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Capabilities needed for enabling climate action in construction.

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Abstract
Climate action is deemed critical across all industries globally. In Construction the capabilities needed to implement this action have not been clearly identified and there have been little attempts to draw from climate action capabilities already in place in other industries. A Structured Literature Review of that literature is summarised and then used to identify what capabilities are needed and proposes a model for capabilities, grounded in Dynamic Capabilities Theory, for climate action in construction. The model identifies seven key capabilities - knowledge, organisational, planning practice, governance, policy, Systems Thinking and actioning capabilities.

Key words: climate change, climate action, capabilities, construction.

1. Background context and problem statement

Climate change, defined as long term shifts in weather and temperature patterns, is one of the largest social, ecological and economic challenges of the twenty-first century. Though some of the changes in climate may be attributable to natural variation, it is unequivocal that human activity has significantly warmed the atmosphere, ocean and land (IPCC 2021). Some of the changes in climate may be attributable to natural variation, however, a large proportion of the change is a result of human activity. The goal of the Paris Agreement is to substantially reduce carbon emissions and limit the rise of average global atmospheric temperatures by 2050. To achieve this goal requires consistent, integrated and wide-spread action strategies from all industries and sectors. With further global warming, every region is projected to increasingly experience concurrent and multiple changes in climate impact-drivers (IPCC 2021). Adequate action is necessary to mitigate potential worsening of climate change, and to respond to projected changes through adaptation, mitigation and resilience activities. There is a continually growing body of literature that deals with the issues at the intersection of climate change and the construction industry, but the question remains, what actions can (and should) members of the construction industry take to ensure climate resilience into the future?

The construction industry emits a large amount of greenhouse gases due to the nature of construction processes and materials (Lorch, 2017). The construction industry currently emits about 39% of the world's energy-related CO2 emissions (Lee et al 2018). It accounts for 36% of global energy consumption The Global Status Report for Building and Construction (United Nations Environment Programme 2021:6), with expectations that global material use is expected to more than double by 2060. It is projected that a third of this will be as a result of the building and construction industry. Energy use in buildings accounts for approximately one quarter of global greenhouse gas emissions (Jones, 2021). While climate change is not reversible, appropriate action can manage the negative effects and slow further damage. To achieve this, global improvements in construction standards, energy use and operational performance are required (Jones,

2021; Francart et al 2019). Francart et al (2019) noted specifically that skills and relevant knowledge needed for climate action are generally lacking in construction.

This paper aims to firstly understand what climate action looks like within the building and construction industry; and secondly, through a systematic literature review, identify what climate action capabilities need to be deployed for climate action, building off climate action already identified across various industries. These aims will focus the research to address a specific problem in construction and address this question ***What are the climate action capabilities required for construction practitioners?***

2. Construction and Climate Change

There has been a general lack of success in reducing GHG emissions in the construction/built environment sector (Lorch, 2017; Hurlimann et al., 2019). Barriers to the uptake of sustainable practices or sustainable technologies embedded in policy include financial, technical, and institutional ones, often arising from a lack of knowledge (Walters et al., 2018). Each can act as deterrents to the absorptive capacity of construction stakeholders e.g., adapting to climate change is argued to be much more cost effective than taking emergency measure afterwards (Chmutina, 2013; Jones, 2021), yet ambivalence and a short-term, immediate focus on costs can guide attitudes to addressing climate change issues and undertaking climate action.

Within the Construction Management literature there is recognition of the role that social and behavioural factors play in meeting sustainability goals (Phua, 2018) but many individual construction firms still find it difficult to integrate sustainable practices into their everyday business. Firms are likely to make a greater commitment to climate change if they see such an engagement as an opportunity to acquire economic and or competitive advantage (Tavakolifar et al 2021), and Kinnunen et al (2022) add that sustainability performance and brand are most likely to be developed via concrete actions, that is, implementing eco-innovation.

However, Phua (2018) and Lorch (2017) and Kinnunen et al (2022) agree that there is a need for clearer alignment of policy mechanisms, business drivers and socio-technical engagement to appropriately address the built environment's contribution to climate change and there needs to be a clearer understanding of the mechanisms for achievement, in essence what are the capabilities needed? Shapiro (2016) argued that there should be effort placed on ensuring that building codes are robust in the face of a changing climate suggesting that building codes have the capacity to mitigate further climate change.

Fragmentation in policy has also been shown to limit the efficacy of climate change mitigation policy within the construction sector (Bollo and Cole, 2019) with a whole of systems, bottom-up approach being more effective (Graham and Rawal, 2019; Lorch, 2017). Solutions suggested include Graham and Rawal's (2019) argument that India must achieve a 50% reduction in building energy usage; and Watfa et al. (2021) who suggested the integrated use of Building Information Modelling (BIM) and Building Energy Modelling (BEM) to minimize the overall energy consumption of residential buildings in the UAE. In

New Zealand, the Building for Climate Change Report (MBIE 2021) stated there is a need for more clear standards and comprehensive training; the need for a clear roadmap for change to support an orderly transition; the need for clear, consistent guidance to achieve low-carbon standards, to reduce costs, and to address a lack of awareness and demand. There is also research in construction which suggests that the resistance to climate action could be addressed with new low-carbon technology development, (Wafta et al, 2021; Mustaffa et al, 2022). However, amongst this research there is only a single reference to better understand the need for relevant capabilities within construction organisations to achieve these strategies (Phua, 2018). Research already shows that organizational climate strongly influences employee behaviours that are valued and rewarded. Climate action/sustainability practice can, Phua (2018) argues, be driven by clear articulation and implementation of organizational values and climate. However, Phua notes, the internal capabilities of firms are important in finding solutions for climate action. What those capabilities are, are not identified.

3. Defining capability

There has been considerable advocacy for a capability-based approach to understand and derive solutions to specific technological problems (Day et al 2016; Burchardt, 2004; Gardoni and Murphy, 2009). It is important then to ground clear definitions of capability in the existing literature. Sen (1993) and Hobson (2011) define capabilities as being able to achieve a range of functionings and the possibilities for actualizing them. Capabilities are meta-level constructs (Osmundsen et al 2020) that are underpinned by different competences embedded in organizational processes and rooted in employee skills and knowledge (Peppard and Ward 2004). Therefore, it often requires a transformation of the workforce (Eden at al 2019), and is associated with, among other structural changes, changes in employee roles and skills (Vial 2019). A capability isn't a specific skill that fits in a given situation. Osmundsen et al (2020) argue that it is a deep-rooted ability which can be applied in many contexts. It is something you train and have to learn to do in context. Ray and Ramakrishnan (2006) argued that capability is a complex combination of appropriate set of competences, glued together by various relevant organizational processes, routines, and bonding mechanisms, towards achieving specific organizational objective(s). In a more technological context, Zoia et al, (2018) said that capabilities were those competencies needed to perform activities, which can add value to products and processes. The notion of a capability is “the outcome of internal competencies and of individual and collective accumulation of adaptive learning processes and new knowledge within a socio-economic and environmental framework” (p. 454).

In this research we have framed the process in terms of Dynamic Capability Theory (DCT). DCT emphasises developing new forms of competitive advantage by integrating, building and reconfiguring both internal and external capabilities (Teece et al., 1997). Eisenhardt and Martin (2000, p.1107) defined DCs as “the firm’s processes that use resources - specifically the processes to integrate, reconfigure, gain and release resources - to match and even create market change…” The definition emphasized the aptness and ability of firms to respond or make changes in the business environment by

developing new capabilities using both internal and external resources. Processes, position and path are the essential elements in defining capabilities needed in firms (Teece et al., 1997) as they undertake routines. Teese et al., (1997) argues that DCs are a type of process that integrates, reconfigures as well as gains and relinquishes resources. They are the firm's ability to integrate, build, and reconfigure internal and external capabilities to address rapidly changing environments. Processes involve the integration of activities, learning and experimenting to know the best and quickest way of reconfiguring and executing tasks to meet the dynamism in the market. Position comprises the processes and assets of the firm including the technological, financial, and institutional, the firms' boundaries and the market. Path involves the past, present and future opportunities available to a firm by assessing the firm's competence and capabilities. Adam and Lindahl (2017) argued that the number of capabilities that are relevant to consider in discussing public construction clients are numerous in quantity and cover a wide range of disciplines, from the technical to the psychological (Adam and Lindahl 2017, Adam et al. 2017). Further, they state that there appears to be unanimous agreement about the importance of both acquiring and further developing client capabilities, but that no all-encompassing method seems to exist for that purpose. Dubois and Gadde (2002) have explained that projects in construction have a unique component to them, a structure often characterized as loosely coupled. Dynamic Capabilities, however, are also typified by their uniqueness in how they manifest from one organization to another (Teece et al. 1997). However, climate change capabilities involve both global and often context and can be organisationally specific. Our task here was to uncover those capacities that are relevant across construction projects.

4. Capabilities for Climate Action - A Structured Literature Review

A Structured Literature Review (SLR) is a summary of literature available on a topic that utilizes statistical techniques to ensure results are valid and repeatable (Tranfield and Denyer 2003; Kitchenham & Charters 2007). An SLR identifies, selects and critically appraises research in order to answer a clearly formulated question (Pittway 2007). Xiao and Watson (2019) argue that 'by undertaking an SLR approach rather than 'ad hoc' approaches to literature construction, development and presentation, there is a defence that critical literature may be identified alongside other materials relevant to the study.' An SLR enables the research to have confidence that their review is empirically grounded and finds both seminal and peripheral articles and reports to ensure that most researcher bias is eliminated (Dixon-Woods, 2011).

An SLR enables the research to have confidence that their review is empirically grounded and finds both seminal and peripheral articles and reports to ensure that most researcher bias is eliminated (Dixon-Woods, 2011). Massaaro et al (2015) argue then that the output from an SLR should inform readers about the main evolution of the focused topic and highlight any significant gaps in that literature. In comparing an SLR with a traditional literature review, Pettigrew and Roberts (2006) have focused on the precision and

deliberate focus of an SLR in comparison. This research follows the structured literature review methodology developed by Opoku & Guthrie (2018), Adam et al 2017; Aljaroodi et al 2019; and Chowdhury et al (2019).

This SLR was conducted to provide an overview of the current literature as it relates to climate action capabilities, and how the construction industry may utilize these capabilities to engage in meaningful and industry-specific climate action. Through this process, several climate action capabilities are identified.

The review protocol for an SLR builds from specific search terms, key words derived from the research question. The intent is to identify papers that deal with the nexus between capabilities and climate action. The addition of terms/phrases dealing with construction/construction industry/built environment were not used initially. This is because, during a preliminary search, the databases used did not contain any papers that contained capabilities and construction and built environment. The SLR initially searched all the most highly cited Construction journals (Table 1) as part of the broader search process but yielded very few papers (16) that met some of the criteria and no papers that met all the criteria for climate action and construction.

Table 1: Construction related journals

Journals	Results found
Construction Management and Economics	0
Building Research and Information:	8 hits. After screening 1: 0 hits
Journal of Construction Research	0
Journal of Information Technology in Construction	0
Project Management Journal	0
Building Services Engineering Research and Technology: an international journal	0
Journal of Management in Engineering	0
International Journal of Project Organisation and Management	0
The International Journal of Construction Management	2 hits. After screening 1: 0 hits.
Journal of Construction Engineering and Management	0
Construction Innovation: information, process, management	0
Journal of Building and Construction Management	0
International Journal of Construction Project Management	0
Building and Environment	0
Construction Economics and Building	0
Journal of Cleaner Production	6

The SLR search paradigm was then expanded and included journals from other domains such as a) Sustainability, b) Corporate Social Responsibility and Environmental

Management, c) Australasian Journal of Environmental Management, d) Green Energy and Technology, e) International Journal of Environmental Research and Public Health, f) International Journal of Sustainability in Higher Education, g) Climate Change Management.

The literature search of domains for examples from construction, engineering, health, business and education returned results that of competencies across those domains and analysed for their relevance to the construction/built environment context. The search terms used were:

- “capabilities” AND “competencies” AND “climate action”
- “capabilities” OR “competencies”) AND “climate action”

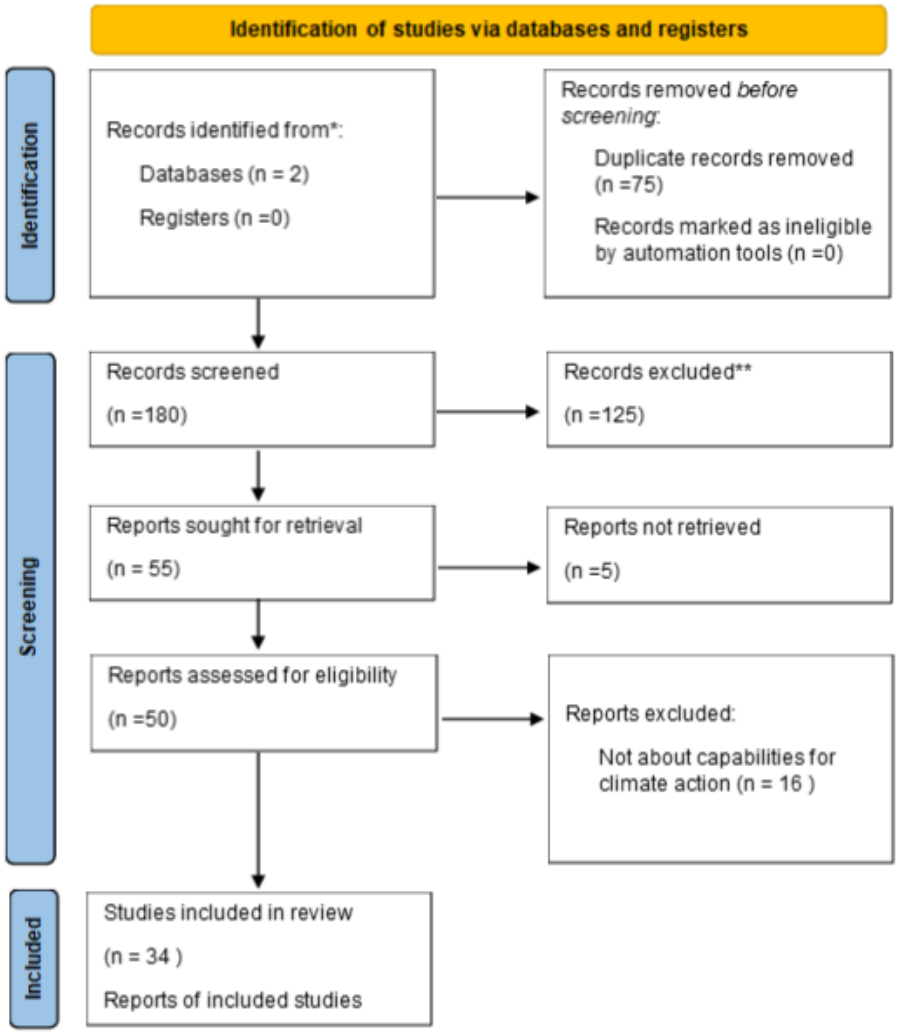
In the search a screening and exclusion protocol was included. The Rule established was to exclude papers (after review of title and abstract, and then after revision of full paper) that:

- Don’t refer to climate action in relation to climate change
- Don’t deal with capabilities and/or competencies as defined in this paper
- Were duplicates

The accepted form of reporting the search is through a PRISMA flow. The outcome of this search yielded the following PRISMA (Figure 1).

The expanded SLR revealed 50 relevant papers. From all the papers reviewed, seven sets of capabilities for climate action either relevant to, or included in, construction were identified. This review was designed to identify a set of capabilities necessary for construction companies to adopt, act on or implement climate action. In the review of the 50 papers, each was critically examined specifically for that purpose. There was no intent to critically evaluate that literature for others relevance to other problems associated with climate change or climate action. One of the key outcomes of this approach has been to identify the paucity of research specifically related to **climate action and construction and the capabilities** needed for that to happen.

Figure 1 PRISMA for climate action capabilities



5 Discussion and framework construction

Hobson (2011) argues that a Capabilities Framework needs to be dynamic, agency-centered, institutionally embedded and allow for contextuality. Hobson's framework (Hobson 2011:158) is built on three sets of factors: institutional factors, individual factors and societal factors. Brits et al (2006) argued for a generalised capabilities framework for business, built on knowledge, ends or outcomes and the means to achieve those ends and, like the framework of Hobson and the arguments of Sen (1993) about capability framework, they are dynamic and flexible, allowing modification and applicability according to context.

In this study the climate action capabilities framework uses a typology based on the frequency of terminology use in the reviewed papers. In the same way as Brits et al (2006), the framework builds initially on knowledge, then examines outcomes and through action capabilities, reports the means to achieve those ends. This then enables the framework to be agency centred with one focus on activities whilst allowing the capabilities to be viewed as dynamic and able to be applied contextually to relevant

organisations/institutions. The results of the SLR, and the proposed framework, are shown below in Table 2.

Table 2: Climate action capabilities items

Capability items	Descriptions / context	Authors Examples
Knowledge capabilities (environmental, sustainability and issues, technical innovation solutions, knowledge governance, of information and strategy relevant to action and climate literacy skills	Understanding specific knowledge domain by architects and by builders. Part of the process is knowledge transference.	Álvarez-Nieto et al 2017; Van Buuren & Eshuis 2010; Feja et al 2019; Hermann et al, 2022; Nelson et al 2022; Slini et al 2016; Dittmer et al 2018; Koumparou 2013; Radzi et al, 2022; Venske, 2021; Jodoin & Singer 2020; Patrick and Smith 2011
	Understand the elements of Climate that affect Climate Variability (Climate Change, Global Warming and Extreme Events)	Alves and Azeiteiro 2018
	Understanding energy use alternatives	Francart et al 2019
		Alves and Azeiteiro 2018
	Understanding and Explaining the Impacts of Climate Change on Biological, Ecological, Environmental (including Environmental, Public and Human Health) and Socio-Environmental Systems;	Charles et al 2022
Organizational conditions	The results shows that the organization rigidity trap has significant role to play in “climate inaction” and climate action has not been a part of their role and responsibility. They are only focusing on economy. To be able to act on climate change there is a need to look outside “natural science” to cross boundary to organization-natural environment. Part of this relates to continuous organizational learning.	Mishra et al 2020; Oliver et al 2021
	Five capabilities identified in the literature: 1) creating, managing and securing good relations with multiple stakeholders, 2) ethically correct and values-based behaviour, 3) a continuously developed self-awareness, 4) good understanding of the interdependencies of a larger	Muff et al 2020
		Patrick et al 2012

	system, and 5) the ability to lead change and innovation towards sustainable development. Values thinking can also be included Promote and act in the definition and implementation of adaptation strategies to climate change. Budgeting and financial skills are essential	 Alves and Azeiteiro 2018 Perera et al 2018
Planning practice capabilities	Planning practice is considered essential at all levels of climate action and includes evidence-based advocacy for climate change action as a core capability of professional planners.	Mitchell and Graham 2020; Patrick and Smith 2011
Governance capabilities	Governance skills are essential at national, organisational and individual levels to best manage climate action strategy to deal with: 1) complex governance system; 2) multi-actors; 3) multi scale governance Leadership skills	Calliari and Vanhala 2022; Oliver et al 2021; Mishra et al 2020; Bulkeley and Kern 2006; Fakhri et al. 2021; Lindbergh et al 2022 Patrick and Smith 2011
Policy capabilities	Identifies the need for critical capability skills in the three aspects of sustainability transitions - 'envisioning, implementing, evaluating'. Evaluate and Criticize the Policy Instruments/Plans/Strategies for Adaptation to Climate Change at Regional, National and Local Level	Oliver et al 2021; Alves and Azeiteiro 2018 Francart et al 2019
Systems thinking capabilities	Ability to apply systems thinking to evidence-based planning (e.g. thinking at an ecosystem health, human-planetary level). Systems thinking has been used to identify (i) the need for new capabilities, (ii) dealing with wickedness, and (iii) behavioural complexity and discordant reference systems.	Freeman and Yearworth 2017; Emberger-Klein et al. 2021; Keeler et al 2017; Oliver et al 2021; Riutannen et al, 2021
Actioning ability capabilities (Analyze and Compare Mitigation Measures and Instruments and Strategies for Adapting to Climate Change) a) Ability to conduct ecological footprint analysis b) Ability to use scenario planning	Skills are fundamental to actions taken at all levels to makes changes that will enable adaptation, mitigation and resilience of construction businesses to climate change.	Patrick and Smith 2011; (Hurlimann, et al. 2021; Alves and Azeiteiro 2018

c) Ability to conduct and use integrated environmental impact assessment models d) Ability to engage partners with ecological perspectives or new paradigms of thinking e) Ability to develop climate change communication strategies. f) Ability to apply social marketing capabilities to climate change contexts g) Ability to use new sustainable technology h) Ability to apply knowledge of 'sustainability' principles for practice (e.g. precautionary principle, environmental justice), and knowledge of environmental frameworks (e.g Brundtland Report, Our Common Future, Agenda 21) i) Ability to understand "data", "technical", "decision-making", communication and "system" of different stakeholders and apply them via project outcome which is building assessment requirements. j) Ability to apply adaptation actions in problem solving.		Kinnunen et al 2022 Dumas et al 2021 Otto et al 2016; Henderson and Tudball 2016

This SLR analysis highlights the significant emphasis on knowledge in capabilities related to climate action across various domains a conclusion consistent with Riuttanan et al (2021). This does not mean that the other capabilities are less important but demonstrates in those research papers that often basic knowledge is missing. Perera et al (2018) developed a list of educational knowledge needs for Construction to meet Sustainability Development Goals. In essence these are also capabilities needed by Construction graduates and are very specific to environmental issues in Construction (Table 3). We compared those specific capabilities (educational needs) to the findings in this SLR (Table 2). The SLR showed considerable alignment. However, larger 'sense-making' capabilities like Systems Thinking and Policy, a highly significant capability already noted by Bollo and Cole (2019) and Bouman who showed that there is a unique, direct and positive relationship between worry about climate change and climate policy support across most countries. It was highlighted that individuals who worried more about climate change were more likely to support climate policies (Bouman et al 2020). These had not been identified by Perera et al (2018).

Table 3 Educational Needs for Construction (capabilities)

Capability items	Perera et al 2018 (construction capabilities)
Knowledge capabilities	Environmental assessment; Management of the built environment; Cross-cultural awareness in global resilience; Disaster management; Professional development; Construction technology and environmental services
Organizational capabilities	Supply chain management; Health and safety; Quality leadership and people management; Teamwork; Time management; Conflict management and dispute resolution; Asset/resource management;
Planning practice capabilities	Budgeting and financial planning; Business planning
Governance capabilities	Consultancy services; Building regulation and planning; Legal/regulatory compliance; Transparency and accountability; Insurance; Project audit and reporting; Risk management; Emergency management; "National regulation is often an insufficient driver in reducing the climate change impact of construction. (Francart et al 2019: 118)"
Policy capabilities	These are missing in Perera et al 2018
Systems thinking capabilities	These are missing in Perera et al 2018
Action ability (practice) capabilities	Quantification and costing of construction works; Procurement and contract admin/practice; Work progress and quality management; Multi-stakeholder management; Communication and negotiation;

Riuttanen et al (2021) utilizing a Theory on Capabilities developed by Weik (2011), confirmed the need for capabilities of systems thinking, problem solving, ability to collect, analyse and evaluate data and information for sustainability issues, adoption of strategy for transformation and leadership through participation and collaboration. These parallel the capabilities the SLR in this study of climate action in Construction uncovered. We also compared the capabilities identified in this SLR with those identified as essential to adoption and use of big data in Construction (Atuahene et al 2023). The capabilities identified by Atuahene et al (2023), which showed that capabilities vary in importance between organisations, as would be expected in a dynamic capabilities context. Their research showed that policy and systems thinking were not considered as significant (Atuahene et al 2023). However, the remaining capabilities have significant alignment. In application of DCT, context is significant, and each set of capabilities is expected to both vary and recognise common elements.

Espallargas and Moron-Monge 2020 argue further that capabilities are more than just knowing; critical climate action capabilities require the additional elements, "knows how" and "shows how and does". In a largely summarized form, they focused on the knowledge elements related to climate action capabilities applying "knows how" and "shows how and does", in a way that mirrors what Teese et al (1997) defines as dynamic capabilities (Fig 2). This model is centered on the requirements of decision makers to take action by sensing the need to change, or take action, and then using that to seize knowledge to plan or regulate, to enable transformation of the status quo to something new.

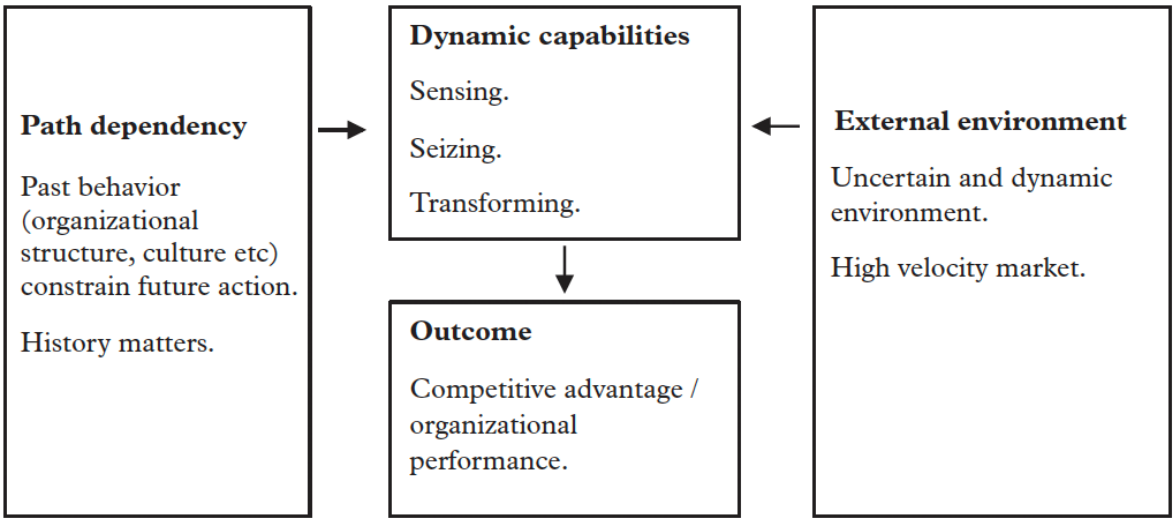


Figure 2: The dynamic capabilities framework (Adam & Lindahl 2017:423, after Teece et al 1997)

The Teese–based model (Fig 2) was then adapted to the findings of the SLR reported in this paper for climate action in Construction (Fig 3). Our proposed model is all inclusive. Without one element of sense, seize, transform, the chance of real change and real action is significantly reduced. The advantage of DCT is simply that it identifies contextually/organisational capabilities, to sense and then seize knowledge, to develop capabilities and skills as competencies, and to produce transformation through action at all levels. Without the need for capabilities of systems thinking, problem solving, ability to collect, analyse and evaluate data and information for sustainability issues, adoption of strategy for transformation and leadership through participation and collaboration, Riuttanen et al (2021) argued that those dynamic elements to sense, seize and transform, real action probably won't happen. This proposed model builds on the models of Teese, Ruittenen, Weik and Espallargas and Moron-Monge, to identify what Teece argues is the requirement to ‘know how’ and the requirements to ‘show how and do’. These capabilities exist in individuals within organisations. These capabilities exist within what each of the modellers describe as ‘context’. In our model this ‘context’ represents organisational conditions (See Table 2). The sum of the individual capabilities in that organisation are considered in much of the literature as organisational capabilities.

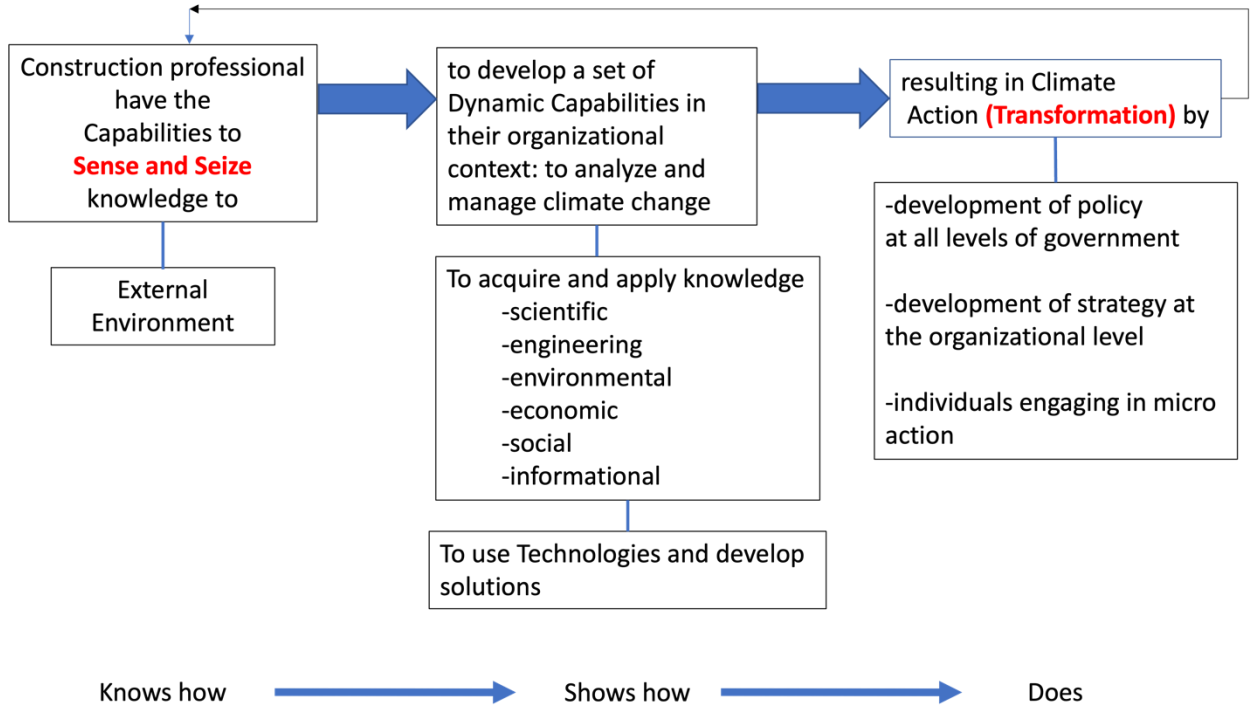


Figure 3: Proposed model of climate action capabilities for construction

6. Conclusion

Climate action capabilities are critical in driving action but have yet to be identified in the construction research literature.

To develop a capabilities framework not only relies on knowledge of the construction domain, but also of how climate change and climate action are embedded within this domain. There is clear evidence in lessons from all domains that climate action addressing climate change has larger scale implications than the normal knowledge specificities of building and construction. There is an identified need for construction practitioners to have some capabilities in understanding and applying climate related policies by governments and understanding how mainstream climate issues have, and are further becoming, part of the consensus of economic variables that affect costs and pricing.

The SLR analysis has highlighted the actions to be seized, analysed and managed to enable transformation and take climate action in construction. The analysis has also clarified that climate action requires a multidisciplinary understanding., This includes the relevant policy framework, specific scientific and engineering knowledge, and the absorptive capacity to understand the science and expected outcomes. There is also a need to understand that climate action in construction will apply to organisations ranging from multi-national and mega in size to micro-organisations. To have the ability to understand, apply and implement use of multiple technologies, it is essential to ask three key questions:

1. Who will engage various people at all size levels of organisations in construction to implement climate action?
2. How do those people actually do it (i.e., what capabilities do they need to become competent and enabling climate action?)
3. How do micro-organisational construction companies such as SMEs, owners, tradespersons, or others (including professional QAs, engineers etc) develop relevant climate change knowledge to enable transformation through climate action?

Phase 2 of the research

The research will adopt the list of competencies (Table 2) and the process model (Fig 3) to undertake a two-phase data collection process. The first stage will use a qualitative research strategy through interviews and focus groups to test the veracity of the competencies and understand how they relate to climate action. The outcomes of this process will be used to redevelop the model and develop a set of hypotheses to be tested through a multi-variate analysis of a survey with construction professionals.

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