



Mapping interactions between sustainable development and heatwave resilience

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Abstract

Urgent action is needed to ensure the achievement of the sustainable development goals (SDGs) by 2030. Under climate change the intensity and frequency of heatwaves are projected to increase and urgent action is also needed to improve heatwave resilience now and in the future. Yet, it remains unclear how countries are planning and implementing policies and actions for this to happen. Interactions between the SDGs have been widely researched. However, little is known about the interactions between the SDGs and heatwave resilience. In response, this study focuses on mapping such interactions. This mixed methods study design with a diverse group of stakeholders from different sectors of society identified key interactions, sources of interactions and solutions for achieving both agendas. The analysis revealed that: (i) synergies largely outweigh trade-offs; (ii) a broad compatibility exists between the two agendas; (iii) no fundamental incompatibilities were found, and; (iv) the two agendas are not being consistently aligned. These findings are essential for parallel and effective achievement of both agendas and to enhance synergies and reduce trade-offs. A series of solutions were identified which can be implemented. Such integrated approaches would enhance success and overall performance by improving collaborations, using common language, regulation and planning, pooling resources, skills, inclusive information and translation to practice.

Keywords Sustainable development · Sustainable development goals · Interactions · Climate change · Resilience · Heatwaves

1 Introduction

Due to climate change, extreme weather events such as heatwaves are expected to increase in frequency, intensity and duration (IPCC, 2022). These increases have and will continue to decrease human health and well-being, and reduce food and water security, among others hindering the achievement of the United Nations 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) (IPCC, 2022).

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Heatwaves affect all individuals everywhere but disproportionately affect some more than others due to underlying sources of vulnerability (Costello et al., 2009; Watts et al., 2015; WHO, 2008, 2019). The most vulnerable populations in society can include the young, old, poor, frail and Indigenous People (IPCC, 2022; Watts et al., 2018; WHO, 2013). Heatwaves can cause serious impacts on human health and well-being both in terms of morbidity and mortality (Costello et al., 2009; Smith et al., 2014; Watts et al., 2017; Watts, et al., 2019) and can be either direct due to physical harm (e.g. heatstroke, injuries) or indirect (e.g. mental illness, access to electricity or services) (Smith et al., 2014; Watts et al., 2015, 2019; Whitmee et al., 2015). Heatwaves also affect the vulnerability and resilience of human systems such as urban, agricultural, technological, political and economic systems (IPCC, 2022). Heatwaves are and will continue to damage the health of vulnerable populations, as they are less able to respond and adapt to, as well as improve their resilience, with potential increases in existing inequalities (Munro et al., 2020; Nunes, 2018, 2019, 2020, 2021; WHO, 2015). Health, social and economic inequalities increase the exposure, susceptibility to impacts, and reduce the ability vulnerable individuals and communities to cope and recover from impacts of climate change (Nunes, 2018, 2019; UN, 2017).

Calls for connecting sustainable development and climate change have been raised but not much has been done as yet (Fuso Nerini et al., 2018, 2019; Zhenmin & Espinosa, 2019). Sustainable development and climate action (Fuso Nerini et al., 2019; Zhenmin & Espinosa, 2019), including heatwave resilience, are intricately connected and are interdependent. As a result, improving heatwave resilience, as well as achieving sustainable development are being suggested as a way forward to minimise the impacts caused by heatwaves on the health and well-being of vulnerable populations and human systems (Beccari, 2016; Fuso Nerini et al., 2019; Zhenmin & Espinosa, 2019). Additionally, there needs to be an acknowledgement and detailed understanding of the complex web of interactions to foster positive planning and action. In this regard, this article is responding to this need and explores how these agendas are being addressed and how diverse stakeholders from different sectors of society perceive the interactions between achieving sustainable development and improving heatwave resilience from a vulnerable populations and human systems perspective, how these agendas can be aligned to avoid silos and ensure that duplication of efforts and trade-offs are avoided (Nilsson et al., 2016; Nunes et al., 2016).

The theoretical framework used in this research paper is based on principles from a resilience of human systems approach and a sustainable development approach. These two theoretical threads create the foundation of a multifaceted, holistic framework for sustainable development and resilience of human systems. This theoretical framework is based on the resilience of human systems and sustainable development concepts.

1.1 The UN 2030 agenda and the SDGs

The UN 2030 Agenda for Sustainable Development was adopted at the UN Sustainable Development Summit in 2015 by 193 UN member states, which have committed to implementing and delivering the 17 SDGs (see Fig. 1) and its 169 targets by 2030 (UN, 2015). The SDGs expand on and are the successors of the Millennium Development Goals (MDGs) (Sachs, 2012). They aim to focus on a variety of interconnected challenges that both developing and developed countries are facing. These include poverty, inequality, health and well-being, climate change, education, among others (UN, 2015). For many the SDGs constitute the opportunity that was missing for different sectors of society to work



Fig. 1 The 17 Sustainable Development Goals *Source* UN, 2015

together for a greater good (Osborn et al., 2015; WHO, 2015), whilst for others this agenda is considered to be too diverse and difficult to achieve (Davis et al., 2015; Le Blanc, 2015; Yamey et al., 2014). The SDGs are considered to be indivisible (Scharlemann et al., 2020) but their implementation and achievement depends on synergies and trade-offs (Kroll et al., 2019; Pradhan et al., 2017). Understanding synergies and trade-offs between individual SDGs has been the focus of interest and research (Allen et al., 2019; Bennich et al., 2020; Breuer et al., 2019; Cernev & Fenner, 2020; Collste et al., 2017; Forestier & Kim, 2020; Fu et al., 2019; Le Blanc, 2015; Liu et al., 2018; Nilsson et al., 2018; Scharlemann et al., 2020; Scherer et al., 2018; Van Soest et al., 2019; Weitz et al., 2014, 2018).

Achieving the SDGs will largely depend on the ability of countries to maximise synergies and minimize trade-offs (Alcamo et al., 2020; Kroll et al., 2019). Additionally, each member state/country and all sectors of society are being called to help support the achievement of such agenda (UN, 2015). Despite this, and with less than 10 years left much is still left to do in order to successfully achieve this agenda. One of such options is to align the achievement of the SDGs with improving heatwave resilience as they may have similar roots and causes (see Sect. 1.4). In doing this, stakeholders from different sectors of society within a country could join their efforts and work towards these two ambitions without undermining the achievement of any and pulling together resources (i.e. time, money).

1.2 Heatwave risks and impacts

According to the IPCC, in all regions of the globe heatwaves have resulted in human mortality and morbidity (IPCC, 2022). Additionally, heatwaves and the risks of extreme heat have intensified in cities and urban areas due to the Urban Heat Island (UHI) effect. With the increased risk of more frequent, intense and prolonged heatwaves and not enough effective responses and adaptation, heat-related morbidity and mortality are likely to increase at the global scale (IPCC, 2022). It is known that substantial proportions of current and future heat-related illnesses and deaths are preventable and what is really needed is to develop and implement policies and actions to minimise morbidity and mortality (Nunes, 2018, 2019). Commonly, deaths from cardiovascular and respiratory diseases are those reported

as underlying cause of death during heatwaves. But the link between deaths during or immediately after a heatwave due to exposure to heat is difficult to establish and mortality attributed to extreme heat are most certainly underestimated. Therefore, heatwaves are called ‘silent killers’ (UKHSA, 2022).

The biggest unknown is how to develop and implement heatwave planning that allows individuals and populations to better prepare for the present and intensifying threat that extreme heat poses to health and wellbeing in order to reduce adverse health effects of extreme heat. Heatwave planning is thus critical and should encompass heat resilience and increased capacity to adapt to extreme heat. Effective heatwave planning will need to involve all sectors of society and not just health, and involve different stakeholders (local and national government, academia, third sector, industry) and focus on those that are most vulnerable to the effects of heat due to social, biological/physical, financial and place-based vulnerabilities in order for it to be equitable and inclusive, and able to reduce the health effects of extreme heat (Nunes, 2018, 2019). In many countries around the world heatwave plans have been developed to protect populations against the threat extreme heat poses by issuing alerts and providing advice and guidance on how to minimise the negative effects of heat. England in the United Kingdom (UK) is one of such examples (UKSHA, 2022).

As a result, heatwaves are a great hazard to consider in the context of sustainable development because we know that the physical environment and development patterns can ameliorate or exacerbate exposure to heat. Additionally, the SDGs may be relevant to heatwave resilience when considering urban versus rural differences for example. Building on this foundation of what is known about heatwave risks, impacts as well as planning will go a long way in helping understand potential synergies and trade-offs between the SDGs and heatwave resilience.

1.3 Heatwave resilience

This article uses the Intergovernmental Panel on Climate Change (IPCC) definition of resilience: “the capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation.” (IPCC, 2022, Annex II, pages 37–38).

Resilience is modified by the occurrence of heatwaves (IPCC, 2012). Improving heatwave resilience is thus a solution to minimize the impacts of heatwaves (IPCC, 2012, 2018). Heatwaves can impact not only on health but also on infrastructure for example (i.e. transport, energy supply, water supply) and span all sectors of society (Howarth et al., 2019). Despite this, frequently such impacts are defined as being confined to health alone and dealt with separately using a siloed approach (Brimicombe et al., 2021; Howarth et al., 2019; Public Health England, 2021). A lot is already known about the factors and processes that contribute to heatwave resilience (Nunes, 2020; Hatvani-Kovacs et al., 2018; Royal Society, 2014). Access and availability of assets have been identified as sources of heatwave resilience and these can range from human assets (e.g. information), physical assets (e.g. quality housing), financial (e.g. income), place-based assets (e.g. amenities, services) and social assets (networks and contacts) (Nunes, 2018).

Furthermore, links have also been found between heatwave resilience and the United Nations (UN) 2030 Agenda for Sustainable Development and its 17 Sustainable

Development Goals (SDGs) which can help achieve both agendas using similar approaches (Nunes, 2018, 2020, 2021; IPCC, 2018).

1.4 Supporting the achievement of the SDGs and heatwave resilience

Climate change is a threat to both sustainable development and heatwave resilience (IPCC, 2018). Within the 2030 Agenda, SDG 13 is the one that directly focuses on climate action and aims at taking urgent action to tackle climate change and its impacts (UN, 2015). In doing so, it specifically addressed the need to improve resilience and adaptation to natural hazards and events such as heatwaves. Despite this, many other SDGs also contribute to this aim, such as SDG 9 (industry, innovation and infrastructure), SDG 12 (responsible consumption and production). As a result, many authors have called for integrated approaches to achieve different SDGs simultaneously and at the same time consider synergies and trade-offs (Allen et al., 2019; Bennich et al., 2020; Breuer et al., 2019; Cernev & Fenner, 2020; Collste et al., 2017; Forestier & Kim, 2020; Fu et al., 2019; Le Blanc, 2015; Liu et al., 2018; Nilsson et al., 2018; Scharlemann et al., 2020; Scherer et al., 2018; Van Soest et al., 2019; Weitz et al., 2014, 2018) when doing so. For instance, through integration of climate change action into multisectoral and multilevel policies, planning and actions can be reinforced by ensuring quality education (SDG 4), gender equality (SDG5) and reduced inequalities (SDG10) (Beccari, 2016; Fuso Nerini et al., 2018; Nunes et al., 2016) for better heatwave resilience (UN, 2015).

Strengthening heatwave resilience is considered to be consistent and coherent with achieving sustainable development (IPCC, 2014, 2018). Furthermore, according to the IPCC (2018), more needs to be done to identify synergies and trade-offs between these two agendas, as well as the development of a joint strategy that simultaneously supports the achievement of the SDGs and heatwave resilience to improve outcomes and avoid trade-offs (IPCC, 2018). As a result, it is thought that aligning both agendas should be prioritised as they have common themes, scopes and purposes (IPCC, 2018). Despite this, little or no attention has been given to the interactions between achieving the SDGs and improving heatwave resilience. Heat response is still not a primary concern among local government and organizations despite the Heatwave Plan for England (UKHSA, 2022) with most attention arising when a heatwave alert is declared. Furthermore, the SDGs are largely missing from the discussion.

This study helps fill this critical gap and improve our understanding of how these two agendas can be aligned. This article thus, focuses on addressing this need and highlights how different stakeholders in different sectors of society have been, are and may be aligning the SDGs and heatwave resilience to improve synergies and reduce trade-offs, and how to achieve both agendas.

The article starts by mapping interactions between achieving the SDGs and improving heatwave resilience, exploring the sources of interactions between them (i.e. synergies and trade-offs) and analysing major interaction themes between achieving the SDGs and improving heatwave resilience. This will be done through a mixed method (i.e. combined quantitative and qualitative) approach based on expert stakeholders' judgment (Griggs et al., 2017). The article uses Nilsson and colleagues' (2016) seven-point scale, as it attributes scores to the different potential interactions, differentiating between three degrees of positive interactions or synergies (indivisible = +3, reinforcing = +2, and enabling = +1), neutral (consistent = 0), and three degrees of negative interactions or trade-offs (constraining = -1, counteracting = -2, and cancelling = -3). The systemic and contextual

interactions can be summarized with this simple scale (Nilsson et al, 2016; Weitz et al., 2018). Synergies can be defined as situations in which achievements on one goal contribute towards progress in improving heatwave resilience. On the other hand, trade-offs can be defined as situations in which progress achieved on one goal will produce effects detrimental to improving heatwave resilience.

2 Methods

A mixed methods study with semi-structured interviews with a mapping exercise using a scale to score interactions between achieving the SDGs and improving heatwave resilience (Table 1) were used.

2.1 Recruitment and participants

This study recruited participants to represent four perspectives: government, private sector, civil society and academia. Inclusion criteria were applied to recruitment (Box 1).

A list of potential participants was generated by two sampling techniques. A purposive sampling and ‘snowballing’ technique (Patton, 2002) were used to recruit a diverse group of stakeholders from government, private sector, civil society and academia. First, publicly available information on websites and email addresses were used to identify potential interviewees employed by government, private sector, civil society or academia and holding a position relevant to sustainable development and heatwave resilience (See Box 1). Second, a snowballing strategy was used whereupon the initially contacted interviewees were able to suggest additional interviewees to be approached (Bryman, 2012). These were identified to participate in the interviews and recruited via formal invitations, to collectively provide a diverse range of perspectives, considerations, experiences and perspectives on the achievement of the SDGs and heatwave resilience. Interviewees were identified based on their experience and knowledge of the context of sustainable development and heatwave resilience policy and practice, their diversity of perspectives in relation to their: role, working sector (government, industry, academia or civil society), organization and disciplinary specialism’s (natural sciences, social sciences, humanities or health perspectives).

In total twenty-six interviewees were recruited from a variety of professional profiles and working areas (Tables 2 and 3). Participants came from national and local government ($n=9$), academia ($n=8$) and civil society ($n=6$), with the private sector being less

Table 1 Scale to score interactions between achieving the SDGs and improving heatwave resilience

| Score | Interaction | Explanation |
|-------|--------------------|---|
| +3 | Indivisible | Inextricably linked to improving heatwave resilience |
| +2 | Reinforcing | Aids improving heatwave resilience |
| +1 | Enabling | Creates conditions that further improving heatwave resilience |
| 0 | Consistent/neutral | No significant positive or negative interaction |
| -1 | Constraining | Limits options on improving heatwave resilience |
| -2 | Counteracting | Clashes with improving heatwave resilience |
| -3 | Cancelling | Makes it impossible to reach improving heatwave resilience |

Adapted from Nilsson et al. 2016

Box 1 Participant eligibility criteria*Inclusion criteria*

Working in England

Able to provide informed consent

Meets one of the following group inclusion criteria:

1. *Government*: Individuals employed by non-ministerial departments and executive agencies, and local councils, and holding a position concerning policy development in sustainable development and heatwave resilience;
2. *Private sector*: Individuals employed by business and industry, and holding a position relevant to sustainable development and heatwave resilience;
3. *Civil society*: Individuals employed by civil society organisations and non-governmental organisations, and holding a position relevant to sustainable development and heatwave resilience;
4. *Academia*: Individuals employed by a Higher Education Institution, research institute, and holding a position concerning research in sustainable development and heatwave resilience

Exclusion criteria

Individuals not working in England

Individuals unable to provide informed consent

Individuals not employed by government, private sector, civil society or academia

Individuals not holding a position concerning sustainable development and heatwave resilience

Table 2 Professional profile of participants

| | Number |
|---------------------------------------|--------|
| National (NG) & local government (LG) | 9 |
| Private sector (PS) | 3 |
| Civil society (CS) | 6 |
| Academia (A) | 8 |
| Total | 26 |

Table 3 Working areas of participants

| | Number |
|--|--------|
| Health and Social Care (including public health, social work) (HS) | 9 |
| Social Science (including economics, geography, sociology, social policy, politics and international studies) (SS) | 8 |
| Technology (including environment and engineering) (T) | 2 |
| Science (including earth and environmental sciences, life sciences, sustainability) (S) | 7 |
| Total | 26 |

represented ($n=3$) (Table 2). Health and social care was the most popular working area ($n=9$), followed by social science ($n=8$) and science ($n=7$), while technology was the least represented ($n=2$). All participants work in England and are distributed throughout the country (e.g. North, South, East and West, urban and rural areas). Some professional profiles and working areas are more represented than others which is a limitation, but the study aimed not to provide an overview of professional profiles and working areas but to

compare participants perspectives, knowledge and experiences of sustainable development and heatwave resilience. Quotes from interviews are referenced in the text via codes; each interviewee has a code: for example NG1, T means first interviewee from National Government working in Technology.

The principal investigator is an environmental social scientist and public health specialist with extensive working experience on heatwave resilience and mixed methods. The principal investigator contacted all participants via email and conducted all the interviews. Prior to conducting the interviews, participants were given information detailing the aims of the study, together with information on the 2030 Agenda for Sustainable Development and the 17 SDGs, as well as the scale to score interactions between achieving the SDGs and heatwave resilience options to be assessed (Table 1).

2.2 The interviews

Twenty-six one-to-one telephone semi-structured interviews with key stakeholders were undertaken. The interview guide was informed by a review of the literature on the subject and participants were asked a series of open-ended questions on the interactions between achieving the SDGs and improving heatwave resilience and asked to score the interactions between achieving the SDGs and improving heatwave resilience using Table 1. Interviews lasted between 20 and 60 min. The study was granted ethical approval by the University of Warwick Ethical Committee. Prior to consent, all the participants were informed that participation was voluntary, and that confidentiality would be maintained in publications. Written consent was obtained from all participants after written and verbal presentation of the study's objectives and the procedures for managing the interview data. All interviews were conducted in English. Interviews were audio-recorded and verbatim transcribed prior to thematic analysis (Braun & Clarke, 2006). The study took place in England with stakeholders from national and local government, private sector, civil society and academia.

Participants' information, audio recordings and transcriptions were stored in the principal investigator's personal password-protected computer, in accordance with the procedures described in the approved ethics application.

2.3 Data analysis

The mapping of interactions between achieving the SDGs and improving heatwave resilience was performed by developing an impact matrix and each interaction was given a score for each participant against a guiding question: "*If progress is made on SDGs (1 to 17) how does this influence progress on heatwave resilience and why?*". Participants were asked to consider and discuss the interactions between the SDGs from a human systems perspective and heatwave resilience. Participants were asked to discuss these themes generally in relation to each of the SDGs (1 to 17) and to use both their personal and professional perspectives, knowledge and experiences.

The scoring implemented uses a consistent system, agreed with the participants. This scale to score interactions between achieving the SDGs and improving heatwave resilience (Table 1) uses a seven-point scale, with +3 for the most positive interactions (i.e. synergies) and -3 for the most negative interactions (i.e. trade-offs). Two systems that have been used successfully with the SDG Synergies Approach are those proposed by Weimer-Jehle (2006), which goes from "strongly promoting" to "strongly restricting", and by Griggs

et al., 2017, which goes from “indivisible” to “cancelling” (Nilsson et al., 2016). The reasoning behind the scoring for each participant and each interaction was also documented for analysis.

The aims of the qualitative data analysis were: (1) to identify common themes; and (2) to identify contrasting experiences and views on the topics raised. Qualitative data were transcribed and subject to thematic analysis (Braun & Clarke, 2006). First, all the transcripts were read for familiarization with the data, to identify direct prominent findings and make initial notes. Second, qualitative coding was conducted upon which a code was assigned to a single sentence, several sentences or larger parts of text by the interviewee. A ‘code’ in this perspective can be agreed as being a concept or a short phrase that captures a phenomenon described by the interviewee. The coding of the data was accomplished using the qualitative data analysis software QSR NVivo 12 Pro and was applied to the interviews. A list of codes was prepared to help identify connections among them (e.g. if codes described similar or different phenomena of interest). Codes relating to similar phenomena were grouped together under overarching concepts and themes.

3 Results

All twenty-six participants were aware of the UN 2030 Agenda for Sustainable Development and its 17 SDGs, as well as heatwave resilience, but their familiarity varied significantly. Furthermore, many participants had not thought about the interactions between achieving the SDGs and improving heatwave resilience which made mapping of interactions and thinking about the sources of interactions somewhat challenging.

3.1 Mapping of interactions

Considering all stakeholders’ scoring, the analysis indicates that synergies largely outweigh trade-offs between achieving the SDGs and improving heatwave resilience (Fig. 2). Particularly, SDG 11 (*Sustainable cities and communities*) was identified as having only synergetic relations with improving heatwave resilience. SDGs 3 (*Good health and well-being*), 4 (*Quality Education*), 5 (*Gender equality*), 9 (*Industry, innovation, and infrastructure*), 10 (*Reduced inequalities*), 15 (*Life on Land*), 16 (*Peace, justice and strong institutions*) and 17 (*Partnerships for the goals*) show synergetic relations as well as no interaction with improving heatwave resilience according to all stakeholders. This indicates that stakeholders identify a broad compatibility between achieving the SDGs and improving heatwave resilience, where progress in one is associated with the fulfilment of the other.

The analysis also highlights the existence of negative interactions (trade-offs) according to all stakeholders’ scoring. These are mainly identified in SDGs 1 (*No poverty*) and 2 (*Zero hunger*), and to a lesser degree in 8 (*Decent work and economic growth*), 6 (*Clean water and sanitation*), 7 (*Affordable and clean energy*), 12 (*Responsible consumption and production*), 13 (*Climate action*) and 14 (*Life below water*).

As stakeholders are very diverse and belong to different groups and sectors of society (see Table 2), further analysis of interactions between achieving the SDGs and improving heatwave resilience by stakeholders’ group is presented below.

Both positive and negative interactions between achieving the SDGs and improving heatwave resilience have been identified by different stakeholders’ groups. Considering the public sector stakeholders, the analysis indicates that they mostly associate achieving the

SDGs and improving heatwave resilience interactions as being positive (Fig. 3). Particularly, SDGs 6 (*Clean water and sanitation*), 10 (*Reduced inequalities*), 15 (*Life on Land*), 17 (*Partnerships for the goals*), 1 (*No poverty*), 2 (*Zero hunger*), 3 (*Good health and well-being*), 7 (*Affordable and clean energy*), 9 (*Industry, innovation and infrastructure*), and 11 (*Sustainable cities and communities*) were identified as having only synergetic interactions with improving heatwave resilience. This indicates that public sector stakeholders identify a broad compatibility between achieving the SDGs and improving heatwave resilience, where progress in one is associated with the fulfilment of the other.

For public sector stakeholders the analysis also highlights the existence of neutral interactions which was identified in SDG 14 (*Life below water*), and the existence of negative interactions identified in SDG 8 (*Decent work and economic growth*).

Considering the private sector stakeholders, the scoring of interactions between achieving the SDGs and improving heatwave resilience synergies largely outweigh trade-offs (Fig. 4). Particularly, SDGs 9 (*Industry, innovation and infrastructure*) and 11 (*Sustainable cities and communities*) show entirely synergetic interactions with improving heatwave resilience. This indicates that private sector stakeholders identify a narrower compatibility between achieving the SDGs and improving heatwave resilience, where progress in one is associated with the fulfilment of the other.

The analysis also highlights that for private sector stakeholders despite most interactions being positive, there is an increase in the number of solely neutral interactions between achieving the SDGs and improving heatwave resilience. These are observed in SDGs 4 (*Quality education*), 5 (*Gender equality*), and 10 (*Reduced inequalities*). Negative interactions were also identified in SDGs 6 (*Clean water and sanitation*), 7 (*Affordable and clean energy*) and 13 (*Climate action*).

For academia stakeholders, the analysis indicates that synergies largely outweigh trade-offs between achieving the SDGs and improving heatwave resilience (Fig. 5). Particularly, SDGs 13 (*Climate action*), 6 (*Clean water and sanitation*), 8 (*Decent work and economic growth*), 9 (*Industry, innovation and infrastructure*), 10 (*Reduced inequalities*), 11 (*Sustainable cities and communities*), 12 (*Responsible consumption and production*) and 15 (*Life on land*) show solely synergetic interactions with improving heatwave resilience. This indicates that academia stakeholders identify a broad compatibility between achieving the SDGs and improving heatwave resilience, where progress in one is associated with the fulfilment of the other.

The analysis also highlights the existence of negative interactions between achieving the SDGs and improving heatwave resilience. These are observed in SDGs 1 (*No poverty*) and 2 (*Zero hunger*).

Considering civil society stakeholders, the analysis indicates that there is a higher variability between synergies and trade-offs between achieving the SDGs and improving heatwave resilience (Fig. 6). Specifically, SDGs 3 (*Good health and well-being*), 11 (*Sustainable cities and communities*) and 13 (*Climate action*) show solely synergetic interactions with improving heatwave resilience. This indicates that civil society stakeholders identify a narrower compatibility between achieving the SDGs and improving heatwave resilience, where progress in one is associated with the fulfilment of the other.

The analysis also highlights the existence of negative interactions between achieving the SDGs and improving heatwave resilience. These were found to exist in SDGs 1 (*No poverty*), 8 (*Decent work and economic growth*), 2 (*Zero hunger*), 12 (*Responsible consumption and production*), 7 (*Affordable and clean energy*) and 14 (*Life below water*).

The analysis above reveals SDG 1 (*No poverty*) and SDG 2 (*Zero hunger*) to be associated with high trade-offs (−3) with improving heatwave resilience by academia and civil

society stakeholders (Figs. 5 and 6). Similarly, SDG 8 (*Decent work and economic growth*) appear to be associated to a lesser extent with high trade-offs (−2) with improving heatwave resilience by public sector and civil society stakeholders (Figs. 3 and 6). Additionally, SDG 7 (*Affordable and clean energy*) is associated with low trade-offs (−1) with improving heatwave resilience by private sector and civil society stakeholders (Figs. 4 and 6). SDGs 6 (*Clean water and sanitation*) and 13 (*Climate action*) are associated with low trade-offs (−1) with improving heatwave resilience by private sector stakeholders (Fig. 4). SDGs 12 (Responsible consumption and production) and 14 (Life below water) are associated with low trade-offs (−1) with improving heatwave resilience by civil society stakeholders (Fig. 6). SDG 2 (*Zero hunger*) is associated with high trade-offs (−3) with improving heatwave resilience by academia stakeholders (Fig. 5).

In summary, a mixture of results on interactions between achieving the SDGs and improving heatwave resilience (Figs. 3, 4, 5 and 6) is observed but synergies largely outweigh trade-offs between achieving the SDGs and improving heatwave resilience. Overall, all SDGs show synergies with improving heatwave resilience (Fig. 2). This leads to trying to understand the trade-offs also observed. Interestingly, the stronger trade-offs (−3) were identified for SDGs 1 (*No poverty*) and 2 (*Zero hunger*) and improving heatwave resilience, followed by SDGs 8 (*Decent work and economic growth*) (−2). Finally, regarding SDGs 6 (*Clean water and sanitation*), 7 (*Affordable and clean energy*), 12 (*Responsible consumption and production*), 13 (*Climate action*) and 14 (*Life below water*) trade-offs were found to be weaker (−1). As a result, there is an increased share of synergies and decreased share of trade-offs, which is a positive sign for a successful implementation and achievement of the 2030 Agenda for Sustainable Development. Nevertheless, it is important to understand what stakeholders perceive to be the sources of interactions, either synergies or trade-offs, which will be addressed below.

3.2 Sources of interactions

This section illustrates the main findings on sources of interactions. These can be classified as synergies and trade-offs which emerged from the interviews with stakeholders. They include stakeholders' views towards the interactions between achieving the SDGs and improving heatwave resilience and how achieving the SDGs can help or hinder improving heatwave resilience.

Overall, stakeholders perceived the SDGs to being intrinsically related to improving heatwave resilience. The achievement of the SDGs was thus considered to interact with improving heatwave resilience and reduce the impacts of heatwaves:

Everything you do in this context has a more or less direct link or indirect link. (A7, S)

3.2.1 Synergies

Overall, participants from all sectors reported synergies between achieving the SDGs and improving heatwave resilience. All participants listed a number of synergies. Synergies included: alignment, essential for each other, facilitating, and empowering.

In most of the goals you can see that creating greater heatwave resilience is very much aligned with the SDGs. (A6, SS)

I would hope that all of them would be indivisible (+3). If you are reducing poverty, reducing inequalities, improving and changing the way we produce energy, empowering women, all those things should hopefully improve general health, general resilience, and making societies stronger [...] unless we are doing terribly wrong. (A4, SS)

In general if you look at all of the goals as a whole you could then identify co-benefits of building heatwave resilience. Addressing each of the goals could help improve resilience as could resilience improve the likelihood of achieving the goals. (A3, S)

All participants were very positive about synergies and noted that opportunities, as well as challenges exist to jointly deliver on the SDGs and improve heatwave resilience. As a result, they also noted that the clarity of the policy and actions around synergies need to be improved so that all sectors of society can work together to achieve a joint objective.

3.2.2 Neutral/consistent interactions: neither synergies nor trade-offs

Many participants talked about and reported that achieving the SDGs and improving heatwave resilience have not really been mentioned, implemented or delivered together. They noted that in most cases they are being addressed separately, or in the case of the SDGs not even being considered at all and as a result they could not think of any synergies or trade-offs:

I don't think there is a link between them. (A7, S).

What is happening and should happen are two very different things. For each of those, how much the SDGs are influencing resilience strategies? I would imagine it's zero (0). I don't really see much evidence of the SDGs really being taken up. (PS3, T)

An interesting point to mention is that the overall majority of participants stating they do not think there is a link between achieving the SDGs and improving heatwave resilience did not provide many reasons for such neutral interactions, which in turn makes it difficult to understand their reasoning.

3.2.3 Trade-offs

Participants that talked about trade-offs between achieving the SDGs and improving heatwave resilience mentioned the fact that it all depends on how it is done:

If you end poverty by creating neo-liberal policies that somehow raise everybody out of poverty but don't change inequality and don't change the way that we use resources, so everyone gets more of everything (e.g. food, cars) then it would make it impossible to reach (-3). (A2, HS)

Using more energy, using extra cooling within physical infrastructure will result on trade-offs (-1). If you are trying to mitigate by improving efficiency you can reduce resilience (-1). Those two work against each other generally. There's no escape from the trade-offs. (PS2, T)

If there are a lot of technical solutions, energy, power requirements to actually keep those expectations of resilience that is not necessarily a great thing. In other countries you are getting an explosion of people wanting air conditioning which on the one hand is prove of them coming out of poverty and moving into middle class, higher income earners, but that is having a massive impact in terms of energy load and energy expectations which is primarily fossil fuel at the moment (-1). (CS6, S)

Let's think how you feed the whole world [...] If we continue to have inefficient agriculture where we lose a lot on the ground at least in the West and use a lot of fuels to produce our crops, then it's likely to increase heatwaves (-3). (A2, HS)

A very interesting perspective from those participants noting trade-offs between achieving the SDGs and improving heatwave resilience was that they found very specific examples to justify their reasoning.

In summary, despite the above differences, participants agreed that the interactions between achieving the SDGs and improving heatwave resilience need to be considered by all sectors and levels of society and managed so that synergies and trade-offs are considered from the onset to avoid problems down the line. One participant emphasized this by saying:

The SDGs are a top level consideration, they should be a top level consideration when you're planning your resilience strategy. [...] So, I would, and I haven't done it, but this is something I will pick up. Is to say right: How do the SDGs link to heatwave resilience and what level of consistency can we have and how do we anticipate the trade-offs [...] the problem is that sometimes people do not realise there is a trade-off [...] The solution is to include trade-offs in guidance documentation. (PS2, T)

It was suggested that achieving the SDGs and improving heatwave resilience should be introduced as overall objectives and appropriate attention should be made to highlight and address synergies and trade-offs. This could be done through alignment of the SDGs and resilience agendas. One participant suggested that this could benefit from strategies and tools already in place since most stakeholders have been using those strategies and tools daily for different processes. Participants thought that some of these strategies may not be optimal but are better than doing nothing.

Additionally, as one of the participants put it: *"it all comes down to what the resilience strategies may involve."* (CS6, S).

3.3 Exploring interactions for achieving the SDGs and improving heatwave resilience

Participants' responses on interactions also highlighted and led to both general and specific considerations about opportunities, strategies and scenarios for the future that may have not yet been explored, providing examples and direct questioning to facilitate understanding of what can be done to achieve the SDGs and improve heatwave resilience:

There are a lot of opportunities, a lot of connections to make. There is always a challenge when you've got such a number of goals and that may be too much and a bit overwhelming for people to think about as an agenda. But, looking at it just through a heat resilience lens is interesting, as actually most things seem to connect some way or another and we may not go through all those steps. (CS3, SS)

I think embedding is the word. What I think I would not want to see is a specific thing for heatwaves and another specific thing for flooding. What you want to do is to have the appropriate level of risk accommodated within your broader risk management strategy. (PS2, T)

It's almost like a comparison of business as usual if you continue with this. What we are doing now, what it would be like in 2030, 2040? [...] there is a need to think about future scenarios where certain types of responses are put in place. So, for example, if there was a really radical push towards having very effective resilience strategies within the public sector, within business, civil society, what would it look like? Having a spectrum of scenarios: business as usual, incremental change, more radical pushing of resilience; and what would the costs and benefits associated with each of those scenarios be. (CS6, S)

3.4 How to achieve the SDGs and improve heatwave resilience

In-line with the analysis presented in the previous sections, the focus here is on the thematic analysis of interactions, examining the main recurring themes which emerged from the interviews with different stakeholders on the sources of interactions between achieving the SDGs and improving heatwave resilience (Sects. 3.1., 3.2 and 3.3.). Eight major themes of (1) Communication, partnership and collaboration, (2) Financial and resources, (3) Information and knowledge, (4) Technical and scientific, (5) Institutional and organizational commitment and regulations, (6) Planning, implementation and strategies, (7) Competing priorities and not a priority, (8) Scales (i.e. time, spatial), emerged from the interviews (see Table 4).

These major interaction themes highlight many of the problems different sectors of society and those working on these topics are facing when addressing both the achievement of the SDGs and improved heatwave resilience. The aim is that by identifying such themes and identifying common ideas it is possible to understand what is being done right, what is being done wrong or less right, as well as finding ways to overcome the problems and expand on the solutions.

All participants agree more needs to be done for England and the UK to deliver on the SDGs and become more resilient to heatwaves now and in the future, and this can be achieved by thinking about different solutions for the problems that have been highlighted in this article.

3.5 Focusing on solutions

The themes discussed above and participants illustrative quotes (see Table 4) constitute an opportunity for all sectors of society to come together and change the focus from problems and instead focus on solutions related to: (1) Communication, partnership and collaboration, (2) Financial and resources, (3) Information and knowledge, (4) Technical and scientific, (5) Institutional and organizational commitment and regulations, (6) Planning, implementation and strategies, (7) Competing priorities and not a priority, (8) Scales (i.e. time, spatial).

This article has put forward themes which can be further developed into solutions to promote synergies and deter trade-offs. It has also highlighted the need develop and implement co-produced and inclusive bottom-up and top-down approaches that can give rise to plans and actions in all sectors of society to focus on these and find solutions to achieve both the achievement of the SDGs and improved heatwave resilience.

Table 4 Major interaction themes between achieving the SDGs and improving heatwave resilience, description and illustrative quotes

| Theme | Description | Illustrative quotes |
|---|---|---|
| 1. Communication, partnership and collaboration | This code identifies synergies and trade-offs linked to communication and partnership between stakeholders, all issues related to collaboration | <p><i>One of the biggest challenges I feel is the lack of collaboration, communication and co-production across different stakeholders. (A3, S)</i></p> <p><i>It needs to become mainstream. Raising visibility, communication exercises, reaching and engaging in conversations with key stakeholders, policy makers, trade organisations, leaders in the various sectors, coming together (CS6, S)</i></p> <p><i>You need partnerships working across public, private, voluntary sector and across different professional interests. [...] develop partnerships across cities and regions trying to make things happen, and that is fundamental. [...] If you have connections and good governance links between different parties in a local setting that is going to make a difference in terms of your ability to respond to heat. (CS3, SS)</i></p> |
| 2. Financial and resources | This code identifies synergies and trade-offs linked to financial and resources aspects | <p><i>Resource constrains, cuts and limited funding available make it challenging. (LG3, HS)</i></p> <p><i>In most organisations is having the capacity, the resources, the time to do anything about it. (PS1, S)</i></p> <p><i>In the current public sector the biggest challenge is being able to be resilient in the context of ever dwindling resources both in terms of staffing and available capital to spend. (NG3, HS)</i></p> |

Table 4 (continued)

| Theme | Description | Illustrative quotes |
|------------------------------|---|--|
| 3. Information and knowledge | This code identifies synergies and trade-offs linked to information collection and management or knowledge production, as well as dissemination | <p><i>With heatwaves, which given climate change may well become a more common phenomenon there will need to be more thinking, more learning, more education and more working out what needs to be done. So, I think an institutional shift is probably required. (CS4, SS)</i></p> <p><i>What needs to be done is general sustainable development. Making clear what is meant by sustainable development, as people don't necessarily link it to things like heatwaves. (PS1, S)</i></p> <p><i>Making sure that everyone has access to the same information. That everyone has opportunities to ask the right people if they have questions. It's not just the case of making sure that information appears on websites, it's about getting literature being put through everyone's door [...] there is no kind of standardised approach to what should be done with the information. (LG5, SS)</i></p> |
| 4. Technical and scientific | This code identifies synergies and trade-offs linked to all aspects of technical and scientific narratives – different 'language' | <p><i>In government, working across departments and divisions, ... sometimes people are working on the same things and same ideas, but the problem is that people have different 'languages' for the same issue; no joint up holistic approach which sometimes makes it quite difficult to work together. (LG3, HS)</i></p> <p><i>At the level of individual assets and maybe within some local authorities as well there might be some planning already in place around climate adaptation strategies and heat resilience but probably quite at a technical level. And also I don't think the public is aware of what might happen further down the line. (CS6, S)</i></p> |

Table 4 (continued)

| Theme | Description | Illustrative quotes |
|--|---|---|
| 5. Institutional and organizational commitment and regulations | This code identifies synergies and trade-offs linked to institutional and organizational commitment and regulations | <p><i>There needs to be a national commitment to have mandatory mechanisms for organisations to do something. [...] A lot of organisations don't have the mandatory mechanisms in place where they have to do anything. (PS1) Our efforts around heatwave resilience are very much driven by the Department of Health and I think this needs to be a cross government political issue that is embedded across all the policies and the goals do provide that opportunity really, to look at how heatwaves will affect different parts of society but also how those different parts of society can then respond through the works of different government departments. (A3, S)</i></p> |
| 6. Planning, implementation and strategies | This code identifies synergies and trade-offs linked to current and future planning, implementation and strategies | <p><i>The SDGs are a top-level consideration, they should be a top level consideration when you're planning your resilience strategy. (PS2, T)</i></p> <p><i>What is happening and what should happen are two different things. [...] I don't really see much evidence of the SDGs really being taken up. (PS3, T) It's far from a simple picture. When people think of the SDGs, well they think 'it's good right? Sustainable development goals, we should be doing that. But I think once you start drilling down into the particulars there are many, many problems that start emerging. So, I think people need to be very careful about how they are going about implementing these things. So that they don't produce these negative impacts, which are clearly there. [...] What really needs to take place is that decision makers at all levels need to be considering when they are thinking about delivering on an SDG, how that improves or undermines resilience. (A8, S) Even when people are willing, implementation is very tricky in the political and economic systems which we have. There is potential for a lot of slippages in terms of implementing that and creating that kind of sustainable development that is aimed. (A5, SS) I think we are quite good in the UK in terms of understanding what needs to be done but then to implement it is tricky and often it needs something like a heatwave or some kind of thing that has gone wrong to then motivate people. (A5, SS) We are not basing our resilience strategy on any of the SDGs (LG2, HS)</i></p> |

Table 4 (continued)

| Theme | Description | Illustrative quotes |
|--|---|--|
| 7. Competing priorities and not a priority | This code identifies synergies and trade-offs linked to the challenges of balancing the diverse needs of different institutions/sectors | <p><i>I think that Brexit has stopped pretty much everything in its tracks. So, although there was a discussion in the summer, I am not perceiving anything now that is carrying that on. So, that was in the summer, is nice and cooler now so let's not worry about it. (A2, HS) Flooding has taken precedence in terms of risks for the UK and with the heatwave this year breaking records, hopefully it means that heatwaves will be considered to be as important risks as flooding going forward. (A3, S) I think in general heatwaves aren't necessarily taken very seriously so that's a sort of starting point of how do you building resilience if you don't think it is necessarily a risk or challenge or a threat to anyone? I think when you compare it to flooding, [...] heat is a much more invisible sort of threat. [...] I think flooding has a lot more focus as an issue and a more regulatory framework around it (CS3, SS) Any climatic resilience that people consider tends to be around the floods rather than the heatwaves. Resilience to heatwaves is a new thing to me I have to say. (PS3, T)</i></p> |
| 8. Scales (i.e. time, spatial) | This code identifies synergies and trade-offs linked to different time and spatial scales | <p><i>There are things we can do now to increase resilience of people to heatwaves but there is also how you reduce the risk of heatwaves and minimise the speed at which climate change is progressing, and that is a long-term issue (LG2, HS) I don't think it will be achieved quickly. It's a long-term goal. (NG1, HS) Taking a global approach is often really hard to do. Also, the problem about building resilience to heat is not only about your local council or city or even country. (LG3, HS) Some of the goals are much more written from a global perspective rather than a UK perspective. (CS2, S)</i></p> |

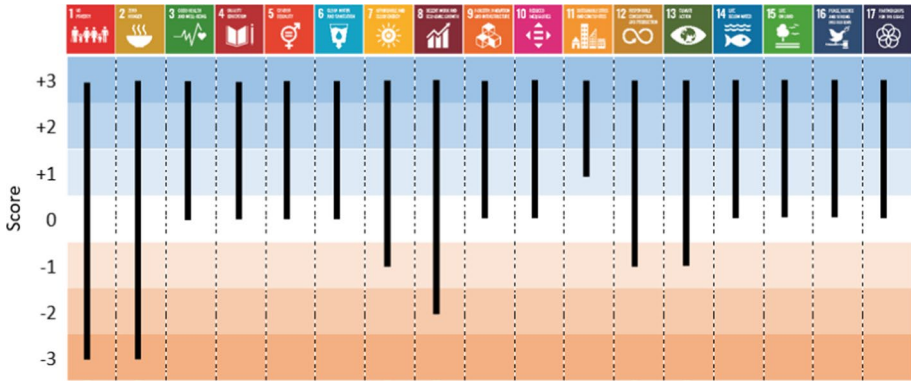


Fig. 2 Scores attributed by all stakeholders to interactions between the SDGs and heatwave resilience. The score represents the strength of an interaction and is represented by the numbers on the left. These indicate a seven-point scale with the range of possible interactions ranging from -3 (highest trade-offs; most negative interactions) to $+3$ (highest synergies; most positive interactions), and 0 (no interaction; consistent/neutral) (See Table 2). The colour rows represent the synergies (shades of blue), no interactions (white), and trade-offs (shades of orange) identified by all stakeholders. The SDGs are represented at the top

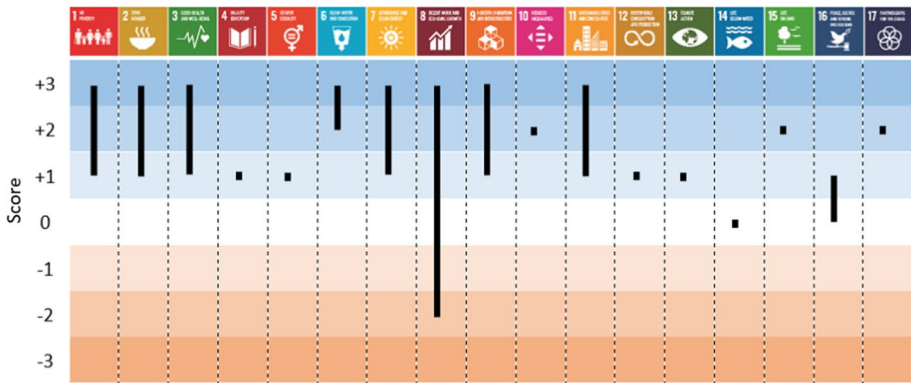


Fig. 3 Scores attributed by public sector stakeholders to interactions between the SDGs and improving heatwave resilience. The score represents the strength of an interaction and is represented by the numbers on the left. These indicate a seven-point scale with the range of possible interactions ranging from -3 (highest trade-offs; most negative interactions) to $+3$ (highest synergies; most positive interactions), and 0 (no interaction; consistent/neutral) (See Table 2). The colour rows represent the synergies (shades of blue), no interactions (white), and trade-offs (shades of orange) identified by all stakeholders. The SDGs are represented at the top

4 Discussion

Analysis of interactions between the SDGs is crucial to understand how these can be achieved but are not deemed enough when thinking of the SDGs as a global agenda in a complex world. Understanding synergies and trade-offs between individual SDGs has been the focus of interest and research so far (Allen et al., 2019; Bennich et al., 2020; Breuer et al., 2019; Cernev & Fenner, 2020; Collste et al., 2017; Forestier & Kim, 2020; Fu et al., 2019; Le Blanc, 2015; Liu et al., 2018; Nilsson et al., 2018; Scharlemann et al., 2020;

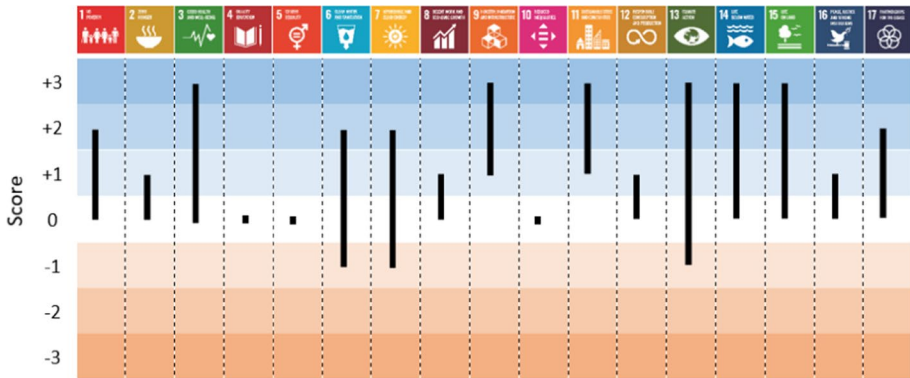


Fig. 4 Scores attributed by private sector stakeholders to interactions the SDGs and improving heatwave resilience. The score represents the strength of an interaction and is represented by the numbers on the left. These indicate a seven-point scale with the range of possible interactions ranging from -3 (highest trade-offs; most negative interactions) to $+3$ (highest synergies; most positive interactions), and 0 (no interaction; consistent/neutral) (See Table 2). The colour rows represent the synergies (shades of blue), no interactions (white), and trade-offs (shades of orange) identified by all stakeholders. The SDGs are represented at the top

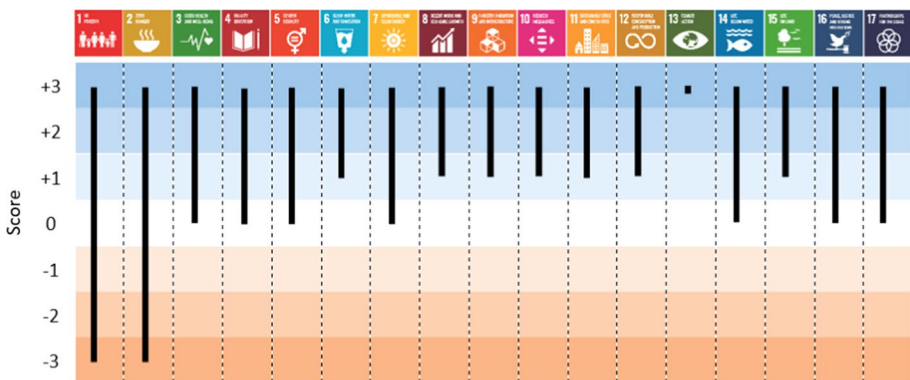


Fig. 5 Scores attributed by academia stakeholders to interactions between the SDGs and improving heatwave resilience. The score represents the strength of an interaction and is represented by the numbers on the left. These indicate a seven-point scale with the range of possible interactions ranging from -3 (highest trade-offs; most negative interactions) to $+3$ (highest synergies; most positive interactions), and 0 (no interaction; consistent/neutral) (See Table 2). The colour rows represent the synergies (shades of blue), no interactions (white), and trade-offs (shades of orange) identified by all stakeholders. The SDGs are represented at the top

Scherer et al., 2018; Van Soest et al., 2019; Weitz et al., 2014, 2018). Such analyses have highlighted that implementing and achieving the SDGs will largely depend on the ability of countries to maximise synergies and minimize trade-offs (Alcamo et al., 2020; Kroll et al., 2019; Pradhan et al., 2017). Despite this, little or no attention has been given to the interactions between achieving the SDGs and other agendas such as climate change (Fuso Nerini et al., 2019; Zhenmin & Espinosa, 2019) and improving heatwave resilience (Nunes, 2020, 2021).

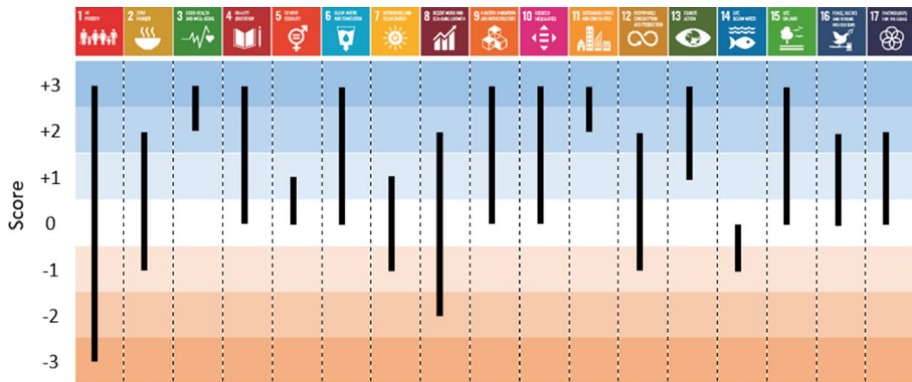


Fig. 6 Scores attributed by civil society stakeholders to interactions between the SDGs and improving heatwave resilience. The score represents the strength of an interaction and is represented by the numbers on the left. These indicate a seven-point scale with the range of possible interactions ranging from -3 (highest trade-offs; most negative interactions) to $+3$ (highest synergies; most positive interactions), and 0 (no interaction; consistent/neutral) (See Table 2). The colour rows represent the synergies (shades of blue), no interactions (white), and trade-offs (shades of orange) identified by all stakeholders. The SDGs are represented at the top

This study helps fill this critical gap and improve our understanding of how the SDGs and heatwave resilience can be aligned. This paper has sought to advance knowledge of the sources and nature of the interactions between these two agendas to understand the challenge that is to address both agendas using a novel approach that is beneficial to the achievement of the SDGs and heatwave resilience through efforts and actions to minimise trade-offs and maximise synergies. Different sectors of society such as national and local government, private sector, academia and civil society play a critical role in prioritizing, developing and implementing policies, practices and actions to help achieve both the SDGs and heatwave resilience. Noting the importance of these sectors of society and the limited understanding of how these diverse stakeholders conceptualize and operate to achieve the 2030 Agenda for Sustainable Development and the SDGs, as well as improve heatwave resilience, this paper aimed to investigate how these agendas can be aligned and achieved. Greater consideration of the perspectives of diverse stakeholders may help understand and explain why the consideration, implementation, achievement and outcomes in-line with the SDGs and heatwave resilience are inconsistently considered, implemented and achieved.

This study mapped the interactions between sustainable development and heatwave resilience. The results show that addressing these interactions was strongly supported by stakeholders from all sectors of society. The analysis reveals that synergies largely outweigh trade-offs. Additionally, the analysis reveals that stakeholders identify a broad compatibility between the two agendas and no fundamental incompatibilities were found to exist. Despite this, the study reveals that there is a low degree of alignment. Additionally, the analysis shows that lack of parallel, joined and effective implementation, planning and actions may genuinely threaten the achievement of these agendas. These findings put emphasis on the need to support policy coherence between different sectors of society that can make it more feasible to achieve and stimulate society as a whole to act on sustainable development and heatwave resilience, as found by other authors in relation to interactions between the SDGs (Beccari et al., 2016; Davies et al., 2013; Kroll et al., 2019; Pradhan et al., 2017). Aligning and connecting sustainable development with climate change (Fuso

Nerini et al., 2019; Zhenmin & Espinosa, 2019) and heatwave resilience can bring vital opportunities to invest in promoting synergies and mitigating trade-offs through connecting different sectors of society and stakeholders under a same purpose.

This study also shows that there are many policies and measures that have significant potential to aid the achievement of the SDGs and heatwave resilience. The results reveal that if these ought to be considered and implemented widely in all sectors of society such actions could provide and effective way to address both agendas and be a solution for scarce resources (i.e. time, money). This would also destroy existing silos within and between different levels and sectors of society, organizations and institutions and, therefore, result in better recognition of the interlinkages between the SDGs and heatwave resilience by society as a whole. The analysis shows that if countries are to take more consideration on aligning these agendas this can be achieved through parallel and effective efforts to allow conditions for better planning and actions. Policy coherence was thus found to be vital across all sectors of society so that countries do not have to choose between achieving the SDGs and improving heatwave resilience, as they could do both. Incorporating the achievement of the SDGs and improving heatwave resilience was suggested to increase this recognition. The analysis reveals that this could be achieved by developing and implementing one single plan that works for both agendas, having the SDGs as the core framework. It is indicated that integrated approaches would enhance success and overall performance in achieving both agendas. Given that the findings show minimal trade-offs between achieving the SDGs and improving heatwave resilience, there may be an argument to be made that focusing on one can indirectly translate to improvements in the other without having to explicitly address both. Furthermore, there is the potential for unpredicted trade-offs (e.g. increased institutional burden) that may arise with trying to address both agendas, especially in a developing country or resource scarce context. Nevertheless, the eight major themes emerging from the interviews can be used to achieve both agendas: (1) Communication, partnership and collaboration, (2) Financial and resources, (3) Information and knowledge, (4) Technical and scientific, (5) Institutional and organizational commitment and regulations, (6) Planning, implementation and strategies, (7) Competing priorities and not a priority, (8) Scales (i.e. time, spatial). It was suggested that this can be achieved by for example, improving collaborations, using common language, regulation and planning, pooling resources, skills, inclusive information and translation to practice.

Taking into account the time frame of 2030 to deliver on the SDGs, the results show that action is urgently needed and that addressing aspects such as coordinated action between stakeholders and sectors of society are critical. Similar findings were obtained in a study by Soergel and colleagues (2021).

The national and local government, civil society, private sector, academia stakeholders who participated in this study agree that achieving the SDGs could be beneficially used to improve heatwave resilience. This finding agrees with that of Soergel and colleagues (2021) where a shift to sustainability needs efforts to address several agendas and problems at the same time.

Given that this study interviews English stakeholders and given that plans and policies around heatwave resilience exist and are used but are not of primary concern among the national and local government and organizations, but where the SDGs are still largely missing from the discussion more needs to be done to raise awareness of heat risk, strengthening preparedness for extreme heat and increase heatwave resilience. A limitation of this study is therefore the single focus—England—a developed country in the global north. Despite this, this can also be seen as an advantage as it shows that

if plans and policies around heatwave response and the SDGs are not in place and are not a priority this may be a missed opportunity that other countries in a developed and developing context that prioritise these will be able to perform better in achieving the SDGs and improving heatwave resilience.

5 Conclusions

This study mapped interactions between sustainable development and heatwave resilience. It showed the diversity of interactions between sustainable development and heatwave resilience, and that sustainable development and heatwave resilience are largely compatible. This is visible in the way that stakeholders have mapped interactions between them, where synergies outweigh trade-offs. Overall, the findings suggest that most SDGs and heatwave resilience can be jointly reached. This conclusion is consistent with interactions between the SDGs (Lusseau & Mancini, 2019) that shows that most SDGs have synergistic relationships. It is less clear how this study's findings relate to other research as research on the interactions between the SDGs and other health, environmental and social issues is still very scarce (Fuso Nerini et al., 2019; Zhenmin & Espinosa, 2019). What needs to be reflected upon is the meaning of these results for the prospect of achieving the SDGs and heatwave resilience.

Though it is concerning that achieving the SDGs are not in the agenda for different sectors of society, the similar is true in relation to improving heatwave resilience due to lack of prioritization of thinking and progress towards improved practice and lack of support from government. Despite this, there is willingness, enthusiasm, determination, as well as technical and practical ability from all sectors of society to act. The combined support from stakeholders is crucial but not enough to move on the two agendas and needs national and local leadership to drive effective action. This research found that more needs to be done to achieve the SDGs and improve heatwave resilience, but it is important to recognize the role stakeholders from all sectors of society play in doing this together as a whole. Recommendations and solutions have been suggested regarding how this can be achieved, and despite some may not be taken up it is important to recognize the expertise, knowledge and skills of stakeholders in England on how these two agendas can be accomplished by maximizing synergies and minimizing trade-offs.

Many other countries, may not yet be on track to achieving the SDGs and improve heatwave resilience, but this research highlights where synergies and trade-offs exist, identifies problems and also highlights solutions to overcome them in all sectors of society. Unless action on aligning different agendas under a core framework are urgently implemented, many countries are risking missing on achieving the SDGs and at the same time missing on accomplishing other agendas (e.g. climate change, inequalities).

The findings contribute to current debates on the achievement of the SDGs and improvement in heatwave resilience, and the increasing importance of understanding the interactions between sustainable development and heatwave resilience. This study also contributes to current and future debates on the interactions between sustainable development and environmental, social and health aspects of society that are in most cases dealt with separately and should in this instance be address simultaneously in an effort to combine resources, maximize synergies and avoid trade-offs.

This study adds to the current knowledge that different stakeholders from different sectors of society acknowledge the urgent need for more efficient communication, use of resources, knowledge, commitment and implementation aimed at achieving both agendas.

This research has shed light on different options that can be used to align sustainable development and heatwave resilience. More research is needed on how this can be effectively achieved in different countries. Future studies are also needed to document best procedures and practices required to the integration of achieving the SDGs and improving heatwave resilience into a whole-of-society approach and framework. In addition, a sustainability, environmental, social, health and economic evaluation of such practices will be needed to document the effectiveness of these types of approaches that focus on achieving them.

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Declarations

Conflict of interest The author has no competing interests to declare.

Ethical approval The study obtained its ethical clearance from the University of Warwick's Biomedical and Scientific Ethics Sub-Committee on 27-07-2018 (Project no. REGO-2018-2265). All participants consented to the study, having been informed that participation was voluntary, and that confidentiality will be maintained in publications.

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