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Research article

Examining Green Star certification uptake and its relationship with Building Information Modelling (BIM) adoption in New Zealand

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ABSTRACT

Although academia has concentrated on issues related to green building recently, Green Star, considered as the primary green rating system in New Zealand, has not caught adequate attention, leading to its slow development with a modest number of certified projects. This research aims to explore the perspectives of the key stakeholders in the New Zealand construction industry towards the use of Green Star, as well as its relationship and possible integration with Building Information Modelling (BIM). Specifically, six themes including 1) benefits of Green Star certification uptake; 2) challenges/barriers to Green Star certification uptake; 3) solutions for Green Star certification uptake; 4) relationship between BIM adoption and Green Star certification uptake; 5) barriers/challenges to the integration of BIM between Green Star; and 6) solutions for the integration between BIM and Green Star were highlighted. The data was collected from 21 semi-structured interviews with industry experts. The results identified a range of benefits and barriers/challenges to the use of Green Star. The research offers a variety of suggestions to encourage Green Star development, with more extensive education playing a critical role, combined with greater integration of BIM with Green Star. The results could be considered baseline information for the construction professionals and academia to have effective strategies towards BIM and Green Star adoption.

1. Introduction

Green building has attracted significant attention recently due to the criticism against the construction industry for being responsible for environmental deterioration. Establishing and evaluating the green rating systems based on sustainable pillars to assess the environmental friendliness of the construction projects has been widely researched with 180 studies in 9 prestigious journals during 2008–2016 (Doan et al., 2017).

Hundreds of rating systems have been developed globally; however, BREEAM (Building Research Establishment Assessment Method) and LEED (Leadership in Energy and Environmental Design) are regarded as the two leading rating tools globally (Doan et al., 2017; Alwisy et al., 2018; Awadh, 2017). BREEAM is believed as having the most influence on the other rating systems (Mao et al., 2009), and it has the highest number of certified buildings compared to the other systems (Doan et al., 2017). Whereas, LEED has attracted the most attention from academia, and is seen as the most popular rating system based on the number of countries that have adopted it (Doan et al., 2017). CASBEE (Comprehensive Assessment System for Built Environment Efficiency) (Shan and Hwang, 2018; Mattoni et al., 2018) and Green Star are indicated as green rating systems in which they are usually compared to BREEAM and LEED (Doan et al., 2017; Alwisy et al., 2018; Nguyen and Altan, 2011).

Green Star New Zealand, is an adapted version of Green Star Australia, established in 2007 by the New Zealand Green Building Council (NZGBC) (NZGBC, 2019a). It has not held its strong attraction in academia, or to building developers and clients, with only 254 certified projects compared to over 2000 accredited projects of Green Star Australia (NZGBC, 2019b; GBCA, 2019). From the Scopus database with the keywords “Green Star” + “New Zealand,” only three journal articles were found focusing on Green Star in New Zealand. Byrd, Rasheed, and their research group contributed two papers concentrating mainly on the Indoor Environmental Quality (IEQ) category of Green

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Star (Byrd and Rasheed, 2016; Rasheed et al., 2017). Rehm and Ade (2013) compared the cost difference between green and conventional office buildings. None of these studies examined the current practice of Green Star certification, its benefits, barriers, or solutions.

Green Star manuals have been adapted and indirectly affected by BREEAM and LEED. However, it has weaknesses regarding sustainability assessment compared to both BREEAM and LEED (Doan et al., 2017). Green BIM has become a technical term recently with the idea of integrating BIM with the green rating systems (Jalaei and Jrade, 2015; Wong and Kuan, 2014; Azhar and Brown, 2009). Integrating BIM with LEED allows designers to design the project easily and efficiently (Jalaei and Jrade, 2015). Automatic sustainability assessment can be achieved when BIM is integrated with BREEAM (Ilhan and Yaman, 2016). BIM is considered a powerful tool that could support green rating adopters to have their projects certified easier and quicker. However, whether the integration of BIM and green rating systems exists or it is workable in the current practice has not been explored.

This raises several questions; Whether Green Star uptake can bring benefits to the adopters, construction industry, and society in New Zealand? Why is the number of Green Star certified projects in New Zealand modest? And how can the current practice of Green Sar be improved? This paper aims to explore the perceptions of the key construction professionals towards Green Star in New Zealand regarding its benefits, barriers/challenges, and the solutions for its development. Also, whether a relationship between BIM and Green Star exists in New Zealand. Barriers/challenges and solutions for the integration of BIM and Green Star will also be revealed.

2. Research methodology

Semi-structured interviews, with key construction professionals, were used to examine Green Star perspectives and its relationship with BIM adoption in New Zealand. The method is suitable as it offers benefits of "deep, rich observational data" (Sieber, 1973; Onwuegbuzie and Leech, 2005) providing insights for the research (Scott, 1965; Eisenhardt, 1989; Haussner et al., 2018). Also, the interviewees can share their opinions freely and actively creating reliable and comparable qualitative data (Cohen and Crabtree, 2006; Galletta, 2013; Harrell and Bradley, 2009).

Purposive sampling and snowball sampling techniques were used, see Fig. 1. The respondents needed to have been working in the construction industry for at least five years with experience in either BIM or Green Star. "There are no hard-and-fast rules about the experience and ability to provide insights … five years is widely regarded by most professional institutions to be the period of time it takes to qualify as a full professional in the construction industry" (Brown and Loosemore, 2015).

19 face-to-face and 3 telephone interviews, were carried out with 26 interviewees between November and December 2017, see Table 1. Interviewees in the interviews 6, 12, 13, and 20 recommended the presence of an additional interviewee to ensure the quality of the answers to the research questions. The sample size in this research is considered appropriate as the saturation point of the data was achieved. Based on the results of Galvin (2015), Guest (Guest et al., 2006), Crouch and McKenzie (2006), and Kvale and Brinkmann (2009)'s research, and previously construction field qualitative studies (Sacilotto and Loosemore, 2018; Hurlimann et al., 2018), 12–15 interviews are appropriate to achieve the saturation.

Table 1 outlines that interviewees have at least 8 years of construction industry experience. They hold senior positions in companies, including design, contracting, consultancies, information technology, a non-profit organisation, and 2 multidisciplinaries, within small and medium-sized enterprises (SMEs) i.e. less than 20 employees (MBIE, 2017; MED, 2011) and large organisations. All interviewees have direct experience in BIM or Green Star; 14 of them had direct involvement in both (or equivalent) projects. 4 of the interviews were conducted outside of Auckland (Canterbury: 1, Wellington: 2, Waikato: 1).

Thematic analysis using NVivo 11 was adopted on 21 transcripts, as it is considered as "a foundational method for qualitative analysis" providing accurate and insightful findings (Nowell et al., 2017; Braun and Clarke, 2006). NVivo is frequently used because of its benefits regarding efficiency, multiplicity, and transparency (Hoover and Koerber, 2011). One transcript (participant 9) was discarded from the analysis due to poor sound quality.

To confirm the validity and reliability of the findings, three stages were adopted, see Fig. 2. Maximum variation was ensured with the participation of the wide variety of the characteristics of the interviewees to enhance the transferability of the findings to readers (Patton, 2015; Merriam and Tisdell, 2015). Sufficient time was spent on each of the interviewees to achieve data saturation, i.e. adequate engagement (Merriam and Tisdell, 2015). Interestingly, the results of the research were saturated at the 12th interview, identical to Galvin (2015) and Guest (Guest et al., 2006)'s suggestions for the sample size. To avoid mistakes and errors, the transcripts and codes were checked thoroughly (Longhofer et al., 2012; Creswell and Creswell, 2017; Gibbs, 2008). Subsequently, member checking was carried out by returning the data and the initial analysis results to the interviewees to validate and revise if necessary (Birt et al., 2016). Peer review was ensured by extensively

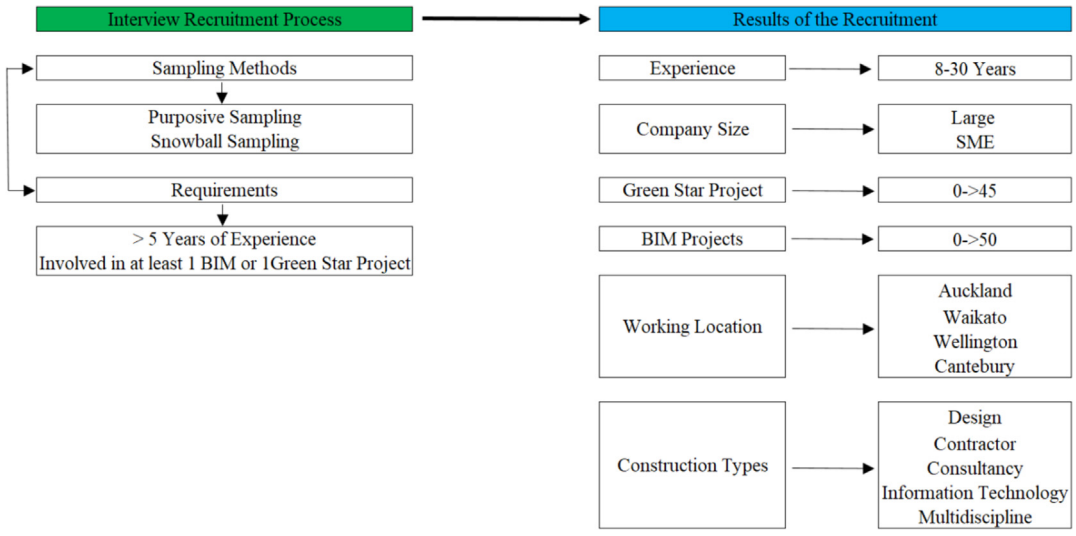

Fig. 1. Interviewee recruitment process.

Table 1
Interviewees demographics.

No.	Construction Position	Experience (years)	Construction Type	Company Size	BIM Projects	Green Star Projects
#1	Senior QS	10	Contractor	Large	1	1
#2	BIM Manager & GSAP[a]	14	Design	Large	> 50	0
#3	Director, Building Scientist, Green Star Assessor, & GSAP	12	Consultancy	Large	> 50	30
#4	Senior Architect, GSAP, & Green Star Assessor	15	Design	Large	30	> 45
#5	Technical Services Manager, Design Manager, GSAP, & Green Star Assessor	22	Contractor	Large	6	30
#6	1) Director & Building Surveyor[b] 2) Building Surveyor	14 4	Consultancy	SME	15	0
#7	Principal & Designer	30	Design	SME	4	3
#8	Senior Cost Manager	20	Consultancy	Large	1	2 (BREEAM)
#9	Project Director	23	Contractor	Large	11	3
#10	Building Services Technical Leader	8	Consultancy	Large	7	1
#11	Director & Building Performance Expert	19	Consultancy	SME	1	5
#12	1) BIM Manager[b] 2) Building Scientist	22 3	Design	Large	> 50	0
#13	1) Associate & Structural Engineer[b] 2) Drawing Office Manager	10 19	Design	Large	> 50	0
#14	Structural Technician	8	Design	Large	1	0
#15	Sustainability Leader, Green Star Assessor, & GSAP	13	Design	Large	> 50	20
#16	BIM Construction Manager	11	Contractor	Large	40	0
#17	Technical Lead & Senior QS	12	Multidiscipline	Large	> 50	0
#18	BIM Consultant, Application Engineer, & Business Analyst	17	Information Technology	SME	> 50	1
#19	Associate Senior Architect	11	Design	Large	> 50	1 (Green Star) 1 (Lotus) 1 (PBRS[c])
#20	1) BIM Development Engineer[b] 2) Senior Structural and Sustainable Engineer, & GSAP	20 8	Consultancy	Large	50	3
#21	Principal QS	8	Multidiscipline	Large	2	0
#22	GSAP & Green Star Assessor	10	Non-profit	Large	0	45

[a] Green Star Accredited Professional.
[b] Corresponding interviewee.
[c] Pearl Building Rating System.

discussing the results of the analysis with the interviewees (Merriam and Tisdell, 2015). The results of the analysis were revised after receiving the minor corrections from the interviewees. Finally, triangulation using multiple sources of data to confirm the findings was carried out (Merriam and Tisdell, 2015; Silverman and Patterson, 2014; Barbour, 2001).

3. Results and discussions

Six main themes were analysed and discussed including the benefits of Green Star certification uptake, the challenges/barriers to that uptake, and possible solutions for Green Star certification uptake. It also examined the relationship between BIM adoption and Green Star certification uptake, associated barriers/challenges to their integration, as well as possible integration solutions.

3.1. Benefits of Green Star certification uptake

All of the interviewees perceived many benefits associated with Green Star certification; "there are a lot of benefits towards a Green Star building. It is essentially a sustainable building" (#12). Most of the interviewees agreed that it could provide "obvious environmental benefits regarding the reduced impacts on the environment" (#5).

Regarding Green Star benefits to the occupants, it could provide "healthy office spaces" (#1) "with a better environment for the users" (#2). In other words, it "improves occupant comfort and occupant performance" (#22) leading to "the reduction in absenteeism and the increase in the productivity by getting through more work with fewer mistakes and fewer business risks from the employees" (#11).

As for the developers, the interviewees revealed a range of befits associated with Green Star certified buildings. These included having a positive impact on sales prices and perceived reputation, "If you also have portfolio projects that are Green Star rated … you have got the perception and the reputation in the market of having of what you own" (#5). Furthermore, interviewee 17 stated that "Green Star is like a trademark … It is a good selling point that they are trying to sell office space to someone."

Regarding the owners, benefits suggested related to cost and energy saving. "It is the obvious benefits of the OPEX (operating expenditure) costs" (#5) because the Green Star certified building is "drawing from nature as much as possible" (#8). The building could be "efficient regarding energy usage and heat loss" (#6) by, for example, "taking the solar glare and solar gain out of the building and divert that heat into something that will actually heat water and provide power" (#8). In case the buildings are used for lease, "it is more attractive to tenants or maybe even charged more for rental" (#3).

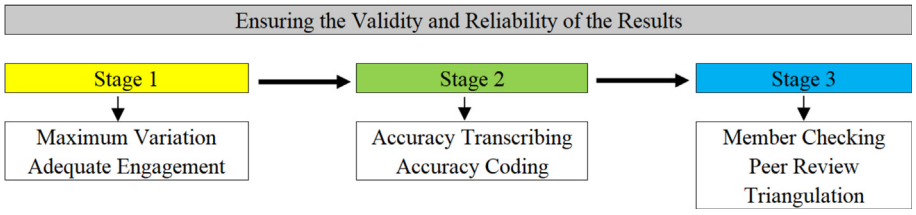

Fig. 2. The process of promoting validity and reliability.

A third of the respondents also indicated that Green Star certification uptake could raise social conscience regarding sustainability development. It potentially "drives the industry for change" (#15) and provides "a bit of a social conscience in environmental impacts" (#8). Finally, three interviewees remarked that Green Star could be considered as "a great benchmarking system" (#11), "the common language thing so that I can compare certain types of buildings" (#15).

The findings are consistent with existing literature. After reviewing and comparing studies in the US, the UK, and Canada with "a small amount of anecdotal evidence" in New Zealand, NZGBC (NZGBC, 2010) identified that certified green buildings could be a benefit for tenants, developers, and owners. All the benefits revealed by the interviewees are found in the NZGBC (NZGBC, 2010). It is not unusual for selecting a rating system to be a property industry benchmark. For example, ENERGY STAR Portfolio Manager Tool, has been used by the United States Department of Energy (Bantanur and Mukherjee, 2012). In New Zealand, Green Star requirements are included in the Proposed Unitary Plan by the Auckland Council (Doan et al., 2017) while Wellington City Council offers 50% remission to 5 Star or higher Green Star certified projects, since July 2015 (WCC, 2015). This is reflected by the interviewees suggesting Green Star as "a great benchmarking system" (#11).

However, the benefits of Green Star certification uptake were perceived unequally amongst the respondents. Reducing environmental impacts was highlighted by most of the interviewees, followed by the benefits to the occupants. However, less than a third of the respondents outlined the benefits to owners and developers. This could imply a question "are the current benefits of Green star attractive to the developers or the investors to pursue?" for further research.

A cross-case analysis was conducted to examine whether respondents demographic characteristics have any impact on the results, see Table 2. It was found out that the benefits of Green Star certification uptake were perceived similarly across all interviewees' types. However, those who have been involved in equal or higher than 20 Green Star projects pointed out much wider benefits of Green Star compared to their counterparts in terms of the benefits to developers and owners, as well as being seen as a benchmarking system. Specifically, amongst 21 interviewees who answered the open-ended question, what are the benefits of Green Star? 6 of them mentioned the benefit of Green Star to developers. 60% of the interviewees who have been involved in at least 20 Green Star projects have perceived this benefit as opposed to their counterparts with only 19%. This tendency is also similar to the benefits of Green Star to owners and being considered as a benchmarking system. This is understandable because those interviewees are Green Star assessors, possessing remarkable skills and knowledge in green buildings.

3.2. Challenges/barriers to Green Star certification uptake

Interviewees discussed the challenges/barriers associated with Green Star certification uptake. Significant ones were the lack of Green Star understanding, cost perception, lack of benchmark projects, lack of client demand, and the complex administration for Green Star registration and assessment.

Green Star understanding/skill was seen as the most significant barrier to Green Star uptake, revealed by over two-thirds of the interviewees. Interviewee 5 stated that "we still struggle with client awareness of what it means." (#5). While the Green Star skills were mentioned by interviewee 7, "we have a lot of people learning, trying to learn how to do it, and not knowing how to do it." Furthermore, "they do not actually understand the long-term cost savings from it (#19). Without exception, the lack of knowledge and skills is a problem identified by GBCA (Green Building Council Australia) to Green Star in Australia (BGCA, 2011).

Cost perception of Green Star uptake was also important. Interviewee 12 stated "there is a perception that green or sustainable buildings are more expensive"; "the cost associated with Green Star

Table 2
Green Star benefits summary.

Green Star Benefit	No of Response	Construction Type				Company Size		No of Green Star Projects		Experience (Years)	
		Design	Contractor	Consultancy	Others	Large	SMEs	≥ 20	< 20	≥ 15	< 15
Benefit to the Environment	17/21 (81%)	7/8 (88%)	3/3 (100%)	5/6 (83%)	2/4 (50%)	15/17 (88%)	2/4 (50%)	4/5 (80%)	13/16 (81%)	6/8 (75%)	11/13 (85%)
Benefit to Occupants	12/21 (57%)	4/8 (50%)	2/3 (67%)	5/6 (83%)	1/4 (25%)	09/17 (53%)	3/4 (75%)	4/5 (80%)	08/16 (50%)	5/8 (63%)	07/13 (54%)
Rasing Social Conscience	07/21 (33%)	2/8 (25%)	1/3 (33%)	1/6 (17%)	3/4 (75%)	06/17 (35%)	1/4 (25%)	2/5 (40%)	05/16 (31%)	2/8 (25%)	05/13 (38%)
Benefit to Developers	06/21 (29%)	2/8 (25%)	1/3 (33%)	0/6 (00%)	3/4 (75%)	05/17 (29%)	1/4 (25%)	3/5 (60%)	03/16 (19%)	3/8 (38%)	03/13 (23%)
Benefit to Owners	04/21 (19%)	1/8 (13%)	1/3 (33%)	1/6 (17%)	1/4 (25%)	04/17 (24%)	0/4 (00%)	3/5 (60%)	01/16 (06%)	2/8 (25%)	02/13 (15%)
Being a Benchmarking System	03/21 (14%)	1/8 (13%)	1/3 (33%)	1/6 (17%)	0/4 (00%)	02/17 (12%)	1/4 (25%)	2/5 (40%)	01/16 (06%)	2/8 (25%)	01/13 (08%)

certification is the biggest barrier" for the uptake (#21). Interviewee 5 outlined "they still believe that to meet the requirements for Green Star, they have to put a significant capital expenditure into the building to upgrade the design to meet the benefits of Green Star." Compared to traditional buildings, Green Star buildings are believed to cost up to 20% more (#2). As a result, "people do not want to pay to get it assessed" (#17).

These findings are consistent with existing literature. Dwaikat and Ali (2016)' review confirmed that the costs of the green buildings are around −0.4% (saving) to 46% compared to the traditional ones, but 80% of the studies provided the positive value for the green cost premium. Interestingly, 15 interviewees believed that a Green Star building would cost higher than or equal to a traditional building. This study reflects the results of the qualitative data analysis of Rehm and Ade (2013)'s research (similarly with 15 industry professionals in New Zealand).

The lack of benchmark projects regarding the Green Star benefits was a serious concern to half the interviewees. Interviewee 22 stated "those have not been proven in the New Zealand market, so I do not know if you could definitively say those are benefits of green building." Interviewee 15 stated "the biggest challenge in my career is the evidence; there is not enough evidence." The literature supports this too. NZGBC has made an effort to mitigate this issue by just officially releasing a new tool, Green Star Performance, last year, "we are currently seeking a handful of pilot projects to be the first in New Zealand to benchmark themselves against the Green Star Performance framework" (NZGBC, 2017). However, no project has been certified with Green Star Performance in New Zealand until now (NZGBC, 2018). This problem has still not been solved yet.

A lack of client demand was indicated as the next barrier/challenge to Green Star uptake. "It really comes down to if the client has that sort of idea in mind and whether they push that" (#12). Interviewee 13 stated "we have not had requests from our clients to build, to design that unless it is a big warehouse or a multi-story building. We generally do not get a request." This is seen as a significant problem to Green Star uptake. According to NZGBC (NZGBC, 2019b), there are only 254 Green Star certified building from 2007 to 2019.

Complex administration was also described as a barrier by a third of the interviewees. "The administrative burden is one of the big barriers of Green Star" (#5). "It is almost too process-driven … It is too strict … They are concentrating not on having a really energy-efficient building" (#10). The problem aligns with the GhaffarianHoseini (GhaffarianHoseini et al., 2017)'s results highlighting the time-consuming nature as well as the difficulty of the Green Star certification process.

To explore whether the demographics of the interviewees could affect their perspectives, the results analysed further based on their demographic characteristics, see Table 3. Interestingly, their perceptions towards the barriers/challenges preventing people from uptaking Green Star showed little difference despite their company types, sizes and their experience in the industry. This could be because Green Star was established over a decade and green building has been an appealing topic recently. Also, the interviewees are those holding senior positions in their companies; they, therefore, are quite well-aware of the challenges/barriers to Green Star uptake. It is noticed that those have been involved in equal or greater than 20 Green Star projects highlighted the lack of understanding and cost perception as the most significant barriers/challenges to Green Star uptake. Based on the data collected from the interviewees, lack of understanding was indicated as the most barrier/challenge, followed by cost perception, which needs to be solved for Green Star development.

Interviewees were also asked for their perspectives around the idea of making Green Star mandatory in New Zealand. Two-thirds of the interviewees indicated that Green Star should or will be mandated. This is because "we are running out of natural resources" (#13). Interviewee 20 stated "we have the safety rating for cars, and we have the energy

Table 3
Green Star barriers/challenges summary.

Green Star Barriers/Challenges	No of Response	Construction Type				Company Size		No of Green Star Projects		Experience (Years)	
		Design	Contractor	Consultancy	Others	Large	SMEs	≥ 20	< 20	≥ 15	< 15
Lack of Understanding	16/21 (76%)	6/8 (75%)	2/3 (67%)	5/6 (83%)	3/4 (75%)	12/17 (71%)	4/4 (100%)	5/5 (100%)	11/16 (69%)	8/8 (100%)	08/13 (62%)
Cost Perception	15/21 (71%)	5/8 (63%)	2/3 (67%)	5/6 (83%)	3/4 (75%)	13/17 (76%)	2/4 (50%)	5/5 (100%)	10/16 (63%)	5/8 (63%)	10/13 (77%)
Lack of Benchmark Projects	09/21 (43%)	4/8 (50%)	1/3 (33%)	2/6 (33%)	2/4 (50%)	06/17 (35%)	3/4 (75%)	2/5 (40%)	07/16 (44%)	5/8 (63%)	04/13 (31%)
Lack of Client Demand	07/21 (33%)	3/8 (38%)	1/3 (33%)	3/6 (50%)	0/4 (00%)	05/17 (29%)	2/4 (50%)	2/5 (40%)	05/16 (31%)	4/8 (50%)	03/13 (23%)
Complex Administration	07/21 (33%)	1/8 (13%)	1/3 (33%)	2/6 (33%)	3/4 (75%)	06/17 (35%)	1/4 (25%)	1/5 (20%)	06/16 (38%)	3/8 (38%)	04/13 (31%)

efficiency rating for our fridges, it should be the same for our buildings … mandating Green Star rating system is a good idea." While the rest of the interviewees indicated that "we can encourage it, but we can never force it" (#7). This could be the reason why only a few local authorities have been active in the Green Star development such as the Auckland Council and Wellington City Council (Doan et al., 2017; WCC, 2015).

3.3. Solutions for Green Star uptake

Education, in both continuing professional development and continuing education, was considered as one of the critical solutions to aid Green Star uptake by most of the interviewees. Interviewee 5 suggested "it is really just education of the building owners to understand what it is that they want, what they want to achieve with that building stock; and do they want to get the efficiency, understanding and getting the benefits of what Green Star is going to?" Also, the building developers need education about the benefits of Green Star as "they can get good clients when they deliver highly efficient buildings" (#20). This is also the solution mentioned by Wong and Abe (2014) suggested that raising the awareness of those who are potential project owners, is crucial for the CASBEE development.

Providing Green Star benchmark projects was also indicated as a practical solution. The clients will be willing to have their buildings certified once "we can prove the benefits of Green Star uptake, saying regarding money, a green building gets a little cost more, but the benefits are blah blah blah" (#2). NZGBC has been active with the release of Green Star Performance "which is good to provide the evidence" (#15).

Providing incentives for Green Star uptake was also suggested as an appropriate way to mitigate the barriers/challenges. Interviewee 13 stated "if the government gives tax incentives for the Green Star building, the client will get the percentage of the value of the building back." Interviewee 3 confirmed "in Wellington, we are very lucky because the council offers a discount to Green Star buildings, so we get a 50% discount on our development … That quite often makes Green Star very attractive."

Interestingly, integrating BIM with Green Star was seen as a solution for Green Star development. "If they can tie up with BIM which is good. They can integrate it; that is a better way to assess the building regarding materials, indoor environment quality, and that kind of stuff" (#2). Interviewee 1 explained "once 6D BIM is developed, the model will be linked to actual Green Star points and credits which could reduce the time for Green Star assessment." This reflects the contents of BIM Uses definitions in the New Zealand BIM handbook mentioned the possibility of using BIM in a construction project for Green Star assessment (BAC, 2016).

The Green Star assessment process was also suggested to be optimised. Interviewee 5 proposed "making the manuals and the technical systems easier to use, using templates, etc., trying to make it easy on the administration." However, interviewee 18 highlighted "this evolution is missing, unfortunately." This is seen in Doan (Doan et al., 2017)'s results showing that Green Star has still many weaknesses regarding its credits assessment as well as the less updated versions compared to BREEAM and LEED. Reducing the costs for Green Star assessment was raised by interviewee 4 as a final solution. However, "how we can reduce it much? It needs to be vigorous in the assessment. Otherwise, it is just a simple checklist, and everybody will be doing it, but it will be worth nothing because it is going to be no kind of legitimacy … There is money involved in upgrading the project, money involved in the professional fees, and then also money involved in the documentary. I am not sure how much we can reduce each of those factors."

It is noticed from the cross-case analysis that those have been involved in equal or greater than 20 Green Star projects strongly indicated the idea of providing incentives for Green Star buildings compared to their counterpart, see Table 4. This could be because they have been involved in many Green Star projects, so they understood the vital

Table 4
Green Star solutions summary.

Green Star Solutions	No of Response	Construction Type				Company Size		No of Green Star Projects		Experience (Years)	
		Design	Contractor	Consultancy	Others	Large	SMEs	≥ 20	< 20	≥ 15	< 15
Providing Education	17/21 (81%)	1/8 (13%)	1/3 (33%)	4/6 (67%)	1/4 (25%)	06/17 (35%)	1/4 (25%)	3/5 (60%)	04/16 (25%)	5/8 (63%)	02/13 (15%)
Showcasing Benchmark Projects	06/21 (29%)	4/8 (50%)	1/3 (33%)	1/6 (17%)	0/4 (00%)	05/17 (29%)	1/4 (25%)	2/5 (40%)	04/16 (25%)	3/8 (38%)	03/13 (23%)
Providing Incentives	05/21 (24%)	2/8 (25%)	0/3 (00%)	2/6 (33%)	1/4 (25%)	05/17 (29%)	0/4 (00%)	2/5 (40%)	03/16 (19%)	2/8 (25%)	03/13 (23%)
Integrating with BIM	04/21 (19%)	2/8 (25%)	1/3 (33%)	1/6 (17%)	0/4 (00%)	03/17 (18%)	1/4 (25%)	1/5 (20%)	03/16 (19%)	2/8 (25%)	02/13 (15%)
Optimising Administration	03/21 (14%)	1/8 (13%)	1/3 (33%)	0/6 (00%)	1/4 (25%)	01/17 (06%)	2/4 (50%)	1/5 (20%)	02/16 (13%)	3/8 (38%)	00/13 (00%)
Reducing Registration Fees	01/21 (05%)	1/8 (13%)	0/3 (00%)	0/6 (00%)	0/4 (00%)	01/17 (06%)	0/4 (00%)	1/5 (20%)	00/16 (00%)	1/8 (13%)	00/13 (00%)

role of the economic encouragement policies towards Green Star investors. Interestingly, those who have been working in the consultancy companies did not mention streamlining the Green Star process or integrating Green Star with BIM at all. This could be understandable because Green Star was released a decade ago; it, therefore, could be streamlined to a certain level; while BIM is still in early stages, preventing the integration between Green Star and BIM. As a result, providing education, showcasing Green Star benchmark projects, and offering incentives were pointed out frequently among the interviewees. Although reducing the registration cost was pointed out by one interviewee as a solution for Green Star uptake, it could be considered as an appropriate solution. This is because that is a Green Star assessor who has been involved in more than 45 Green Star projects. In other words, the interview is well-aware of the Green Star practice in New Zealand.

3.4. The relationship between BIM adoption and Green Star certification uptake

Thirteen interviewees stated that there is no relationship between BIM and Green Star currently. However, 20 of the interviewees felt that adopting BIM could potentially support Green Star certification uptake. Interviewee 1 explained, “the BIM model is linked to sustainability via 6D information where the Green Star credits are linked to the model.” This is because “potentially any information that Green Star needs can be held within the BIM workflow so that they could be any amount of information from the concept design to construction to implementation and facility management, and Green Star can get that information from BIM” (#13). This aligns with the ninth BIM Use, Sustainability (Green Star/NABERS) Evaluation, in the BIM handbook (BAC, 2016).

Interviewee 11 believed “adopting BIM could make the work of GSAP easier.” Interviewee 8 strongly confirmed that “if you can get efficiencies from BIM then that would surely help to gain Green Star certification.” As a result, “it should be possible to do the Green Star assessment almost purely by looking at the Revit model … all of that kind of stuff that was in there” (#3). An ideal way could be “an investment in developing a tool that has plugged into it” (#20), then “hopefully we can press a button, and it will tell us how many points our building is going to get” (#17). These findings have parallels to Ryu and Park (2016)'s results indicated the usefulness of implementing BIM for LEED energy simulation. Also, Ilhan and Yaman (2016) developed an IFC-based framework for the integration between BIM and sustainable data model with the BREEAM materials category assessment for validation. All of these implied the possibility of the BIM-Green Star integration offering efficient Green Star assessment, a potential solution to push the development of Green Star uptake.

Whether Green Star certification uptake could affect the BIM adoption rate was also explored during the interviews. Two-thirds of the interviewees believed that Green Star uptake could have impacts on BIM adoption for some aspects. Interviewee 2 shared “Green Star should affect BIM because Green Star offers better design, BIM is a tool to achieve the design, so Green Star should be leading, and BIM supports that.” In contrast, interviewee 5 perceived that “I do not think Green Star can influence the adoption of BIM … The design is still a driven process that sits outside of what the Green Star is, that does not drive the process.” The opinions shared were varied, and not many studies have researched the relationship between BIM and green rating systems. However, GhaffarianHoseini (GhaffarianHoseini et al., 2017) developed the conceptual framework of potential benefits and challenges of BIM and Green Star implementation, which reflects the idea of Green Star uptake could have impacts on the BIM adoption rate.

3.5. Barriers/challenges to the integration between BIM and Green Star

To understand why there is no perceived relationship between BIM and Green Star currently, the interviewees were asked to determine the barriers/challenges to their integration. The BIM and Green Star certification processes were described as separate from each other by a third of the interviewees. “There are two models living … how my design process can marry up with the green process in a nice way” (#2). The interviewees' perceptions are consistent with the existing literature. Azhar (Azhar et al., 2011) indicated that only around one-third of the LEED credits could be achieved with BIM adoption, which is also the figure for BEAM (Building Environmental Assessment Method) Plus credits in Wong and Kuan (2014)'s research.

Challenges to integration outlined by interviewees were very similar to challenges associated with Green Star as a stand-alone system, ranging from a lack of BIM and Green Star understanding, the need for extensive information required and the cost perception. Interviewee 14 shared “it is a combination of lacking awareness and costs, but I think it is more about the fear of costs, and the fear of what they do not quite understand.” “Understanding what information we need out of the model to provide for the Green Star outputs” was remarked by interviewee 12.

Lack of client demand was also highlighted as a significant barrier/challenge to the integration. Interviewee 11 explained the opinion by asking rhetorical questions, “how many projects out there in New Zealand that have required BIM? How many projects are required Green Star? And how many for both? That is a huge barrier because if you cannot get uptake in either of their own to get them to happen at the same time. So, that is both at the point where not many projects have been done yet until you start to get some overlap.” In other words, BIM and Green Star projects are not the common focus in New Zealand currently. Interviewee 6 shared the practices in his company that “we never looking for the Green Star rating.” This reflects the modest number of Green Star registered projects from 2007 to 2019, with only 254 projects (NZGBC, 2019b).

Green Star submission requirements were indicated as the next barriers/challenges. Interviewee 20 shared “NZGBC is working on the traditional base, sort of the tick boxes, filling forms, it is straightforward.” Therefore, “there is no real advantage to a BIM project over somebody using 2D AutoCAD because the documentation is assessed in the same way.” “So at the moment, there is not necessarily any advantage regarding the green building assessment” (#3). Furthermore, “NZGBC requires it to be a contract document, you would have to show that the Revit model is a contract document” (#4) which is not happening yet.

The low level of BIM development in New Zealand was also identified as a crucial barrier/challenge. Interviewee 3 suggested that the LOD should be up to 400 or 500, and the BIM maturity level should reach the highest level to have “all that information loaded in”; then, “it should, in theory, be possible to do your Green Star assessment almost purely by looking at the Revit model.”

Table 5 summarises the barriers/challenges to the integration of BIM and Green Star. Two different processes and lack of understanding were perceived as the most significant barriers/challenges. Interestingly, interviewees who have been working in large companies provided more barriers/challenges compared to SMEs. It could be because they have participated in the projects required both BIM and Green Star and are knowledgeable on this topic.

3.6. Solutions for the integration between BIM and Green Star

Before the interviewees were asked about the solutions to have BIM and Green Star processes integrated, they strongly indicated the potential of this action. Interviewee 5 stated “as soon as we can link that data, then you can see huge benefits in actually improving certifications, and because the administrative burden was one of the drawbacks of Green Star … this will drastically reduce that.”

NZGBC, then, was suggested to be more active in this integration. Instead of using the tradition process with 2D documents, they could “take on the whole digitising their processes, make the processes better, IT savvy and that kind of stuff” (#2). Interviewee 7 suggested that

Table 5
Barriers/challenges to the integration of BIM and Green Star summary.

Green Star & BIM Barriers/Challenges	No of Response	Construction Type				Company Size		Experience (Years)	
		Design	Contractor	Consultancy	Others	Large	SMEs	≥15	< 15
Two Different Processes	07/21 (33%)	2/8 (25%)	2/3 (67%)	2/6 (33%)	1/4 (25%)	07/17 (41%)	0/4 (00%)	3/8 (38%)	04/13 (31%)
Lack of Understanding	07/21 (33%)	5/8 (63%)	0/3 (00%)	1/6 (17%)	1/4 (25%)	06/17 (35%)	1/4 (25%)	3/8 (38%)	04/13 (31%)
Lack of Client Demand	06/21 (29%)	1/8 (13%)	0/3 (00%)	5/6 (83%)	0/4 (00%)	04/17 (24%)	2/4 (50%)	4/8 (50%)	02/13 (15%)
Green Star Submission Requirement	04/21 (19%)	2/8 (25%)	0/3 (00%)	2/6 (33%)	0/4 (00%)	03/17 (18%)	1/4 (25%)	3/8 (38%)	01/13 (08%)
Low Level of BIM Development	04/21 (19%)	2/8 (25%)	1/3 (33%)	1/6 (17%)	0/4 (00%)	04/17 (24%)	0/4 (00%)	0/8 (00%)	04/13 (31%)

NZGBC could "supply a template to Navisworks because it is clever enough that you can actually pull it out the schedule area." Furthermore, NZGBC should collaborate with other stakeholders to have the integration worked effectively. Interviewee 17 talked about NZGBC and supplier relationships, stating that "NZGBC as an organisation would need to start setting up points within different objects; they would have to work with certain suppliers … However, the collaboration among the stakeholders themselves during the projects is also essential." To ensure understanding, "it is very important for the team at some point to have a sort of kick-off and determine what we want to use the BIM model for during our process" (#16). Interviewees 11 and 15 suggested a need for collaboration between NZGBC and the software development company to develop an add-on for BIM that can link the data tightly.

Executing BIM correctly was identified as a significant solution. Because the integration process will require extensive information, "we need to get to a point where the model has so much detail" (#4). However, the level of BIM development in New Zealand is still low. This, therefore, requires considerable efforts among stakeholders to have BIM in New Zealand developed with higher LOD and BIM maturity level.

Providing education, training, and showcasing BIM-Green Star benchmark projects were also suggested to mitigate the problem. Interviewee 7 shared that stakeholders need to be "educated and understand what they (BIM & Green Star) are, and how they come together." Besides, "we could prove it to somebody that it works a certain way … a higher profile project might get a lot more attention" (#14).

Making BIM mandatory was interestingly raised as a quick and effective solution. Interviewee 11 believed "mandating is probably going to be the fastest way to get the nation as a whole to have some experience of new things and therefore build up that story that supports its use." This was followed by the interviewee 4's opinion that "if BIM is mandated, and it is a common standard, then you could see it and somehow manage to work with Green Star, there would be a benefit."

Table 6 provides a summary of solutions for the integration of BIM and Green Star in New Zealand. Similar to the barriers/challenges to the integration, those have been working in large companies provided wider solutions to the integration. Integrating the processes of BIM and Green Star was perceived as the most effective solution, followed by executing BIM correctly.

3.7. Further discussions and future studies

Although Green Star New Zealand has been common recently, the total certified buildings are still limited, with only 254 certified projects since 2007 (NZGBC, 2019b). Why Green Star has not been attracted much attention was partly answered in Doan (Doan et al., 2017) research. The ability of Green Star regarding sustainable assessment is still modest compared to the most popular ratings, including BREEAM, LEED, and CASBEE (Doan et al., 2017). Due to geographical isolation and its unique characteristics, it is a challenge to adopt the research results from other green building practices. For example, although insulated glazing is widespread globally, interviewee 8 mentioned the realistic of the New Zealand buildings that "they (New Zealand) have just discovered double glazing." Also, it could be unnecessary to raise the awareness towards the benefits of BREEAM and LEED compared to Green Star because of its strong attraction to project owners and developers globally with around 570000 and 90000 certified projects respectively (BREEAM, 2019; USGBC, 2019). In other words, using multiple sources from outside of New Zealand to apply for the current practice of Green Star in New Zealand is considered inappropriate. Whereas, only three studies were conducted with the aims to accelerate the development of Green Star in New Zealand as mentioned above.

This research contributes to the green practice in New Zealand by identifying the critical benefits, barriers, and solutions for Green Star development. It is the first research to evaluate the vital role of each factor affecting Green Star uptake based on the experts' perspectives. Specifically, providing education should be considered as the most priority approach to encourage people to adopt Green Star. The research also revealed the effectiveness of the solutions to improve the current Green Star practice. Although cost perception was determined as the major challenge to Green Star uptake, reducing Green Star registration fees was considered as the least effective solution. In other words, raising awareness amongst construction stakeholders and showcasing benchmark projects should be primarily focused rather than minimising the fees for Green Star registration.

It is clear from the summary of Green Star benefits that most of the interviewees are well-aware of the benefits of Green Star to the environment. However, benefits to occupants, developers, owners and raising social conscience were limited perceived by them. This could be explained by the low ability of Green Star to assess the society and

Table 6
Solutions for the integration of BIM and Green Star summary.

Green Star & BIM Solutions	No of Response	Construction Type				Company Size		Experience (Years)	
		Design	Contractor	Consultancy	Others	Large	SMEs	≥15	< 15
Integrating the Processes	09/21 (81%)	3/8 (38%)	1/3 (33%)	4/6 (67%)	1/4 (25%)	08/17 (47%)	1/4 (25%)	4/8 (50%)	05/13 (38%)
Excecuting BIM correctly	07/21 (33%)	3/8 (38%)	1/3 (33%)	3/6 (50%)	0/4 (00%)	07/17 (41%)	0/4 (00%)	4/8 (50%)	03/13 (23%)
Collaborating between Construction Practitioners	06/21 (29%)	3/8 (38%)	1/3 (33%)	1/6 (17%)	1/4 (25%)	06/17 (35%)	0/4 (00%)	0/8 (00%)	06/13 (46%)
Providing Education	05/21 (24%)	4/8 (50%)	0/3 (00%)	0/6 (00%)	1/4 (25%)	03/17 (18%)	2/4 (50%)	3/8 (38%)	02/13 (15%)
Changing Green Star Submission Requirements	03/21 (14%)	2/8 (25%)	0/3(00%)	1/6 (17%)	0/4 (00%)	02/17 (12%)	1/4 (25%)	1/8 (13%)	02/13 (15%)
Providing Green Star Material Database	03/21 (14%)	1/8 (13%)	1/3 (33%)	0/6 (00%)	1/4 (25%)	03/17 (18%)	0/4 (00%)	1/8 (13%)	02/13 (15%)
Providing Benchmark Projects	03/21 (14%)	1/8 (13%)	1/3 (33%)	1/6 (17%)	0/4 (00%)	02/17 (12%)	1/4 (25%)	1/8 (13%)	02/13 (15%)
Mandating BIM	02/21 (10%)	1/8 (13%)	0/3 (00%)	1/6 (17%)	0/4 (00%)	01/17 (06%)	1/4 (25%)	2/8 (25%)	00/13 (00%)

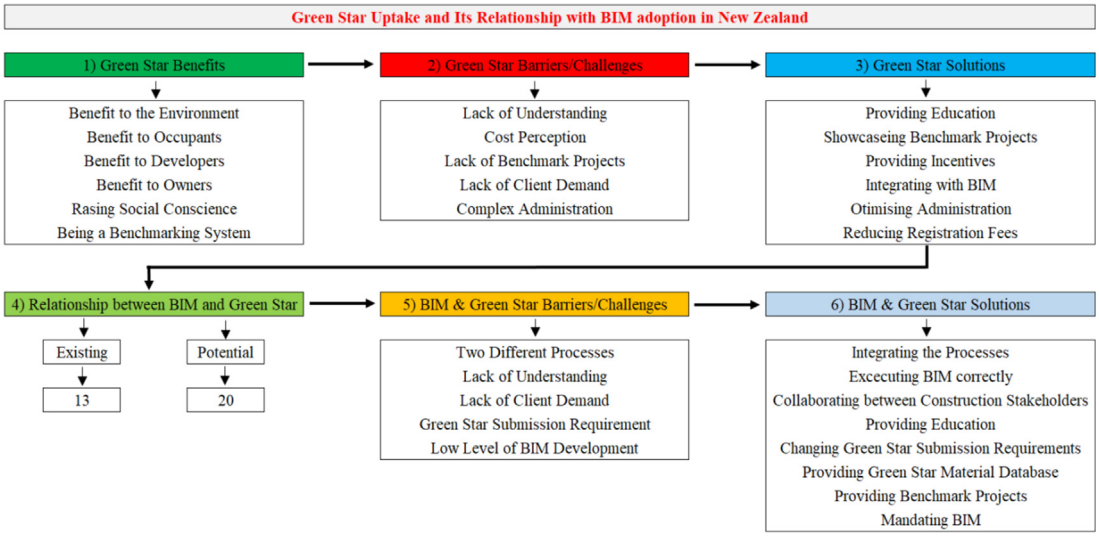

Fig. 3. Results of Green Star uptake and its relationship with BIM.

economy pillars of the sustainable concept. Doan (Doan et al., 2017) found out that Green Star heavily focuses on the environment with most of the credits developed to determine whether the project is environment-friendly. Whereas, only 10% of the credits were adopted for society measurement purpose and none of them was allocated for economy assessment (Doan et al., 2017). This is in contrast with BREEAM, LEED, and CASBEE where Neighbourhood Development/Communities/Urban Development tools were created to measure the sustainability of a project comprehensively in both society and economy criteria (Doan et al., 2017). Ameen (Ameen et al., 2015) also pointed out the differences of indicators amongst BREEAM, LEED, CASBEE, SBTool (Sustainable Building Tool), and Pearl. In other words, this confirms the inappropriateness of using research results of other green rating systems to apply for Green Star practices due to the differences amongst characteristics of each rating system.

As a result, this research suggests a need for an in-depth analysis of BREEAM and LEED practices before applying their results to other green rating systems. Hundreds of green rating systems have been developed to measure the sustainability of construction projects, but they are not equivalent to each other (Knowles and Sinha, 2013). This is because of the differences amongst characteristics of each rating system along with the different regional contexts where they are applied (Ameen et al., 2015; Knowles and Sinha, 2013). Because BREEAM and LEED have developed continuously with the suggestions from global researchers, their practices could be hardly applicable to other rating systems where they are still struggling to catch attention from researchers and construction stakeholders. Green Star could be considered as a representative for other rating systems when it is still in its early stages requiring the improvement in many aspects. The results provided in this research could provide valuable lessons to other green rating systems when the critical and effective benefits, barriers, and solutions were detailed.

Regarding the integration of BIM and green rating systems, only a few research papers were conducted to examine the feasibility of them (Seghier et al., 2018). Because of the earliest establishment of BREEAM and LEED compared to the others, most of the developed green BIM models are BREEAM-BIM or LEED-BIM models (Seghier et al., 2018). However, most of the models have been stopping at examining the theoretical possibility of the integration; the statistics provided are still limited. Azhar (Azhar et al., 2011) only verified the integration of BIM with 5 of 69 LEED credits. Whereas, only materials categories were selected to develop the IFC-based framework to link BIM with BREEAM (Ilhan and Yaman, 2016). According to Seghier (Seghier et al., 2018), who reviewed all green BIM models in various databases such as Scopus and Google Scholar, very few credits of energy, water, and materials categories of LEED were connected to BIM. While the credits of materials of BREEAM are the only category targeted by researchers. This indicates the need for further investigation of green BIM. Also, whether the practical possibility of green BIM should be explored.

This research contributes to the current knowledge by providing insights into green BIM research. It confirmed the potential of integration Green Star with BIM. However, it pointed out the challenges and provided the solutions for the integration, which have not been existed. To put Green Star-BIM into practice, the Green Star process should be streamlined to match closely with the BIM process. Also, effort should be invested to develop the current BIM practice to achieve higher BIM maturity level and LOD.

The data collection in this research was carried out mainly in Auckland which may not be entirely appropriate to reflect the situation in New Zealand. The next stage of the larger project is to use the quantitative approach to collect the data from the experienced construction professionals, Green Star practitioners, assessors, and GSAP specifically, in the whole of New Zealand to validate the results of these interviews.

Based on the perspectives of the interviewees regarding the benefits of using BIM to enhance the Green Star certification uptake, understanding the BIM practices and assessing the success of the BIM projects in New Zealand are crucial to the development of BIM and Green Star. Further research will focus on building a framework for BIM assessment providing all the essential criteria and their inter-relationships impacting the implementation of BIM.

4. Conclusion

This paper examined the perspectives of construction professionals in New Zealand towards the Green Star situation and its relationship with BIM adoption. 21 interviews with 25 interviewees were conducted with experts for either BIM or Green Star projects. The respondents perceived that the most significant benefits of Green Star are to the environment and the occupants. Four additional benefits were outlined as benefits to the developers, the owners, raising social conscience to green building, and being a beneficial benchmarking system, see Fig. 3.

The significant barriers/challenges to the Green Star certification uptake were identified as a lack of understanding, cost perception, lack of benchmark projects, lack of client demand, and complex administration. To mitigate these six solutions were suggested by the interviewees, providing education was seen as paramount for further Green Star development.

The results indicated that a relationship between BIM and Green Star does not exist currently. However, there is potential for integration. Where the use of BIM and Green Star is executed appropriately and linked to each other. It is believed that the Green Star process could be more straightforward for all of the relevant project stakeholders combined with an increase to the BIM adoption rate. However, five main barriers/challenges were suggested for the lack of current integration. These were the nature of the separate processes, lack of client demand, inappropriate Green Star submission requirements, low level of BIM development, and lack of both BIM and Green Star understanding. Integrating BIM process with Green Star process was suggested as the most effective solution for this, followed by executing BIM correctly to achieve higher BIM level and LOD.

In summary, this research has contributed to the existing body of knowledge in two key ways. It is the first research providing valuable insights into the use of Green Star in the context of New Zealand. Also, the potential of taking advantage of using BIM to enhance the uptake of Green Star uptake and vice versa. The results are useful for construction practitioners and academics to understand the current relationship between BIM and Green Star in New Zealand to generate further practices and further studies. Additionally, similar to hundreds of green rating systems established globally, Green Star New Zealand is still in its early stages compared to the development of BREEAM and LEED. Research and results on Green Star New Zealand could offer learning lessons and guidelines for the other green rating systems, which generally fail to attract attention from academia.

Note

This entire research paper will be used as a thesis chapter in Dat Tien Doan's thesis submitted to Auckland University of Technology in fullfilment of the requirements for a degree of Doctor of Philosophy.

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