Designing a Pre-Assessment Tool to Support the Achievement of Green Building Certifications

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***Abstract*—**The impact of common buildings on climate and environment has prompted people to get involved in the green building standards aimed at implementing rating tools or certifications. Thus, green building rating systems were introduced to the construction industry, and the demand for certified green buildings has increased gradually and succeeded considerably in enhancing people's environmental awareness. However, the existing certification process has been unsatisfactory in attracting stakeholders and/or professionals who are actively engaged in adopting a rating system. It is because they have faced recurring barriers regarding limited information in understanding the rating process, time-consuming procedures and higher costs, which have a direct influence on pursuing green building rating systems. To promote the achievement of green building certifications within the building industry more successfully, this paper aims at designing a Pre-Assessment Tool (PAT) framework that can help stakeholders and/or professionals engaged in the construction industry to clarify their basic knowledge, timeframe and extra costs needed to activate a green building certification. First, taking the first steps towards the rating tool seems to be complicated because of upfront commitment to understanding the overall rating procedure is required. This conceptual PAT framework can increase basic knowledge of the rating tool and the certification process, mainly in terms of all resources or information of each credit requirements. Second, the assessment process of rating tools is generally known as a "lengthy and time-consuming system", contributing to unenthusiastic reactions concerning green building projects. The proposed framework can predict the timeframe needed to identify how long it will take for a green project to process each credit requirement and the documentation required from the beginning of the certification process to final approval. Finally, most people often have the initial perception that pursuing green building certification costs more than constructing a non-green building, which makes it more difficult to execute rating tools. To overcome this issue, this PAT will help users to estimate the extra expenses such as certification fees and third-party contributions based on the track of the amount of time it takes to implement the rating tool throughout all the related stages. Also, it can prevent unexpected or hidden costs occurring in the process of assessment. Therefore, this proposed PAT framework can be recommended as an effective method to support the decision-making of inexperienced users and play an important role in promoting green building certification.

***Keywords*—**Barriers, certification process, green building rating systems, pre-assessment tool.

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I. Introduction

WITH international issues continuously drawing people's attention from all over the world, global warming and climate change are now widely recognised as the most serious environmental problems. These issues have resulted in a shift towards emphasising the need for the reduction of Greenhouse Gas Emissions and the development of green buildings in the world's construction industry.

Buildings create a considerable impact on the Earth resulting in 80% of the world's potable water, 50% wastage of materials and resources, 45% of the world's total energy use and 35% of the world's CO_2 emissions [1]. United Nations Environment Programme (UNEP) reported that non-green buildings have continued to use a lot of energy and world CO_2 emissions, showing more than 40% of global energy consumption and one-quarter of global human-induced CO_2 emissions in OECD countries [2]. There is a direct correlation between CO_2 emissions and the energy consumption. It means that the CO_2 comes from fossil fuels burning which provides 80% of the world's energy supply [3] and such energy consumption is responsible for about 70% of the world's CO_2 emission [4].

The environment impact of urban and construction activities can be demonstrated and compared through green techniques and rating systems that enable "sustainable development to take place in a more measured and accurate way" [5]. Hence, approaches to green building rating tools have been proposed to evaluate the extent and level of sustainability throughout the building lifecycle. A considerable percentage increase in constructing green buildings has resulted from some responses with green building assessment tools worldwide [6]. The current trend is towards achieving green building certifications. A huge momentum is developing in the pursuit of certified green buildings in the global construction market.

The concept of environmental sustainability has been recognized by everyone involved in the construction, engineering and architecture industries for years [7]. Nevertheless, it is still unclear that how addressing sustainability in the building sector is carried out successfully with unquestioned evidence, and that a fundamental concept of sustainable building has proven its worth over many years. Most researchers agree that the progress towards "sustainable development" is not delivered entirely [8], [9]. Smith also states that there is not much to take part in sustainability in the building industry due to unreliable evidence [5]. Although people can lead to the change in the implementation of sustainable buildings, the adoption of sustainability may be seen to be a hindrance for the building industry, resulting in a slow rate of progress [10]. Besides, more than 600 green building assessment tools that were developed all over the world have been proven to be used by approximately 50% of green building projects [11]. However, such rating systems were not completely successful in helping to give structural and civil engineers chances for more involvement and contribution to a green building project [12], [13]. Wu and Low emphasized on the needs of project management to training green building professionals involved in construction and engineering [14]. In light of the management of green building certification, there is a lack of connection in "green" rating systems which lead to some distance between belief from experienced professionals and their practical performance [11].

Some researchers point out that the reason why people are still yet to be convinced on rating tools is that of the public's hesitation and unwillingness to accept green building standards. Traditionally, people may face several problems such as unexpected events, the complexity of the certification process and urgent priority works, especially when they are not familiar with the certification system that needs to be done. Also, they may not take into account the amount of time needed to complete the certification so that they are likely to have negative perspectives on adopting rating systems. Studies have shown that green buildings have lost their appeal, reporting that unenthusiastic people refer to the idea as a contemporary trend [15]. The use of a rating tool as a strategy to deliver environmental benefits is uncertain as it is also known as a general way of promoting a brand image of the green buildings [16].

II. Barriers to Green Building Certification

A global trend of implementing a green building rating system and of certifying a green building is widely prevalent in the construction industry. This significant development has a positive impact on the environment, building performance, operation cost savings and occupants' health and well-being [17], [18]. Generally, green building rating tools have succeeded considerably in encouraging the building industry and stakeholders to adopt and accept green buildings. However, there remain major barriers to green building certification schemes regarding knowledge, time and cost issues, which could hinder the potential interest and growing demand for green building certification. More specifically, Darko and Chan identified that the major reasons for avoiding green building certifications were higher upfront cost, lack of knowledge, lack of incentives from governments, lack of interest and demand from clients and lack of effective green building policies or regulations [19]. Ahn et al. also highlight the main barriers involved in green building assessment being the high-cost estimates at the first stage, the length of time for payback, a conservative trend toward keeping conventional standards, and subcontractors' ignorance and techniques [20]. According to the Green Building Market Report, respondents (e.g. developers, architects, engineers) were asked to select a top barrier to green building certification and talk about their experience and opinion of green building certification in the survey. The findings reveal that cost (51%), lack of information on certification requirements (38%), the difficulty of the certification process (35%) and time of the certification process (33%) are considered as the most important barriers to green building activities throughout South East Asia [21].

A. Insufficient Knowledge

Barriers to knowledge can be interpreted in many ways such as lack of understanding and information, unfamiliarity and low awareness amongst the public and/or stakeholders in the construction industry. Although knowledge of green building rating system and the certification process can be obtained through research, education or training programmes, skills and experience, there are empirical studies showing various barriers about knowledge of current green building certifications.

The first issue of knowledge is the absence of definite proof about credible green building research and lack of education. It may cause insufficient information, which impedes developing public awareness and expertise or knowledge on green buildings [22].

> "There appears to be somewhat limited knowledge amongst the survey respondents who have been involved in green building certification for about four years about the financial performance or benefits of incorporating these design features, technologies and building materials" [23].

Also, Samari et al. claim that low public awareness and limited knowledge of the benefits of green building technologies and construction professionals are barriers to adopting green building rating systems [24].

The second reason why it is difficult to persuade the public who have not enough knowledge to acquire green building information is that of a 'pay per view' system that charges an expense related to registration fees and consulting fees [15], even the education and training system. The role of education and training system could be important for the public to be motivated in green building development and promote the green building market significantly [5], [25], [26]. Despite the importance of the level of expertise and knowledge through green building education, the public or any group of stakeholders are not likely to be content with green building practices unless they are educated and informed. Thus, Bond remarks on the shortage of well-trained technical professionals for building high-performance buildings [23]. Markelj et al. also state that

> "most of the existing building sustainability assessment methods (BSAM) are either not adapted for independent use by the architects or are the requirements for criteria fulfilment quite complex and require specific knowledge of an expert consultant" [24].

Insufficient education and training programmes, reduced public awareness and inadequate comprehension of green building certification can be a barrier affecting the property industry [15].

Furthermore, buildings are generally designed to comply with a building code that has minimum requirements, which might be related to the barriers to knowledge. People are still not sure why their buildings should be designed to achieve sustainable goals because green building standard seeks to go beyond the building code. For example, the New Zealand Building Code was first established in 1991, and all building works in New Zealand must comply with the building code requirements to ensure that buildings are safe, healthy and durable for everyone who may use them. However, New Zealand homes that have been built by poor standards suffer from many serious problems such as asthma, allergy and respiratory illnesses which make people sick [25]. According to NZGBC's policy paper, the current building code hasn't been updated since 2007, and thus its policy is inadequate to build sustainability [26]. Although the green project is required to have much skill or effect [26], there is a shortage of unskilled labour and professionals in a market [27]. It is a challenge for architects or building designer to improve the building performance of green building concepts [28].

B. Difficulties with Time Management

Effective time management and time estimation of a project are one of the essential aspects of the certification process. However,

> "practical procedures such as paperwork, the proportion of time-consuming work, and confirmation also greatly affect the difficulty" [29].

All stakeholders who are involved in the certification would think that they devote a great deal of time, waiting for the whole assessment process and preparing for all documents to be completed before the deadline. According to previous literature, protracted and extended periods of project time make it difficult to fit in green building rating schemes [30]. The Green Building Market Report also concludes that there is concern among building owners, professional services and contractors that green building certification would require additional time to activate training programmes and additional research for proper materials aimed at green buildings [21].

For instance, green projects requiring a certification often take a long time because of the time-consuming submission process in the traditional assessment programme, collecting and managing the documents and passing through the documentation, all of which are a barrier to the uptake of rating tools. It means that those barriers hinder key decision makers from investigating green building certification because all clients want to know is how much time their project will take and often judge whether the plan has succeeded or failed depending on whether it has been delivered on time and budget. Besides, the procedure for assessing and certifying is usually long and demanding so that

> "checking the broad spectrum of content demands much time and requires the use of different tools for testing the results" [24].

C. Perceptions of Cost Impacts on Green Building Projects

Costs are the most important factor that needs to be considered when conducting green building projects for the first time. However, the perception of green-rated buildings being costly is regarded as one of the main impediments to building sustainable growth, despite some evidence on the benefits of green-rated buildings [4].

Many studies found that public is still yet to be convinced due to unclear estimates, insufficient data on upfront costs and the additional finance required in the initial investment of adopting green-design projects [30], [31]. Further, the most significant barriers were associated with a vague cost assumption such as the lack of initial asset and low capital investment, as well as higher expenditures for completion [32]. Bond maintains that building 'green' is relatively costly in comparison to common buildings to be built and operated. This is one of the reasons why people do not implement green buildings [23]. In comparison to constructing common buildings, progressing toward green building practices require consideration of the additional costs involved in new technologies applicable to renewable energy sources, such as solar and geothermal heat, the initial expense of establishments to satisfy the specification, and the employment of skilled workers [33]. Hence, the higher quality level of the green building certification leads to a cost increase in the high capital investment in applying new technology in the design and construction [34]. If an upfront capital commitment to the first design stage is required, most contractors, clients and developers are reluctant to use costly rating tools. In general, conducting rating tools are generated based on a quote for a registration fee, a third-party assessment and other additional optional choices which make it more difficult to adopt the schemes voluntarily. Kubba points out that the capital expenditure of choosing the Green Globes® rating system requires an annual fee for using the online tool service, a consultant fee to be billed separately, a third-party's assessment fee and so forth. These have to be dependent upon project location and size (hectares/acres) [35].

Another big hindrance is that government incentives that are currently available do not draw key players' attention to the promotion and development of green projects [36]. That is, shortage of funds and incentive programmes from the government can be challenging. In general, incentives play a relevant role as a key driver in pursuing green building certification. Green building incentives promote green building certification or development [37]. Hashim et al. noted that financial incentives directly related to the flow of funds act as a tool of interest that draws the attention of most developers [38]. Many governments in different countries have demonstrated a strong commitment towards the public in establishing various financial incentives for greater use of green building rating systems such as tax credits, low-interest loans, subsidies and so forth [37]. However,

> "there are some criticisms of green building incentives such as lack of enforceability mechanism, the attachment of green building incentives to certification and lack of a mechanism to determine the optimum level of incentives

required" [37].

In Malaysia, for example, there have been no plans for the development of green projects yet because of insufficient incentives introduced by the government [38].

Moreover, Geng et al. report that a lack of incentives discourages developers from promoting the use of eco-friendly and technological innovation for green building projects [33]. Developers would prefer to choose simpler, cheaper, more energy and water efficient methods over complicated and costly ones despite the benefits included by achieving a higher rating score using green techniques. Also, Bond claim that a controversial issue of split incentives between property owners and tenants concerning the beneficial factors gained from investing in green buildings [23].

The Green Building Council South Africa (GBCSA) researched the cost of green buildings pursuing Green Star SA certification. The GBCSA report concludes that even though the higher certification levels between 4 and 6 stars result in the additional cost of green buildings, it is on average a 5% cost premium of the total project cost compared to non-green buildings [39]. Kats also collected the cost data of 33 certified green buildings to compare them to the same buildings constructed by a conventional method. He concluded that an average extra cost premium of 2.7% is needed to get green building certification [40]. It means the average premium is no higher than that perceived by the consumer. Another barrier is that clients with a focus on making money quickly from real estate are not as likely to be interested in green building options [15]. However, most people are more interested in the immediate building costs than in the lifetime building costs. It is because they are expected to get a return on investment in less 7 and 20 years [41]. Thus, it is difficult to persuade people to invest the extra money needed to conduct green building project [42]. Nobody will show a willingness to embrace the additional costs involved in building green [15]. Consequently, the initiative and execution of current green building rating tools will be expected to make slow progress in the future.

III. Green Building Certification in New Zealand

New Zealand ratified the Paris Agreement on 4 October 2016 and submitted its Nationally Determined Contribution to the United Nations Framework Convention on Climate Change (UNFCCC). "New Zealand's current target is to reduce greenhouse gas emissions by 30% below 2005 levels by 2030" [43]. New Zealand's gross CO2 emissions were mostly affected by the agriculture and transport sector. However, it is costly and difficult to reduce the substantial CO2 emissions from the agriculture and transport sectors. There are some possibilities that can lead to a long-term and proactive approach to the carbon agenda within the building sector. According to the NZGBC report, the building sector is one of the fastest-growing sources of GHGe, and commercial buildings use up over 20% of electricity and cost NZ $800 million annually [44]. Therefore, it is seen as having more efficient solutions to reduce carbon emissions which can be reduced by simply improving energy efficiency in the construction industry.

New Zealand's construction industry will be faced with three issues in the next future. The first issue relates to the growing population which would lead to a significant increase in the number of households. The New Zealand government reports that New Zealand has shown the second highest population growth, which is directly related to the growth of the construction industry in reaction to shortages of new buildings across New Zealand. Over the period 1991 to 2015, dwellings and household growth exceeded the population growth rate [45], with an increase of approximately 40% since 1990 [46]. However, the trend for 2013 to 2015 has been reversed, and population growth has outpaced dwelling and household growth. For this reason, it is most likely that the New Zealand building industry will be activated very fast so that they will need more dwellings and households that are certified as green buildings, which will become important in the future. The second issue is that there are some questions to be considered to lead the construction boom and the future New Zealand building to sustainable outcomes through the widespread application of green building certification. Why is it important to achieve the green building certification? Why are rating tools not currently guaranteeing enough for sustainable outcomes? Why do we need to increase the number of certified green building in New Zealand? Besides, there remain major barriers to green building certification in terms of knowledge, time and cost which is related to the third issue.

As a result, more achievement of green building certification would not only deal with the current situation of environmental issues, the growing population and the demand for construction activities but also deliver tangible sustainability on the New Zealand construction industry.

A. Perceived Barriers to Sustainable Property Investment

With the establishment of the NZGBC in July 2005, they have introduced the concept of sustainability of the built environment to the property industry in New Zealand, which influences on the building industry, and they released Green Star NZ in 2007. As a result of a growing movement and pressure to link the construction and property industry with sustainable investments, sustainability has not only raised the awareness on the commercial property market, but also its implementation has increased remarkably over the past decade [47]. Smith and Baird have stated that the implementation of Green Star NZ can only be successful if the tool is widely accepted and adopted by industry its member [48]. If key stakeholders are reluctant to adopt the tool, voluntary uptake will not occur, and implementation will be slow [49]. Smith surveyed for about three weeks to identify potential barriers in the early phases of Green Star NZ's implementation [5]. Participants were selected from the New Zealand building industry, in particular, stakeholders (i.e., property developers or managers, investors, building contractors and architects) and end-users (i.e., assessors, consultants). They reported the main drivers for the sustainable building are 'rising energy costs' (49% of the response), 'client demand' (41%) and 'environmental condition' (32%). On the other hand, 'perceived higher upfront costs' (65%), 'lack of education' (48%) and 'lack of awareness (47%) were deemed as the obstacles to a sustainable building.

The level of involvement in sustainable activities of the building industry does not mean the same level of their interests to participate in sustainability. In this sense, people seem to think that sustainability is a 'nice-to-have' requirement rather than a 'must-have' requirement in the decision making of their investment. Although the property investment is increasingly used to apply sustainable strategies to the investor's business initiative, it has not been higher than in other developed countries and has grown relatively slowly in the New Zealand market. Some studies identified that the importance of investment in driving the sustainable development has weakened since New Zealand's housing markets were affected by the Global Financial Crisis (GFC) and the Christchurch earthquakes [52]. After the GFC had a direct impact upon New Zealand's housing markets, such as housing supply or housing price, many developers found it more difficult to gain credibility for new constructions. Thus, New Zealand construction plummeted by 56% with building consents (i.e., residential building permits) and fall by 15.3% in the price of new housing between 2007 and 2011 [53]. Also, some property industry has taken a more proactive approach to focus seismic design for buildings which became more important to office tenants after the Christchurch earthquake occurred in 2011. As a result, Statistics New Zealand reported that earthquake-related building activity increased between 2010 and 2013 across Christchurch [43].

Several other possible issues and barriers were also identified. First, Statistics NZ believes that because building activities take place when building consents are issued, the pattern between building activities and building consents will be similar over time [54]. So, there was a significant decrease in the building activities since building consents were not issued much, especially in 2012. Also, another reason for this shortfall may be the impact of land-use restrictions that have been imposed since 2005. In Auckland in particular, there is a lack of construction workers because of lower labour costs and unattractive jobs. Approximately 9,000 more is needed to solve an ongoing issue of demand for new houses [55].

Other than these factors, Myers et al. found that

> "even though the NZGBC and government have taken targeted measures, considerable hesitation and scepticism is existing in the property market from both an investor's and building owner's perspective" [50].

The New Zealand property industry had been pressurised to implement green rated buildings by the government. Thus, all new constructions must achieve Green Star-certified buildings with at least 4 star rating, which is one of the Eligibility criteria of the Green Star NZ [51]. However, this policy was abolished in 2010 because green buildings were not regarded as a top priority for the government anymore. In recent years, the NZGBC and Property Council of New Zealand have announced a new policy plan for the built environment at the Green Property Summit 2017. They have focused on how the construction and property sector in New Zealand work with government collaboratively to make better homes and buildings, especially commercial buildings, communities and cities. They aim to meet lower carbon emissions for the environment and to create healthy cities for New Zealanders. This plan will combine building green and provide suppliers and innovator with certainty that could convince them to invest development funds for new techniques and products for building green. Additionally, developing the policy plans are likely to start increasing the number of certification or the use of rating tools again [51]. Therefore, it is anticipated that green building growth is less likely to increase in these circumstances and the current delivery of green-rated buildings is not viewed as a great success in New Zealand.

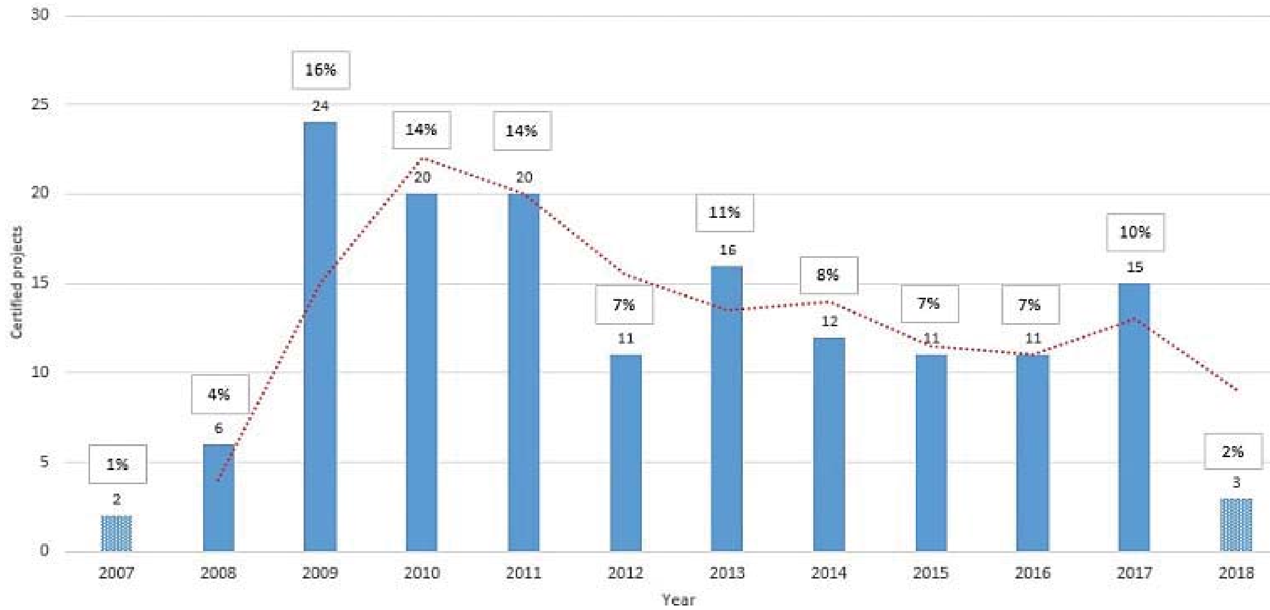

Fig. 1 The number of Green Star NZ™ certified projects in New Zealand between 2007 and 2018 (*Note: 2007 and 2018 do not account for the whole year)

B. The Downturn in the Green Star NZ™ Certification

Green Star NZ™ tool is the most widely recognised green building rating system and certification programme in New Zealand which is currently in use with the highest number of certified buildings. The importance of green building certification has gradually increased since the Green Star NZ was introduced in 2007 and its development has been reflected in the New Zealand construction industry [4]. Many of the first project registration would have occurred in 2007, as shown in Fig. 1. These registrations have resulted in the number of certified projects from 2009 to 2011 which showed the highest growth of 14 ~ 16 % in their total percentage. Since then, although the number of certifications is higher in some years and lower in others, the trend not only seems to have deteriorated but also the number of actual certified projects is still comparatively low from its first introduction. In comparison with Australia, for instance, there have been 1,792 Green Star certified projects, and 569 registered projects (as of May 2018) since the Green Star Australia has been available in 2003 [56]. There could be a possible reason why the number of certified projects has decreased between 2009 and 2017 in the New Zealand construction industry. The following section attempts to take an in-depth look at the Green Star NZ (GSNZ) certification process and to find the gaps between three current issues occurred in the certification process.

C. Three Barriers to Green Star NZ™ Implementation

There are many challenges facing business people, exporters, policy makers and anyone with interest in the Green Star NZ™. The most sensitive issues arise from the three barriers of the complexity of using the rating tools, time-consuming procedures and high costs, all of which spread scepticism about the process of rating systems.

The Figs. 2 and 3 are the main steps in the GSNZ certification process. Although the workflow of the certification may seem quite straightforward, it is not as easy as we might think. After project eligibility has been determined with the NZGBC, the project owner or a representative is required to pay the certification fees or discounted fees that are available to an NZGBC member. Then, once the project is officially registered, project teams and the building owner can take part in an introductory meeting to ask questions, such as about the GSNZ certification process and submission.

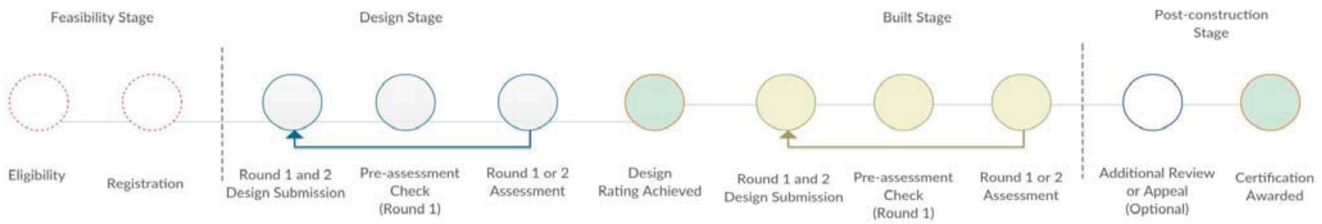

Fig. 2 The Green Star NZ™ certification in New Zealand

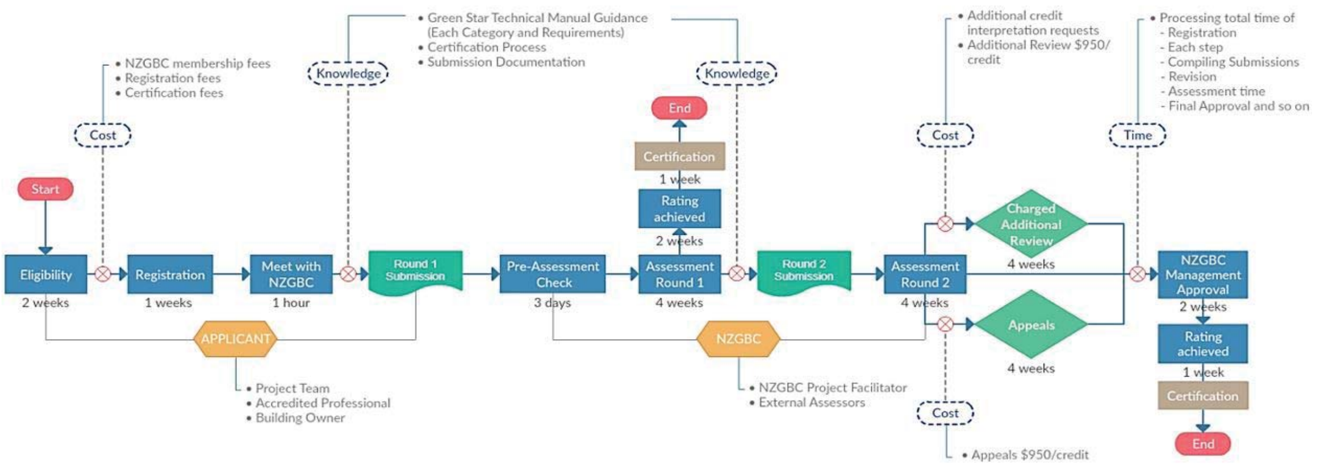

Fig. 3 Three barriers occurred in the certification process of the Green Star NZ™ (adapted from the NZGBC website)

In Round 1 Submission, the NZGBC should receive all supporting documentation as requested within at least a week, before the full submission is completed. Then, the submission should be returned to the Green Star Accredited Professional (GSAP) who will revise the documentation provided if it does not satisfy the assessment and comply with GSNZ standards. Round 1 assessment is implemented by an NZGBC Project Facilitator and two external Assessors only, who will send their comments to the project team. Based on the submission provided by the project teams, it is checked whether or not the submission has adhered with the guideline outlined in the Document Checklist before the Round 1 Assessment. However, if the project fails or does not achieve certification within Round 1 Submission assessment, it is necessary to process the

Round 2 assessment.

In contrast, if a project achieves a Green Star rating in the Round 1 assessment, the NZGBC Project Facilitator will encourage the project team to get the recommended points and Green Star rating. However, if the targeted rating is not awarded after the Round 2 assessment or the evidence provided was insufficient to award the points, a project team can start Post-Round 2 Clarification (PR2Cs), Charged Additional Reviews (CAR) or Appeals to resubmit the required documentation. To process PR2Cs, CAR and Appeals, a flat fee should be paid in full and be submitted within 30 days of receiving the Round 2 comments [51].

As shown in Fig. 3, barriers are often evident in the assessment process of the Green Star NZ™, and they will be explained in further detail. First of all, all those professionals who will be responsible for green certification such as the design team or project managers may have difficulties in approaching the assessment process by themselves without employing consulting services. Also, understanding at first sight how the credits are processed and approved holistically can be challenging which results in the need for the repeated explanation of the requirements for the criteria unless they are educated on the subject or have taken a Green Star course. The second problem is caused by the fact that unskilled people cannot determine how long their own projects will need within the time typically required to collect the required information and input the data. As shown in Fig. 2, the assessment process of Green Star NZ rating tools has two stages: design rating and built rating. A design phase rating is a temporary step towards achieving a built rating. In other words, it is not necessary to target only design rating for final authorised certification because it will expire when the project is intended to achieve the built rating or to reach 24 months after practical completion. Also, the registration for design rating should be achieved prior to practical completion of the project. For applying for the built rating, it should be conducted only after construction and will be certified no later than two years following certification of practical completion**.** As a result, people cannot predict the exact time of each certification process to be prepared and to be finished. Based on the notification on the NZGBC website, there is no specification about when certification should be achieved. Thirdly, to officially conduct the Green Star NZ™ rating tool, additional costs are associated with the registration fee, which changes depending on the size of the project. However, people who pay NZGBC membership fees can obtain their qualification for membership at a discounted price. If project teams do not achieve the targeted rating or points, they will be required to go through some circumstances such as additional review and appeals, Credit Interpretation Requests (CIRs) and Project Inquiries. Additional fees, for the processes stated above, will be charged. Therefore, this paper focuses on designing a new framework of the PAT to support the Green Star NZ™, which is one of the most largely used rating tools in New Zealand.

IV. The Consideration of a PAT

A. The Role of a Pre-Assessment Framework

A PAT can be a way to provide essential information about knowledge, time and cost at the beginning of the certification process. A well-designed PAT could affect how clients or experts who are in green certification approach their future project by providing a rough outline of the whole certification process.

Some researchers found that the PAT is useful in clarifying the objectives of building owners at the early design stage and in setting the desired ratings [57]. Also,

> "specific rating systems allow a preliminary score to be acquired on the basis of a smaller number of core criteria, which are assessed according to the usual procedure" [24].

In the United States and Canada, there is a precedent for the PAT of the green building rating system. Their rating tools use this PAT: BREEAM and Green Globe. They are intended to serve as a self-monitoring tool, allowing the user to be involved in the PAT. Both PATs stress that clients need this information to plan green building certification effectively in the early planning stage of the project. Also, those tools place more emphasis on getting an indication of the credit content or summary, potential points that clients would achieve and quotes for registration before certification.

First, the BREEAM certification process in the first step is to use a pre-assessment of the building completed by a pre-assessment assessor that will help clients who wish to conduct the pre-assessment better understand the BREEAM process. To be specific, the tool provides not only an overview of the BREEAM rating system but also possible scores or certification levels that will be achieved when the pre-assessment of the building is carried out. It is an optional tool available for access and use by the public for free. When a new project is registered, the pre-assessment allows the client to input their building and site details into the tool and to select each category that is relevant to the project by using questionnaires. Also, BREEAM's PAT provides the detailed assessment of any criteria and has a category summary table that can be used to gain more information such as credit summary and final reports about scores, and the BREEAM rating and assessment report.

Second, the Green Globes® is a web-based rating tool that starts with an online survey to provide feedback on a client's new project at an early stage of the process. It can be used through eight different steps: project initiation, site analysis, programming, concept design, design development, construction documents, contracting and construction, and commissioning. Also, the online assessment tool comprises approximately 150 questions and 'yes or no' answers by inputting data from energy and water bills. Once all of the documentation is completed, a third-party assessor reviews the submitted documents and a final report with the overall points, and some suggestions are provided. To date, the Green Globes® offers "30-day free trial" for the online evaluation, allowing clients hands-on experience. Clients should create their account and enter their basic project information into the online assessment tool. Then, clients can view the pre-assessment questionnaire and review a printable survey with a projected score that they would achieve based on their responses. Also, they receive a quote for certification and third-party assessment. The final report with a preliminary score and rating is provided for the assessor's report. However, access to the full Green Globes online evaluation is limited to the person who has paid the Green Globes subscription [58].

Therefore, this proposed study will design a PAT to support the GSNZ certification process at an early stage. The PAT not only gives overall knowledge about the rating tool but also reminds users of the processing time and unexpected costs, which can incur in the process of rating systems before users start using the rating system. In addition, the PAT could be used as a useful tool to help clients identify whether they know specific information of rating tools they need to understand before beginning certification process.

B. Identified Gaps in the Knowledge

Although clients are ready to implement the rating tool, taking the first steps towards a green project can still prove to be complicated. In many cases, designers are required to explain requirement descriptions or characteristics in more detail to the client [59]. Thus, a checklist that can be used as 'easy first steps' would encourage companies in the building industry to participate in the sustainability development [15].

Furthermore, plans are being envisaged to set up user performance criteria that have trustworthy and inclusive strategies for buildings in New Zealand [60], so that the limited experience of clients is counteracted through the efficiency of this framework process. Therefore, this study seeks to contribute to the design of a PAT framework that can assess and predict knowledge about GSNZ credits and final rating level (or total point), the period of the rating process and extra costs incurred within the certification process before the beginning of certification.

Firstly, the framework will enable all users or stakeholders to develop fundamental knowledge and increase their awareness by implementing the rating tool more entirely and by awarding a final rating when selecting a suitable answer based on basic project information and the requirements of each credit. For instance, the Green Globes® self-assessment process can be read as a successful precedent for the PAT framework to support the Green Star NZ™. Kubba points out that in Canada and the U.S., the Green Globes® rating system is used as a self-assessment, online-based evaluation system [35]. It can be helpful to allow clients to fill out the online questionnaire to identify the preliminary scores achieved based on their basic project information. After completing the questionnaire, the client would be offered suggestions and comments for raising the credit score. However, a PAT suggested in this paper focuses more on the timeline module to show the projected events that can identify the credit criteria, requirements and submission checklist needed to process the rating tools.

Secondly, the framework shows the estimated time required for the rating process to complete the final certification in advance without uncertain assumptions and long waiting times, and also illustrates step-by-step procedures during the rating process. According to Shen et al., the design of an optional choice interface is used as an evaluation tool for users to review the design, to help develop further requirements and to remind them of what is already established [61]. Van der Zwart and van der Voordt found that it is essential to measure building performance at a comparatively early (during design) stage because any alteration in buildings that are already built and occupied is likely to be a complicated work and costly in the future [62]. This study will explore the possibilities of measuring the assessment results for user satisfaction before the design rating phase by applying analytical methods.

Finally, this framework will help the user of the tool to identify extra costs required in the process of assessment such as certification fee and third-party assessment, thus preventing the additional costs of a consultant service, the high registration fee and other unexpected costs. This study identifies the gaps in costs which have not been opened to the public or are hidden in the process of traditional certification. There might have insufficient information on the hidden additional cost of some categories or credits which could be a barrier to implementation. In some cases, there are hidden costs related to getting the material credit that is suggested and is not commonly used in a building. Also, another gap is associated with indirect costs in the certification process. For example, if no one knows how to do the certification, this barrier might result in the hiring of consultants who are specialised [32]. Fullbrook et al. conclude that "sustainable design is most successful when experienced consultants are brought in at an early stage" [49]. Myers et al. assert that if the financial incentive for investment in green buildings is proven, applications for green buildings will increase and promote faster and higher green growth [63]. The interaction between the rating tool and project management tools would make it easier to identify how this PAT framework is implemented by tracking time flow and determining where any cost barriers to green building certification have happened.

V. Methodology

A. Data Collection

A combination of quantitative and qualitative method will be used in this study. Two approaches of the methodology will be designed to find major barriers to the Green Star certification in the New Zealand building industry. Firstly, a literature review on the topic which is related to three barriers relating to knowledge, time and cost will be discussed and guided the design of the survey. Secondly, a survey of a group of experts who have had experience in the Green Star certification process in New Zealand will be conducted, namely Green Star professionals who are well-qualified for the Green Star rating tool, and project manager and the design team. The survey will be divided into two parts. The part one is undertaken through the personal interview to gather a variety of perceptions of the professionals, who are a member of NZGBC or GSNZ advisor, on the current issues or trend of Green Star certification in New Zealand. Also, the questionnaire is the second part of the survey. The purpose of the questionnaire is to review and collect data from participants, especially the design team and project managers, about limited knowledge related to each credit of the Green Star NZ, time spent during the certification process and hidden costs. The aim is to obtain information and feedback on their perception of why the number of the Green Star NZ certification is declining and what actions could be implemented in encouraging the widespread use of green building programmes. The survey includes an online questionnaire and personal interview based on questions which will be interviewed and mailed to the participants to gather qualitative responses from them. Questions are derived from the literature review on barriers to adopting the green building certification. The findings from this section could identify the key features of green building certification that would be barriers when pursuing green building programmes. These will be breakdown into three categories such as knowledge, time and cost issues that could be within the credit or criteria of the Green Star NZ rating tool. Respondents will be asked to complete a set of questions and evaluate the level of importance (e.g. 1 point, 'Least Important' and 5 points, 'Most Important'). In addition, based on the advice of experts who are involved in the certification process, the questionnaire is designed to allow respondents to answer some questions that indicate the minimum and maximum range of time and cost.

In part two, the method of collecting primary data will be conducted through past data of the existing building certified with the Green Star in New Zealand. Detailed information of those buildings will be obtained from NZGBC or consulting companies experienced in the use of Green Star NZ. In other words, those data collection will be carried out with all participants who are Green Star professional, project manager and the design team who are involved in the certification process. The objective of this method is to develop a database of a typical model which will be connected to the case study model that has the most similar or relevant characteristics. This data will be reviewed to see if there are common features or similarities within the information of the buildings. The requirement of the data is recognised to clarify documents or information, concerning how much time it took for each credit in the certification process and where additional costs have arisen, as well as the certification levels or each credit achieved. Moreover, the data are divided into three areas (i.e., certification levels or total points, time and cost) and then into several detailed categories to find predictable patterns and relationships between the collected data.

Since the implementation of the Green Star NZ in 2007, 148 projects around New Zealand achieved (as of December 2017) the Green Star NZ rating with different certified titles such as Office Design and Built, Industrial Design and Built, Office Interiors, Education and Custom rating. Auckland accounts for the largest portion (55%) and far exceeds the other areas. Also, the main rating title that has been achieved in Auckland is "Office Design and Built rating" (67%). For this purpose, selecting the data of 81 GSNZ commercial buildings certified as "Office Design and Built rating" in Auckland is considered to be an ideal method to create some common features of typical models in the study area.

B. The design of a PAT

In phase 1, typical models will be designed for the outcomes of the PAT after all of the data is collected from Green Star buildings that were already certified successfully in New Zealand. The proposed PAT can be used to project specific assumptions of three barriers that are mostly caused by knowledge, time and cost. Developing the database needed when designing a typical model serves as a representative example of GSNZ certified buildings. The typical model is primarily intended to be a new type of building to present achieved credit or criteria of green building rating tool, timeframe and unexpected costs to complete the certification process based on data collection. In other words, the typical model will be created by the data, identifying which credits or criteria were achieved, how much implementation time spent and where there were hidden costs incurred in an excel spreadsheet. Therefore, phase 1 aims to develop a typical model for categorising existing building information and critical factors related to knowledge, time and cost to retrieve information that has the most similar or relevant data stored in the external database. The data needs to be extracted and matched by a database management system (DBMS). It can be used to interact with the database and users and to allow data to be accessed by many users. The database of more than five categories will be compared depending on the scope. Different sets of comparative data are selected and divided into GSNZ credits selected, certification types (4 - 6 stars), total costs, certification timeline and total building area to recognise entity types, relationships, attributes, and integrity rules among the collected data. Thus, the considered categories of these sets are compared depending on three major outputs (i.e., by levels or points, timeframe, costs), respectively. To develop any database, Jalaei and Jrade suggest the following four steps: (1) the tables are created; (2) the relationship among the tables is found; (3) the data is entered into the table; (4) the data is obtained from the tables [64].

> "Content-analysis", which is a research method for "analysing the contents of documentary materials such as books, magazines, newspapers and the contents of all other verbal materials which can be either spoken or printed" [65].

It is a qualitative analysis to estimate the proportions of patterns in the existing documents and correlations between patterns, without interviewing the respondents. Also, the categorisation and classification of written text, hypertexts, images, or other forms of textual data are used in content-analysis is used in context analysis with a computer-based method. Therefore, the tables will be prepared as an Excel spreadsheet and created by storing different types of information such as basic project information, GSNZ categories, final results of achievement (points or level ratings), the time required and the extra costs incurred. The results of developing typical models could help the user of the PAT to have an overview of their new initiatives through the case study for required knowledge, estimation on time and extra costs encountered when implementing Green Star certification.

Phase 2 is to help users to access the current version of the

"Technical Manual" of Green Star NZ and related documents so that all resources and materials provided on the NZGBC's website can be used in the PAT. First of all, each step in the certification process will be made with hyperlinks in MS Excel, which is a link to open another file or page such as a web browser, a picture or a programme when user click it. Moreover, the PAT can allow users to understand in detail what they need to do to prepare and submit documentation that is required to demonstrate compliance with each credit throughout all stages of certification. Pre-checklist can also be used to identify whether credits are achieved or will be achieved based on the credits selected by users.

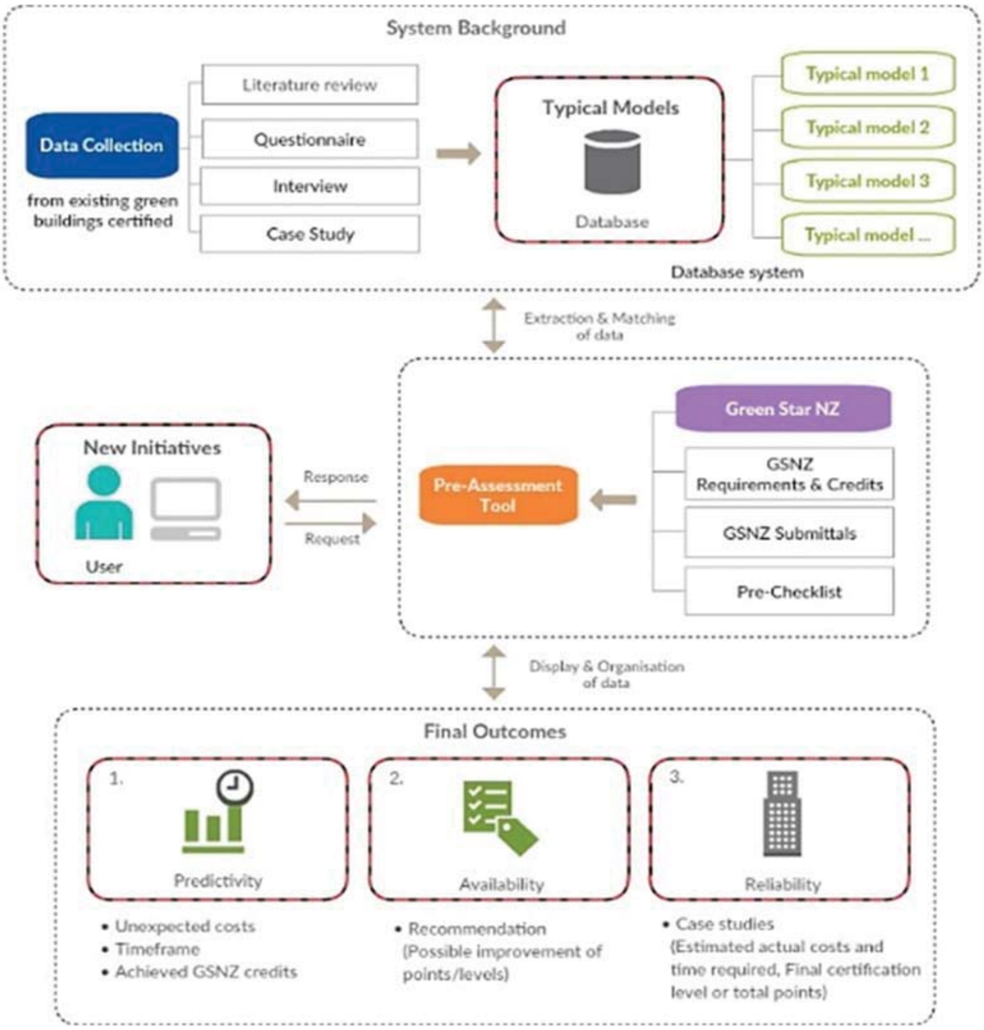

Fig. 4 The process of the proposed PAT framework

Phase 3 includes three sections of the PAT outcome: (1) achieved GSNZ credits, timeframe and unexpected costs which are based on a database of typical models created in Phase 1. They will be visually presented and what events are scheduled and how much time it should spend on each step of the certification process between the project lengths. The benefit of the PAT using the timeline from Excel is that it can show all activities users want to know what or when needs to be done. Therefore, the PAT in an Excel timeline will make it easy for users to understand chronological process or schedule and critical milestones such as specific points where additional costs will be required or have occurred beforehand; (2) Recommendation or comments that lead users to improve the rating level and achieve points within their new project; and (3) Case studies that have successfully received Green Star certification in New Zealand will provide building information, namely final certification level or total points time required for completing certification and estimated extra costs (with the range of costs). Therefore, the outcome of the PAT can optimise decisions regarding green building certification by instantly providing users with the information and knowledge needed to identify whether their projects meet the credit requirement.

VI. Validation of the PAT

The validation of this study will be intended to measure the effectiveness, participants' satisfaction and efficiency [61], [66] of the PAT in improving user's understanding with the certification process and focusing on an economic consideration about time and cost. After obtaining the prediction outcomes of the PAT, these results will be compared with existing certified building for validation of the PAT. Case studies will be selected to look at Green Star certified buildings that achieved 4, 5 and 6 stars office buildings located in Auckland in New Zealand.

> "The selection of a case study allows for further insight into the research issues, which would be overlooked in any large number of study" [67].

This validation will be conducted to compare case studies selected with typical models of the PAT. It is mainly focused on whether the typical model could provide prediction result for three factors (i.e. achieved certification level and points, timeframe and extra costs). A typical model is designed to determine the structured data elements and to find out how they are linked to each other. It is carried out based on the identified data requirements for the PAT and then stored in the data management system.

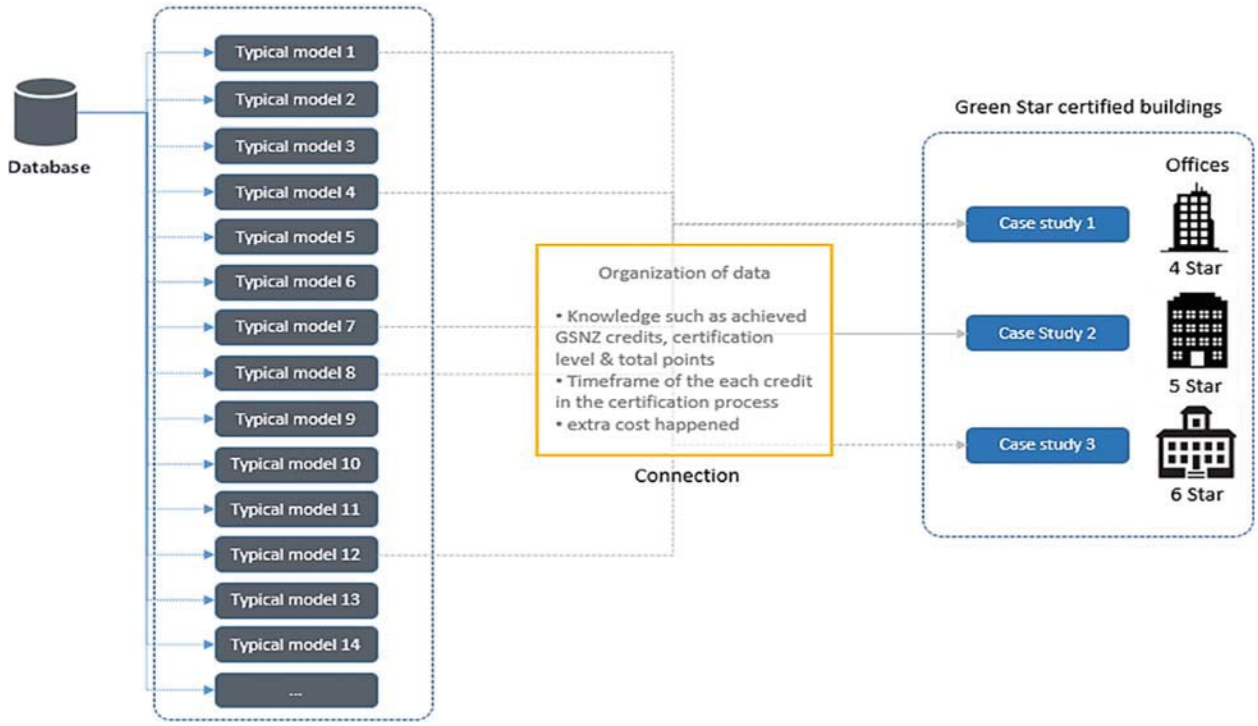

Fig. 5 The process between typical models and case studies

As shown in Fig. 5, there will be some typical models with different kinds of attributes in the database. The case study is created based on the building information, such as project name, project location, project type, and the scheduled construction period and certification types. Case studies will be automatically connected to one of the typical models that have the most similar characteristics. Thus, the database is linked to enable typical models to find out a similar typical model and then it is organized into Excel spreadsheet. The other case study will be performed with the same method.

VII. Conclusion

This paper described that a current green building rating tool does not consider the characteristics of reliability, availability and predictability in the sustainable outcome of certified green buildings related to knowledge, time and cost. Also, there are no parties in the building industry who know how to plan their project time and total costs when implementing a lengthy certification process. As a result, the adoption of rating systems is challenging for those people involved in green building projects, which can lead to lower growth rates in green building certifications.

The PAT is expected to perform a vital role in the use of the green building rating system, providing an effective way for decision making and the promotion of green building certifications. It will positively support the certification process by developing a timeline that shows knowledge requirements, time and costs through an easy-to-understand process of the rating tools. When utilising a rating tool, users of the PAT will be able to estimate how long the whole process or each credit will take, analyse multiple tasks, and determine the order of the certification requirements needed to be completed in advance. Furthermore, this tool could be facilitated more effectively by GSNZ professionals, project managers and the design team who are involved in green construction projects through the certification process of the project. It can not only allow users of the PAT to view how their project, or the building's design, meet compliance requirements of GSNZ and to predict time and costs but also make better design decisions and optimise project results. Therefore, the development of a PAT could be an effective mechanism to overcome current barriers and to make green building certification more acceptable from the people's perspective, leading to an increased number of green buildings certified.

This study looked at the literature review about three barriers to green building certification and focused on designing a conceptual framework of the PAT with the methodology. However, this is ongoing research, which is working on developing a design of the PAT framework to suggest for future study that can be translated into a web-based system to be associated with the Green Star NZ certification.

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