable waste management systems
Mechanical and biological treatment (MBT) in new landfills with composting	

5. Discussion

In this section, the findings are discussed in light of the benefits of exploring the NDC-SDG linkages and the impact that climate actions in the waste sector have on sustainable development.

5.1. Is there any use in linking Nationally Determined Contributions to the Sustainable Development Goals? Reflections on applying the Q-SCAN method and research outcomes

The exercise of linking the Macedonian NDC to the SDGs proved to be beneficial because it brought national policymakers one step closer towards mainstreaming climate change in sectoral policies. As such, this work stands as an example of how waste management can be incorporated in SDG nexus studies through the Q-SCAN method. Future studies may benefit from the quantification of the SDG links, both in relation to one another, and, in comparison with SDG links in other sectors (see Gjorgievski et al. (2021) for an example of the energy sector).

5.1.1. Political support as a benefit

One of the reasons approaches like Q-SCAN are beneficial is that PAMs are given higher priority when they are seen as contributors towards other near-term goals (Hammil and Hayley, 2017) and the need for PAM funding is perceived as lower in cases where policies are clearly deemed aligning (Northrop et al., 2016). Mantlana et al. (2021) also stand witness to this as they describe that NDC-SDGs interlinkage has yielded political support for climate change policies and lowered the need for resources such as funding. Thus, this study confirms that participatory processes are effective for SDG delivery because they build trust in policy and increase policy acceptance (Fuldauer et al., 2019), altogether termed as "raising political support".

5.1.2. Policy coherence as a benefit

Another one of the most stressed benefits of linking the NDC to the SDGs and of exploring SDG interactions in a scientific manner is policy coherence. Understanding NDC-SDG links can aid policy coherence on national or local levels, thus increasing cooperation among policymakers who are often siloed. Environmental SDGs are the most complex and least coherent out of the SDGs because policies that are coherent at the highest level of the policymaking process can still lose much of their coherence during implementation (Coscieme et al., 2021). Our study was able to establish that the NDC PAMs are to a large extent coherent, i.e., synergistic to the SDGs, which implies that they are coherent with other policies aimed at progress towards the SDG targets.

At the same time, it is imperative to move beyond a technocratic approach to policy coherence as Brand et al. (2021) criticize that policy coherence studies often miss a political dimension. The current study tackles this by including stakeholders directly in the process. Discussions during the workshop often took political character so, arguably, our study was inclusive of politics. In terms of policy coherence, navigating policy trade-offs may be more significant than mapping synergies ex-ante (Brand et al., 2021) since the larger trade-offs produce more winners and losers (while synergies produce only winners), making it more difficult to manage and prioritize between conflicting policies

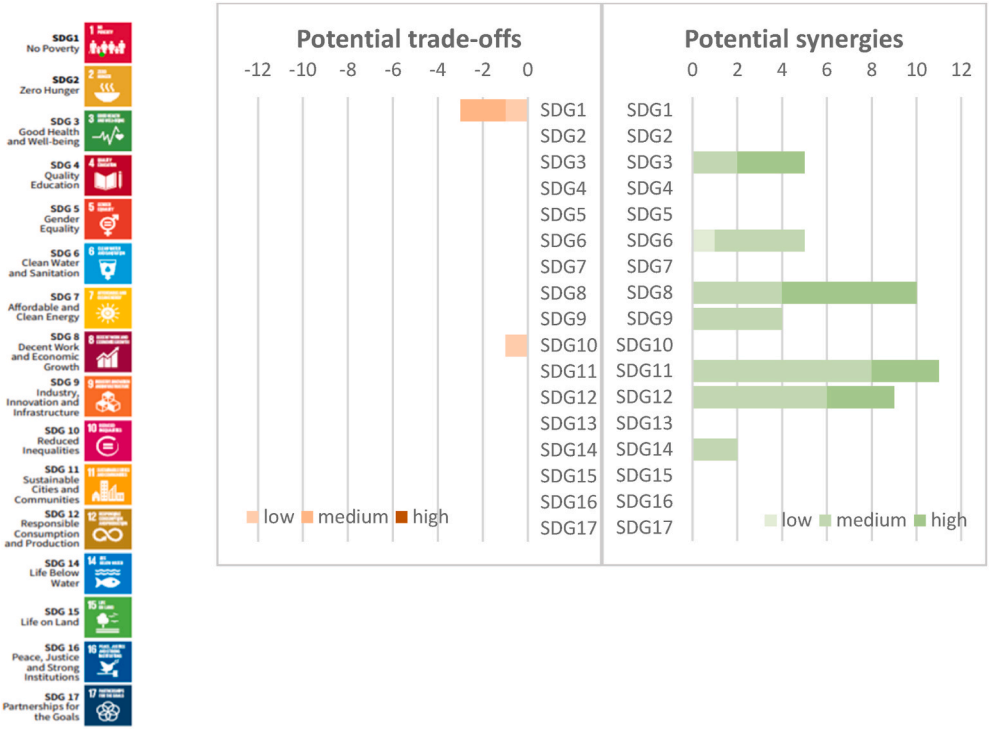

Fig. 2. Synergies and trade-offs between four Macedonian enhanced NDC measures in the waste sector and the SDGs. The score for each SDG denotes the cumulative number of links judged to be of low, medium and high importance by national stakeholders as represented by color shades.

Table 3
The level of stakeholder consensus represented by average variance for SDG link scores. A low average variance value indicates high consensus and vice versa.

Link to SDG	Average variance
1	0.34
3	0.53
6	0.95
8	0.50
9	0.61
10	0.29
11	0.81
12	0.43

(Breuer et al., 2019).

5.1.3. Benefits for policy implementation

Although the benefits of establishing NDC-SDG links have clearly been recognized in the policy formulation phase [e.g., Atteridge et al. (2020) and Mantlana et al. (2021)], they are yet to be effectively demonstrated in the policy implementation phase. Pinkse and Kolk (2012) suggest multistakeholder partnerships as one of the ways of filling that gap. Their explorative study of multistakeholder partnership case studies proposes that such partnerships fulfil important governance functions such as information sharing, capacity building and rule-setting in addition to achieving policy goals. Further, business community engagement taking place through these kinds of partnerships is emphasized as a way of addressing common resource and learning gaps in the climate change and sustainable development policy arena. These are ideas to build up on the stakeholder engagement process started during this research or for similar research aimed at inspecting whether establishing NDC-SDG links is beneficial to the policy implementation process or not.

5.1.4. Barriers and drawbacks of NDC-SDG linkage

Despite the benefits and ideas mentioned above, there are some arguments not to integrate climate change and sustainable development planning because they might create additional hurdles for policy actors (Yedla and Park, 2009). For example, complex governance arrangements such as a lack of history of coordination among departments, overlapping authorities, department-specific jargon, unequal access to information and pre-existing knowledge can make communication difficult (England et al., 2018). Extra coordination among different institutions requires extra resources, which may not be easily available especially in the case of developing countries. In addition, most SDG nexus studies are abstract and are thus of limited use to policymakers who deal with problems on the ground (Breuer et al., 2019). However, despite being abstract, the stakeholders in our study expressed that it increased evidenced-based policy and transparency.

Shockley (2018) proposes some more philosophical cautions against establishing NDC-SDG links. Specifically, he argues that NDCs and SDGs differ in the fact that NDCs are actor-dependent while SDGs aren't, making it harder to determine accountability for SDG implementation. Instead, he suggests either to make NDCs actor-independent like the SDGs by freeing nations and national actors from accountability or to completely integrate NDCs into the SDGs (specifically SDG 13: Climate action) and put the spotlight entirely on the 2030 Agenda.

5.2. How do waste sector climate policies impact sustainable development? Takeaways from the case study and comparison to existing literature

Our results showed that Macedonian enhanced NDC PAMs in the waste sector are expected to have an overall positive effect on sustainable development in the country. Specifically, stakeholders agree that their biggest contribution will be towards achieving SDG 8: Decent work and economic growth and SDG 3: Good health and well-being. However, the highest level of consensus among stakeholders was regarding trade-offs, as they anticipate that the PAMs will likely negatively impact progress towards SDG 1: No poverty and SDG 10: Reduced inequalities.

While this study looked at all waste NDC PAMs together, the impact per SDG varies per PAM. Thus, the results merely represent expected effects given proper implementation of all waste NDC PAMs.

5.2.1. Takeaways for the Macedonian context

There are 27 links in the waste sector according to the SCAN-tool, but our national case study only looked at 24 links because none of the Macedonian PAMs are related to mitigation actions on increasing energy efficiency (see Table 2). Given that there were only 3 trade-off links based on the SCAN-tool to begin with, it is not surprising that our case study confirmed a largely positive impact on SDG progression. Despite the fact that most identified links concerned SDG 11: Sustainable cities and communities (5 links, score: 11), it has a similar score with SDG 8: Decent work and economic growth (4 links, score: 10) because stakeholders deemed that the links to SDG 8: are of higher importance and would have greater impact given the national PAMs. Similarly, even though there were more links to SDG 6: Clean water and sanitation (3 links, score: 5), it has the same score as SDG 3: Good health and well-being (2 links, score: 5) for identical reasons.

5.2.2. Comparison to existing literature

It can be said that the Macedonian waste PAMs are representative of common waste NDC PAMs since most Paris Agreement signatories are at the early stages of developing disposal and recycling schemes (Powell et al., 2018). This study showed that Macedonian waste NDC PAMs are connected to 8 SDGs (1, 3, 6, 8, 9, 11, 12, 14), which is less than the 12 SDGs stated in other scholarly literature (Rodić and Wilson, 2017). This is because it is a participatory study, meaning that the links were established through both scholarly theory and local stakeholder discussion, thus reducing the number of links identified in literature to only those stakeholders consider nationally relevant.

A thorough comparison of our results with those of Fuso Nerini et al. (2019) and Thacker et al. (2019) is presented in Table 4. Specifically, it lists the links to SDG targets (Fuso Nerini et al., 2019) relevant to the waste sector and their corresponding strength. These are only a fraction of the waste sector links identified with the SCAN-tool (Gonzales-Zuñiga et al., 2018), but are comparable because they use the same weighting scale based on Nilsson et al. (2016). They are consistent with the results of our study. Specifically, Fuso Nerini et al. (2019) give ranges for most of these links and the values from our study fall within those ranges. Notably, targets 6.a, 12.3 and 12.6 are not included in the SCAN-tool and also not directly captured by North Macedonia's PAMs, thus they are incomparable. Special emphasis should be given to targets 6.3 and 11.6 as they fall within the upper limits of the ranges given by Fuso Nerini et al. (2019), leading to the conclusion that stakeholders find that these links are more impactful in the North Macedonian context than the average global context.

Table 5 compares the results of our study with that of Thacker et al. (2019). The two studies are comparable because they both base the links on scholarly literature, but their comparability is limited since they differ in geographical scope and results vocabulary. Specifically, our study focuses on North Macedonia and ranks link importance with quantitative values agreed on by stakeholders, while theirs is global and assesses how many of the SDG targets are subject to 1) no, 2) direct or 3) indirect influence based on expert judgement in consultation with scholarly literature. In fact, most of the inconsistencies between the two studies reflect differences in results from Thacker et al. (2019) and the SCAN-tool (Gonzales-Zuñiga et al., 2018) rather than our study specifically. Such is the case regarding links to SDG 2: Zero hunger, 4: Quality education, 15: Life on land and 16: Peace, justice and strong institutions. Our study deemed the links to SDG 3: Good health and well-being (score: 5) and SDG 8: Decent work and economic growth (score: 10) to be of medium and high importance, while Thacker et al. (2019) only noted indirect influence on these SDGs, suggesting that these links are perceived to be of higher importance in North Macedonia compared to the global picture. On the other hand, the links to SDG 6: Clean water and sanitation and SDG 14: Life below water are found to have a direct influence in Thacker et al. (2019), but only have links of low and/or medium importance in this study.

Table 4
Comparison of waste sector links to SDG targets in our study and Fuso Nerini et al. (2019).

Sustainable Development Goal Target	Results from Fuso Nerini et al. (2019)	Our results
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	1–2	1
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	1–2	2
6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	1	Not included
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	1–3	3
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including postharvest losses	1–3	Not included
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	1–3	2
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	1–3	2
12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	1–3	Not included

Our results are also in line with research on the contribution of solid waste management to the SDGs. Hannan et al. (2020) find that reuse and recycling policies have a significant potential for job creation and provide other economic benefits. Similarly, they show that standardized waste management can prevent the spread of infectious disease. As mentioned before, our study also emphasized the synergies with SDG 8: Decent work and economic growth and SDG 3: Good health and well-being as those of highest importance. Moreover, the arguments Hannan et al. (2020) provide regarding links to SDG 11: Sustainable cities and communities are consistent with the arguments provided by the stakeholders in our study. Specifically, these concern air quality improvement through the eradication of open burning practices, which is one of the PAMs that is expected to improve quality of life in cities. In addition, reduced waste pollution and more efficient resource use improves the quality of urbanization, which is an issue rapid-growing cities often face.

Finally, our study confirms the co-benefits of transforming linear resource cycles to circular ones on climate and industry (Wang and Stanisavljevic, 2019) as evidenced by the positive links between NDC PAMs and SDG 9: Industry, innovation and infrastructure. Both

Table 5
Comparison of waste sector links to SDGs in our study and Thacker et al. (2019).

Sustainable Development Goal	Results from Thacker et al. (2019)	Our results
1: No Poverty	Indirect influence	Links of low and medium importance (−3)
2: Zero Hunger	Indirect influence	No links
3: Good Health and Well-being	Indirect influence	Links of medium and high importance (5)
4: Quality Education	Indirect influence	No links
5: Gender Equality	No influence	No links
6: Clean Water and Sanitation	Direct influence	Links of low and medium importance (5)
7: Affordable and Clean Energy	No influence	No links
8: Decent Work and Economic Growth	Indirect influence	Links of medium and high importance (10)
9: Industry, Innovation and Infrastructure	Direct and indirect influence	Links of medium importance (4)
10: Reduced Inequalities	Indirect influence	Link of low importance (−1)
11: Sustainable Cities and Communities	Direct and indirect influence	Links of medium and high importance (11)
12: Responsible Consumption and Production	Direct and indirect influence	Links of medium and high importance (9)
13: Climate Action	Indirect influence	Not included
14: Life Below Water	Direct influence	Link of medium importance (2)
15: Life on Land	Indirect influence	No links
16: Peace, Justice and Strong Institutions	Indirect influence	No links
17: Partnerships for the Goals	Indirect influence	Not included

Gallego-Schmid et al. (2020) and our stakeholders agree that even small transformations towards circularity can have huge impacts on GHG emissions.

5.2.3. *Important NDC-SDG links in the waste sector*

The findings of this study indicate that the biggest trade-offs of NDC PAMs are regarding poverty and socioeconomic inequalities reduction, emphasizing the need for a 'just transition' in terms of integrating workers who would otherwise be left behind. In fact, waste sector climate policies tend to be more vulnerable to trade-offs in developing countries because of the potential social costs incurred by vulnerable groups like children, women, elderly, unemployed or migrants (Kaza et al., 2018), which are more prevalent in these countries. If these informal waste pickers are not integrated in the formalization of recycling schemes, then both the livelihoods of these workers and the efficiency of the waste management system may suffer. The stakeholders in our case study expressed the highest level of consensus on this issue. One idea for addressing this trade-off is to include partnership with informal workers within the design of specific policy proposals. For example, informal workers may be offered special housing, health or education benefits or the government can intervene by regulating the price of recycling material, thus ensuring income stability for these groups (Kaza et al., 2018). Further, examples in Kaza et al. (2018) show that governments may address this by directly employ informal workers or connect them to large manufacturing companies who would be interested in using the recycling material.

Despite the fact that only small share of global GHG emissions directly stem from the waste sector, the potential of waste management policies to contribute to climate change mitigation is significant due to the fact that emissions are continuously increasing (IPCC, 2007) and its links to other sectors (O'Neill, 2019). For example, a shift to circular economy practices and material re-use would significantly impact energy sector emissions like those from virgin material extraction and transport. Waste prevention and material re-use policies are especially important for Small Island Developing States because of high per-capita infrastructure costs (Fuldauer et al., 2019). Therefore, reuse and recycling policies are especially emphasized in these regions.

Future studies can benefit from the categorization of SDG links with high, medium and low importance as links perceived to be of high importance would be more worthwhile to study in detail. In this case study, the link between SDG 8: Decent work and economic growth and waste NDC PAMs were deemed of high importance. Specifically, these describe increased resource efficiency through reduced waste production and job creation through recycling formalization. Similarly, links related to reduced waste production and its potential to lower the environmental impact of cities (SDG 11: Sustainable cities and communities) and increase efficiency in natural resource use (SDG 12: Responsible consumption and production) were rated as important. Moreover, the link to SDG 3: Health and well-being was ranked as important because of expected reduction of respiratory diseases due to adequate waste management. These particular links can benefit from extra studies because they are judged to be of high importance. Last, future studies can be rooted in the consensus analysis since links for which there is dissensus might indicate cognitive biases or areas that would encourage scholarly debate.

6. Conclusions

Waste policies and measures are a key part of climate change mitigation, yet their effects on other national policies are often unclear. When developed in silos, policies and measures are vulnerable to policy resistance or, even worse, regress due to conflict with existing policies. This case study assesses the effect of NDC waste policies and measures on the SDGs. A participatory approach was undertaken, which yielded a tangible graph depicting quantified links in the waste sector, their relevance in the national context of North Macedonia and their strength in relation to one another, which embodies the main novelty of this work. At the same time, the study created benefits for the community by fostering dialogue and learning among participants. Our results show that climate change mitigation policies in the waste sector have an overwhelmingly positive effect on the SDGs. The positive effect is strongest for SDG 8: Decent work and economic growth and SDG 3: Good health and well-being. On the other hand, stakeholders expressed strong consensus that there may be a negative effect on the development of SDG 1: No poverty. These findings reaffirm the importance of integrating informal workers who might otherwise be left behind and posit circular economy policies as most synergistic for promoting economic prosperity while, at the same time, mitigating climate change. It is imperative that waste be included in future nexus studies in order to study the implications of these links in more detail, especially in terms of feedback and dynamics stemming from interconnections between the rest of the goals.

CRediT authorship contribution statement

Ema Gusheva: Methodology, Investigation, Validation, Writing – original draft, Visualization. **Vladimir Gjorgievski:** Methodology, Writing – review & editing. **Teodora Obradovic Grncarovska:** Validation, Writing – review & editing. **Natasa Markovska:** Conceptualization, Supervision, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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