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Environmental management systems in the architectural, engineering and construction sectors: a roadmap to aid the delivery of the sustainable development goals

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Abstract

Realisation of the sustainable development goals (SDGs) will provide improvements to people's lives and longevity of the planet. The architectural, engineering and construction (AEC) sectors have a potentially huge role in aiding the delivery of many SDGs; however, there appears to be a lack of research into the engagement within this sector. The leading environmental management system (EMS), ISO 14001, can enable organisations in the AEC sectors to improve their business operations, whilst minimising their impacts on the environment and improving society. Therefore, the study sets out to use institutional theory to determine the usefulness of ISO 14001 as a tool within the AEC sector and to demonstrate how the organisational benefits could facilitate the delivery of the SDGs. A stepwise PRISMA review process facilitated the compiling of academic articles and professional reports ($n=44$), which enabled the creation of an inventory of the perceived benefits ($n=85$) and the recognised barriers ($n=63$) to implementing ISO 14001 across the AEC sectors. These barriers and benefits were confirmed by environmental practitioners as being relevant to the incorporation of an EMS. The most widely reported benefits within the AEC sectors were improving environmental performance and compliance with legislation. Lack of government pressure and lack of expertise were the most widely reported barriers, followed by cost to AEC organisations utilising an EMS. Following on from this inventory of benefits, it was possible to develop of a conceptual roadmap, which illustrates where linkages exist with the SDGs. SDG 4, 8, 12 and 13 are shown as exhibiting the most associations with the benefits. This roadmap was reviewed by AEC sector professionals who confirmed its usefulness. Therefore, it is surmised that the roadmap could aid strategic organisational sustainable planning or for organisations to demonstrate the delivery of their corporate social responsibilities.

Keywords ISO 14001 · PRISMA · Sustainability · Corporate social responsibility

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1 Introduction

Since the 1970s, the extraction of natural resources has increased threefold and estimations show that by 2060 material use could further double to 190 billion tonnes and greenhouse gases could increase by 43% (UN, 2019). Data from the United Nations (UN) (2019) suggest that extraction and processing of materials, fuels and food produces half of the total global greenhouse gases and this together with water stress is responsible for more than 90% of biodiversity loss. Othman and Nadim (2010) noted that the AEC sectors use around 50% of the natural resources consumed, utilise 40% of the energy generated and produce 50% of the waste created globally. This makes the building sector a significant contributor to harmful emissions (Ade and Rehm, 2019; Cucuzzella, 2009). Furthermore, the building sector also consumes 12% of freshwater and 30% of raw materials and it is responsible for around 20% of wastewater and up to 40% of landfill waste globally (Ade and Rehm, 2019). It is, therefore, clear that the AEC sectors have enormous potential for making a considerable impact in terms of sustainability in a positive or negative manner.

The UN, (2020a) estimated that in terms of most vulnerable countries (MVC) and their populations, in 2020, another 71 million people would be pushed back into poverty and that 2.2 billion people would lack safe drinking water. Water scarcity could displace 700 million people by 2030 (UN, 2020b). The Circle Economy, (2020) notes that 50.8 billion tonnes of minerals are consumed each year and 38.8% of that goes into housing. Along with these data, the Waste Framework Directive 2008/98/EC states that all European Union (EU) member countries need to achieve at least 70% re-use, recycling, or other recovery of non-hazardous Construction and Demolition Waste (CDW) by 2020. These figures suggest that the AEC sectors have a huge impact on sustainability and through their efforts could make a huge contribution to the fulfilment of the SDG objectives, by utilising a cradle-to-cradle approach (McDonough and Braungart, 2002). This study sets out to use institutional theory to determine the usefulness of ISO 14001 as a tool within the AEC sector and to demonstrate how the organisational benefits could facilitate the delivery of the SDGs.

Sustainability within the AEC sectors, particularly within construction, has received increasing attention over recent years (Berardi, 2012). AEC sectors impacts will be varied, and it is acknowledged that to mitigate the potential impacts effective sustainable development action is required. Boyko et al., (2012) and Villeneuve et al., (2017) highlighted the risks these activities can impose on the natural environment and their impact in terms of the social, economic, cultural, and political dimensions of sustainability.

The current predictions suggest that by 2050, two-thirds of the global population will be living in urban areas (Mattoni et al., 2018). There is an expectation that there will be 14 new mega cities with a demand for over 500 million m² of new office space and more than 250 million new houses (Ade and Rehm, 2019; Ding, 2008). The design and construction of these cities will have a major impact on the delivery of the SDGs and the future health of the planet.

It has been noted by researchers that for business to be truly sustainable it needs to go beyond the traditional economic approach and short-term issues (Næss, 1994; Goubran et al., 2019). Cucuzzella, (2016) has suggested a multistep framework requiring system-wide innovations to change unsustainable practices. Dyllick and Muff, (2015) proposed four levels for sustainability in business, the first being business as usual. However, this is discounted as it is generally accepted that business as usual is no longer acceptable. As a result, there are only actually three options, namely: (i) sustainability with economic considerations, (ii) sustainability with the creation of value across the pillars of sustainability,

or (iii) focussing on the sustainability challenges to bring about a better society (Dyllick and Muff, 2015). In this paper, the SDGs are used to enable organisations to work towards solutions, using an existing standard, ISO 14001.

Environmental management systems (EMS) (particularly ISO 14001) aim to enable organisations to prevent pollution, deliver continual improvement, and comply with legislation (BSi, 2015). Although it is acknowledged that environmental standards have focused on continual improvement, they do not actually specify a level of improvement or harm reduction (i.e. pollution prevention). Therefore, they have been accused of not enabling a transformation in terms of sustainability (Brown, 2016). Others had suggested that standards are being used increasingly to create economic value, cost savings, or increased market share and opportunities for business rather than environmental improvements (Jones and Laquidara–Carr, 2018). However, it must be acknowledged that while businesses exist to create wealth, this does not mean that they cannot make a positive environmental contribution at the same time. It is possible that companies can be sustainable in terms of economics, society, and the environment. Some researchers have suggested that potential links exist between environmental rating tools and the SDGs (Alawneh et al., 2018; Gibberd, 2015). Gibberd, (2015) combined the ecological footprint criteria and the human development index to suggest a BEST index. Alawaneh et al. (2018) looked at how a combined water and energy efficiency method could be developed to assess and improve United Nations (UN) Sustainable Development Goals (SDGs) delivery. However, there has been no focus on a tool to enable companies to demonstrate the benefits that can be achieved through working on the SDGs. It must be noted that there is a risk that the benefits, which are being achieved, are those that can be delivered at the lowest cost to the organisations or that the organisations use the system as purely a public relations (PR) tool, rather than to improve their environmental performance. This has promoted the view of the standards being less effective in promoting sustainability than market mechanisms, such as carbon trading (Bon and Hutchinson, 2010). This study intends to demonstrate the opportunities that can be created using a roadmap.

The previous section has highlighted the contribution that the construction sector has in relation to the achieving of the SDGs, but it is noted that there is a lack of research in the relationship between the sectors and engagement with the SDGs (Gade and Opoku, 2020). Analytical mapping tools have been created to trace the integration of the SDGs within projects (Goubran and Cucuzzella, 2019). Thuesen and Opoku, (2018) noted that a potential route for addressing this issue within research would focus on: understanding the links between the goals, means to measure the impact of progress, working with specific projects to attain the target and knowledge transfer. But there is no mention in this or other articles of what benefits the organisation will gain from engagement with the SDGs.

Researchers have reviewed how the construction sector could contribute to the SDG work with Lynch and Mosbah, (2017) highlighting SDG 1 (no poverty), SDG 9 (industry, innovation, and infrastructure), and SDG 11 (sustainable cities and communities). Goubran et al., (2019) also notes that buildings play a part in the use of renewable energy (SDG 7), in sustainable consumption and production (SDG 12), and in climate adaptation (SDG 13). Di Foggia, (2018) agrees that SDGs 11 and 13 are the significant ones. However, if research continues to focus on standard tools and regional case studies, the findings will remain of limited use when the aim should be transformational change.

There are of course issues in terms of the potential trade-offs that could occur if organisations only focus on one or two of the SDGs as their work to improve those could have negative impacts on other targets (Allen et al., 2019; Maes et al., 2019; Moyer and Bohl, 2018). Therefore, a roadmap is necessary to ensure that companies have the tools to deliver

effectively on the SDGs. Then they can make a positive contribution to them without negatively affecting the work of others. The aims of this study are to complete a structured review of AEC sector literature on the benefits and barriers of ISO14001 implementation; to produce a roadmap that utilises the known benefits of implementing environmental management systems in the AEC sectors; and use the road map to support the delivery of the SDGs. The question is can ISO 14001 be used to create a roadmap by organisations to aid the delivery of the SDGs?

The study used a PRISMA review of AEC literature to identify articles that were then scrutinised for known benefits and barriers of implementing environmental management systems (da Silva and Amaral, 2019). These were then endorsed by environmental experts. A roadmap linking these benefits to each of the SDGs was produced and then validated by AEC industry experts, before drawing conclusions and recommendations for future research.

The theoretical framework selected was that of institutional theory (Hoffman, 1997), which proposes that external (social and environmental) factors influence action at an institutional level (Meyer and Rowan, 1977). This suggests that organisations are in the position of being encouraged to conform to social standards of legitimacy and to abide with social expectations (Orrù et al., 1991). This theory of the need for institutional and social legitimacy will be the framework for this research. In the next section, the background to the SDGs will be reviewed, followed by the results section where the benefits and barriers of the use of ISO 14001 will be assessed in relation to the creation of the roadmap, this will be followed by the discussion and conclusions sections.

2 Sustainable development goals

Sustainability and environmental management have become key in our society since the Earth Summit in Rio de Janeiro in 1992 (UN, 2020c). Governments and organisations have tried a variety of ways to promote engagement with environmental sustainability from implementing legislation and issuing guidance to recommending management systems and voluntary standards. This has led to increasing interest in the implementation of schemes such as ISO 14001 to manage the environmental impacts of organisations, which not only has resulted in cost savings and better use of resources, but also brought about an increased focus on the protection of the environment (Pesce et al., 2018). ISO 14001 enables organisations to manage their impacts on the environment, through operating procedures, objectives, and a policy, which commits them to continual improvement, legal compliance, and prevention of pollution (Owolana and Booth, 2016; Johnson, 2020). It is a tool that also allows organisations to monitor and measure the positive impacts that they are having and justify their work to insurers, customers, stakeholders across the globe (Arimura et al., 2008; Nishitani, 2009) and regulators, as well as the public (Zeng et al., 2011).

This interest in the sustainability agenda from the public has increased in recent years (Erdos, 2019; Jung et al., 2020). While there was talk about sustainability prior to 1992 (Scoones, 2007), it was the Earth Summit conference in Rio that brought the subject of sustainability to the attention of the media. Following on from Rio, a roadmap for Agenda 21 was created (Spangenberg et al., 2002), which highlighted ways for society to be more sustainable in terms of social, economic, and conservation of resources (Shah, 2008). Following on from this work in 2000, there was the release of the millennium development goals (MDG), eight in total, again the focus was on poverty, gender equality, and the

prevention of HIV/AIDS and malaria. These aimed to reduce extreme poverty and improve health by 2015 but the primary focus was on the benefits to humans (Wagstaff *et al.*, 2006). The MDGs were reviewed in 2015 and became the SDGs. These SDGs comprise of 17 goals (Table 1) that cover relevant thematic areas (e.g. energy, water, climate, urbanisation, transport, science, and technology) based around five key themes of people, planet, prosperity, peace, and partnership (Caldés and Rodríguez-Serrano, 2018). The SDGs are more ambitious than the MDGs with a focus not just on poverty but on the human and natural environment (Gusmão Caiado *et al.*, 2018). These goals form a voluntary approach to deliver a better society for all, but for these to be effective they must be engaged with by industries and sectors worldwide, not just governments.

In society, individuals are now more powerful in terms of their impact on companies through their purchasing power and social media. There is, therefore, both an opportunity and a risk in terms of how and whether companies engage with the SDGs. The aims and objectives of the SDGs are broader and more encompassing than is possible for any sector to achieve alone but as Goubran *et al.* (2019) states the construction sector has direct or indirect influence on the SDGs with 17% of the SDG targets being directly dependent and 27% indirectly dependent.

It must also be noted that the interlinkages between the various targets (Allen *et al.*, 2019; Le Blanc, 2015; Tosun & Leininger, 2017) could result in actions being taken to advance one goal having a detrimental impact on another goal. Maes *et al.* (2019) supported this by highlighting 102 SDG targets, which had links to all the goals. It should also not be assumed that the only SDGs that are impacted by the AEC sectors are SDG 15 (i.e. life on land) and SDG 11 (i.e. sustainable cities and communities) (Gusmão Caiado *et al.*, 2018; Allen *et al.*, 2019). There is a need for more interdisciplinary research to achieve the SDG aims and objectives as a sector and society (Salvia *et al.*, 2019). In an analysis by Goubran *et al.* (2019), it was found that the sector is related to all the goals but that the largest contribution was made in respect of SDGs 6, 7, and 11. It is contested here that SDGs

Table 1 The seventeen sustainable development goals (source: UN, 2015)

#	Sustainable development goal
SDG1	No poverty
SDG2	Zero Hunger
SDG3	Good health and Well-being
SDG4	Quality Education
SDG5	Gender Equality
SDG6	Clean Water and Sanitation
SDG7	Affordable and Clean Energy
SDG8	Decent work and Economic growth
SDG9	Industry, Innovation and Infrastructure
SDG10	Reduced Inequalities
SDG11	Sustainable Cities and Communities
SDG12	Responsible Consumption and Production
SDG13	Climate Action
SDG14	Life Below Water
SDG15	Life on Land
SDG16	Peace Justice and Strong Institutions
SDG17	Partnerships for the goals

4, 8, 12, and 13 are also significantly impacted. Based on extensive literature searches, this is the first known study to demonstrate the potential opportunity of supporting the delivery of the SDGs through the utilisation of environmental management systems.

3 Research design and methodology

To achieve the purpose of this study, an interpretivist epistemology (Hudson and Ozanne, 1988) was used together with abductive reasoning (Bryman and Bell, 2015) with elements of positivism. In an interpretivist epistemology (Hudson and Ozanne, 1988), reality is multiple and relative, within the confines of institutional theory (Hoffman, 1997). An institutional theory approach was used as this suggests environmental problems are neither technologically or economically guided, rather they are mostly behavioural and culturally derived. While technology or economic activity may be the cause of the environmental destruction, our own beliefs, cultural norms, and societal institutions direct those activities (David, 1985). Therefore, any organisation will be influenced not only by the character of the organisation and culture itself but also the social legitimacy that comes through engagement with its stakeholders.

The research process consisted of the five stages (Figure 1). Initially, a literature review was undertaken to discover the common barriers and benefits that have been reported by other researchers in the use of ISO 14001. The review used a PRISMA evidence-based transparent process (Moher et al., 2009), whereby journal articles were identified, then screened for suitability (Table 2) before inclusion in a structured review (Liberati et al., 2009). There are many reasons for conducting a literature review (Randolph, 2009). In this study, peer-reviewed literature was the focus (Abanda et al., 2015). These findings were shared with a group of Institute of Environmental Management and Assessment (IEMA) professionals ($n=25$) whose involvement was to confirm or refute the validity of the findings. The findings were used to create a roadmap and then a second validation process was undertaken using AEC professionals to confirm the usefulness of the roadmap in terms of the specific sectors of interest.

A range of databases (including Scopus and Web of Science, amongst others) were used to cover a variety of different discipline areas (such as engineering, business, social science). The search was limited to common phrases or keywords (such as

ISO 14001, Environmental Management Systems and EMS) within relevant fields (such as architecture, engineering, construction) and the literature search was constrained to articles from 1999 to 2020 (years inclusive), and restricted to peer-review journal papers, reviews, conference papers and book chapters, and only works published in the English language. The typical code used to search the databases was: TITLE-ABS-KEY (('ISO 14001' OR 'EMS' OR 'Environmental Management System') AND ('architecture' OR 'engineering' OR 'construction')) AND (LIMIT-TO (LANGUAGE, "English")). In this initial stage, the focus was on identifying the benefits of ISO 14001; therefore, words connected to the SDGs (and similar) were excluded from search terms, to maximise the list of possible benefits. Of the original 155 articles, some were duplications which resulted in 137. These were then reviewed by reading the abstract and introduction. Subsequently, questions were asked to clarify whether the article should be included in the study. These questions were related to the content and the research question (Table 2). The first section of questions formed exclusion criteria where all the questions had to have a positive answer. The second question section was in the form

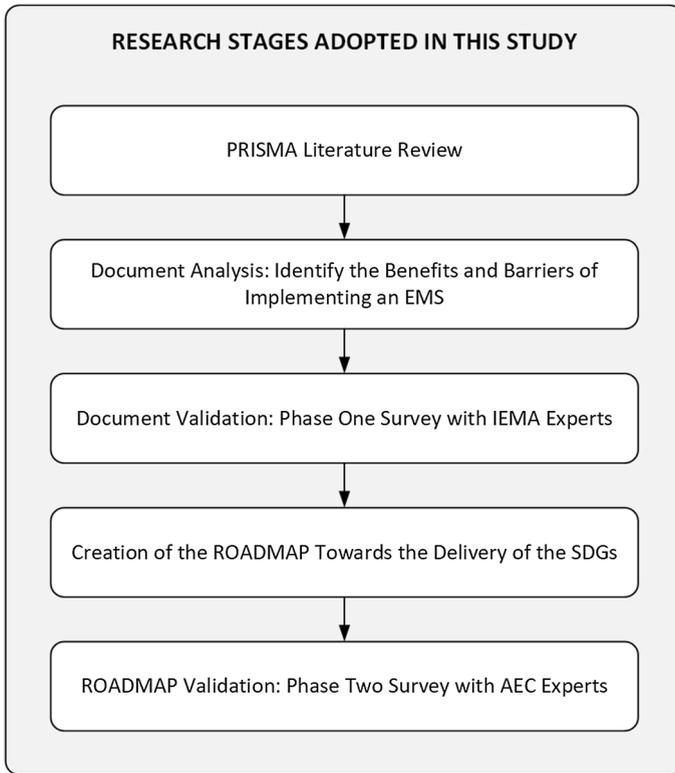


Fig. 1 Stages of the research design used in this study

Table 2 Protocol for the structured review undertaken (adapted from da Silva & Amaral, 2019)

Review Phase	Data collected	Requirements and questions
Search the data bases using keywords	Year Authors Methodology Sector Country Article type Source text	
Assessment of the content	Objectives Main results	Yes to all questions to include the paper: Does the paper focus on ISO 14001? Is it concerned with the AEC sector? Are the findings clear?
Research question related	Research questions	Yes to at least one question to include the paper: Does the study define benefits of the implementation of ISO 14001? Does the study define barriers to the implementation of ISO 14001?
Data extraction	Benefits of ISO 14001 Barriers of ISO 14001	

of inclusion criteria where at least one answer had to be positive. This resulted in 44 articles which were eligible to be included in the review.

Document analysis (Bowen, 2009) was then used to identify all the known benefits and barriers of implementing EMS in the AEC sectors. This involved a structured process of examining and interpreting the information to gain an understanding and thereby increasing knowledge (Corbin and Strauss, 2008). The information was then collated in a database and analysed, before the content was validated (Ezekannagha et al., 2020). The benefits were then reviewed to see if the same benefits could be achieved through working towards the attainment of the SDGs.

To validate the literature review, the list of benefits and barriers were shared via a Qualtrics questionnaire survey (recording participant details and opinions) with a panel of environmental experts, who were members of the Institute of Environmental Management and Assessment (IEMA) LinkedIn group. Eligibility criteria used to include participants as experts were that they needed to be: (i) an IEMA member of five years or more; (ii) hold the minimum of a Bachelor degree qualification; and (iii) be working in an environmental management role. Using the confirmed list of benefits, it was now possible to draft the roadmap to investigate whether similar benefits could be obtained by engaging with the SDGs. The incentive to use a roadmap was to provide a strategic abstract visual representation of information (Blackwell et al., 2008). Therefore, the roadmap created in this study was constructed by cross-linking each of the validated benefits of implementing ISO 14001 in the AEC sectors against each of the SDGs. Acknowledging that some of the SDG targets could be achieved more easily than others, an indication of the relative expected timescales was included. The creation of the roadmap was based on the collective roundtable opinions of the authorship team who have shared AEC and sustainability experiences exceeding 100 years and 50 years, respectively. However, since this approach could be considered as being subjective, a decision was made to seek the opinions of independent AEC industry experts with sustainability experience to validate its creation and, hence, Stage Two was implemented.

In Stage Two, the Roadmap was shared via a Qualtrics questionnaire survey (recording participant details and opinions) with a panel of AEC industry-facing professionals from each of the sectors and who are based in organisations that hold ISO 14001 certification. Eligibility criteria used to include participants as experts was that they needed to be: (i) a member of an AEC professional body; (ii) hold the minimum of a Bachelor degree qualification; and (iii) employed in one of the AEC sectors for a minimum of five years and to have worked on sustainability-related projects during that time.

4 Findings

This section presents the outcomes of the literature review and shares the opinions of IEMA experts on the information that was extracted from the review. Subsequently, the section describes the roadmap created by the authors and shares the views of the AEC experts who proffered opinion towards its validation.

4.1 Identification of the benefits and barriers of implementing EMS in the AEC sectors

The PRISMA search resulted in 137 articles being screened and checked for eligibility before a final group of articles ($n=44$) was used for the literature review (Figure 2). A

summary of these works is presented in Table 3, highlighting the continued interest in this area across a range of sectors.

The benefits and barriers extracted from the works presented in Table 3 are listed and cross-referenced to their sources (Tables 4 and 5). These have been reviewed and the frequency of each benefit and barrier being reported is presented (Figs. 3 and 4). In terms of the benefits (Table 3 and Figure 3), the most widely reported benefits are: improved environmental performance (Owolana and Booth, 2016; Shen and Tam, 2002), improved corporate image (Shen and Tam, 2002; Turk, 2009, 2012), and compliance with regulations (Turk, 2009; Johnson, 2020), whilst some of the least reported ones are: subcontractor relations (Turk, 2009) and to facilitate trade (Sakr et al., 2010). These are primarily institutional benefits. In terms of barriers (Table 5 and Figure 4), the most widely reported ones are: cost (Shen and Tam, 2002; Babakri et al., 2003; Johnson 2020), lack of expertise (Turk, 2012; Schmidt and Osebald, 2017), and lack of training (Turk, 2009; Schmidt and Osebald, 2017). The least reported barriers are industry not being ready (Kein et al., 1999) and complexity of the standards (Turk, 2009). Once again, the barriers are institutional in their perspective. From this work, it was possible to group the benefits to enable an effective roadmap to be created from the groupings: corporate image, market share, cost saving, environmental impact, operations, compliance, and CSR. This produced a more user-friendly list in terms of benefits.

It should be noted that during the review process it became clear that the benefits and barriers can differ depending on the sector and the maturity of the sector in terms of their environmental engagement. Nonetheless, common themes were found. Researchers have highlighted the economic benefits to an organisation who choose to engage in ISO 14001 (Gavronski et al., 2008; Pokinski et al., 2003), and the environmental benefits have tended to be those that focus on cost or material savings (Haklik, 1997; Hibiki and Arimura, 2011), such as using less energy, lower waste charges, reduction in the materials used, and ensuring legal compliance, thereby avoiding fines. This is the traditional economic business approach, conforming to institutional theory (Hoffman,

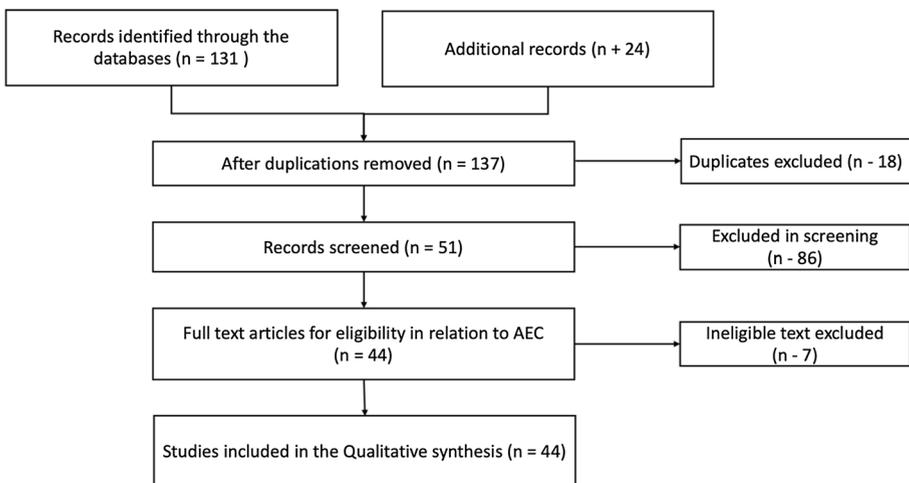


Fig. 2 Outcomes of the various stages involved in the PRISMA literature selection and identification process

Table 3 Summary details about the articles and reports ($n=44$) identified from the PRISMA literature review

#	Year	Country	AEC Sector	Method(s) used	Author(s)	Source title and source type
1	2020	UK	Construction	Questionnaire	Bailey et al	ICE Management, Procurement and Law/ Journal Article
2	2020	Various	Construction	Interview	Johnstone	Journal of cleaner production/ Journal Article
3	2019	Italy	Construction	Questionnaire	Chiariini	Business Strategy & the Environment/ Journal Article
4	2018	South Africa	Construction	Questionnaire	Ololade and Rametse	Business Strategy & the Environment/ Journal Article
5	2017	Germany	Construction	Questionnaire	Schmidt and Osebold	Journal of civil engineering and management/ Journal Article
6	2016	Various	Construction	Literature review	Campos et al	Journal of cleaner production/ Journal Article
7	2016	Australia	Construction	Audit	Dejkovski	Waste management/ Journal Article
8	2016	Chinese	Engineering	Survey	Feng et al	Journal of cleaner production/ Journal Article
9	2016	Nigeria	Construction	Survey	Owolana and Booth	Journal of Environmental Engineering and Landscape Management/ Journal Article
10	2015	Bulgaria	Construction	Questionnaire	Harizanova	Economic Engineering in Agriculture and Rural Development/ Journal Article
11	2015	Vietnam	Engineering	Questionnaire	Nguyen and Hens	Journal of cleaner production/ Journal Article
12	2015	Malaysia	Construction	Case study	Yusoff et al	Issues in Social & Environmental Accounting/ Journal Article
13	2012	Italy	Engineering	Questionnaire	Arena et al	International Journal of Business management/ Journal Article
14	2012	Turkey	Construction	Questionnaire	Turk	Environmental management—Book
15	2011	USA	Engineering	Survey	Frchetti	Journal of cleaner production/ Journal Article
16	2011	Spain	Construction	Case study	Gangolells et al	Building and Environment/ Journal Article
17	2011	Hong Kong	Construction	Survey	Lam et al	Journal of environmental management/ Journal Article
18	2011	Spain	Construction	Questionnaire	Rodriguez et al	Journal of environmental management/ Journal Article
19	2011	Finland	Construction	Action research	Teriö and Kähkönen	Construction management and economics/ Journal Article
20	2011	China	Engineering	Questionnaire	Zeng et al	Journal of cleaner production/ Journal Article
21	2010	Malaysia	Engineering	Questionnaire	Abdullah and Fuong	Asian Social Sciences/ Journal Article
22	2010	Egypt	Construction	Survey	Sakr et al	Journal of cleaner production/ Journal Article
23	2010	Latvia	Construction	Case study	Tamboveva	Economics and Management/ Journal Article
24	2009	Turkey	Construction	Questionnaire	Turk	Total Quality Management & Business Excellence/ Journal Article
25	2008	Germany	Engineering	Survey	Frondel et al	Ecological economics/ Journal Article

Table 3 (continued)

#	Year	Country	AEC Sector	Method(s) used	Author(s)	Source title and source type
26	2007	Spain	Construction	Survey	Rodriguez et al	Resources, conservation and Recycling/ Journal Article
27	2007	Slovenia	Construction	Survey	Selth	Journal of civil engineering and management/ Journal Article
28	2005	USA	Engineering	Structured interviews	Curkovic et al	Proceedings of the Decisions Science Institute/ Conference paper
29	2005	Various	Construction	Literature review and case study	Swaffield and Johnson	Architectural Engineering and Design Management/ Journal Article
30	2004	China	Construction	Literature review	Chen et al	Automation in construction/ Journal Article
31	2004	USA	Construction	Case study	Christini et al	Journal of Construction Engineering and Management/ Journal Article
32	2004	Australia	Engineering and Construction	Survey	Zutshi and Sohal	Technovation/ Journal Article
33	2003	USA	Engineering	Survey	Babakri et al	Journal of Cleaner Production/ Journal Article
34	2002	USA	Construction	Review	Ball	Building and Environment/ Journal Article
35	2002	Singapore	Construction	Survey	Ofori et al	Building and Environment/ Journal Article
36	2002	Hong Kong	Construction	Survey	Shen and Tam	International Journal of Project Management/ Journal Article
37	2002	USA	Construction	Literature review and case study	Valdez and Chini	Environmental Practice/ Journal Article
38	2001	Hong Kong	Construction	Review	Pun et al	Journal of cleaner production/ Journal Article
39	2001	Hong Kong	Construction	Case study	Tse	Journal of Environmental Assessment and Policy/ Journal Article
40	2000	China	Construction	Case study	Chen et al	Journal of Construction Engineering and Management/ Journal Article
41	2000	Singapore	Construction	Questionnaire	Ofori et al	Construction Management and Economics/ Journal Article
42	2000	USA	Construction	Case study	Quinn	Pollution Engineering/ Journal Article
43	2000	Australia	Construction	Case study	Walker	The TQM Magazine/ Journal Article
44	1999	Singapore	Construction	Questionnaire	Kein et al	Construction Management and Economics/ Journal Article

Table 4 List of the known benefits of implementing environmental management systems in the architecture, engineering and construction sectors reported in published articles and reports

Benefits of implementing environmental management systems in the architecture, engineering and construction sectors	Authors who have reported the benefits
Enrich corporate and public image	Ofori et al. (2002); Shen and Tam (2002); Valdez and Chini (2002); Adetunji et al. (2003); Swaffield and Johnson (2005); Frondel et al. (2008); Turk (2009); Sakr et al. (2010); Teriö and Kähkönen (2011); Arena et al. (2012); Turk (2012); Harizanova (2015); Owolana and Booth (2016); Ololade and Rametse (2018); Bailey et al. (2020)
Enhance image with legislators	Arena et al. (2012)
Improve relationships with stakeholders	Adetunji et al. (2003); Turk (2009)
Credibility of the organisation	Turk (2012)
Green image	Walker (2000); Shen and Tam (2002)
Reduced complaints	Owolana and Booth (2016)
Market differentiation	Tse (2001); Owolana and Booth (2016)
Investor confidence	Adetunji et al. (2003)
Competitive advantage	Ofori et al. (2000); Tse (2001); Ofori et al. (2002); Shen and Tam (2002); Adetunji et al. (2003); Christini et al. (2004); Curkovic et al. (2005); Turk (2009); Sakr et al. (2010); Teriö and Kähkönen (2011); Feng et al. (2016); Schmidt and Osebold (2017); Bailey et al. (2020)
Long-term competitiveness	Valdez and Chini (2002); Swaffield and Johnson (2005); Feng et al. (2016)
Higher profits	Feng et al. (2016)
Market-based pressures	Kein et al. (1999); Valdez and Chini (2002); Zeng et al. (2011)
Stakeholder pressure	Adetunji et al. (2003); Sakr et al. (2010)
New market opportunities	Adetunji et al. (2003); Turk (2009)
Tender requirement	Adetunji et al. (2003); Turk (2009); Rodríguez et al. (2011); Bailey et al. (2020)
Equal access to green market	Arena et al. (2012)
Facilitate trade	Sakr et al. (2010)
Pressure from competitors	Adetunji et al. (2003); Turk (2009)
Remove trade barriers	Ofori et al. (2002); Adetunji et al. (2003); Curkovic et al. (2005); Turk (2009)
To increased market share	Walker (2000); Turk (2009)
Customer satisfaction	Kein et al. (1999); Walker (2000); Ofori et al. (2002); Curkovic et al. (2005); Selih (2007); Turk (2009); Arena et al. (2012); Turk (2012); Harizanova (2015); Ololade and Rametse (2018)
Improved customer perception	Turk (2009)
Customer trust	Turk (2009)

Table 4 (continued)

Benefits of implementing environmental management systems in the architecture, engineering and construction sectors	Authors who have reported the benefits
Cost reduction	Ofori et al. (2000); Tse (2001); Shen and Tam (2002); Valdez and Chini (2002); Adetunji et al. (2003); Christini et al. (2004); Swaffield and Johnson (2005); Selih (2007); Frondel et al. (2008); Turk (2009); Teriö and Kähkönen (2011); Arena et al. (2012); Harizanova (2015); Owolana and Booth (2016); Ololade and Rametse (2018); Bailey et al. (2020)
Lower insurance costs	Tse (2001); Teriö and Kähkönen (2011)
Cost savings through energy efficiency	Quinn (2000); Tse (2001); Shen and Tam (2002); Adetunji et al. (2003); Swaffield and Johnson (2005); Johnstone (2020)
Reduce resources used	Quinn (2000); Adetunji et al. (2003); Ofori et al. (2000); Swaffield and Johnson (2005); Turk, (2009); Bailey et al. (2020); Johnstone (2020)
Reduced carbon footprint	Johnstone (2020)
Reduce waste generation at source	Quinn (2000); Tse (2001); Ofori et al. (2002); Curkovic et al. (2005); Swaffield and Johnson (2005); Rodríguez et al. (2007); Turk (2009); Franchetti (2011); Teriö and Kähkönen (2011); Bailey et al. (2020); Johnstone (2020)
Save costs related to water use	Quinn (2000)
Better environmental information flow	Christini et al., (2004); Nguyen and Hens (2015)
Continuous improvement	Schmidt and Osebold (2017)
Reduction in pollutants	Turk (2009)
Monitor and measure supplier performance	Turk (2009)
Environmental impact reversal awareness	Shen and Tam (2002); Turk (2009)
Improved environmental performance	Quinn (2000); Ball (2002); Ofori et al., (2002); Adetunji et al., (2003); Chen et al., (2004); Christini et al., (2004); Curkovic et al., (2005); Turk (2009); Gangolells et al. (2011); Arena et al. (2012); Turk (2012); Harizanova (2015); Nguyen and Hens (2015); Yusoff et al., (2015); Owolana and Booth (2016); Ololade and Rametse (2018); Bailey et al., (2020); Johnstone (2020)
Pollution prevention	Frondel et al., (2008); Owolana and Booth (2016); Bailey et al., (2020)
Increase public awareness of environmental issues	Shen and Tam (2002)
Reduced env impact	Quinn (2000); Ball (2002); Shen and Tam (2002); Valdez and Chini (2002); Christini et al., (2004); Turk (2009)
Reduced environmental risks	Turk (2009); Turk (2012)
Protect the environment	Ofori et al., (2000); Pun et al., (2001); Ofori et al., (2002); Shen and Tam (2002); Turk (2012); Harizanova (2015); Owolana and Booth (2016); Ololade and Rametse (2018); Bailey et al., (2020); Johnstone (2020);

Table 4 (continued)

Benefits of implementing environmental management systems in the architecture, engineering and construction sectors	Authors who have reported the benefits
Reduce waste generation at source	Quinn (2000); Ofori et al., (2002); Rodríguez et al., (2007); Turk (2009); Franchetti (2011); Teriö and Kähkönen (2011); Bailey et al., (2020); Johnstone (2020)
Increased recycling	Bailey et al., (2020); Johnstone (2020)
Environmental awareness	Turk (2009); Turk (2012); Ololade and Rametse (2018)
Desire for certification	Turk (2009)
Reduce emissions	Turk (2009)
Commitment to environmental responsibility	Turk (2009)
Reduce environmental incidents	Turk (2009); Bailey et al., (2020)
Better employee morale	Owolana and Booth (2016); Chiarini (2019); Bailey et al., (2020)
Employee environmental awareness	Christini et al., (2004); Rodríguez et al., (2007); Nguyen and Hens (2015); Yusoff et al., (2015); Owolana and Booth (2016); Johnstone (2020)
Employee involvement and collaboration	Chiarini (2019)
Motivated employees	Yusoff et al., (2015)
Employee satisfaction	Adetunji et al., (2003)
Subcontractor relations	Turk (2009)
Involvement of senior management	Tse (2001)
Top management commitment	Chiarini (2019)
Increasing staff skills	Christini et al., (2004); Yusoff et al., (2015); Chiarini (2019)
Better working conditions	Ofori et al., (2002); Christini et al., (2004); Turk (2009); Schmidt and Osebald (2017); Bailey et al., (2020)
Efficient operations	Ofori et al., (2000); Swaffield and Johnson (2005); Turk (2009); Teriö and Kähkönen (2011); Johnstone (2020)
Improved quality in product/service	Arena et al. (2012)
Cost savings through process improvements	Ofori et al., (2002); Valdez and Chini (2002); Turk (2009)
Improve organisational systems	Ball (2002); Christini et al., (2004); Turk (2009); Teriö and Kähkönen (2011);
Increase in efficiency and productivity	Ofori et al., (2000); Pun et al., (2001)
Management open to research/criticism	Turk (2009)
Higher productivity	Ofori et al., (2002)
Standardised processes	Ofori et al., (2000); Ofori et al., (2002); Ololade and Rametse (2018)
Improved risk management (H&S)	Bailey et al. (2020); Christini et al. (2004); Ofori et al. (2000); Owolana and Booth (2016)
Corporate management	Quinn (2000); Adetunji et al., (2003); Christini et al., (2004); Selih (2007); Turk (2009)
Conformity	Turk (2009)
Flexible	Christini et al., (2004)

Table 4 (continued)

Benefits of implementing environmental management systems in the architecture, engineering and construction sectors	Authors who have reported the benefits
Industry standards	Bailey et al., (2020)
Compliance with regulations	Kein et al., (1999); Pun et al., (2001); Adetunji et al., (2003); Chen et al., (2004); Ofori et al., (2002); Rodríguez et al., (2007); Selih (2007); Frondel et al., (2008); Turk (2009); Nguyen and Hens (2015); Dejkovski (2016); Schmidt and Osebald (2017); Ololade and Rametse (2018); Johnstone (2020)
Liability threats	Ofori et al., (2002)
Ensuring legal compliance	Ofori et al., (2000); Shen and Tam (2002); Dejkovski (2016)
Reduction in fines	Shen and Tam (2002); Adetunji et al., (2003); Bailey et al., (2020)
Lower risk of liabilities/due diligence	Adetunji et al., (2003); Owolana and Booth (2016)
Cost of non-compliance	Adetunji et al., (2003); Ofori et al., (2002); Turk (2009); Teriö and Kähkönen (2011)
Improved relations with regulators	Valdez and Chini (2002)
Improved community relations	Arena et al. (2012)
Social pressure (community/activists)	Adetunji et al., (2003); Zeng et al., (2011)
Increase stakeholder confidence	Turk (2012)
Social legitimacy and responsibility	Turk (2009); Turk (2012); Ololade and Rametse (2018)
Less complaints	Turk (2009); Turk (2012); Bailey et al., (2020)
Community participation	Shen and Tam (2002)
To improve industry/ government relations	Adetunji et al., (2003); Arena et al. (2012)
Government support/ incentives	Adetunji et al., (2003); Selih (2007)

1997), that has existed for many years. In this research, it is noted that there are both institutional and social legitimacy factors as to why a company engages in environmental management. In terms of ISO 14001, traditionally it has been used to focus on the significant aspects of the company's operations and the mitigation of negative impacts. A change in perspective from this to how positive impacts can be instigated would help companies who are compliance focused to move to society focused approaches and help deliver on projects connected to the delivery of the SDGs. However, as it is the companies who choose what the focus of their operation is and whether they choose to be sustainable or not, there would need to be an incentive to enable more to choose the more altruistic options. For instance, a grading to all ISO 14001 certificates that demonstrated a company's contribution to global issues may encourage more engagement in the SDG objectives.

This study found that there were 63 barriers to engagement with ISO 14001 from the papers reviewed, mainly in the construction sector but with a great variety in the countries involved. These factors would need to be considered in future research as potential limiting factors to the delivery of the SDGs.

One of the most often cited barriers is that of keeping pace with requirements: either of the standard or legislation. These were closely followed by the need to have

Table 5 List of the known barriers to implementing environmental management systems in the architecture, engineering and construction sectors reported in published articles and reports

Barriers to implementing environmental management systems in the architecture, engineering and construction sectors	Authors who have reported the benefits
Negative publicity	Teriö and Kähkönen (2011)
Purely image building	Curkovic et al., (2005); Dejkovski (2016)
Open to public scrutiny	Zutshi and Sohal (2004)
Cost	Kein et al., (1999); Chen et al., (2000); Ofori et al., (2000); Tse (2001); Ofori et al., (2002); Shen and Tam (2002); Valdez and Chini (2002); Babakri et al., (2003); Chen et al., (2004); Zutshi and Sohal (2004); Swaffield and Johnson (2005); Rodríguez et al., (2007); Selih (2007); Lam et al., (2011); Sakr et al., (2010); Teriö and Kähkönen (2011); Turk (2009); Turk (2012); Campos et al., (2016); Feng et al., (2016); Owolana and Booth (2016); Schmidt and Osebald (2017); Bailey et al., (2020)
Costs may be higher than BENEFITS	Ofori et al., (2000); Ofori et al., (2002); Shen and Tam (2002); Abdullah and Fuong (2010); Ololade and Rametse (2018); Bailey et al., (2020)
Doesn't add value	Dejkovski (2016); Ololade and Rametse (2018)
Top management commitment towards implementation	Pun et al., (2001); Shen and Tam (2002); Babakri et al., (2003); Turk (2009); Rodríguez et al., (2011); Ololade and Rametse (2018)
Industry not ready	Kein et al., (1999)
Setting up management structures	Shen and Tam (2002); Yusoff et al., (2015); Owolana and Booth (2016)
Identification of env aspect/impact	Kein et al., (1999); Abdullah and Fuong (2010)
Little improvement in environmental performance	Kein et al., (1999); Ofori et al., (2002); Babakri et al., (2003); Dejkovski (2016); Johnstone (2020)
Lack of link to EIA	Chen et al., (2004)
Lack of environmentally sound technology	Tse (2001); Shen and Tam (2002); Owolana and Booth (2016); Bailey et al., (2020)
Lack of concern over environmental issues	Babakri et al., (2003); Chen et al., (2004); Schmidt and Osebald (2017)
No environmental improvement	Ofori et al. (2002); Valdez and Chini (2002)
Decreased competitiveness	Shen and Tam (2002)
Existing subcontractor system	Tse (2001); Shen and Tam (2002); Selih (2007); Turk (2009); Sakr et al., (2010); Bailey et al., (2020); Johnstone (2020)
Unsuitable standard	Tse (2001); Shen and Tam (2002)
Change of existing practice	Shen and Tam (2002); Zutshi and Sohal (2004); Yusoff et al., (2015); Owolana and Booth (2016); Bailey et al., (2020)
Not required for export	Shen and Tam (2002)
Public not interested	Chen et al., (2000); Chen et al., (2004)
Lack of resources	Tse (2001); Babakri et al., (2003); Rodríguez et al., (2011); Feng et al., (2016)
Disruption to workflow	Owolana and Booth (2016)
Bureaucratic	Kein et al., (1999); Tse (2001); Turk (2009); Tambovceva (2010)

Table 5 (continued)

Barriers to implementing environmental management systems in the architecture, engineering and construction sectors	Authors who have reported the benefits
For sales not environmental stuff	Shen and Tam (2002)
Lack of employee involvement	Tse (2001); Shen and Tam (2002); Valdez and Chini (2002); Swaffield and Johnson (2005); Selih (2007); Owolana and Booth (2016); Ololade and Rametse (2018); Bailey et al., (2020); Johnstone (2020)
Inadequate organisational structure	Shen and Tam (2002); Johnstone (2020)
Employee resistance	Shen and Tam (2002); Babakri et al., (2003); Zutshi and Sohal (2004); Turk (2009); Owolana and Booth (2016)
Lack of awareness	Ofori et al., (2002); Zutshi and Sohal (2004); Tambovceva (2010); Ololade and Rametse (2018); Chiarini (2019)
Time	Chen et al., (2000); Tse (2001); Shen and Tam (2002); Turk (2009); Lam et al., (2011); Terio and Kahkonen (2011); Owolana and Booth (2016); Bailey et al., (2020)
Audits	Shen and Tam (2002)
Documentation	Tse (2001); Shen and Tam (2002); Zutshi and Sohal (2004); Selih (2007); Turk (2009); Owolana and Booth (2016); Schmidt and Osebald (2017); Bailey et al., (2020)
Can use ISO 9000 to deliver objectives	Ofori et al., (2000); Ofori et al., (2002); Turk (2012)
Complexity of standards	Turk (2009)
Lack of knowledge about ISO 14001	Kein et al., (1999); Shen and Tam (2002); Valdez and Chini (2002); Turk (2009); Turk (2012); Schmidt and Osebald (2017); Ololade and Rametse (2018)
Lack of support	Owolana and Booth (2016)
Uncertainty of benefits	Ofori et al., (2000); Ofori et al., (2002); Babakri et al., (2003); Turk (2012); Campos et al., (2016)
Lack of incentives	Ofori et al., (2002); Shen and Tam (2002); Turk (2012); Bailey et al (2020)
Relies on peer pressure and management incentives, which may be ineffective	Shen and Tam (2002)
No major impacts in the sector	Shen and Tam (2002); Ololade and Rametse (2018)
Lack of guidelines	Shen and Tam (2002); Ololade and Rametse (2018)
Incompatible subcontracting systems	Tse (2001); Shen and Tam (2002); Owolana and Booth (2016); Bailey et al., (2020)
Suppliers and subcontractors must also improve	Shen and Tam (2002); Zutshi and Sohal (2004); Swaffield and Johnson (2005); Owolana and Booth (2016) Bailey et al., (2020)
Competitive pressures	Shen and Tam (2002)
Lack of stakeholder support	Ofori et al., (2000); Tse (2001); Ofori et al., (2002); Shen and Tam (2002); Zutshi and Sohal (2004); Selih (2007); Turk (2009); Turk (2012); Owolana and Booth (2016); Bailey et al., (2020); Johnstone (2020)

Table 5 (continued)

Barriers to implementing environmental management systems in the architecture, engineering and construction sectors	Authors who have reported the benefits
Lack of stakeholder demand or pressure	Kein et al., (1999); Ofori et al., (2000); Tse (2001); Shen and Tam (2002); Selih (2007); Turk (2009); Owolana and Booth (2016); Schmidt and Osebald (2017); Bailey et al., (2020)
Separate design and build	Selih (2007)
Lack of rigour	Lam et al., (2011)
Focus on process, not results	Shen and Tam (2002)
Change is stressful	Bailey et al., (2020)
Sector is weak in terms of environment	Kein et al., (1999); Tse (2001); Shen and Tam (2002); Selih (2007); Ololade and Rametse (2018)
Risk low	Shen and Tam (2002)
Lack of materials/technology	Tse (2001); Selih (2007); Owolana and Booth (2016)
Need for tailor made training	Tse (2001); Shen and Tam (2002); Yusoff et al., (2015); Owolana and Booth (2016); Bailey et al., (2020)
Lack of experienced consultants	Ofori et al., (2000)
Lack of experience	Shen and Tam (2002); Rodríguez et al., (2011); Turk (2012); Owolana and Booth (2016)
Lack of expertise	Ofori et al., (2000); Ofori et al., (2002); Shen and Tam (2002); Zutshi and Sohal (2004); Turk (2009); Sakr et al., (2010); Tambovceva (2010); Turk (2012); Campos et al., (2016); Owolana and Booth (2016); Schmidt and Osebald (2017); Ololade and Rametse (2018); Bailey et al., (2020)
Lack of training	Tse (2001); Babakri et al., (2003); Zutshi and Sohal (2004); Swaffield and Johnson (2005); Turk (2009); Rodríguez et al., (2011); Yusoff et al., (2015); Owolana and Booth (2016); Schmidt and Osebald (2017); Ololade and Rametse (2018); Bailey et al., (2020)
Lack of knowledge	Ofori et al., (2002); Shen and Tam (2002); Zutshi and Sohal (2004); Sakr et al., (2010); Tambovceva (2010); Turk (2012); Ololade and Rametse (2018)
Legal ramifications	Teriö and Kähkönen (2011)
Legal issues resulting	Teriö and Kähkönen (2011)
Legal compliance	Kein et al., (1999)
No mechanical control	Ball (2002)

environmental expertise, the cost involved, and the lack of perceived value. All these barriers will potentially also impact on a company's willingness to engage with the SDGs.

The SDGs cover a range of sustainability issues with many underlying targets in the topic areas. From these issues, it was possible to map against the benefits of ISO 14001 to establish that the same benefits could be achieved while making a positive societal impact (Table 1). The aim of the roadmap is to enable the sector to map their

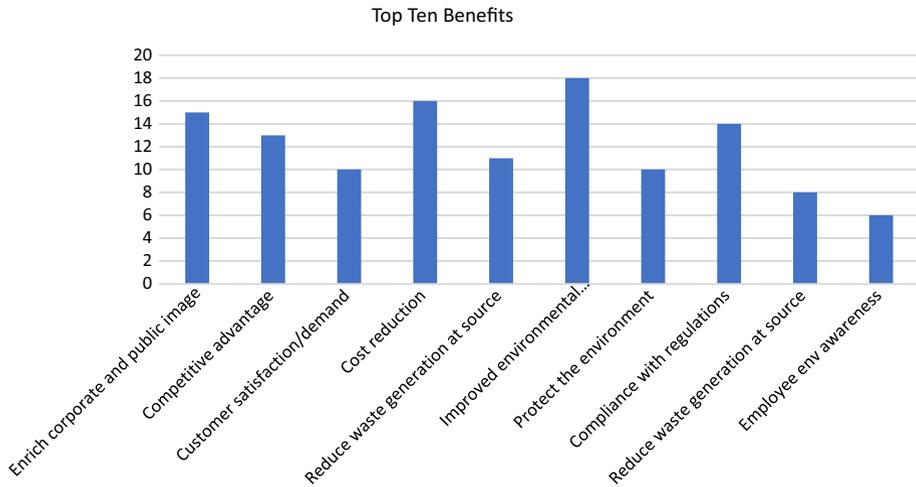


Fig. 3 Top 10 most frequently reported benefits of implementing environmental management systems in the Architecture, Engineering and Construction sectors

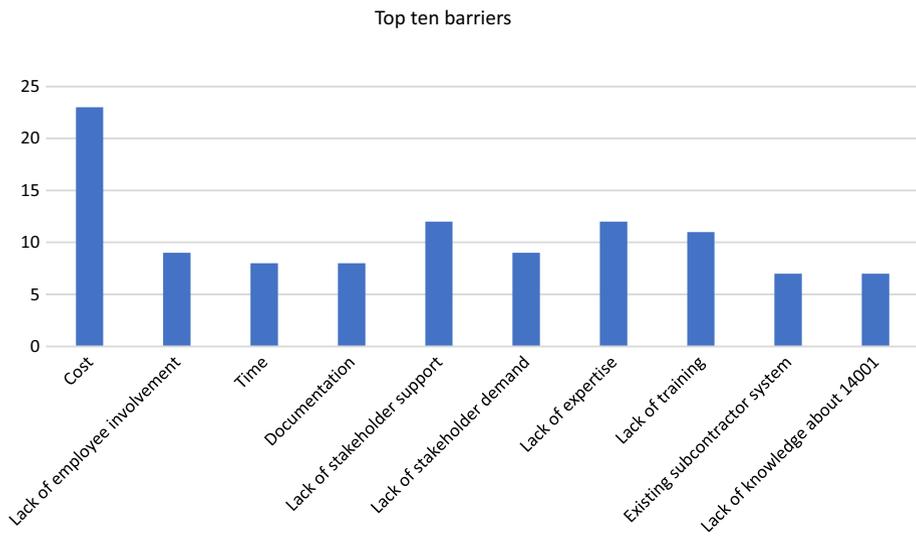


Fig. 4 Top 10 most frequently reported barriers to implementing environmental management systems in the Architecture, Engineering and Construction sectors

contribution to sustainability and to highlight the positive impacts that can be delivered through their operations. Thus, by using the SDGs in areas of operation it is possible that they can also deliver the benefits of engaging with ISO 14001. The difference would be that the SDGs enable an organisation to engage positively with the sustainability agenda outside the walls of their organisation and be seen to be making a positive difference to society.

4.2 Validation of the identified benefits and barriers of implementing EMS in AEC sectors

The lists of benefits and barriers (Tables 4 and 5) extracted from the literature were presented to IEMA experts for verification as being accurate and complete. The profiles of the participants show they are all IEMA members, with the minimum of a Bachelor degree and they have all been working in environmental management roles for more than five years (Table 6).

All participants (100%; $n=25$) confirm both lists as accurate. Most participants (84%; $n=21$) agreed that both lists were complete. Some participants kindly qualified their responses to the completeness questions by suggesting that there are other known benefits and barriers outside those extracted from the AEC literature. Whilst this is duly acknowledged, this study is focussed solely on the AEC sectors so inclusion of benefits and barriers outside the AEC sectors would not be appropriate for the purpose of inclusion in the road-map output from this study.

Table 6 Participant profiles of the Environmental Management professionals used to validate the lists or benefits and barriers identified in the literature review

Participant	Highest academic achievement	Environmental professional body membership	Years of professional environmental or sustainability experience
1	MSc	IEMA	6–10 years
2	MSc	IEMA	11–15 years
3	MSc	IEMA	6–10 years
4	MSc	IEMA	11–15 years
5	MSc	IEMA	> 20 years
6	MSc	IEMA	11–15 years
7	BSc	IEMA	> 20 years
8	MSc	IEMA	11–15 years
9	MSc	IEMA	11–15 years
10	MSc	IEMA	6–10 years
11	MSc	IEMA	6–10 years
12	MSc	IEMA	6–10 years
13	MSc	IEMA	6–10 years
14	MSc	IEMA	11–15 years
15	MSc	IEMA	6–10 years
16	MSc	IEMA	6–10 years
17	MSc	IEMA	6–10 years
18	MSc	IEMA	6–10 years
19	MSc	IEMA	6–10 years
20	MBA	IEMA	> 20 years
21	MSc	IEMA	11–15 years
22	MSc	IEMA	6–10 years
23	MSc	IEMA	6–10 years
24	MSc	IEMA	6–10 years
25	MSc	IEMA	6–10 years

4.3 Creation of a roadmap to deliver the SDGs

The roadmap was created by mapping the benefits of ISO 14001 against the SDGs to ascertain which benefits could be delivered through engagement with the SDGs. The roadmap (Figure 5) shows 1,462 total potential cells where benefits could be achieved of which 503 were considered to produce a tangible opportunity to the organisation in terms of similar benefits to those achieved using ISO 14001. Blank cells have been excluded due to their minimal cost benefit profile and hence the following percentages are calculated from the more realisable benefits. Most of these are green (74%; n=372), suggesting achievable

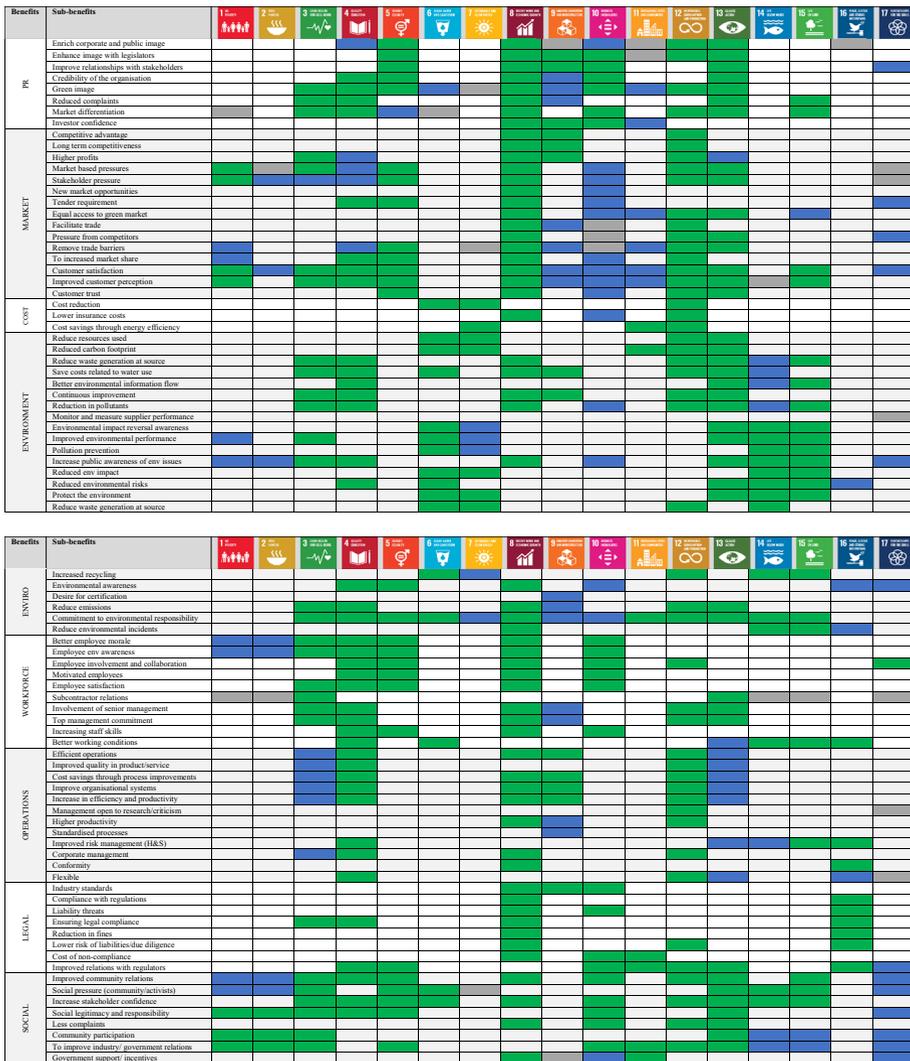


Fig. 5 Roadmap of how EMS benefits link to the SDGs (✓ Green block = short-term achievement; ✓ blue block = medium-term achievement; ✓ grey block = long-term achievement) resources

opportunities for AEC organisations operating EMS to contribute to the delivery of the SDGs and these could be achieved quite swiftly. There are blue coloured cells (equating to 21%) and grey coloured cells (equating to 5%) for the medium- and longer-term benefits. The intention is that organisations could use this as a tool to focus work to achieve their desired outcomes but also by contributing to the work on delivery of the SDGs.

All the EMS benefits have linkages across to the SDGs. SDGs 8, 12, and 13, link with at least one of the sub-benefits for each of the group benefits. SDG 8 links with the greatest number of sub-benefits ($n=59$), while SDG 2 links with the least number of sub-benefits ($n=12$). All SDGs link with at least ten of the sub-benefits, with four (SDG 4, 8, 12, and 13) linking with at least half of the benefits. The public relations, market, and social group benefits link to the most SDGs (mostly 5, 8, 10, 12). In terms of the sub-benefits: customer satisfaction, commitment to environmental responsibility, green image, improved community relations, and improved industry/government relations link to the most SDGs (3, 5, 10, 12, 13).

4.4 Validation of the roadmap

After the roadmap was created by the research team, it was presented to a group of 12 AEC industry experts to validate. The group of experts are from all parts of the AEC sectors, and all met and/or exceeded each of the participant criteria detailed earlier. As with a similar study (Ezekannagha et al., 2020), where validation was sought, a small cohort of participants were invited because the profile of the experts was deemed to be an overriding factor in the validation process. Table 7 shows the professional requirements for the nine experts who shared their thoughts and opinions of the roadmap. Most of the experts have between 6 and 10 years' experience working in the AEC sectors and in some cases participants have even more experience in the sectors. All have worked on sustainability projects, and everyone had a minimum of a Bachelor degree, with the majority qualified above this level.

They were invited to review the document and to make comments about its usefulness in assisting organisations to engage with the SDG agenda. While most of the participants thought that the roadmap was useful there were requests for instructions for the roadmap to make the process simpler. This roadmap tool was thought to be of use in one of two ways, depending on if the focus is on achieving the SDGs where it will show the potential benefits of this or, if the objective is to gain the benefits and, therefore, see which SDGs would help in the achievement of these. In terms of the green, blue, and grey blocks, the green blocks are mapped to areas which are closely linked to the sector and would be easiest to achieve in the short term. The blue blocks tend to be areas outside the standard operations of this sector and will therefore require collaboration with other parties to deliver on the goal. The grey blocks are areas where it is more likely to be longer term before benefits are seen, as in the case of partnerships where the stakeholders may not be at the same point of the journey towards sustainability and therefore may not wish to be involved now but in the long term.

5 Discussion

This study sets out to establish if the potential benefits and barriers of ISO 14001 could facilitate the AEC sectors to move towards a more sustainable approach and whether these benefits could also be achieved within organisations while facilitating the delivery on the

Table 7 Participant profiles of the Architecture, Engineering and Construction sector professionals used to validate the roadmap

Participant	AEC sector	Years of professional experience	Highest academic achievement	Professional body membership	Years of professional environmental or sustainability experience
1	Architecture	> 20 years	RIBA part 3	ARB	< 1 year
2	Architecture	1–5 years	MSc	CIAT	< 1 year
3	Architecture	6–10 years	MSc	RIBA	6–10 years
4	Engineering	6–10 years	MSc	CIBSE	1–5 years
5	Architecture	1–5 years	BSc	CIAT	1–5 years
6	Construction	> 20 years	MSc	CIOB	16–20 years
7	Engineering	6–10 years	PhD	ICE	< 1 year
8	Construction	> 20 years	MSc	ICE	6–10 years
9	Engineering	6–10 years	PhD	IMechE	1–5 years
10	Engineering	> 20 years	MSc	IMechE	11–15 years
11	Construction	6–10 years	BSc	ICE	6–10 years
12	Construction	1–5 years	MSc	CIBSE, ICE, CIOB	1–5 years

SDGs. The SDGs are a global challenge and provide a means for organisations to focus on the economic, environmental, and societal needs of the planet and to increase their social legitimacy (Suchman, 1995). The SDGs may appear a huge challenge but if all organisations contributed, the combined effect would create a greater impact. The roadmap is a means of encouraging organisations to move from their current institutional focus to a more socially legitimate position (Suchman, 1995) and enable them to consider what they are achieving through their EMS and to establish how they can achieve similar benefits while having an increased positive impact on the global issues. In many cases, this could bring bigger rewards in terms of positive stakeholder relations (Jizi, 2017), genuine positive impact on societal issues and well-being of their staff and neighbouring communities.

To enable this to happen, there needs to be a clear understanding of which SDGs will be the easiest to target first. While other researchers have highlighted SDG 1, 9, and 11 (Lynch & Mosbah, 2017) 7, 12, and 13 (Goubran et al., 2019), it is suggested here that first and foremost the AEC sectors should be focusing on: SDG 4—quality education to ensure that the workforce has understanding about the environment and sustainability; SDG 8—decent work and economic growth; 12—responsible consumption; and 13—climate action. If these are combined with SDG 17, which is partnership for goals, this would enable construction companies, architects, planners, and government to work together to achieve sustainability. As previously noted, the construction sector has a huge impact on the sustainability of society. This roadmap is a method to improve the performance of this sector in delivering positive impacts for society. It should be acknowledged that there will be restrictions in terms of how companies can engage. Some will not have the finances or staff to make huge impacts due to their size (Hahn and Kühnen, 2013), but every person and every organisation can make some impact. It may be that they focus on small positive steps to move to a more sustainable agenda within their strategy or work on a local project. Nonetheless, whatever they do, there is clear interest in terms of sustainability from the public (Erdil et al., 2018) and this will only increase over time. Currently there are huge challenges in terms of biodiversity, food, and health throughout the world (Daszak et al., 2000) and the SDGs will help as a global focus on improving our interactions (Georgeson et al., 2017) and how we can maintain work to improve the issues.

6 Conclusions

Literature shows there is worldwide interest in the adoption of sustainable practices within the AEC sectors. Therefore, it is proposed that a need exists for an amalgamated approach that is relevant for the sectors and all organisations working within them. In terms of the benefits and barriers of implementation of ISO 14001 noted here are similar to research that has been conducted in other industry sectors. This study has highlighted an extensive list of benefits to support the implementation of ISO 14001 within the AEC sectors, and while it is acknowledged that there are also barriers, to move forward in a sustainable manner the use of ISO 14001 as a framework would enable companies to focus on delivery of SDG objectives. This linking of the benefits of ISO 14001 to the SDGs in a roadmap has shown how organisations could help in the delivery of the SDGs. There is a general desire amongst the global population for sectors to be seen as being more responsible in terms of sustainability. The market mechanisms, however, limit the options in terms of what can be delivered, and it is suggested here that the standards could be used more effectively. One potential way forward is for the professional bodies to push for a level to be created for

their individual sectors, that companies could then sign up to. A gold standard: they could gain a sector specific badge, meaning, that while organisations can use an EMS for the benefit of the impacts of the organisation and monitoring of their progress; they could also utilise it to demonstrate their commitment to the SDGs, by going above and beyond the standard.

If the AEC sectors are to play a leading role in the journey to sustainability, there is a need for a clear delivery plan for achieving the SDGs. This would help to ensure not just environmental survival but social and economic success against issues such as climate change and the resultant migration of populations. The sectors, need to work on the SDGs and to align with the 5 Ps: people, planet, prosperity, peace, and partnership, which require actions to be taken by a range of stakeholders including governments and businesses to go beyond the purely environmental objectives of sustainable development. This provides a huge opportunity for the AEC sectors to be ahead of the curve in terms of using the roadmap to help demonstrate the economic viability of delivery of the SDGs and the resulting social legitimacy.

As the SDGs will benefit the whole of society, it must be remembered that the achievement of these goals will result in an increased standard of living for all; everyone will benefit. Going forward it would be useful to understand:

- The impact of the roadmap when used by an organisation to focus on the delivery of the most relevant SDGs.
- An investigation into the opportunities and challenges of using the roadmap within the sector.
- Whether the roadmap changes an organisations perspective on the deliverability of the SDGs.
- Whether the roadmap could be focused on the national and local issues to gain a true perspective of where society is in terms of sustainability.
- How the roadmap could be used in other sectors that have an impact on a global scale.
- How the barriers to implementation of ISO 14001 may delay the delivery of SDGs through businesses.

Industries such as construction are dependent on the environment, and therefore, it would be expected that they should be amenable to promoting sustainability, not just in terms of their operations but also in terms of how they interact with the communities that are situated around their operations. More research is needed in the application of the roadmap in practical terms to test the validity of the design and use. It is suggested that this should be a first step to understand the usefulness of the roadmap in helping organisations assess where they can make positive changes and how these can be highlighted to stakeholders.

This roadmap will improve the opportunities for organisations to promote their involvement with the local community, which will promote social legitimacy and allow stakeholders to have an increasingly transparent view of the company's sustainable performance. It will enable the process to highlight any conflicts that have occurred and how the response to these conflicts was appropriate and had been justified. This would result in a system which not only enables the SDGs to be worked towards on a global scale, but also the actions and impacts of those organisations who are engaging can be measured, recorded, and actions justified, benefiting society, the environment, and the economic performance of the organisation involved, thereby, increasing both their institutional and social validity. Data provided to the sector bodies from the organisations would deliver more information

on how their sectors are progressing in terms of the SDGs and demonstrate to all stakeholders which sectors and particular organisations are truly committed to sustainability.

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Data availability Available on request.

Declarations

Conflict of interest The authors declare that they do not have any conflict of interest.

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