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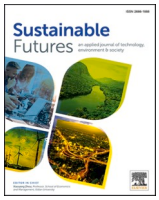

Critical review of the drivers and barriers for adopting net zero carbon procurement for construction projects

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ABSTRACT

To meet the net zero 2050 target in construction, a net-zero carbon public procurement policy is needed. This paper adopts a systematic review approach to explore the drivers and barriers to adopting net-zero carbon procurement. The top three drivers include developing sustainable public procurement policies, increasing investment in low-carbon procurements, and high demand for green construction projects. The top three barriers include inadequate budget for net-zero procurement implementation, weak capacity in public and private institutions to implement net-zero policies, and low stakeholder involvement. The paper's findings provide insights for stakeholders to effectively adopt net-zero carbon procurement for construction projects.

1. Introduction

The widespread adoption of the net-zero carbon concept in construction management has sparked significant interest across the global construction industry (Hasan AM [1]; Ida [2]). Many organizations in the construction industry have committed to achieving net-zero carbon emissions by 2050, in line with the Climate Change Act's goal of reducing greenhouse gas emissions (Helen [3]). Since the built environment is responsible for over a third (38%) of global emissions, and 70% of an organization's emissions stem from the supply chain, procurement plays a crucial role in meeting the net zero targets. This includes both the physical attributes of the items being procured and the performance standards of these assets [4].

The main challenge lies not in setting these net zero targets, but in fulfilling and demonstrating them. It has been reported that the gap between aspirations and achievements in the built environment is often associated with the conduct of procurement [5,6]. In construction project management, procurement begins with preparing the design documents for the required work and continues with the documentation of requests for proposals, an invitation to tender [7]. Different service providers, contractors, and suppliers submit their tenders or proposals, upon which the merits of the potential bids are discussed and evaluated (Hasan AM [1]). Once a provider has been chosen, terms are finalized, the contract is ratified, and the service is delivered, or the goods are provided [6]. This is usually called the traditional procurement process.

In place of the traditional procurement processes in construction activities, Net Zero procurement (NZP) has gained significant traction in the construction industry forming part of the larger global goal to attain zero carbon emission targets (Mosey 2022, [8]). NZP targets are embedded within the design and procurement process of the construction industry's long-term goals and the industry is grappling with the implementation and delivery of those targets. At the core of Net-zero procurement is the purchase of climate-friendly materials for construction projects together with rendering services that are conscious of the carbon footprints ([9], I. [10]). NZP is inclusive of checklist of specifications of net-zero carbon emissions on goods and services for construction activities [11]. These specifications in the construction procurement processes promote climate-friendly projects to attain circular economy. The specifications of NZP also demand the disclosure of the commitment of parties involved in the construction procurement contracts especially the suppliers to attaining scientific-backed net-zero targets (H. [3]). The net-zero specifications add up to the existing traditional procurement checklists on quality and performance of the contracts.

Although, procurement is a key stage in achieving the planned outcomes of construction projects, it is unclear the drivers and barriers that

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affect the adoption of net zero requirements for construction procurement (Mosey 2022, H. A. M. [1]). Essentially, understanding the drivers and barriers on net zero procurement will provide in depth knowledge on the issues affecting the successful adoption of net zero for construction procurements. More importantly this will enable government authorities to develop effective procurement and tendering policies for the adoption of net zero requirements for construction projects. Currently, in construction management research, there are inadequate studies on NZP despite heightened interest in the subject. Importantly few studies that have closely discussed NZP in construction include Hamdan et al [1]; Bataille et al. [12]; and Das et al. [13]. However, these few past studies mostly focused on the general application of the net zero carbon concept and general issues associated with them. Importantly the past studies failed to holistically ascertain the drivers and barriers associated with the adoption of NZP for construction projects. Considering this, it is therefore critical for more studies to be conducted to explore the emerging barriers and potential drivers for NZP adoption in the construction industry.

In this regard, this systematic review seeks to ascertain the drivers and barriers of net-zero procurement in construction projects and further develop a conceptual model. The novelty of this study is the provision of a conceptual model with hypotheses based on the comprehensive checklists on drivers and barriers of NZP derived from literature. Additionally, this review provides insight into the various areas of concern of NZP which could be adopted for further investigations. The findings of this paper inform governments and construction stakeholders of the potential challenges and strategies for incorporating net zero requirements in the public procurement process. This will ensure effective adoption of net zero carbon procurement for construction projects. The rest of the study has methodology, followed by the findings together with discussions. The concluding section include the implications of the study and recommendations for future directions.

2. Research method

2.1. Search Strategy

The research method utilised in this study is systematic literature review (SLR). SLR seeks to identify, summarise, and analyse the findings of existing literature to address specific research question while employing necessary measures to limit bias and random error [14,15]. To understand and report the outcomes of the systematic review, the 2020 updated guideline for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was adopted [7,4]. The PRISMA 2020 guideline includes a 27-item checklist that provides a uniform standard that assist reviewers to, precisely, and thoroughly document and report on the findings of systematic reviews and meta-analyses [16]. The PRISMA guidelines also address the risk of bias, reproducibility and quality issues that may surround process of uncovering the results of a systematic review [17]. The search strategy includes the identification of relevant variants of search terms including “net-zero emissions”, “procurement” and “construction projects” were generated from a preliminary reading on the subject matter as keywords. The expanded form of the search terms includes the following keywords: “net-zero” OR “net-zero emissions” OR “net-zero targets” OR “low-carbon emissions” OR "zero emission” OR “carbon ‘neutral” OR “procurement” OR “project delivery" OR "project procurement” “building projects” OR “construction projects” OR “infrastructure” OR “buildings” OR “public facilities”. Prominent academic databases in the construction and engineering management field such as Scopus, Web of Science, ProQuest, and Google Scholar were utilised for the search. These databases have wider coverage, documents, and data on this topic together their greater usage in research in the construction and engineering field [18,19].. The first-round search in the academic databases produced a total of 124 peer-reviewed journal and conference articles and 8 grey literatures of institutional reports on net-zero procurement for project development. The details include Scopus [7], Web of Science [20], ProQuest [21], Google Scholar [22], and PubMed [23].

2.2. Relevant article selection process

At this stage, title screening ensued using the search results from Section 2.1. The goal was to ensure there were no duplicates from the five bibliographic databases and articles that do not meet the inclusion criteria are removed at the first sight. This process resulted in the removal of 54 duplicate documents. The retained 70 documents were then compiled and screened for duplicates. For the abstract screening, studies that did not have a core focus on “net-zero emissions”, “procurement” and “public project lifecycle” in the abstract were excluded. This stage of screening led to the further exclusion of 23 visibly inapplicable documents and retaining 47 documents. At the final stage of the selection process, three further inclusion and exclusion criteria were applied to ensure the eligibility of the selection of the studies with full-text reading of the documents. First, the choice of document type and source for the peer- reviewed papers used were limited to peer-reviewed journal articles, institutional reports, and conference papers. All book chapters, books, data papers, commentaries, and opinion pieces on this topic were excluded. Second, selected studies were written in English, and all other documents not published in English were excluded. Lastly, only documents that provided comprehensive information on net-zero procurement strategies for construction projects were included.

A comprehensive full-text reading and assessment of the document resulted in the inclusion of 24 documents (15 peer-reviewed articles and 9 grey literatures of thesis and reports) as the final studies used in the review analysis. The summary of the research method is shown in the PRISMA flowchart (Fig. 1).

2.3. Data extraction and synthesis

Following the full-text reading of the 24 publications, the following bibliographic data were extracted into the Microsoft Excel: article title, year of publication, country, project type, research design and publication source. These data were collated and analysed forming the basis of the first section of Section 3. In addition, texts, phrases, keywords, and statements were retrieved from the s documents. The extracted data were coded and translated into themes according to the patterns of similarities of the commonalities towards providing details to information. Thematically, the themes were compared, re-read and analysed to establish the best explanations to drivers and barriers of net-zero procurement for construction projects.

3. Results and Discussion

3.1. Characteristics of relevant literature for this study

As demonstrated in Table 1, the studies included 15 peer-reviewed journal articles, and 9 conference articles and reports. The peer-reviewed journal articles are scholarly works assessed by experts in the same field of construction management and published by academic journals such as Sustainability, Journal of Cleaner Production, and Journal of Architectural Engineering [24]. On the other hand, the reports and conference papers which are grey literature are included in this analysis. Grey literature are documents that are not published commercially like the peer-reviewed articles, and they may not be available through a search in the standard bibliographic databases [25]. Except Sanders et al. [26] and Pless et al. [27], all the studies published after 2015, the aftermath of the kick-off of the United Nations Sustainable Development Goals that champion climate action and net-zero carbon emission issues [28]. Almost every study was conducted in a developed country within the European and North American continents. India is an exception, a developing nation that recorded a study with a

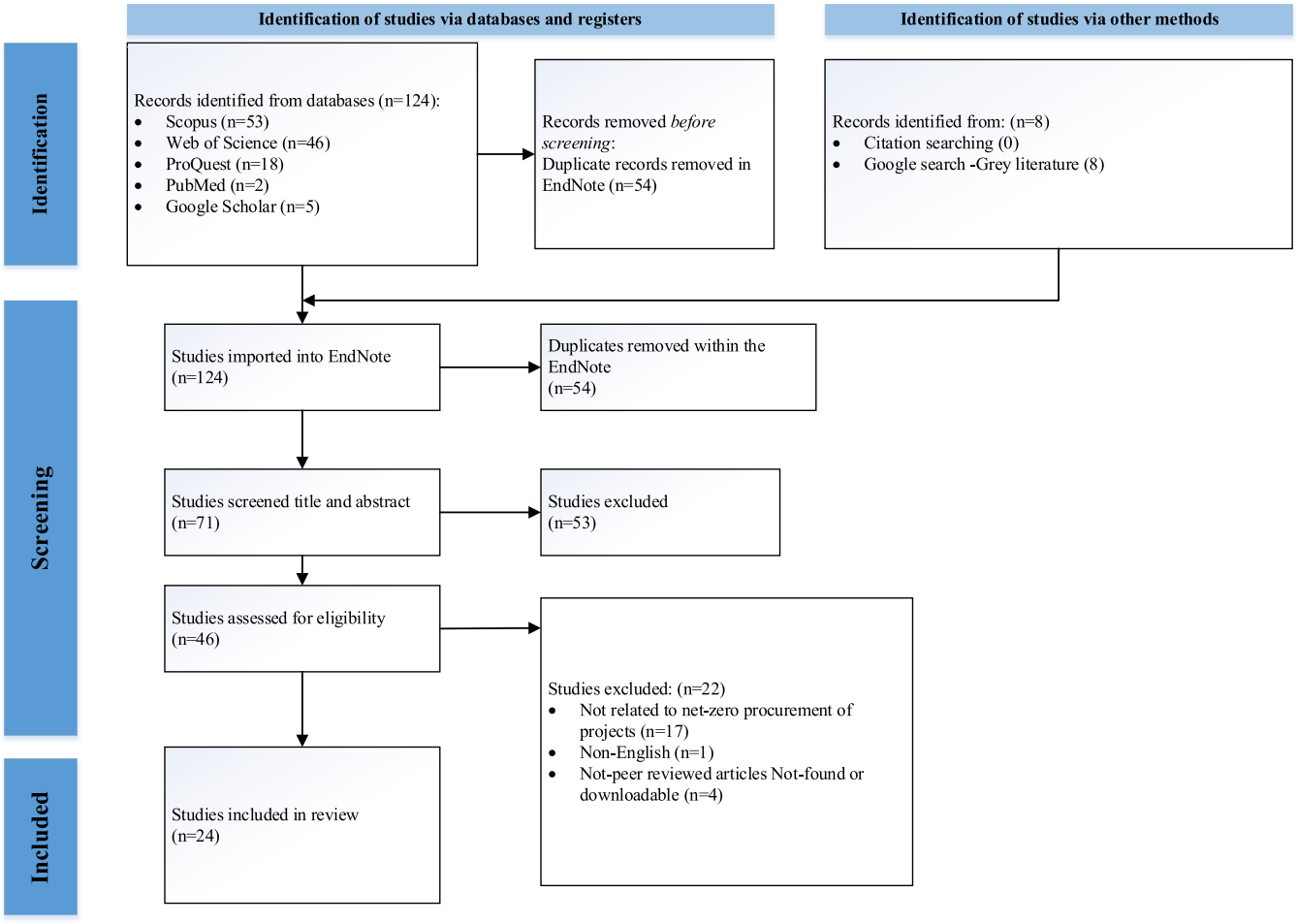

Fig. 1. PRISMA method flowchart.

national target of achieving net zero in 2070 [13]. In these advanced nations, construction projects are designed and built to meet the national targets on net-zero emissions [29]. The majority of the studies covered construction building projects with few studies on other public infrastructure such as roads and light rails. Studies included had research designs of systematic review, qualitative studies, mixed method, cross-sectional studies, and grey literature.

3.2. Drivers of net-zero carbon procurement

After a thorough review of the 24 publications, the 36 key drivers were derived, and these are shown in Table 2. In the table, the number of references of a variable is presented in Column 3. This frequency or number of times a variable has been mentioned was used to form the basis for the overall rankings (see Column 4). Based on the rankings, the top three drivers include developing sustainable public procurement policies: increasing investment in low/zero carbon procurements and High demand for green construction projects. Discussion on the top three ranked drivers are shown below

3.2.1. Developing sustainable public procurement policies (D1)

This driver was ranked 1st with 16 references. This clearly indicates its significance towards the adoption of NZP. Increasingly, traditional procurement policies are evolving around the world due to international and national targets to meet sustainable and inclusive development, minimise the effects of extreme climate change, attain net-zero emissions and value for money in construction activities (Mosey 2022, [22]). These targets have triggered numerous public sector reforms in procurement of goods and services for the entire life of projects from conception to disposal and decommissioning stages. Recent United Nations' Conferences on Climate Change call for deliberate and comprehensive procurement policies in a sectors including the construction industry to achieve net-zero carbon reduction in the procurement processes a [40]. In addition, World Trade Organisation's Fundamental Conventions and International Labour Organisation's standards demand ethical, fair, and human rights inspired supply chain policies in the public procurements. The standards and agreements are having trickle down impacts on formulation of new policies and revision of existing policies towards net-zero procurements [41].

Further, there are specific United Nations Sustainable Development Goals (UN SDGs) that promote the reformation of public procurement policies. For instance, UN SDG 9 and 13 (climate action and resilient infrastructure) provide guidelines towards sustainable infrastructure development while ensuring total reduction of carbon emissions with sustainable supply chain models UNSDG 17 calls for partnership with suppliers who are climate-friendly and committed to the supply of net-zero carbon raw materials for construction activities [42]. In United Kingdom and Australia, there have been procurement policy realignment to climate change issues in recent with the main focus to attain net-zero targets in 2050 [43,44]. In the long run, it is expected that these changes in procurement legislations will help ensure decarbonization of the construction activities for resilient and sustainable infrastructure development.

3.2.2. Increasing investment in low/zero carbon procurements (D2)

The driver achieved a 2nd place ranking with 11 references. There is

Table 1
Description of selected publications.

ID	Article (Authors)	Publication/Source	Document type	Study Setting	Project type	Study Design
1	Sanders et al. [26]	Journal of architectural engineering	Journal article	United States	University Campuses	Qualitative
2	Rebane and Reihan [5]	Management of Environmental Quality: An International Journal	Journal article	Estonia	Buildings	Qualitative
3	Sparrevik et al. [9]	Journal of Cleaner Production	Journal article	Norway	Buildings	Mixed method
4	I. Karlsson et al. [10]	Renewable and Sustainable Energy Reviews	Journal article	Sweden	Construction projects	Mixed method
5	I. Karlsson et al. [30]	Energies	Journal article	Sweden	Buildings	Mixed method
6	Kuittinen and Häkkinen [11]	Buildings and Cities	Journal article	Finland	Buildings	Mixed method
7	Garcia-Freites et al. [31]	Biomass and Bioenergy	Journal article	United Kingdom	Net Zero Bioenergy	Mixed method
8	Karlsson et al. [32]	Developments in the Built Environment	Journal article	Sweden	Residential buildings	Mixed method
9	Shamsi et al. [33]	Journal of Cleaner Production	Journal article	Canada	Electric Vehicle Charging Infrastructure	Quantitative method
10	Chen et al. [34]	Journal of cleaner production	Journal article	OECD countries	Construction projects	Literature review
11	H. McGarry et al. [3]	Case Studies in Construction Materials	Journal article	United Kingdom	Network Rail	Qualitative
12	Vimal et al. [8]	Journal of Cleaner Production	Journal article	India	Building	Cross-sectional study
13	Wagner et al. [35]	Sustainability	Journal article	Poland	Port Infrastructure	Mixed method
14	H. A. M. Hamdan et al. [1]	Environment Systems and Decisions	Journal article	Norway	Zero-emission neighbourhood (ZEN) projects	Qualitative
15	Stokke et al. [6]	Environment Systems and Decisions	Journal article	European Cities	Zero-emission infrastructure projects	Qualitative
16	Hamdan and De Boer [36]	IOP Conference Series: Earth and Environmental Science	Conference article	Norway	Zero-emission neighbourhood (ZEN) projects	Grey literature
17	Mah et al. (2016)	2016 ASEE Annual Conference & Exposition	Conference article	Canada	Building	Grey literature
18	Nina et al. [37]	Transportation Research Procedia	Conference article	Netherlands	Transport	Grey literature
19	Pless et al. [27]	ASHRAE Winter Conference	Conference article	United States	Net Zero Energy Office Buildings	Grey literature
20	Fufa et al. [38]	IOP Conference Series: Earth and Environmental Science	Conference article	Norway	Net Zero Construction	Grey literature
21	Mosey (2022)	Kings College	Report	United Kingdom	Net Zero Construction	Grey literature
22	WEF [39]	World Economic Forum	White Paper (Report)	OECD countries	Net Zero Construction	Grey literature
23	Brandon [21]	OECD	Report	OECD Countries	Public infrastructure	Grey literature
24	Kadefors (2019)	KTH Royal Institute of Technology	Report	Sweden	Infrastructure construction projects	Grey literature

an undeniable surge in the demand for low-carbon construction, alongside pressing needs for indoor air quality and stringent safety measures for users. To reach this goal, project managers procure climate-friendly materials with green finance. Financial institutions such as The Hongkong and Shanghai Banking Corporation (HSBC), Bank of China, JPMorgan Chase, Wells Fargo, and World Bank are changing their loan granting requirements for stakeholders in the property and construction sector to green and low carbon status [45]. These requirements are promoting green finance in the supply chain of materials and services in the built environment [6]. Moreover, Organisation for Economic Co-operation and Development (OECD) countries such as France, United States, United Kingdom (UK), Australia and Canada have a policy on attaining net-zero target by 2050 [46]. With this goal in sight, all financial transactions and multilateral financial assistance given to developing nations from these rich OECD countries ensure a total reduction of greenhouse carbon emission and promotion of sustainable supply chains [47]. Net-zero procurement financial instruments such as green credit, climate finance, carbon finance for mortgages and climate-resilient infrastructure funds are becoming taken prominence in the construction industry [48,49].

3.2.3. *High demand for green construction projects (D3)*

This driver was placed 3rd. International and national policies to attain net-zero emissions are pushing the construction industry to minimise activities that emit high volumes of greenhouse gas that have negative impacts on the environment. Also, there is a call to transition to green construction development to promote the creation of net-zero, smart and sustainable cities [50]. For instance, Hong Kong, China, Australia, and United States have Green Building Councils that require and supervise green buildings in the major cities of the countries listed above. Rapidly, most countries are experiencing rural areas turning into urban mega cities with housing crisis and slums that inimical to the environmental protection and human well-being. This calls for the construction of green and affordable houses and public facilities to accommodate the increasing urban population [51]. The early contract involvement of net-zero procurement delivery methods guarantees attainment of green construction of green buildings [52]. Major government contractors and suppliers to mega construction projects are insisted to provide clean products to cushion carbon emission-free infrastructure development while ensuring inclusivity and fair wages to workers at construction sites [23]. The partnership between project managers and private financiers in the built environment also emphasise on low-carbon construction due to high demand for green buildings on the property market. Residential homeowners are motivated to purchase houses with net-zero content that improve their health, cater for disability status, and social diversity inclusivity.

3.3. *Barriers of net-zero project procurements*

Thirty-three barriers for adopting net zero procurement were identified in the selected articles and they are presented in Table 3. Similar to the rankings of the drivers in Section 3.2, the barriers are ranked based

Table 2
Success factors of net-zero project procurements.

Code	Drivers/success factors	References (refer to Table 1)	Rank
D1	Developing sustainable public procurement policies	1, 2, 4, 6, 7, 8, 9, 11, 13, 15, 17, 18, 21, 22, 23, 24,	1
D2	Increasing investment in low/zero carbon procurements	1,3, 5, 7, 8, 10, 12, 13, 16, 17, 22,	2
D3	High demand for green construction projects	6, 7, 8, 9, 12, 13, 15, 18, 19, 20,	3
D4	Adoption of climate-smart procurement models into construction projects	1, 2, 4, 6, 7, 8, 9, 13, 15,	4
D5	Increased sustainable consumption and production	5, 6, 7, 8, 9, 12, 14, 15,	5
D6	Recent summits on tackling climate crisis	6, 7, 8, 9, 13, 14, 15, 16,	6
D7	Alignment with global agenda on net-zero emissions	5, 6, 7, 8, 9, 12, 14,	7
D8	Boosting green procurement practices in the construction industry	1, 2, 6, 7, 8, 9, 13,	8
D9	Preserving the natural environment	1, 4, 5, 6, 7, 8, 9,	9
D10	Maintaining ecological balance from procurement practices	2, 5, 6, 7, 8, 10, 11,	10
D11	Rise in quality packaging of materials	1, 2, 10, 12, 15, 17,	11
D12	Innovative urban infrastructures	5, 6, 7, 8, 9, 15,	12
D13	Job creation of supply chain	1, 4, 5, 7, 13, 15,	13
D14	Adaptation strategies for low-carbon procurement	6, 7, 8, 9, 15, 18,	14
D15	Joint effort with private sector and local authorities	6, 7, 8, 9, 15, 24,	15
D16	Higher value in green materials	6, 7, 8, 9, 18,	16
D17	Technological advancement in supply chain	1, 2, 4, 5, 11,	17
D18	Social participation, inclusion, and support	1, 4, 11, 15, 20,	18
D19	Increasing user awareness on net-zero strategies	2, 5, 15, 22, 28,	19
D20	A shift towards social inclusion and diversity	2, 5,21, 23, 6	20
D21	Rapid promotion of green and sustainable purchasing of construction materials	16, 24, 3, 5	21
D22	Public sector support, maintenance of urban infrastructure procurement	1, 24, 2	22
D23	Control of anthropogenic activities	4, 23	23
D24	Project implementations and interventions	1, 6	24
D25	Low inflation and interest rates	20, 24	25
D26	Socio-economic infrastructure development	1, 2,	26
D27	Need for climate and green finance	6, 7,	27
D28	Training on net-zero supply chains	1, 2,	28
D29	Improved documentations on project procurements	1, 4,	29
D30	Capacity building to transition to sustainable construction supply chain	1, 2,	30
D31	Available strategies to collaborate and coordinate green procurements	1, 4,	31
D32	Development of comprehensive procurement database	6, 7,	32
D33	Clean pre-tendering processes	1, 2,	33
D34	Well-defined IT public procurement strategies	1, 4,	34
D35	Preserving natural resources	2, 5,	35
D36	Strategic planning and design of green procurements	16,	36

on the number of times or reference count. The top three ranked barriers include inadequate budget for net-zero procurement implementation; weak public institutions and private firm capacity to implement net-zero policies and inactive involvement of stakeholders towards net-zero goals. These topmost three barriers are further explained below.

Table 3
Barriers to net-zero project procurements.

Code	Barriers	References (refer to Table 1)	Rank
B1	Inadequate budget for net-zero procurement implementation	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13, 15, 16, 17, 19, 21, 22, 23	1
B2	Weak public institutions and private firm capacity to apply net-zero procurements	1, 3, 4, 5, 6, 7, 8, 9, 11, 13, 14, 16, 18, 19, 21, 22, 23	2
B3	Inactive involvement of stakeholders towards net-zero goals	1, 2, 3, 4, 5, 6, 8, 11, 12, 13, 15, 17, 18, 19, 21, 23	3
B4	Excessive costs related to net-zero supply of construction materials	1, 3, 4, 5, 6, 7, 9, 11, 13, 14, 17, 18, 20, 21, 23	4
B5	Little support from construction industry on net-zero procurements	2, 3, 4, 6, 7, 9, 11, 12, 13, 17, 19, 20, 22	5
B6	Non-disclosure of net-zero procurement strategies	1, 3, 6, 7, 10, 12, 15, 16, 19, 20, 22, 23	6
B7	Lack of coordinated global efforts to transition to net-zero supply chains	1, 2, 3, 5, 8, 10, 13, 15, 19, 22, 23	7
B8	Information gap on net-zero procurements	3, 4, 5, 8, 10, 11, 14, 18, 19, 21	8
B9	High consultation fees on green procurements	1, 3, 4, 7, 9, 13, 17, 19, 22	9
B10	Difficulty in measuring the environmental impacts of projects procurements	1, 3, 5, 8, 12, 16, 17, 20,	10
B11	No reporting or accountability on measures towards net-zero targets	1, 3, 4, 5, 12, 16, 19, 22	11
B12	High risk profile on net-zero procurements	4, 7, 11, 15, 17, 18, 19	12
B13	Limited of national policies on net-zero procurements	1, 5, 7, 14, 16, 20, 23	13
B14	Prevalence of misappropriation of funds/Corruption	4, 7, 9, 18, 21, 23	14
B15	Negative political influences on national procurement transactions	3, 12, 15, 17, 20	15
B16	Insufficient incentives to invest in low carbon supply chains	1, 2, 5, 7, 13	16
B17	Project procurement policy misalignment with net-zero goals	1, 3, 12, 16	17
B18	Lack of technical expertise within the project team	1, 3, 14, 16	18
B19	Few smart technologies on project procurements	1, 4, 14, 21	19
B20	Low awareness and education on net-zero procurements within the construction industry	3, 15, 18	20
B21	Questionable suppliers' environmental practices	1, 6, 10	21
B22	High transition costs to green project procurements	1, 6, 21	22
B23	No social justice and diversity policies in procurements	14, 16, 19	23
B24	Ineffective collaborations on net-zero strategies on procurement	1, 14	24
B25	Little or no training on net-zero procurements	1, 16	25
B26	Insufficient innovation on net-zero construction supply chains	1, 3	26
B27	Limited council compliance on net-zero procurements	6, 9	27
B28	Unavailability of rating and tracking systems on green project procurements	1, 2	28
B29	No transparency in procurement contract governance	1, 3	29
B30	Unrealistic targets on carbon emission reduction on construction procurements	1, 3	30
B31	Ambiguities surrounding the definition of net-zero procurements	1, 4	31
B32	Conflicting interests on green procurements	3, 15	32
B33	Unclear mandate of the procurement team	1, 6	33

3.3.1. Inadequate budget for net-zero procurement implementation (B1)

This barrier was ranked 1st with a reference count of 18. Financing net-zero procurement to obtained goods and services for construction activities is more expensive [44]. At the organisational and project levels, it was identified in the selected publications there is inadequate budgetary funds for net-zero materials [9,32]. In comparison, it was evident from the studies that project management practitioners still rely on traditional and high carbon emitting products to construct projects [38]. In developing countries such as Ghana, India, Mexico and China, and even most developed nations there is heavy reliance and purchase of climate-threatening products for infrastructure development. Kadefors (2019) and Lo and Chen (2020) mentioned that fossil products are cheaper comparative net-zero construction materials. The transportation sector for instance is more reliant on fossil fuel products such as crude oil, coal tar, and gas due to the low costs associated with them in comparison with renewable energy products which are expensive (Jacobs, 2022). Despite worldwide outcry to minimise the fossil products, the financial supports from key stakeholders in the construction industry have proven to be not enough to shy away from using fossil products. Furthermore, there is a huge financing gap in supporting net-zero supply chain to promote climate-smart projects (White & Wahba, 2019). For example, Ahmed et al. [23] cited lapses in funding of the green procurement implementation on Pakistan's Sindh province Water Project to meet the project's climate and clean energy targets.

3.3.2. Weak public institutions and private firm capacity to implement net-zero policies (B2)

This barrier was ranked 2nd with a reference count of 17. It remains a challenge, the mismatch between construction firms and industry, national and international policy targets on net-zero emissions. Different project firms implement different policies which are not in consonance with the cutting-edge net-zero projects. Project managers from the studies such as Kuittinen and Häkkinen [11] and Nina et al. [37] possess different worldview on the implementation of net-zero procurement. Existing procurement strategies either avoid net-zero procurements or weak systems for implementation in many construction firms. A prevailing gap in construction firm's capacity to implement net-zero procurement, according to Zhang et al. [53] pose a significant challenge in addressing extreme climate change in the construction sector. Project teams within construction firms were found to lacking expertise, groups, units, and institutions to design and procure net-zero materials for construction activities. Insufficient capacity-building through training, mentoring and supervision to transition to low emission procurement transactions are hampering sustainable construction. Moreover, inconsistencies in the transition risk assessment and management of net-zero procurement at the firm level serve as major barriers to obtaining resources to build climate-friendly projects.

Inactive involvement of stakeholders towards net-zero goals (B3)

This barrier was ranked 3rd. Low stakeholder involvement in promoting net-zero supplies of construction materials is a major obstacle to low carbon construction development. Lövbrand and Stripple [54] asserted that, the deal plan for net-zero procurement strategies for construction projects should include, a multi-stakeholder engagement from within and outside the construction industry. However, the findings from Chen et al. [34] indicated a low rate of stakeholder involvement and privy to information on decisions surrounding net-zero purchasing strategies for construction projects. Vimal et al. [8] and Garcia-Freites et al. [31] stated that it is complex and expensive to gather the opinions of all stakeholders in designing net-zero procurement practice framework. As a result, to effectively implement climate change policies in the supply chain do not receive thorough stakeholder level support [47]. Little is known about the collaboration of private suppliers and councils in the implementation of net-zero procurements for resilience building and project implementations [55].

4. Conceptualisation of the drivers and barriers of NZP towards achieving net zero carbon project success

To develop the conceptual model, first, the list of drivers and barriers was put into 11 broad categories, six drivers and 5 barriers (see Table 4). The groupings are done based on the individual meanings and relationship of variables with each other. The meanings and relationships were derived from the selected publications after a thorough content analysis.

Following the categorization of the drivers and barriers, a conceptual model that hypothesizes the relationship between the drivers, barriers, and Net Zero Carbon project success was developed.

Fig. 2 shows the conceptualization of the drivers and barriers to net zero procurement for achieving Net Zero Carbon project success. The references for the various hypotheses proposed for the conceptual framework are shown in Table 4 (last column)

The hypotheses developed in the figure are based on the project success theory proposed by Pinto (1986), Rockart (1982); Lim and Mohamed [56], and Osei-Kyei and Chan [19]. In these studies, the authors explained that certain critical circumstances or essential areas are always needed to ensure the successful implementation of projects. These set of circumstances and essential areas are termed as Critical Success Factors and therefore form the basis of the project success concept/theory. Applying the same concept, this study developed a set of drivers or success factors of NZP which if carefully implemented should lead to the net zero carbon project success. Considering this, 11 major hypotheses which explain the relationship between the drivers, barriers, and net zero project success were developed.

Considering the theory of project success, the following are hypothesized about the driving factors, barriers of NZP, and Net Zero Carbon project success:

H_1:DVG1 Agreements and policies on net-zero procurements improves Net Zero Carbon project success.

H_2: DVG2 Economic incentives improve Net Zero Carbon project success.

H3: DVG3 Digitisation of construction supply chains improve Net Zero Carbon project success.

H_4: DVG4 Diversity and inclusive procurement strategies improve Net Zero Carbon project success

H_5: DVG5 Sustainable construction practices improve Net Zero Carbon project success.

H_6: DVG6 Effective communication in procurement channels improve Net Zero Carbon project success

H_7: BG1 Regulation & policy barriers decrease Net Zero Carbon project success.

H_8: BG2 Social & diversity barriers decrease Net Zero Carbon project success.

H_9: BG3 Economic barriers decrease Net Zero Carbon project success.

H_{10}: BG4 Operational barriers decrease Net Zero Carbon project success

$H_{11:}$ BG5 Technological barriers decrease Net Zero Carbon project success.

5. Emerging trends and future roadmap

Based on the findings of the above review, there are emerging areas d which could be proposed. These are comprehensively discussed below.

5.1. Reforms in existing procurement regulations

A comprehensive review of studies demonstrates little or no changes in the procurement regulations and approaches in construction industry. There is more reliance on the traditional design-bid-build with little discussions on the scientific transition and reforms in the regulations to net-zero procurements. Further, the rule-based publication of climate-friendly information from legislative bodies around the world is

Table 4
Hypothesising the outcomes of the systematic review.

Latent variables	Manifest variables (refer to Table 2 and 3)	Expected sign	Hypotheses	Sub-hypotheses	References (See Table 1)
Drivers					
DVG1- Agreements and policies on net-zero procurements	D1, D6, D7, D24, D29, D33	Positive (+)	H1:DVG1	H1:DVG1 minimises BG1; H2:DVG1 minimises BG2; H3: DVG1 minimises BG3; H4:DVG1 minimises BG4; H5:DVG1 minimises BG5. H6: DVG1 improves Project Success	6, 7, 8, 9, 13 5, 7, 8, 10, 12
DVG2- Economic incentives	D2, D13, D25, D26, D27	Positive (+)	H2:DVG2	H7:DVG2 minimises BG1; H8:DVG2 minimises BG2; H9: DVG2 minimises BG3; H10:DVG2 minimises BG4; H11:DVG2 minimises BG5. H12:DVG2 improves project success	
DVG3- Digitisation of construction supply chains	D17, D34	Positive (+)	H3:DVG3	H13:DVG3 minimises BG1; H14:DVG3 minimises BG2; H15: DVG3 minimises BG3; H16:DVG3 minimises BG4; H17:DVG3 minimises BG5. H18:DVG3 improves project success	1, 4, 11, 1, 2, 4, 5, 11,
DVG4- Diversity and inclusive procurement strategies	D11, D12, D15, D18, D20, D22	Positive (+)	H4:DVG4	H19:DVG4 minimises BG1; H20:DVG4 minimises BG2; H21: DVG4 minimises BG3; H22:DVG4 minimises BG4; H23:DVG4 minimises BG5. H24:DVG4 improves project success	15, 18, 19,
DVG5- Sustainable construction practices	D3, D4, D5, D8, D9, D10, D14, D16, D21, D23, D30, D31, D35, D36	Positive (+)	H5:DVG5	H25:DVG5 minimises BG1; H26:DVG5 minimises BG2; H27: DVG5 minimises BG3; H28:DVG5 minimises BG4; H29:DVG5 minimises BG5. H30:DVG5 improves project success	16, 1, 4, 5, 6, 7, 8, 9,
DVG6- Effective communication in procurement channels	D19, D28, D32	Positive (+)	H6:DVG6	H31:DVG6 minimises BG1; H32:DVG6 minimises BG2; H33: DVG6 minimises BG3; H34:DVG6 minimises BG4; H35:DVG6 minimises BG5. H36:DVG6 improves project success	1, 2, 6, 6, 7, 8
Barriers:					
BG1- Regulation & policy barriers	B5, B7, B10, B13, B15, B17, B20, B24, B26, B27, B29, B31	Negative (-)	H7:BG1	H37:BG1 decreases project success	1, 4, 21, 8, 10, 13, 15, 19,
BG2- Social &diversity barriers	B3, B23, B32	Negative (-)	H8:BG2	H38:BG2 decreases project success	14, 16, 19, 19, 21, 23
BG3- Economic/financial barriers	B1, B4, B9, B14, B22	Negative (-)	H9:BG3	H39:BG3 decreases project success	4, 7, 9, 13, 4, 7, 9, 18
BG4- Operational barriers	B2, B6, B8, B11, B12, B16, B18, B21, B25, B28, B30, B33	Negative (-)	H10:BG4	H40:BG4 decreases project success	1, 2, 5, 13
BG5- Technological barriers	B19, B26	Negative (-)	H11:BG5	H41:BG5 decreases project success	4, 14, 21, 20
Net Zero Carbon Project Success:					
Achieving Net Zero Targets for Projects	Successful delivery of net-zero construction projects to satisfy stakeholders				

inadequate on low carbon supply chains in construction projects [57]. Several external factors hinder transition legislations on net-zero procurement including the refusal of countries to set national targets of net-zero emissions [58]. Therefore, the achievement of net-zero targets will be attained if an immediate resources and collective action are geared towards reforming existing procurement contracts and legislations to address climate change issues in construction projects.

5.2. Consolidation of robust database

A comprehensive and robust database on net-zero procurements is required for effective and sustainable project management [59]. However, no database has been built for net-zero procurements in the construction industry. Net-zero transactions are effected without prior information and empirical data to refer to [60]. Bataille et al. [12] and Sörensen et al. [61] mentioned the challenges associated with collecting data on climate-friendly procurements with far-reaching problems in logistics, funding and disagreements among stakeholders Thus, it is urgent that researchers help the construction industry to build a large database that will serve as reference point for net-zero procurement design, selection and implementation.

5.3. Digitization in procurements

Achieving net-zero procurement goals demand that construction firms and suppliers assess, quantify, and minimise carbon emissions. Due to its complex nature of the climate crisis and fossil-based emissions, it is expedient artificial intelligence and other smart technologies are adopted to assist in transition to net-zero procurement [62]. The decarbonisation of procurement systems in building infrastructures require digital twins and Building Information Modelling (BIM) software to detect and minimise the outcomes of extreme climate change in construction projects. In reaching sustainable supply chains in the construction sector, digitization is very important to neutralise emission contents of projects by capturing big data, complex analysis, and management of net-zero procurements in the lifecycle of projects. Smart technologies are important in forecasting the amount of energy consumption in residential buildings, the best approach to know the supply of goods and services for maintenance purposes. This area has received less research and discussions in the construction management literature It is suggested that future studies with enough financial support should develop integrated smart technological platforms to improve and monitor the progress of net-zero procurements in construction activities.

6. Implications for practice and Future research

This review paper has several implications for practice and research. These implications are discussed below.

6.1. For Industry Practice

First, the findings of this research will help promote the awareness and integration of sustainable practices in the construction industry by encouraging firms and practitioners to collaborate and apply net-zero principles into project supply chain planning and execution, leading to reduced environmental impact and long-term cost savings.

Second, the findings are significant to decision making and formulation of environmental policies related to net-zero procurement not only in the construction industry but other industries. The study will help inform the regulatory bodies and key players in the industry of the need for stricter regulations, updated codes of conduct, or the development of new industry standards to address emerging environmental

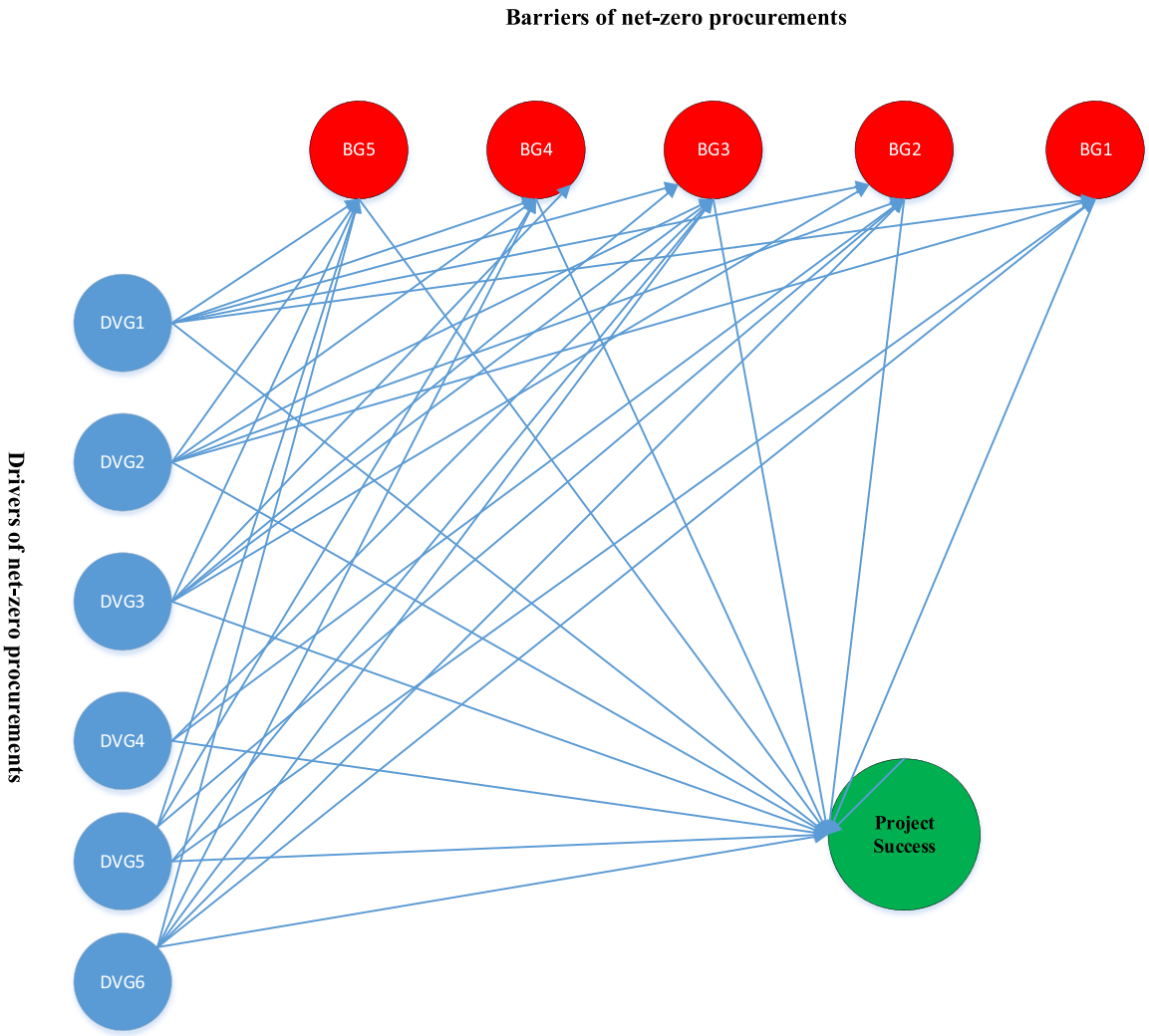

Fig. 2. Conceptual model of the drivers and barriers of NZP towards achieving net zero project success (refer to Table 4 for interpretation of codes and supporting references).

issues through procurement transactions. It may also inform the need for including environmental assessment as a prerequisite for project approval and funding to enhance the efforts to mitigate environmental impact on construction projects. Government may offer incentives or tax breaks for companies who adopt sustainable construction to promote sustainable environmental protection and measures towards net-zero targets.

Third, the outcomes of this study call for the promotion the inclusion of the well-being of workers, construction organisations and communities associated with the construction industry into procurement contracts. As the world gravitates towards diversity and inclusive policies, project procurements and supply chain channels should be shaped by the tenets of net-zero which is place the health and safety of people at the centre stage of development. Diversity and social inclusion net-zero procurement policies in the construction industry will ensure everyone including communities and cultures is respected and integrated into the project management. Emphasis on reduction of wage losses, unemployment, improved education and better health and safety care are implemented within the construction sector. Greenwashing, bluewashing, and all forms of unethical reporting behaviours are expected to be eschewed in the net-zero procurement implementation.

Aside the above implications of the study, the following recommendations are made for policy practice and directions towards the adoption of net zero procurement.

First, it is recommended that practitioners and net zero project stakeholders will develop pre-procurement risk mitigation strategies at the planning stage of the net zero projects that consider net-zero limits and expectations for projects.

Second, governments should allocate adequate budget towards the proper adoption and implementation of net zero procurement. The allocation of adequate funds will help equip public procurement institutions with the necessary financial resources to successful implement net zero procurement.

Third, training policies should be developed by governments to help upskill and reskill public procurement personnel and industry workforce on net zero procurement concepts and issues. This will help build the capacity of stakeholders in the procurement process towards the implementation of net zero procurement.

6.2. *Future research studies*

From the results of this study, it is recommended that future studies will adopt empirical surveys and Partial Least Square- Structural Equation Modelling technique to explore and deepen the theoretical understanding of the impact of these hypotheses within a geographic context or case study.

Further, future studies should consider exploring the net-zero procurement practices and align these practices with existing standards and

certification schemes, in order to provide a clear roadmap for net zero procurement implementation.

7. Conclusions

This study has explored the drivers and barriers to adopting net-zero procurement in the construction sector. Following the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocols, several databases were searched to retrieve relevant articles related to the research aim. From the search, 24 articles and reports were selected for further analysis. Based on the analysis, 36 drivers and 33 barriers were identified. From the rankings using the number of references, the top three ranked drivers include developing sustainable public procurement policies; increasing investment in low/zero carbon procurements, and high demand for green construction projects. The top-ranked barriers include inadequate budget for net-zero procurement implementation; weak public institutions and private firms capacity to implement net-zero policies and inactive involvement of stakeholders towards net-zero goals. Drawing on the project success theory proposed by Pinto (1986), 11 major hypotheses were developed to explain the relationship between the drivers and barriers of NZP and achieving net zero project success. The findings from this study will be impactful towards the future implementations of net zero procurement for infrastructure projects. More importantly, the findings will help practitioners to develop performance objectives and risk assessment models for future net zero procurement. The major limitation of this study is the lack of empirical data to test the proposed hypotheses. It is therefore recommended that future research studies will adopt empirical surveys and the Partial Least Square technique to explore the impact of these hypotheses within a geographic context or case study.

CRediT authorship contribution statement

Robert Osei-Kyei: Writing – review & editing, Supervision, Resources, Methodology, Investigation, Conceptualization. **Timur Narbaev:** Supervision, Software, Resources, Conceptualization. **Jin Xiaohua:** Software, Resources, Project administration, Investigation, Conceptualization. **Ursa Komac:** Software, Resources, Methodology, Investigation. **Isaac Akomea-Frimpong:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Gabriel Castelblanco:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

There is no conflict of interest for this paper.

Data availability

Data will be made available on request.

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