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ORIGINAL PAPER

# Sustainable Development Goals—Climate Action Nexus:Quantification of Synergies and Trade-offs

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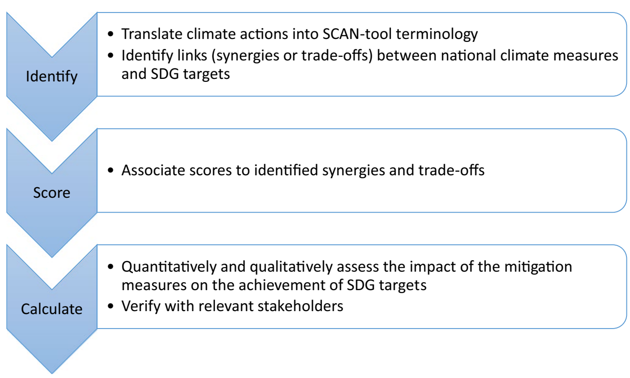
## Abstract

Since 2015, the intended climate actions of the Paris Agreement signatories have been reported as nationally determined contributions (NDC). These climate actions are fully aligned with the 13th Sustainable Development Goal (SDG) which calls for urgent action to combat climate change. The same, however, cannot be said for their relation to the other 16 SDGs of the 2030 Agenda for Sustainable Development, since climate action can either enhance or compromise the prospects for SDG implementation. In light of this challenge, this paper proposes a simple method for quantifying the synergies and trade-offs between national climate actions and the SDGs. The method, referred to as Q-SCAN, makes use of a seven-step scale and the SDG Climate Action Nexus tool. The effectiveness of the method has been demonstrated on a case study of North Macedonia, a non-Annex I, Western Balkan country with a coal-intensive energy system. Based on the experience in the preparation of the country's enhanced NDC, the paper elaborates how the method can be used to contribute to the alignment of the national climate actions with the SDGs and how it can be used to improve stakeholder engagement.

### Graphic abstract




**Keywords** 2030 Agenda · Climate change mitigation · Energy transition · Sustainable Development Goals (SDG) · Sustainability

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## Introduction

In 2015, the General Assembly of the United Nations adopted the 2030 Agenda for Sustainable Development (UN General Assembley 2015). Signed by 193 countries, the 17 Sustainable Development Goals (SDGs) and 169 specific targets of the 2030 Agenda present a ‘plan of action for people, planet and prosperity’. However, there are correlations between different aspects of this plan which entail that moving forward in one area requires compromise in another (Nilsson et al. 2016). The multivariate nature of sustainability (Sikdar 2019) and the lack of uniformity of metrics (Sikdar 2003, 2009, 2020) only emphasize the challenge of providing clarity to those who most need it—policymakers.

The implementation of the SDGs is more easily initiated when there is a sound evidence base for action. Different approaches have been used to reduce this complexity down to a comprehensible framework. For example, various guides and tools that can be used for SDG assessment are offered in Johnsson et al. (2020). Most notably, Nilsson et al. (2016) proposed a method based on which the interactions between the SDGs can be studied. Moreover, Gue et al. (2020) reviews how artificial neural network have been used in this area of research. A range of complementary evidence- and science-based methods for prioritizing SDGs are discussed in Allen et al. (2019). Furthermore, Mulligan et al. (2020) examines nature’s contribution towards SDG 6 (Clean water and sanitation), while the achievement of SDG 14 (Life under water) in the United Arab Emirates is discussed in Gulseven (2020). Measures in the energy sector have also spurred notable interest in the research community, as they have wide societal implications (Santika et al. 2019). Using Nilsson’s framework, Fuso Nerini et al. (2019) analyse the links between the SDGs and climate action. In a different paper, Fuso Nerini et al. (2018) also analyse the synergies and trade-offs between energy and the SDGs. In both Fuso Nerini et al. (2018, 2019), the authors find that better coherence is necessary if we are to achieve the desired climate and energy goals without making compromise with other SDGs.

The intended climate actions are best reported as national determined contribution (NDC), based on the legally binding Paris Agreement that was signed in 2015 (United Nations Framework Convention on Climate Change 2015). Identifying the synergies between the NDC and the 2030 Agenda can be a motivating factor for countries to persevere in meeting their commitments (Dzebo et al. 2018). However, the literature that focuses on these interactions has been somewhat limited. Beyond Nerini’s paper (Fuso Nerini et al. 2019; Dal Maso et al. 2020; Antwi-Agyei et al. 2018) have done notable work in this area. In particular, Dal Maso et al. (2020) studies the contribution of mini-grids in Kenya to the SDG and NDC. Using a combined qualitative and quantitative analysis, it evaluates the synergies and trade-offs that minigrids might have and the extent to which they contribute to meeting the NDC. On the other hand, using iterative content analysis, Antwi-Agyei et al. (2018) explore the alignment between the NDC of eleven West African states and the SDGs.

This paper aims to contribute to the SDG Climate Action Nexus debate by proposing a method that facilitates the quantification of the links (synergies and trade-offs) between national climate actions and SDGs. The method, referred to as Q-SCAN, is based on Nilsson’s scale and is similar to the approach of Fuso Nerini et al. (2018), since it takes the nexus analysis down to the SDG target level. The biggest advantage of the method is the systematic process for the initial identification of the links. Hence, the contribution of this paper is twofold. Firstly, it offers a simple, yet effective method for identifying and quantifying the synergies and trade-offs between SDGs and climate actions. The effectiveness of the method has been demonstrated on the Electricity and Heat, Buildings and the Transport sectors of North Macedonia. Secondly, based on the experience of North Macedonia, the paper elaborates how the method can be used to contribute to the alignment of the national climate actions with the SDGs and how it can be used to improve stakeholder engagement.

## Methods

In this paper, the links between SDGs and national mitigation actions are considered to be either synergies or tradeoffs. The proposed method (Q-SCAN) for quantifying the strength of these links consists of three steps—identify,

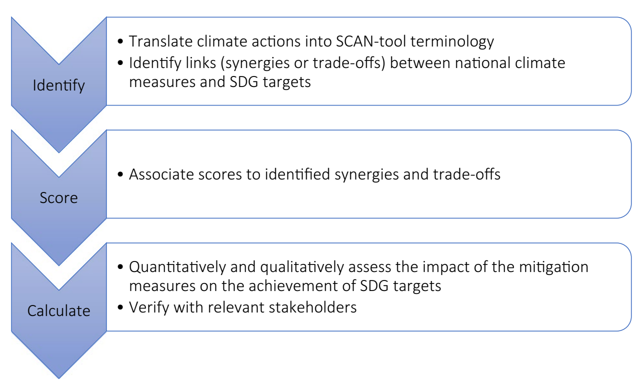



**Fig. 1** An illustration of Q-SCAN; the three steps are depicted on the left-hand side, while the required tasks for each step are given on the right-hand side

score and calculate. The three steps, as well as the required tasks within each step, are illustrated in Fig. 1. Firstly, the links between the national climate actions (policies and measures (PAMs)) and the individual SDG targets are identified using the SDG Climate Action Nexus tool (SCAN-tool) (Gonzales-Zuñiga et al. 2018). Then, the identified links are 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.

## Identifying the synergies and trade-offs

The synergies and trade-offs between the climate actions and the SDG targets are identified using the SCAN-tool. The SCAN-tool is a user-friendly and practical tool which offers a better understanding of how climate action can reinforce or hinder the achievement of SDG targets. There are separate versions of the SCAN-tool intended for mitigation and for adaptation. In this paper, only the SCAN-tool for mitigation is used.

It covers various actions across sectors related to activities that produce or reduce greenhouse gas (GHG) emissions. Those sectors include: (1) Electricity and Heat, (2) Transport, (3) Buildings, (4) Industry, (5) Waste, (6) Agriculture and (7) Forestry plus a sector with (8) General PAMs. Each mitigation action falls into one of three broad categories: (1) changing activity, (2) reducing emission intensity and (3) increasing energy efficiency. The General PAMs sector includes measures from the following categories: awareness, capacity, finance, pricing and innovation. For the Electricity and Heat sector, only the 'reduce emissions intensity' and 'energy efficiency' categories are relevant. On the other hand, all three categories are relevant for the Transport, Buildings, Industry and Waste sectors. The Agriculture sector consists of measures in the 'changing activity' and 'reduce emissions intensity' categories, while in the Forestry sector, only the 'changing activity' category is relevant. For each sector, a category contains one or more mitigation actions that are specific to that sector.

On the SDGs side, a total 15 SDGs are considered. Potential links to SDG 13 (Climate action) are not listed, as these links are implicitly represented in the assessed sectoral mitigation actions. Links to SDG 17 (Partnerships for the goals) are not included because this goal is about mobilization of international resources to achieve the SDGs and is not a development area comparable to the other SDGs. Figure 2 offers a visual depiction of the links between the various sectors and the SDGs that can be found in the SCAN-tool.

The practical application of the SCAN-tool starts with a translation of the national climate actions into the mitigation actions defined in the SCAN-tool. This is achieved by synchronizing the nomenclature of the national climate actions

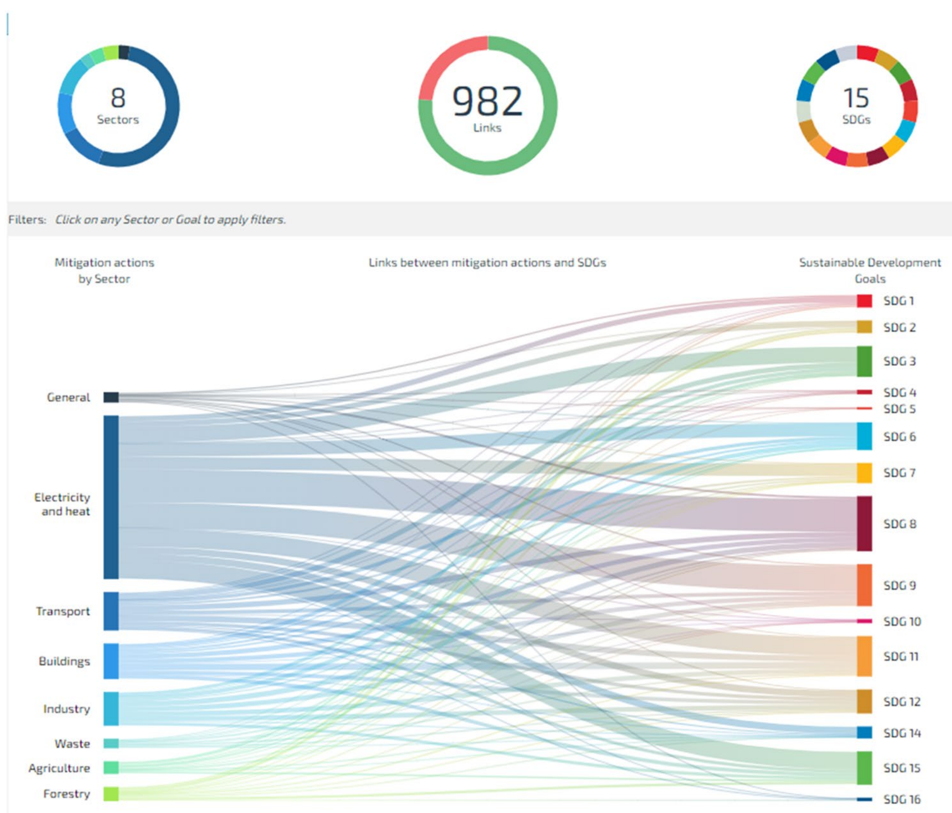



**Fig. 2** A visual preview web-based version of the SCAN-tool (Gonzales-Zuñiga et al. 2018)

with the terminology, i.e. mitigation actions, in the SCAN-tool. After this step, the links between the national climate actions and the SDG targets are identified by searching in a pool of 982 potential links, out of which 751 are potential synergies.

## Scoring the identified synergies and trade-offs

After the links between the climate actions and the SDG targets are established, they can be scored using a seven-step scale. In this paper, the scale introduced by Nilsson et al. (2016) has been used. More specifically, the scale is used to quantify the impact of a mitigation measure on the achievement of an SDG target. This is somewhat different to the approach in Nilsson et al. (2016) where the synergies and trade-offs are analysed between SDGs, and not between mitigation measures and SDGs, as is the case here. As shown in Fig. 3, the scale distinguishes positive links (synergies) and negative links (trade-offs), raking the strongest synergies with + 3 and the strongest trade-offs with − 3. Adequate scores are associated with each identified link. Whenever an SDG target that is not relevant to the national circumstances was encountered in the analysis or whenever a mitigation measure did not affect an SDG target, 0 score was given.

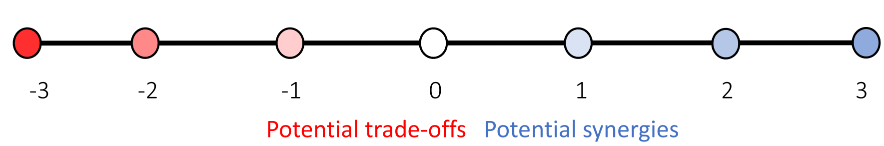
These scores quantify the *relationship* that a certain climate action has with the realization of an SDG target. According to Nilsson's scale, this relationship may be indivisible, reinforcing, enabling, consistent, constraining, counteracting or cancelling. In that sense, the applied scale quantifies the *contribution* of each climate action to the achievement of an SDG target. This is different than the specific set of indicators defined by the UN SDG framework for each SDG target, which measure the *progress in the achievement* of the target as a whole. While these indicators are very useful for giving a holistic progress check for realization of an SDG target, they were not found directly relevant for the methodology in this paper, since our work focuses on quantifying the individual contributions of different actions to the SDG targets.

## Calculating the integral score for each SDG

A formal mathematical notation can be introduced based on the discussion provided above. define The set of links is defined as $L_i = \{\ell(\mathrm{SDG}_i, a_1), \ell(\mathrm{SDG}_i, a_2), ..., \ell(\mathrm{SDG}_i, a_p)\}$, where $\ell(\mathrm{SDG}_i, a_j)$ represents the link between $\mathrm{SDG}_i$ and the climate action $a_j$. The set of all SDGs is denoted by $\mathrm{SDG} = \{\mathrm{SDG}_1, \mathrm{SDG}_2, \dots, \mathrm{SDG}_{17}\}$, while set of all the climate mitigation actions is denoted by $A = \{a_1, a_2, \dots, a_p\}$. Considering the scale depicted in Fig. 3, a score is associated with each link. The score of the link $\ell(\mathrm{SDG}_i, a_1)$ is a value of the set $S$ which contains all possible scores, $S = \{-3, -2, -1, 0, 1, 2, 3\}$, in line with the methodology of Nilsson et al. (2016). For each SDG, two integral scores are calculated—one integral score for the synergies and one integral score for the trade-offs.

**Fig. 3** A visual representation of the applied scale, adapted from Nilsson et al. (2016)

| Score | Name | Meaning |
|---|---|---|
| +3 | Indivisible | Inextricably linked to achievement of an SDG target |
| +2 | Reinforcing | Aids the achievement of an SDG target |
| +1 | Enabling | Creates condition that further an SDG target |
| 0 | Consistent | Neutral interaction, or non-relevant link |
| -1 | Constraining | Limits option on an SDG target |
| -2 | Counteracting | Clashes with an SDG target |
| -3 | Cancelling | Makes it impossible to reach an SDG target |



The integral score of an SDG for the synergies, denoted $\mathrm{IS}_{\mathrm{synergies}}$ is calculated using the following equation:

$$\mathrm{IS}_{\mathrm{synergies}} = 1 \cdot N_{\mathrm{enabling}} + 2 \cdot N_{\mathrm{reinforcing}} + 3 \cdot N_{\mathrm{indivisible}}$$

where $N_{\mathrm{enabling}}$ is the number of links that are given a score of 1, $N_{\mathrm{reinforcing}}$ represents the number of links that have been given a score of 2, while $N_{\mathrm{indivisible}}$ represents the number of links that have been given a score of 3. Similarly, the integral score for the trade-offs can be calculated as:

$$\mathrm{IS}_{\mathrm{trade\text{-}offs}} = (-1) \cdot N_{\mathrm{constraining}} + (-2) \cdot N_{\mathrm{counteracting}} + (-3) \cdot N_{\mathrm{cancelling}}$$

where $N_{\mathrm{constraining}}$, $N_{\mathrm{counteracting}}$ and $N_{\mathrm{cancelling}}$ are the number of links connected to $\mathrm{SDG}_i$ that have been given a score of $-1$, $-2$ and $-3$, respectively.

In the simplified example shown in Fig. 4, there are nine links in total, one with each of the five climate actions. Out of the synergy-related links, there are 2 indivisible, 2 reinforcing and 1 enabling links. This leads to an integral score of the synergies equal to $\mathrm{IS}_{\mathrm{synergies}} = 11$. On the other hand, within the trade-off-related links, there are 1 cancelling, 2 counteracting and 1 constraining, which results in an integral score of $\mathrm{IS}_{\mathrm{trade\text{-}offs}} = -8$. The integral scores offer a quantitative and qualitative assessment of the cumulative impact that the national climate actions have on the achievement of the SDGs. The quantitative assessment is made through the values of the integral scores, while the qualitative assessment comes from the differentiation among links with varying 'strengths'.

# Case study—the Macedonian enhanced NDC measures

## Economic, technical and strategic context

North Macedonia is a landlocked country located in the Western Balkan region, with a total population of 2.08 million citizens. In the past years, the country has made notable reforms to reinforce better macroeconomic policies, improve job opportunities and open up the economy so that it invites foreign investments. Currently, however, its economic growth is challenged by weak state institutions, low efficiency of local companies and a lack of suitable national framework conditions. In 2019, North Macedonia had a GDP/capita of 6022 USD and purchasing power parity (PPP) that is equal to 17,607 USD/capita (State Statistical Office of North Macedonia 2021). The primary energy consumption per capita in North Macedonia was only 40% of that in the EU. This is a result of the relatively low energy consumption at a national level, coming from the relatively high energy poverty. At the same time, the low national GDP coupled with limited industrial activity yields a primary energy consumption per GDP which is about 2.4 times greater than that of the EU average.

In power sector, 57% of the electricity generation and 42% of the installed capacity are covered by the largest national thermal power plant Bitola (REK Bitola), (capacity of 3 × 223 MW), making the country highly coal-intensive. While being the backbone of the power sector, REK Bitola is approaching its end of operation and, according to the Strategy for Energy Development of the Republic of North Macedonia, should be decommissioned by 2027 (Ministry of

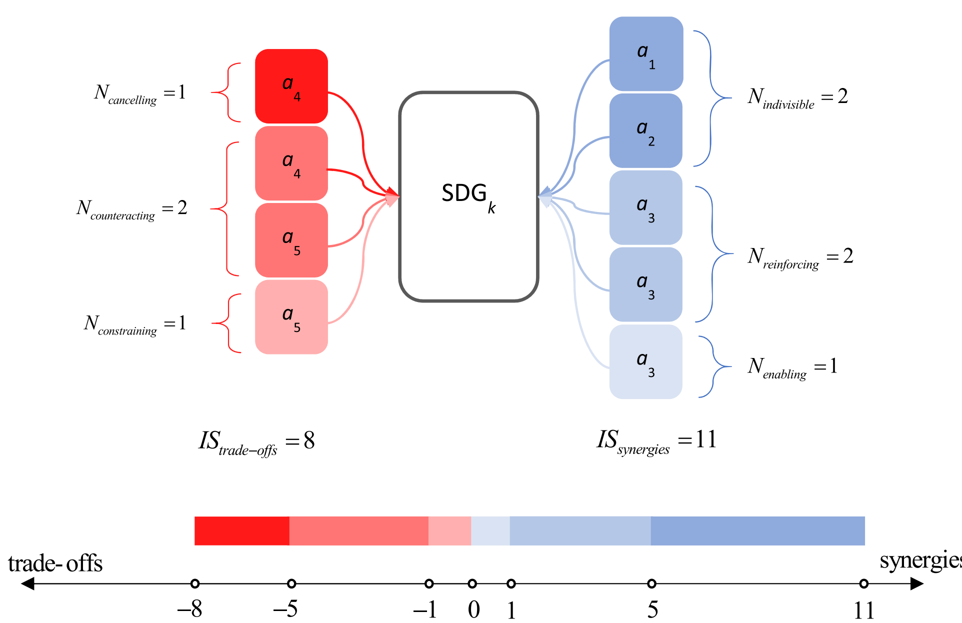



**Fig. 4** An illustrative example of the integral score calculation

Economy of the Republic of North Macedonia 2019). During the lifetime of REK Bitola, the electricity prices of end-consumers are expected to increase, as state subsidies and cross subsidies are eliminated (Miljević 2020). The decommissioning of the existing thermal power plants (REK Bitola and REK Oslomej) leaves national security of energy supply and the jobs of over 2500 employees that are working in the power plants at risk. Renewable energy sources represent around 25% of the energy in the power sector and 32% in the heating and cooling sector (Ministry of Economy of the Republic of North Macedonia 2020). The latter is mainly a result of the use of biomass for heating with individual wood stoves. The poor insulation reported in various national surveys (State Statistical Office of North Macedonia 2021) as well as the low energy consumption compared to EU averages indicates that the country deals with significant challenges related to energy poverty. With that in mind, many of the points in the SWOT analysis of the Macedonian energy system conducted in 2009 (Markovska et al. 2009) still hold true at the time of this writing.

As a non-Annex I party to the United Nations Framework Convention on Climate Change (UNFCCC), the country ratified Paris Agreement in November 2017, based on the initial nationally determined contribution to the global efforts for GHG emissions reduction (Government of North Macedonia 2015) and robust analyses conducted in Dedinec et al. (2016b, c). Since 2017, the country has transposed the third energy package of EU, moving towards a more enabling framework for achieving the SDG. In 2020, the country adopted a new Strategy for the Energy Development of Republic of North Macedonia until 2040 (Ministry of Economy of the Republic of North Macedonia 2019), setting ambitious goals, that were again reiterated in the National Energy and Climate Plan (NECP) (Ministry of Economy of the Republic of North Macedonia 2020). Moreover, an enhanced NDC was prepared against a backdrop of the country being a candidate for EU membership and becoming 30th member of the NATO Alliance.

## Analysis

The SDG Climate Action Nexus mapping exercise in Macedonian conditions was conducted with the mitigation actions from the enhanced NDC. The enhanced NDC is fully aligned with the NECP and has a total of 63 measures (Ministry of Economy of the Republic of North Macedonia 2020). Out of these measures, 26 are related to decarbonization, 25 measures focus on energy efficiency, 8 mitigation measures focus on the internal electricity market, while 4 measures deal with research and development (R&D) and competitiveness.

The links between a relevant subset of the 63 national climate actions (enhanced NDC) and 15 SDGs were identified using the SCAN-tool. To achieve this, the enhanced NDC was first translated into the terminology recognized by the SCAN-tool. Then, using the SCAN-tool, the synergies and trade-offs between the national measures and 15 SDGs were identified by selecting from a pool of 982 possible links and determining which links are relevant, and to what extent are they relevant on a national level.

The quantification method presented in Subsection 2.3 was applied for this purpose. The scores were determined using an expert judgement-based approach, which has been common in the literature (Cutter et al. 2015; Le Blanc 2015; Allen et al. 2019). To ensure that the judgement of the scores is justified, only the measures related to the Electricity and Heat sector, Buildings and Transport were chosen as these sectors are within the expertise of the authors. The validity of the chosen scores was later verified in a UNDP-organized workshop where the results were discussed and analysed with national stakeholders.

## Results

The results are given as graphs with qualitative and quantitative information on the synergies and trade-offs between the enhanced NDC (national mitigation measures) and the SDGs. Each sector (Electricity and Heat, Buildings, Transport) has been analysed separately, and the results are shown in Figs. 5, 6 and 7.

With regard to the Electricity and Heat sector, most emphasized are the synergies between the national climate measures and SDG 8 (Decent work and economic growth). This is a result of the new job opportunities related to the deployment of renewable energy and the improved economic efficiency per unit of product. The second most dominant are the synergies with SDG 9 (Industry, Innovation and Infrastructure), due to the enhancement of the existing energy infrastructure, as well as the development of new sustainable

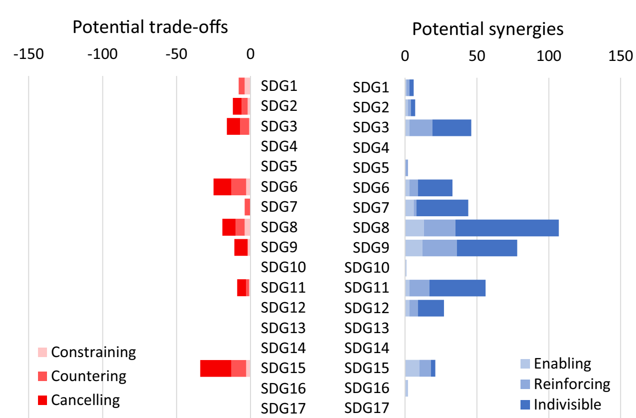



**Fig. 5** Synergies and trade-offs between the measures in the Electricity and Heat sector and the SDGs

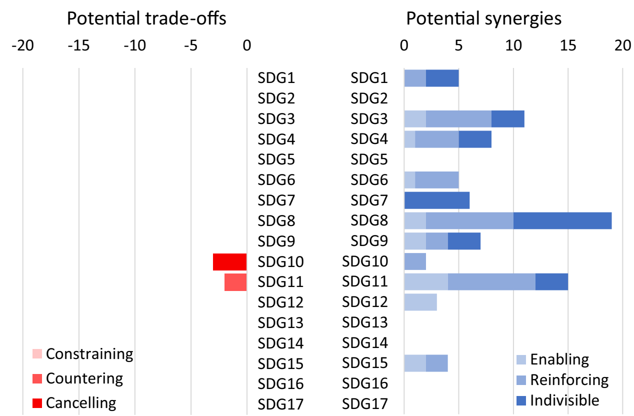



**Fig. 6** Synergies and trade-offs between the measures in Buildings sector and the SDGs

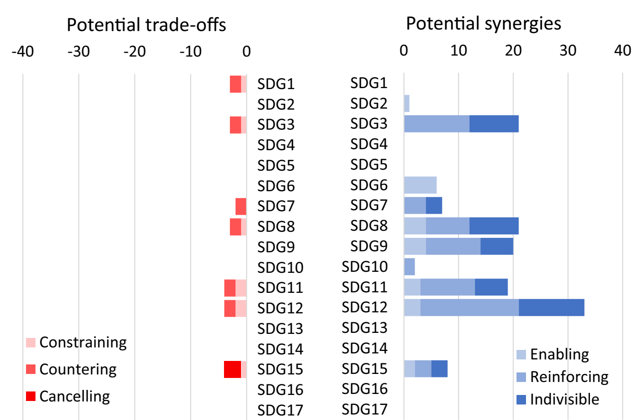



**Fig. 7** Synergies and trade-offs between the measures in Transport sector and the SDGs

infrastructure. To enhance the flexibility of the power sector and to improve energy security, a number of large hydropower plants are foreseen. In total, they should offer GHG reduction of about 740.7 Gg CO2-eq in 2030. However, renewable energy projects should be carefully planned to avoid unwanted negative impacts. Figure 5 also shows the synergies between actions in the Electricity and Heat sector and SDG 11 (Sustainable cities and communities). They arise from the measures for making local communities more self-sufficient and smart.

Potential trade-offs, on the other hand, are found with a total of 9 SDGs. Most notable are the potential trade-offs with SDG 15 (Life on land). They are related to increased land requirements for renewable energy projects, as well as potential forest degradation or river route changes. Furthermore, the analysis shows that there are potential trade-offs with SDG 6 (Clean water and sanitation). Increased water use for bioenergy crops and non-thermal water pollution due to cooling in power plant operation have been noted as reasons for these potential trade-offs. Avoiding job loss and ensuring a just energy transition are other key challenges worth noting, as seen by the potential trade-offs relevant to SDG 8 (Decent work and economic growth). To mitigate them, about 140 MW of solar PV generation has been envisaged in the enhanced NDC for coal-intensive regions, i.e. in the vicinity of REK Bitola and REK Oslomej (Ministry of Economy of the Republic of North Macedonia 2020).

As illustrated in Fig. 5, the synergies and trade-offs for some SDGs, such as SDG 6 (Clean water and sanitation) are well balanced. This comes as a combination of the national conditions and the climate mitigation actions proposed in the NDC. For example, replacing electricity generation of the coal power plants with renewable energy, such as solar PV of wind generation, contributes to reducing thermal and non-thermal water pollution. On the other hand, river route changes and dams built for small and large hydropower plants may affect the water scarcity of local communities, while the sediments created from the dams may interfere with the freshwater wildlife. As a result, there is a balance that needs to be considered so as to avoid the potential trade-offs outweighing the synergies.

With respect to the Buildings sector, Fig. 6 shows that the potential synergies notably outweigh the potential trade-offs. The measures in this sector include: increased use of central heating systems and heat pumps, phase-out of incandescent light bulbs, construction of new energy efficient or passive buildings, energy efficiency measures for public facilities and retrofitting of existing buildings. These measures should contribute to achieving (i) SDG 8 (Decent work and economic growth), as a result of new jobs in building construction and retrofit, (ii) SDG 11 (Sustainable cities and communities), due to improved energy autonomy and 'smartness' of communities, and (iii) SDG 3 (Good health and well-being), from the reduced air pollution and GHG emissions. On the contrary, the potential synergies in the Buildings sector could (i) increase the housing prices, thus making housing less affordable and (ii) increase the prices of some appliances (by restricting the use of cheaper, but energy inefficient solutions).

As shown in Fig. 7, the measures in the Transport sector highlight synergies with SDG 8 (Decent work and economic growth) as a result of the increased productivity per unit of economic output. Moreover, there are synergies with SDG 11 (Sustainable cities and communities) that are related to the foreseen modal shift in transport (from combustion engine cars towards public transport), as well as to the increased use of electric vehicles. The economic and environmental effectiveness of different mitigation actions for the Macedonian Transport sector have already been assessed in Dedinec et al. (2013). In a similar study, Dedinec et al. (2016a) show that electric vehicles in North Macedonia can offer storage capacity that can be used to balance high shares of renewables and contribute to the reduction of local air pollution. The latter point, in particular, is in line with the goal (SDG 3 (Good health and well-being)) for improving the health and well-being of citizens. The potential trade-offs in the Transport sector are related to (i) the risk of reduced security of supply (electrifying transport will increase the electricity demand in currently coal-intensive system), (ii) bad waste management and lack of battery recycling (the country is lacking a suitable waste management framework) and (iii) potential longer-term job losses in the petrol sector.

In Figs. 5, 6 and 7, the links with SDG 13 (Climate action) were not explicitly listed since all analysed measures are directed towards the achievement of SDG 13, while the links to SDG 17 (Partnerships for the goals) were omitted because this goal focuses on the mobilization of international resources to achieve the SDGs. Hence, it is not directly relevant to the analysis. Moreover, because North Macedonia is a landlocked country, there are no links to SDG 14 (Life below water), which considers the sustainability of ocean, seas and marine resources.

## Discussion

Our analysis highlights the relationship between national climate actions in North Macedonia and the challenges associated with the SDGs. Analysing the links between the climate actions (enhanced NDC) and the SDGs helps identify the strengths and weaknesses of national strategies and offer a holistic analysis of the issue (Pukšec et al. 2018).

### Q-SCAN—an open and participatory method

It was found that the proposed Q-SCAN method offers a simple and systematic approach for quantifying the synergies and trade-offs between the national climate actions, on the one hand, and the SDGs, on the other. Moreover, the method enables experts to effectively communicate the benefits and the shortcomings of the national policy agenda in the form of visual graphs. In its initial application in Macedonian conditions, the exercise was mainly conducted by the authors. At the other end, key stakeholders participated in a capacity building workshop in which the methodology was presented and the results were discussed and verified. Nevertheless, the methodology is simple enough to facilitate the participation and the wide engagement of various stakeholders. For example, sector experts, academia and key stakeholders can be invited to participate in the second step of the method, i.e. they can score the links (synergies and trade-offs) based on the scale presented in Fig. 3. Ultimately, this should provide a level playing field in which different actors can participate, but it should also improve awareness raising and contribute to the 'nobody left behind' principle. It is expected that this method will be used again for future strategic documents, where stakeholders will actively participate in the technical work as well, thus providing valuable input regarding the relevance and the level of importance of some links in the country specific conditions.

This participatory approach is highly relevant not only at a national level, but also for workshops organized by other stakeholders. For instance, the method can also be used by cities, businesses and other organizations in evaluating their energy-related commitments. While this was not common in the past, the UN recently proposed the use of 'Energy Compacts'—a new platform that allows different stakeholder to report their voluntary commitments and contributions in the achievement of SDG 7. Q-SCAN can be found suitable for this purpose, since it is aligned with three of the five principles based on which the Energy Compacts are developed—(i) Alignment with the 2030 Agenda for Sustainable Development Goals, (ii) Alignment with Paris Agreement and net zero by 2050 and (iii) Leaving no on behind, strengthening inclusion, interlinkages and synergies). With that in mind, Q-SCAN can help ensure the alignment with SDGs, ensure the alignment with the NDC and help enable the achievement of the SDGs while having a just transition.

### NDC enhancement

In the Macedonian case study, enhanced NDC has been developed so as to further progress the NDC reported in 2015. The main components of the NDC enhancement can be seen in the following areas: (i) mitigation ambition, (ii) implementation and (iii) communication.

This work has contributed to the enhancements of the implementation and communication aspects. In terms of implementation, the most relevant direct and indirect links between the measures and the SDGs were identified based on this work. Hence, each measure of the enhanced NDC has been related to an SDG to which it directly or indirectly contributes. Furthermore, the work presented in the paper enables a step forward to be made in the communication of the enhanced NDC. This is achieved by analysing the SDG Climate Action Nexus so as to quantify the links between climate actions and the SDG targets. Despite being a non-Annex I country, these efforts have moved the strategic reporting of North Macedonia much closer to best practices reported in the literature (Fuso Nerini et al. 2019), such as those in Canada (Government of Canada 2019), Sweden (Government Offices of Sweden 2019), South Korea (The Government of the Republic of Korea 2016) and Indonesia (Bastos Lima et al. 2017). As noted in Fuso Nerini et al. (2019), the existing best practices (The Government of the Republic of Korea 2016; Bastos Lima et al. 2017; Government of Canada 2019; Government Offices of Sweden 2019) address the links with the SDG holistically, without identifying the synergies and trade-offs among SDG targets. The method presented here, on the other hand, offers a robust framework that can be used to quantify the links at the level of individual targets. This method can easily be incorporated in national revisions of the NDC or other strategic documents, thus adding value to the quality of the reporting.

### The big picture

The integral scores show that the total synergies of the analysed sectors are about four times the value of the potential trade-offs  (Fig. 8). The strongest synergies remain with SDG 8 (Decent work and economic growth). In the case of North Macedonia, the high unemployment has been a burning issue for the past few decades (unemployment rate was 30.2% in 2006 and 16.1% in 2020) (State Statistical Office of North Macedonia 2021). Capitalizing on the job opportunities in renewable energy deployment and in the construction and retrofit market, could accelerate the country's motiontowards the achievement of SDG 8 (Decent work and economic growth). This may further improve by introducing new infrastructure and innovation (SDG 9). Past analysis of the Macedonian energy system have highlighted the importance of diversifying the generation fleet (Taseska-Gjorgievska et al. 2014) and the implementation of renewable energy sources (Dedinec et al. 2012) for the reduction of greenhouse gas emissions (Ćosić et al. 2011). However, North Macedonia has been lagging behind the countries in the region in terms of investments in research and development (R&D). The gross domestic expenditure on R&D as a percentage of GDP in North Macedonia in 2018 was only 0.37%, while that of Croatia, Bulgaria, Serbia and Montenegro are 0.97%, 0.76%, 0.92 and 0.50%, respectively (Eurostat 2021). Also, increasing the percentage of the active population that works in research (currently only 0.28%) could accelerate the development of innovative solutions related to electricity, heat, buildings and transport. Together with an enabling framework, R&D could spearhead the development of knowledge-intensive services, such as Energy Service Companies (ESCOs), aggregators or electric vehicle service providers.

There is a significant trade-off with the SDG 15 (Life on land) which has to be considered. This trade-off come from the land requirements from renewable energy projects (van Zalk and Behrens 2018), potential forest degradation and potential river routes changes. For example, in 2015 the Bern Convention's decision-making body urged the Macedonian government to stop the development of the *Boshkov most* hydropower plant, since it could additionally endanger the Balkan Lynx (Bankwatch network 2017). Clearly, the development plans of *Boshkov most* were a result of a fragmented and incoherent decision-making framework, since they did not account for the potential trade-offs of the project. As a result, they induced unwanted setbacks in the implementation of national climate policies and prolonged the reaching of the national climate targets. They can be avoided, however, if future policies and measures align biosphere restoration and climate action. Also, there are important trade-offs with SDG 3 (Good health and well-being), SDG 6 (Clean water and sanitation) and SDG 8 (Decent work and economic growth) to take into account. For instance, unsatisfactory infrastructure could lead to increasing the number of accidents associated with new modes of travel (e.g. walking, cycling) (SDG 3 (Good health and well-being)) (de Hartog et al. 2010), increased biomass cultivation for energy could result in fertilizer run-offs and increased water use (SDG 6 (Clean water and sanitation)) (Mulligan et al. 2020), while the deployment of renewable energy to displace the conventional coal fleet could introduce job loss if a just transition is not in place (SDG 8 (Decent work and economic growth)) (McCauley and Heffron 2018).

## Conclusions for a coherent policy framework

Policy makers are faced with numerous dilemmas when weighing the socio-economic costs and benefits of climate action. This paper proposes a simple method that enables them to quantify the synergies and trade-offs between national climate actions and SDGs. The effectiveness of the proposed method was illustrated on a case study of North Macedonia, a non-Annex I, Western Balkan country with a coal-intensive energy system. Drawing from the experience in the preparation of the country's enhanced NDC, the paper shows that method can be used to contribute to the alignment of the enhanced NDC and SDGs. Moreover, it discusses how it can be used to improve stakeholder engagement. This is a very useful feature, having in mind the challenges that await municipalities, businesses

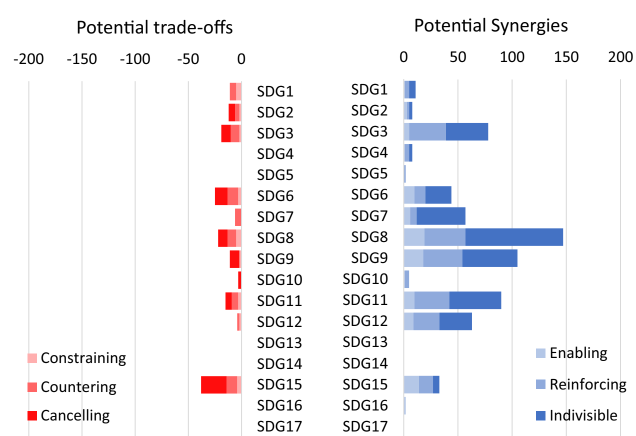



**Fig. 8** Synergies and trade-offs between the measures in the three sectors and the SDGs

and other organizations when developing and reporting their voluntary commitments in the form of Energy Compacts.

The analysis shows that for the mitigation actions of the selected sectors, the potential synergies notably outweigh the potential barriers. The strongest synergies outweigh the trade-offs by a factor of three. At the same time, the total synergies outweighed the total trade-offs in these sectors by about factor of four. However, the findings also reveal that as a result of the potential trade-offs, there are 'hidden' conflicts that can occur between the climate actions and other national policy goals. These potential trade-offs may impair the implementation of climate action, since they incentivize policy makers to focus on short-sighted, as opposed to long-term goals. This effect is additionally exacerbated by national strategic inconsistencies (e.g. there have been four parliamentary elections in the period 2011–2020 in North Macedonia). The analysis conducted in this paper should therefore serve as a blueprint that reinforces the NDC. Regardless of short-term conditions, it should offer to the policy makers a clear guidance and outlook of the existing and future challenges.

**Author's contribution** VZG was involved in investigation, methodology, formal analysis and writing the original draft; EM took part in investigation, writing, reviewing and editing; AA had contributed to conceptualization, supervision, writing, reviewing and editing; and NM performed methodology, conceptualization, supervision, writing the original draft, writing, reviewing and editing.

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**Availability of data and materials** Please refer to the SCAN-tool (Gonzales-Zuñiga et al. 2018) and the National Energy and Climate Plan of North Macedonia (Ministry of Economy of the Republic of North Macedonia 2020).

**Code availability** The Excel-based version of the SCAN-tool (Gonzales-Zuñiga et al. 2018) has been used (https://ambitiontoaction.net/scan_tool/).

**Declaration**

**Conflict of interest** The authors declare no conflict of interests or competing interests.

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