**Managing Project Knowledge in Delivering Sustainable Retrofitted Buildings: A Decision Support Framework**

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**Abstract**

This paper highlights the significance of knowledge management in construction activities, focusing particularly in the case of sustainable retrofitted building projects. It has been acknowledged that the industry has a poor attitude to project learning and the capture of project knowledge. Knowledge has been recognised as a most valuable asset in any industry because of its association with innovation, timely project delivery and competitive advantage. In a knowledge-based industry like construction, the work of the key stakeholders is ultimately about making decisions. However, the contribution of knowledge management to the area of decision-making has been largely ignored in the industry. Decision-making is the processing of knowledge that leads to action. Furthermore, most decisions in the delivery of sustainable retrofitted building projects are complex and interdisciplinary. Thus, there is a need for project knowledge to be managed and presented as a framework to enable the key stakeholders make an appropriate and informed decision. This paper presents a new knowledge management paradigm for assisting key stakeholders that are involved in delivering sustainable retrofitted building projects in making informed decisions. The proposed framework was developed after intensive reviews of the related literature.

**Keywords**:

Knowledge management, Project knowledge, Decision support framework, Sustainable retrofitted building projects, Key stakeholders

**Introduction**

The construction industry has been recognised as being poor at learning on a consistent basis and it is also particularly slow in adapting to progressive change ([KLICON, 1999](#_ENREF_41)). The fragmented and sometimes unstable nature of the industry has led to steady loss, or ‘leakage’ of knowledge compared to other industries ([Carrillo *et a*l., 2000](#_ENREF_12), [Kamara *et al*., 2000](#_ENREF_38), [Orange *et al*., 2003](#_ENREF_52), [Shellbourn *et al*., 2006](#_ENREF_64), [Anumba *et al.*, 2006](#_ENREF_7), [Udeaja *et al*., 2008](#_ENREF_80), [Tan *et al*., 2010b](#_ENREF_75), [Duah *et al*., 2014](#_ENREF_21)). Knowledge management has been considered to be a means of harnessing and utilising intellectual resources to address some existing construction problems especially in sustainable retrofitted building projects ([Abdul-Rahman and Wang, 2010](#_ENREF_1)). It could, of course, be argued that construction organisations have been managing knowledge informally for years, but the challenges facing the industry suggest that it needs knowledge to be managed with a more structured, coherent approach ([Hari *et al*., 2005](#_ENREF_30), [Tan *et al*., 2006](#_ENREF_76), [Petri, 2014](#_ENREF_57)) in order to enable better-informed decisions. This is particularly the case with the delivery of sustainable retrofitted building projects: not only has the building sector been targeted to as one of the sectors most responsible for greenhouse gas (GHG) emissions, but also there is a general belief that the sector can address the problem most effectively through retrofitting of existing buildings ([Jowsey and Grant, 2009](#_ENREF_34), [Ibn-Mohammed *et al.*, 2013](#_ENREF_33)). Hence the increased need for decision support frameworks, and these are all the more necessary because every project is unique due to largely variations of scope of work, specifications, geographic locations and discipline requirements ([Wang *et al*., 2009](#_ENREF_82), [Zhang *et al.*, 2009](#_ENREF_84)).

**Background**

The need to address climate change issues has imposed significant problems and risks to all countries around the world. It is widely-accepted that climate change is one of the all-encompassing global environmental changes that are having harmful effects on natural and human systems, economies and infrastructure. A major contributor to these changes has been GHG emissions into the atmosphere and this has produced a broad spectrum of policy responses and strategies for sustainable development at local, regional and global levels. It is recognised that with the fast increase in urbanisation and industrialisation, more GHGs are released or discharged into the atmosphere ([Zhang *et al*., 2014](#_ENREF_83)). Studies revealed that the built environment is responsible for some of the most serious global and local environmental change ([Li *et al*., 2013](#_ENREF_44)). In Europe, the Stern report pointed out that the built environment accounts for 50% of GHG emissions while in the UK more than 50 % of all emitted carbon can be attributed to energy use in buildings ([Stern and Taylor, 2007](#_ENREF_72)). An Australian report has estimated that, in a developed economy, the replacement rate of the existing buildings by the new build is only around 1.0 to 3.0% per annum ([ACC, 2007](#_ENREF_2)) therefore, rapid sustainable energy improvement is needed in the industry for timely reduction of energy use globally. In the UK, the government aspires to achieve zero-carbon reduction standards for new buildings from 2016 for domestic buildings, public sector buildings by 2018, and by 2019 for other non-domestic buildings ([Petri, 2014](#_ENREF_57)). However, since an estimated 70% of the 2010 building stock will still be in use by 2050, it is clear that low carbon/sustainable retrofits will have a potentially huge contribution to the GHG reductions proposed by the UK by 2050 ([Stafford *et a*l., 2012](#_ENREF_70)).

Sustainable building retrofit has been defined as incremental improvements to the building fabric and systems with the primary target of improving energy efficiency and reducing carbon emissions in the building ([Fulton *et al*., 2012](#_ENREF_27)). In the UK, the housing stock is dominated by existing homes, a huge number of which are energy-inefficient ([Petri, 2014](#_ENREF_57)). Retrofitting of existing buildings has been shown to have tremendous economic, health, social, and environmental benefits ([USEPA, 2010](#_ENREF_81), [Syal *et al*., 2014](#_ENREF_73)). Expanding on the benefits of sustainable retrofitting, different research evidence from around the world continues to support the hypothesis that sustainable retrofit measures and programs result in highly cost-effective investments, even when the narrowest criteria are used ([Clinch and Healy, 2003](#_ENREF_14), [Duah *et al.*, 2014](#_ENREF_21)) and further studies have revealed that it offers a significant opportunity for reducing energy consumption and GHG emissions ([Ma *et al*., 2012](#_ENREF_46), [Li *et al*., 2013](#_ENREF_44)). Thus, sustainable retrofitted building projects has been considered as one of the main and best approaches to achieving sustainable development in the built environment ([Ma *et al*., 2012](#_ENREF_46)). Additionally, it has been argued that a substantial reduction in energy demand from existing buildings could reduce the pressures on energy security imposed by obtaining energy from potentially unreliable sources ([Ibn-Mohammed *et al*., 2013](#_ENREF_33)). However, delivering sustainable retrofitted building projects poses a challenge to the industry due to the relative absence of managed (i.e. captured and re-used) project knowledge ([Shellbourn *et al*., 2006](#_ENREF_64), [Petri, 2014](#_ENREF_57)). The part played in this by the fragmented and temporary nature of the industry has already been noted, and added to this is the frequent transfer of personnel between projects, the rarity of ‘lessons learned’ project feedback, and the shortage of skilled workers in the first place ([Kazi, 2005](#_ENREF_39), [Tan *et al*., 2010a](#_ENREF_74)). Although the industry has been described by ([Shellbourn *et al*., 2006](#_ENREF_64)) as knowledge-driven, the management of project knowledge has not been fully adopted and its absence has contributed to a lack of appropriate decision-making ([Pietrosemoli and Monroy, 2013](#_ENREF_58)) by its key stakeholders. Thus [Duah *et al*., (2014](#_ENREF_17)) have highlighted the need for the management of project knowledge to underpin appropriate and informed decision support framework. In turn, DSFs would enable the key stakeholders to make an informed and appropriate decision hence solving the key knowledge issues in stakeholder engagement with sustainable retrofitted building projects.

**What is Knowledge and Knowledge Management?**

It is important to comprehend what constitutes knowledge and what falls under the category of information or data. This is because the word "knowledge" often takes on a variety of meanings ([Davenport and Prusak, 2000](#_ENREF_19), [Frost and Ueda, 2010](#_ENREF_26)) and it is necessary to differentiate data and information from knowledge and what it constitutes. Davenport and Prusak (2000: 5) in describing of knowledge state that ‘*knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms*’. According to [Thierauf (1999](#_ENREF_78)) and [Bali *et al.* (2009](#_ENREF_8)) dataare facts and figures which communicate a specific idea, but are not necessarily structured in any appropriate way and it provides no further information regarding patterns, context, etc. It is argued that for data to become *information*, it must be contextualized, categorised, calculated and condensed ([Davenport and Prusak, 2000](#_ENREF_19)). Information therefore paints a bigger picture; it is data with relevance and purpose ([Bali *et al*., 2009](#_ENREF_8)). In essence, information is found in answers to questions that begin with such words as *who, what, where, when, and how many* ([Ackoff, 1999](#_ENREF_3)). However, since a clear definition has been set between knowledge, information, and data, it is pertinent to go one step further to state the two ways knowledge exists. Knowledge has been recognised to exist both in explicit and tacit forms ([Smith, 2001](#_ENREF_67), [Shellbourn *et al*., 2006](#_ENREF_64), [Duah *et al.*, 2014](#_ENREF_21)).

Explicit knowledge is knowledge that can be codified and documented. This would include such things as project information, design drawing and specifications, cost reports and other information archived in paper or electronic format ([Smith, 2001](#_ENREF_67), [Zhang *et al*., 2009](#_ENREF_84)). Tacit knowledge is knowledge that is not expressed openly; it is difficult to articulate; which often resembles intuition; and that is a cumulative store based on practice, experience, mental maps, insights, expertise, know-how, trade secrets, learning, skills sets embedded in the past and present of people’s experiences, processes and values ([Smith, 2001](#_ENREF_67), [Hussain *et al.*, 2004](#_ENREF_31), [Turban *et al*., 2005](#_ENREF_79), [Taylor, 2007](#_ENREF_77), [Lin *et al*., 2005](#_ENREF_45)). Such knowledge is unstructured and intangible, it is difficult to codify ([Zhang *et al*., 2009](#_ENREF_84)). It is argued that much new knowledge is created through the synergistic link and interplay between tacit and explicit knowledge ([Nonaka and Takeuchi, 1995](#_ENREF_51)). In order for knowledge management (KM) to succeed in the industry, one needs to understand what constitutes knowledge as aforementioned and this leads to definition of KM in the ensuing paragraph.

Knowledge management (KM) can be described as the organisational optimisation of knowledge to achieve enhanced performance, increased value, competitive advantage and return of investment, through the use of various tools, processes, methods and techniques ([Skyrme and Amidon, 1997](#_ENREF_66)). Expanding upon this definition, [Frost and Ueda (2010](#_ENREF_26)) stated that KM encompasses the understanding of: ‘‘*where and in what forms knowledge exists; what the industry needs to know; how to promote a culture conducive to learning, sharing, and knowledge creation; how to make the right people at the appropriate time; how to best generate or acquire new relevant knowledge; how to manage all of these factors so as to enhance performance in line with the industry’s strategic goals and short term opportunities and threats*’’.

**Knowledge Management in the Construction Context**

[Abdul-Rahman and Wang (2010](#_ENREF_1)) have argued that the construction industry’s poor record in managing project knowledge results in huge wastage of resources, a detrimental effect to the quality of projects, and a constant ‘reinventing of the wheel’ ([Abdul-Rahman and Wang, 2010](#_ENREF_1)). A research survey by [Carrillo *et al*. (2004](#_ENREF_10)) of leading construction organisations in the UK shows that about 42 per cent have a KM strategy, and 32 per cent plan to have a strategy within a short term ([Carrillo *et al*., 2004](#_ENREF_13)). The percentages recorded indicate poor adoption of KM and the need for KM to be properly adopted and utilised in the industry for optimal performance in projects delivery. The success of a construction business in a competitive market relies critically on the quality of knowledge it possesses regarding its markets, products, services and technologies ([Faraj *et al*., 1999](#_ENREF_25), [Kamara *et al*., 2000](#_ENREF_38)). The industry has been faced with different challenges ranging from tight time schedules, low profit margins and the complexity, diversity and non-standard nature of construction projects ([Zhang *et al*., 2009](#_ENREF_84)). To address these challenges, to remain competitive, productive and profitable, and to adequately respond to the needs of clients, many authors suggests that the management of project knowledge is critical (see, for example, [Carrillo *et al*. (2000](#_ENREF_12)); [Clough *et al*. (2000](#_ENREF_15)); [Pathirage *et al*. (2006](#_ENREF_54)); and [Pathirage *et al*. (2007](#_ENREF_55)).

Many research studies have given examples of the potential benefits of adopting KM in construction activities. These include: improved decision-making; improved efficiency of people and operations; improved innovation ([Al-Ghassani et al., 2004](#_ENREF_4), [Egbu and 2005](#_ENREF_22), [Anumba and P.M, 2005](#_ENREF_6), [Shellbourn et al., 2006](#_ENREF_64), [Boddy et al., 2007](#_ENREF_10), [Duah et al., 2014](#_ENREF_21)). Others include increased flexibility to adopt and change; reduced process cycle times; shared best practices; improved management learning and improved construction project delivery ([Skyrme and Amidon, 1997](#_ENREF_66), [Davenport and Prusak, 1998](#_ENREF_18), [Egbu and 2005](#_ENREF_22)). More benefits include: facilitation of the transfer of KM across a variety of project interfaces; increased intellectual capital; improved support for teams of knowledge workers ([McCampbell *et al*., 1999](#_ENREF_47), [Soliman, 2000](#_ENREF_68), [Al-Ghassani *et al*., 2004](#_ENREF_4)); capacity to retain the tacit knowledge and explore explicit knowledge ([Anumba and P.M, 2005](#_ENREF_6), [Shellbourn et al., 2006](#_ENREF_64), [Udeaja et al., 2008](#_ENREF_80), [Duah et al., 2014](#_ENREF_21)) and finally, risk minimization ([Robinson *et al*., 2005](#_ENREF_61)). The next discussion will focus on the need for managing knowledge in delivering sustainable retrofitting building projects.

**Managing Knowledge in Delivering Sustainable Retrofitted Building Projects**

The lack of managing project knowledge as a hindrance to delivering sustainable retrofitted building projects has been specifically cited by [Ala-Juusela *et al.* (2006](#_ENREF_5)); [Shellbourn *et al*. (2006](#_ENREF_64)); [Hakkinen and Belloni (2011](#_ENREF_29)) and [Shari and Soebarto (2012](#_ENREF_63)). [Hakkinen and Belloni (2011](#_ENREF_29)) argued that knowledge management in retrofitted building projects enable the consideration of wide spectrum of aspects including building performance, environmental issues, life-cycle costs and service life, and rapid adapting of the design to the specific requirement case. [Robinson *et al*. (2005](#_ENREF_61)) agree that the lack of managing knowledge in the industry has posed a threat to delivering sustainable building principles and best practices and go on to conclude that KM principles are essential drivers for all improvements in construction organisations. In managing projects, [Anumba and P.M (2005](#_ENREF_6)) and [Shellbourn *et al*. (2006](#_ENREF_64)) agree that to achieve sustainable construction particularly sustainable retrofitted building projects, it is essential that the industry intensifies its efforts to move towards a knowledge intensive mode. [Eliufoo (2008](#_ENREF_23)) agrees that sustainable buildings can be best achieved if construction activities are informed by new resources of knowledge and expertise.

[Dewick and Miozzo (2002](#_ENREF_20)) and [Pitt *et al*. (2009](#_ENREF_59)) argued that institutional challenges and limitations (such as corporate governance structure and the extent of stakeholder ownership) are at the root of the typical absence of KM in the industry and its reluctance to change this. [Sayce *et* *al*. (2007](#_ENREF_62)) blame the lack of KM practices between construction stakeholders (which impedes dissemination of knowledge and information) for the reluctance in the uptake of sustainable retrofitted building projects as the lack of technical information and knowledge to manage them poses a challenge to the industry in their delivery. This further supports the contention that KM is a necessity for improving the delivery of sustainable building projects ([Shari and Soebarto, 2012](#_ENREF_63)). To attain the goals of sustainable construction and sustainable development, it is essential to realise the need for KM to be properly embraced in the industry to manage knowledge issues. The need for KM in delivering these projects is vital in order to have an improved understanding of sustainable issues in the built environment and how key stakeholders grasp varied technologies as a solution in achieving sustainable construction ([Anumba *et al*., 2006](#_ENREF_7), [Sayce *et al*., 2007](#_ENREF_62)).

Returning to the notorious fragmentation of the industry, [Khalfan *et al*. (2002](#_ENREF_40)) and [Shellbourn *et al*. (2006](#_ENREF_64)) have argued that knowledge is lost with the movement of people from one project to the other, and that any knowledge that is actually gained in a project is often poorly organised and lack in details without any mechanism or technology in place to retrieve it. This problem has prompted researchers such as [Shellbourn *et al*. (2006](#_ENREF_64)) and [Udeaja *et al*. (2008](#_ENREF_80)) to champion KM systems that properly manage knowledge through mechanisms that capture, store, share and reuse it. Such an integrated solution would arguably increase the uptake and effectiveness (from the point of view of their sustainability) of retrofitted building projects ([Zhang *et al*., 2009](#_ENREF_84)) despite the peculiar difficulties of these projects which are articulated by, for example, [Duah *et al*. (2014](#_ENREF_21)).

**Knowledge through Informed Decision-making for Key Stakeholders**

[Menassa and Baer (2014](#_ENREF_48)) described *stakeholders* in this context as the people who directly or indirectly have a vested interest in the building, its operation, and the outcome of a future sustainable retrofit project. They considered that the building stakeholders can include clients, owners, tenants, and investors, building operators, designers (architectural, mechanical, civil and electrical) and project managers. [Zhang *et al*. (2009](#_ENREF_84)) argued that knowledge will not generate any value unless it is actively used and this can be elucidated in a framework for optimal value. The need for stakeholders in construction especially in sustainable building retrofitted building projects to adopt implementation strategies that promote and support sustainable decisions through knowledge-based decision criteria has been suggested ([Pan and Dainty, 2012](#_ENREF_53)). Decision support frameworks can assist the key stakeholders to confront uncertainties and ill-structured problems through direct interaction with data and information through managing knowledge ([Anumba *et al*., 2006](#_ENREF_7)). The use of a decision support framework permits the user to draw upon a well-established pool of knowledge about a given domain to offer advice on how to best deal with technical or business problems ([Sprague *et al*., 1989](#_ENREF_69), [Power, 1998](#_ENREF_60)). Sustainable retrofit projects involve complex processes that are typically unfamiliar to key stakeholders therefore the need to manage knowledge ([Shellbourn *et al*., 2006](#_ENREF_64)) through an informed decision-making framework is necessary in order to align stakeholders’ requirements and determine an economically, socially and environmentally acceptable engineering solution ([Lapinski *et al.*, 2007](#_ENREF_43), [Klotz and Horman, 2010](#_ENREF_42)). During the building project life cycle, key stakeholders make decisions on daily matters based on their knowledge and expertise ([Anumba *et al*., 2006](#_ENREF_7), [Menassa and Baer, 2014](#_ENREF_48)). This makes the domain of sustainable retrofitted building projects ideal for the deployment of a decision support system for many reasons particularly for project knowledge to be properly managed by the key stakeholders to make appropriate decisions for optimal project performance, timely delivery and competitive advantage.

Experience and expertise can be captured and encapsulated in a decision support system that provides a sound technical framework for decision-making ([Anumba *et al*., 2006](#_ENREF_7), [Udeaja *et* *al*., 2008](#_ENREF_80), [Tan *et al*., 2010b](#_ENREF_75)). Sustainable retrofitted building project decisions are also influenced by many micro-level factors such as deterioration and obsolescence of a building, indoor environmental quality as well as social and economic factors ([Kaklauskas *et al*., 2005](#_ENREF_37)). In order to achieve significant sustainable solutions in sustainable retrofitted building project, [Boecker *et al*. (2009](#_ENREF_11)) emphasised that engaging all stakeholders early on the project is necessary in order for project knowledge to be well-managed from the early planning stages to help in making an informed decision. The authors further argued that a diversity of values, opinions, expectations and perspectives among stakeholders is to be expected but need to be properly managed to turn it from a liability that can significantly impede project success into an asset.

**Review of Decision Support Frameworks Developed for the industry**

An investigation of the relevant literature has revealed that some studies have developed decision support framework and frameworks for construction projects especially in sustainable construction as it regards to decision-making within the stakeholders. [Anumba *et al*. (2006](#_ENREF_7)) developed an integrated decision support system to assess existing office building conditions and recommended an ideal set of sustainable retrofit actions, considering trade-offs between retrofit cost, improved building quality, and its environmental impacts. [Juan *et al*. (2009](#_ENREF_36)) developed a decision support system for housing condition assessment and refurbishment strategies. [Juan *et al.* (2010](#_ENREF_35)) developed a decision support system to assess existing office building sustainability conditions and recommend an optimal set of retrofit measures that considers the trade-offs between cost, resource consumption, energy performance, and greenhouse gas emissions. [Juan *et al*. (2010](#_ENREF_35)) developed a hybrid decision support system for sustainable office building renovation and energy performance improvement. [Entrop *et al*. (2010](#_ENREF_24)) investigated energy performance indicators in Dutch residential dwellings and developed a methodology that incorporated additional revenues within the financial analysis of energy saving techniques. The research integrated a long-term financial gain as a benefit for pursuing sustainable retrofits into the decision-making process and revealed that much shorter payback periods in return on investment (ROI) methodologies could be realised.

Furthermore, [Bluyssen *et al*. (2011](#_ENREF_9)) presented a quantitative approach to determining the value of single or multi-phase investment in sustainable retrofits for existing buildings by taking into account different uncertainties associated with the life cycle costs and perceived benefits of the investment. The results of a case study in the research indicated that when uncertainty is high, dividing the decision into several phases helps increase the value of the investment and provides stakeholders with flexibility to abandon the retrofit project if necessary. [Pan and Dainty (2012](#_ENREF_53)) developed a systematic approach for UK house building organisations to identify value-based decision criteria and quantify their relative importance for accessing building technologies systematically. [Menassa and Baer (2014](#_ENREF_48)) developed a framework to assess the role of stakeholders in sustainable building retrofit decisions. [Ibn-Mohammed *et al*. (2013](#_ENREF_33)) developed a decision support framework for evaluation of environmentally and economically optimal retrofit of non-domestic buildings, and in 2014 the same authors integrated economic considerations with operational and embodied emissions into a decision support system for the optimal ranking of building retrofit options ([Ibn-Mohammed *et al*., 2014](#_ENREF_32)). [Duah *et al*. (2014](#_ENREF_21)) developed a knowledge elicitation strategy to elicit and compile home energy retrofit knowledge that can be incorporated into the development of an intelligent decision support system to help increase the uptake of home energy retrofits. [Syal *et al*. (2014](#_ENREF_73)) in their research developed an information framework for intelligent and decision support system for home energy retrofits. [Zhang *et al*. (2014](#_ENREF_83)) developed a multi-criteria decision framework for the selection of low carbon building measures for office building in Hong-Kong. [Ibn-Mohammed *et al*. (2014](#_ENREF_32)) developed the Integration of economic considerations with operational and embodied emissions into a decision support system for the optimal ranking of building retrofit options.

These studies have addressed some of the issues in delivering construction projects particularly sustainable retrofit projects, but have not addressed the need to properly manage project knowledge through decision support framework by the key stakeholders. Having acknowledged the gap in knowledge as it regards decision-making, this research aims to develop a decision support system that will enable the key stakeholders that are engaged in sustainable building retrofit projects make informed and appropriate decisions to avoid post decision project mistakes and at the same facilitate the uptake of such projects within the environment. The following discussion relates to Figure 1, which is the proposed Framework for Decision Making.

**Proposed Decision Support Framework**

The relevant literature discussed above was fundamental and also helped in the development of the proposed decision support framework shown in Figure 1. The objective of the proposed framework (Fig.1) is to enable key stakeholders involved in sustainable retrofitted building projects make an informed and appropriate decisions in delivering the projects. The processes involved in the framework will help key stakeholders involved in the project to address the knowledge gaps (such as, lack of capturing and reuse of knowledge) towards making an informed decision. The framework consists of eight stages of decision- making.



**Figure 1. Proposed Framework for Decision Support**

The first stage - *problem recognition* - refers to the recognition of an existing problem before going ahead with defining the problem ([Courtney, 2001](#_ENREF_17), [Shim et al., 2002](#_ENREF_65), [Zhong, 2008](#_ENREF_85)). The the second stage is to *define the problem* and this involves specifying the purpose or decision goals (for example, articulating the parameters of objectives and functions, relationships etc.) and this leads to the next step which is to consider tacit knowledge. The next step which is the third stage in the process is to *consider tacit knowledge*. The role and relevance of tacit knowledge has been considered earlier in this paper. This type of knowledge is very relevant to the framework’s procedure, before making decisions because it would allow all the key stakeholders to make suggestions according to their professional and project experience and this would contribute to making better- informed decisions. The fourth stage is the *consideration of explicit knowledge* that relates to the decision in question. Again, the relevance of explicit knowledge has been afore-mentioned. This is very important in making an informed decision since the knowledge that exists therein has been readily articulated and transferable to others and this leads to consideration of post decision mistakes before making decision.

The fifth stage is theneed to consider *post decision mistakes* which *is* very relevant in making an appropriate decision. This suggests the need to avoid past decision mistakes by considering the ‘why’, ‘how’ ‘what’ led to the inappropriate decision made in the past and also acknowledge lesson learned to avoid making same kind of mistakes. Taking this into consideration in decision-making harvests a platform of informed decision successes. At this juncture, steps that have been considered have to be integrated.

The sixth stage is *Knowledge integration* in making decisions has been referred to as the process of combining several types of explicit and tacit knowledge into new patterns and new relations in decision-making. In their study Nemati *et al* (2002) cited the work of [Perkins (1986](#_ENREF_56)) on the ‘Gestalt theory’ of learning states; that all problems which may confront us have potential solutions, and these solutions are matters of relations. The authors further argued that our understanding of the problems demand our awareness of certain relations and we cannot solve any existing problem without discovering certain new relations hence the need to integrate knowledge available to make appropriate decision. Drawing conclusions from a number of authors such as ([Steiger, 1998](#_ENREF_71), [Nemati *et* *al*., 2002](#_ENREF_50), [Metaxiostis *et al*., 2003](#_ENREF_49)) integration of explicit and tacit knowledge is the analysis of multiple related ‘what-if’ cases of a decision-making process and this helps to find new synergy that will determine the key factors of the decision problem and demonstrate how these key factors interact to influence informed decisions.

Following the integration of knowledge, the seventh stage is *knowledge analysis* and this will help the key stakeholders identify relevant knowledge necessary to be captured in order to help select the best solutions before making a decision. It will also assist the key stakeholders to understand knowledge perspectives at deeper level and develop new insights about them which will help in selecting the best solutions for informed decision-making ([Goldkuhl and Braf, 2001](#_ENREF_28)). According to [Cote and St-Denis (1992](#_ENREF_16)) this ensures coherence amongst the stakeholders and helps in resolving any decision conflicts that may exist.

The stage eight is penultimate stage in the process which is the *selection of the best solutions* which includes two steps, firstly, is the creation of evaluation indexes and their weight of importance which depends on the key stakeholders’ preferences. Secondly, is the actual process of evaluation against the objectives and goals that have been set as explained by ([Zhong, 2008](#_ENREF_85)). These will be necessary for the key stakeholders having analysed the integrated knowledge gathered. The key stakeholders having selected the best solution will be able to make an informed project decision. The proposed framework will enable the key stakeholders not only to make an informed decision, but also to transfer the decision process to new key stakeholders that may emerge during the project lifetime.

**Conclusion**

The essence and significance of knowledge management (KM) in the construction industry, particularly in sustainable retrofitted building projects has been critically discussed. The discussion in this paper has also been able to establish the need for KM to be properly adopted if the industry indeed wants to champion the cause of sustainable development through sustainable retrofitted building projects.KM has been described as a process that involves the creation, capture, storage, dissemination, sharing, utilisation, and reuse of knowledge. This processes should lead to industry benefits (e.g. innovation, improved performance and competitiveness) if put in place. It is important to note that KM is not an end in itself, but a means towards the achievement of good decision-making that in turn supports business goals. KM should reflect both individual and collective knowledge within the context of organisations, it should be supported by various tools (e.g. IT, frameworks), processes, methods and techniques. Knowledge managed and elucidated in form of a decision support framework as proposed, is necessary due to its relevance in enabling project stakeholders to optimise the benefits associated in delivering sustainable retrofitted buildings and also it helps them to avoid repetition of mistakes and post-decision dissatisfaction. This is because an understanding of what constitutes ‘knowledge’ has a bearing on the KM decision-making hence the development of the proposed decision support framework for the key stakeholders.

Furthermore, it is pertinent to note that the proposed decision-support framework will enable the researcher to develop a decision-support system prototype after empirical data has been collected from intended case organisations/studies.

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