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Review

The relationship between the energy efficiency of buildings and occupants: A review

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Abstract: Green buildings are supposed to provide a sustainable solution for energy usage, but their low performance raised some questions in the literature. The researchers determine that occupants are the key factor for this energy deficiency. In the last two decades, a stream of research focuses on the greening of occupants, but a synthesis of findings and results are absent in the literature. In this study, we reviewed the literature on green buildings and occupants. Based on the findings we classified four classes. The first class consists of green occupants and green buildings, which is the ideal solution for high-energy efficiency. The second class is of brown occupants and green buildings and is the prime reason behind outperformed green buildings and yields negative-medium level efficiency. The third class comprises green occupants and brown buildings and yields positive-medium level efficiency, which helps to start the journey towards sustainability. The fourth class is the combination of brown buildings and brown occupants and has the lowest efficiency and worst impact on the environment throughout the lifecycle. Further, we link these classes with the energy-saving efficiency of buildings and finally recommended an efficient solution for second and third world countries. The study contributes to green building literature and packed with managerial implications to gain the maximum benefits of green buildings.

Keywords: Sustainable environment; Green buildings; Energy; Building efficiency; Occupants; Greening.

1. Introduction and preliminaries

The concept of green buildings introduced in late 90's but after the year 2000 due to the establishment of rating systems, they got high attention. Green buildings are water and resource-efficient in addition to energy efficiency and are considered to adopt energy efficiency practices on a priority basis, thus offer sustainable solution (National Stone Institute). Also there is an exponential increase in the energy demands over the globe due to increasing population, automated systems, and climate change. It is estimated that it will reach 50% only in the building sector until 2050 if the experts do not take appropriate action to deal with it [1]. The green building is a head-turning topic nowadays to deal with energy requirements and expected to use fewer resources especially energy as compared to conventional (brown) buildings.

Anyhow, there are contradicting findings present in the literature that the green buildings are often found fail to achieve the required performance. The researchers state that there is a huge difference between the calculated and real-time energy consumption of certified green buildings keeping the function and size constant [2–5]. This difference varies case to case in the range of 30% to 100% [6–8]. Here raises the issue, that why the green buildings are underperforming and what are the factors which could help green buildings meeting their target performance? This issue motivated the researchers to check non-technical drivers of energy consumption in green buildings, with a focus on activities of occupants in buildings [9,10]. There is a consensus of researchers that the low performance of green buildings can be dealt with working on occupants' behavior because energy consumption behavior of occupant significantly affect the energy performance of

buildings [11,12]. So we argue that earning green certification for a building is not enough in the journey of a sustainable environment.

The researchers found a positive impact of energy consumption behaviors of occupants on the performance of building in terms of energy usage [11,12]. In [13] Brockman states that occupants are very important to consider as they account for 50% usage of the energy of a building. The second problem arises about the performance of brown buildings. There are countless brown buildings which will still serve for more than 20 years and consumes a larger portion of energy. There is almost no work in the literature which could help to increase efficiency of these buildings. Mixed mode buildings (building which contains both green and brown counterparts) could be the greening practice in developing countries to move forward in the path of sustainability. Anyhow, still the numbers of brown building are very high and need robust solution.

Therefore as a result of work on this aspect: Incentive programs, education and training regarding green behaviors, trash management, use of vegetation as facades of buildings, green certification of tenants, use of artificial machinery to develop reports of energy usage at individual level, development of management practices, baby steps of government like awareness signs and banners on public places and use of media came as solutions. But each of these solutions consulted their own technique and discussed them separately resulting in fragmented literature. A holistic framework is absent in the literature and a need exists to synthesize all provided results and solutions. These reasons generated a gap for our paper.

Thus our review is determined to clarify four research issues in the literature. First, the underperformance of green buildings having all technical facilities. Second, the role of occupants in reducing the efficiency of green buildings. Third, the role of occupants in increasing the efficiency of brown buildings. Four, the methods to change energy efficiency behavior of occupants.

These problems are very critical to deal specially when the literature is fragmented into different categories and results are inconsistent. In this paper, we establish a systematic research framework to answer the above-mentioned questions. Our review fulfills the following purposes. First, we provided simplified results of past work and their relationship with the efficiency of buildings which will help governments, companies and even individuals to take steps towards sustainable environment using these existing brown buildings. Second, we highlight the four different domains of green building research providing the research direction for under research domain. Third, with the help of systematic literature review of the greening of occupants regarding energy consumption behaviors we have classified four classes of occupants and buildings which have an impact on the energy consumption efficiency of the buildings and illustrate them in a building efficiency matrix. The study provides the synthesized findings of the literature on green buildings energy efficiency and occupants. It will also help the managers to achieve the maximum energy efficiency from the green buildings and can turn the brown buildings more performing by working on the behaviors of occupants.

The remaining of the paper is organized in the following manner. In section two methods are discussed. In section three the previous work is analyzed and section four comprised of results. We discussed the study findings and provided the suggestions in the last section. This section also includes study limitations, future direction, and conclusion.

2. Methodology

We followed a systematic literature gathering process to collect the studies for this review. Anyhow to get a broader understanding of the phenomena we started with a general search to check studies available on the topic of the greening of occupants. We found numerous results however a handful of papers investigated greening of occupants in terms of energy use. After this as the first step of systematic literature gathering process, we selected the terms "green building", "greening", "occupants" and "tenants" in the title of papers, on keyword lists, or in the abstracts.

2.1. Inclusion and exclusion criteria

We included the articles that are published in English language during the time span of 2000 to September 2018. After this basic screening we included the review and research papers and focused on articles which discussed greening and occupants in detail. We excluded the data which just discussed greening and occupants as side topic. There were many topics where we achieved consensus after discussing the matter briefly. It was our basic concern that the whole structure of the paper revolve around greening of occupant.

3. Procedure

We conducted the search from the well-known six databases that includes Web of Science, Science Direct, ProQuest, JStor, EBSCOHost and Google Scholar. For further clearance, we also collected some data from the reference lists of selected articles. Doing all this we found 453 articles fulfilling our criteria out of which 179 were duplicate. After reading the title and abstract of remaining articles, 240 papers were found irrelevant. Remaining thirty-four full length articles were studied carefully and twenty articles were found out of the context. Mostly research have been done on residential buildings and least considered type is office buildings. Finally, this exercise results in a set of thirteen articles as a set of research which are shown in Table 1, while the flowchart diagram [14] is shown in Figure 1. The data was coded by two researchers and the agreement level was achieved after the discussion when a disagreement was found.

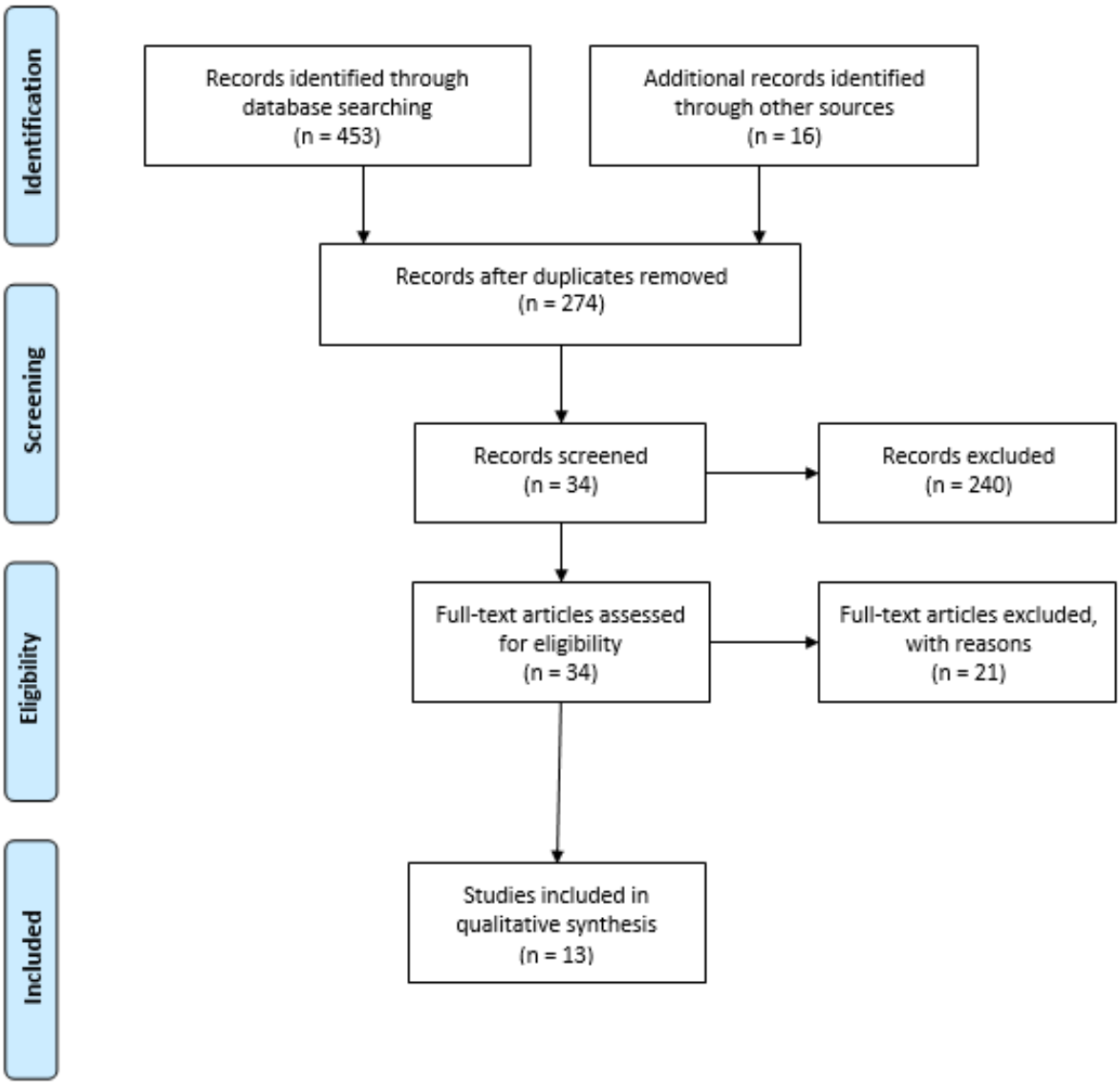

Figure 1. PRISMA flow diagram

Table 1. Papers selected for review

Sr. No.	Author & Year	Title	Journal
1	Koehler [15]	Green facades-a view back and some visions	Urban Ecosystems
2	Steinberg *et al.*, [16]	Developing a focus for green building occupant training materials	Journal of Green Building
3	Mirel *et al.*, [17]	Certifiable Green	Journal of Property Management
4	Deuble *et al.*, [18]	Green occupants for green buildings: The missing link?	Building and Environment
5	Milenkovic and Amft [19]	Recognizing energy-related activities using sensors commonly installed in office buildings	4th International Conference on Ambient Systems, Networks and
6	Hope and Booth [20]	Attitudes and behaviors of private sector landlords towards the energy efficiency of tenanted homes	Energy Policy
7	Cao *et al.*, [21]	Development of an Energy-Aware Intelligent Facility Management System for Campus Facilities	Defining the Future of Sustainability and Resilience in Design, Engineering, and Construction
8	Mokhtar *et al.*, [22]	Strategies for improving energy saving behaviour in commercial buildings in Malaysia	Engineering, Construction and Architectural Management
9	Aghili *et al.*, [23]	Key Practice for Green Building Management In Malaysia	4th International Building Control Conference 2016
10	Huebner *et al.*, [24]	Understanding electricity consumption: A comparative contribution of building factors, socio-demographics, appliances, behaviours and attitudes	Applied Energy
11	Aulia *et al.*, [25]	Identification of Increasing Green Behaviour in Citraland Bagya City, Medan	1st Annual Applied Science and Engineering Conference
12	Azar and Menassa [11]	Framework to investigate energy conservation motivation and actions of building occupants: The case of a green campus in Abu Dhabi, UAE	Applied Energy
13	Ohueri Chukwuka *et al.*, [26]	Energy efficiency practices for Malaysian green office building occupants	Built Environment Project and Asset Management

We found no research relevant to our criteria from 2000 to 2006. Description of studies which are included in the review is tabulated below:

4. Findings

After careful construing of literature it is found that from 2004 to 2006 with the efforts of Levitt Northfield Sustainability Tenant Incentive Program NSTIP was conceived. They were also first to enroll in the Xcel Design Assistance Program XDAP. In these programs, occupants were incentivized for doing green activities. They developed 51 points of compliance and compiled a handbook containing how to comply and what are the benefits in terms of cost. This method helped them a lot to increase the efficiency of that retail center. In addition to this, it promoted the culture and generated a ripple effect in the area and supply chain as well [27]. McConnell in [28] worked on the greening of the solid waste management program. This program is a four "R" strategy: Review, Reduce, Reuse and Recycle. This is a very organized and effective program and if followed by occupants will lead towards a sustainable environment. Another step was to provide an incentive to occupants for use of green facades (vegetation on the front of the building). It is widespread in Germany by Koehler [29] and he emphasizes that these living walls must be used all over the globe. Steinberg *et al.,* [16] developed a decision matrix and helped to find relevant and necessary information for the training of occupants. Their work explained briefly that the provision of green policies and mechanisms is not enough. Occupants must be trained, and these actions must be promoted. A manifesto was developed and presented in Passive and Low Energy Architecture PLEA conference. Occupants were termed as active determinants of energy performance of building and conditions and directives were also provided [30].

In the same year, another revolutionary step was taken by Hines (Interests Limited Partnership: Real estate company). They introduced Green Office Tenant certification. In this program, there were a total 100 points from which tenant must score 70 points to earn certification. Tenants were evaluated in seven categories and energy efficiency is one of them. They distributed the tenant guide containing information about taking baby steps to enhance the performance of building in many terms including energy consumption [17]. Here ends the work of a decade regarding the greening of occupants/tenants or also sometimes termed as inhabitants.

In the most recent decade, a progressive pattern is observed in the literature in terms of publications, variety and demographic conditions of research. Further studies on occupant behavior and green buildings showed that users of green buildings offer high forgiveness factor (tolerance to building environment) to the features of their building than any other building [18]. A technical analysis was conducted by Milenkovic and Amft [19] to show that occupant behavior has a significant influence on the energy consumption of a building. They used HMM (Hidden Markov Models)-based recognition of office desk activities and by modifying the HMM transition probability estimated energy consumption in the simulation. A review study by Hope and Booth [20] pointed out some facts that why landlords of the private sector do not focus on the energy efficiency of their buildings. They summarized that fast growth, high upfront cost and ineffective policy measures are the main causes. They also identified the lack of studies available on private landlords regarding energy efficiency behaviors.

Energy-aware intelligent facility management system was designed and tested by Lee *et al.,* [31]. Their focus was on the HVAC system only, but they clearly showed the positive impact. Basically, this system was designed with a concept to help and assist occupants to develop energy consumption behaviors. Observations are the best motivator and they could realize the severity of a cause incomplete sense. In a study on commercial buildings, energy consumption behaviors of occupants of green and brown buildings were compared [22]. The results showed that the occupants have better behaviors in the green buildings. They recommended that there must be the regular distribution of posters and guidelines along emails and the live updates regarding energy use of the particular building must be a regular practice as well. New staff must also be briefed on the company's policy about energy saving. These strategies were successful in encouraging of green behaviors.

At management level, sustainable approaches must be incorporated into daily routine. Aghili *et al.,* [23] developed five key practices after reviewing the data available in the context of management to enhance the efficiency of green buildings. The set of these practices is general and enlighten two very important things: One is time and the other is stakeholders. This study suggests that sustainability can be achieved when these practices are incorporated and prioritized at each phase of the green building starting from procurement and

Table 2. Quick review of selected papers

Study type	Place	Sample size	Contribution
Case study	U.S	41 initiatives	Multi criteria decision analysis
Case study	U.S	43000	Certification of occupants
Case study	Georgia	One building	Energy aware intelligent system
Research paper	Indonesia	45 respondents	Motivation and socializing of occupants is necessary
Research paper	Australia	02 building	Forgiveness factor
Research paper	Netherlands	01 building	Recognition of energy-related activities
Research paper \Case study	Abu Dhabi - UAE	227 campus users	Factors such as respondentsŠ demographics, the level of control over building systems, and motivation drivers (e.g., ?nancial, social, and environmental) highly affect energy saving actions and need through consideration for effective human-focused energy conservation strategies.
Research Paper	Malaysia	53 respondents	integration of technological strategy; organizational strategy; and occupants behavioral strategy will critically reduce energy consumption
Research Paper	Malaysia	03 buildings	Energy efficient use of electric appliance Ű Computer
Research Paper	United Kingdom	845 households	appliance ownership and usage are the most influential variables in understanding electricity consumption
Review	Multiple	Green building standards	Key management practices
Review Paper	Germany	16 articles	Green facades
Survey	Malaysia	53 landlords	Integration of technological strategy, organizational strategy and occupants behavioral strategy critically reduce energy consumption of green office buildings in Malaysia.

leading to designing, building, operation and demolition. Besides that, it also recommends that every person including designers, buyers, constructors, building users and all other persons related to the building must be aware of sustainable practices.

In a unique study with respect to technicality for residential buildings, variability was measured in electricity consumption and found to be 35% [24]. Four classes of predictors were also explained and the analysis showed that appliance ownership and usage is the only variable with the highest value to explain he use of energy in the residential building [24]. This study suggested that income of occupants and size of households may vary the study results. Aulia *et al.,* [25] suggested that socialization activities are very necessary for the education of occupants for green behaviors. A study in Abu Dhabi, found that only the will of occupants to use less energy is not enough to determine the energy usage behavior. Other factors like demographics, control of occupants over systems of the building, the frequency of energy communication from management and especially the reasons due to which occupants save energy are the real drivers of energy-saving behavior. They contributed a general framework to test their assumptions applicable to any type of building.

In a very well-focused recent study, Chukwuka *et al.,* [26] did a mixed method research on a sample of fifty-three employees in a green building in Malaysia. They suggested that organizational strategy, integration of technological strategy and occupants' behavioral strategy will enhance the energy efficiency of buildings. In the light of their results, they developed a set of energy efficiency practices which is a great contribution.

Table 3 provides the details about the methods and details of the selected studies about the greening of occupants for building energy efficiency. We have also discussed the methods and their usage for a better understanding.

Table 3. Review of literature on occupants & energy saving behaviors

Methods	Details	Discussion
Appreciation for green facades [15]	The plantation was used at the front of buildings as living facades. Occupants were provided incentives by the government of Germany for doing so. This work is based on a review of studies in Germany and other potential countries regarding this technique. It was recommended that this technique must be adopted at the global level.	This technique helps to develop habitat for several species, cools temperature inside buildings, reduce cost as they replace expensive materials. But studies are limited to Germany and Western countries. Further research is required especially in countries with harsh weather.
Training of occupants [16]	Multi-criteria decision analysis was done to concise the training material, so that maximum attention could be gained by occupants. By using this analysis and testing it on a focus group 40 LEED credits were reduced to two main points which are energy saving and waste reduction. The focus of research was to increase the impact of training material.	There was no literature on the effect of occupants on the performance of green buildings and positive results of training of occupants on the efficiency of buildings. It is the best way to cater for this issue as it involves every person.
Certification of Occupants [17]	A 100-point scale was developed to assess occupants. Points were termed as leaf and occupant must earn 70 points to get certified.	This initiative sheds lights upon differentiation of green certification of building and occupants' role. This clears that occupant has to work for sustainability too. The only building cannot play the whole part. Moreover, the certification will further increase their knowledge about green practices.
Encouragement of occupants having energy saving behavior [22]	Three strategies were developed, and their success was observed in energy-saving behaviors. First, awareness of occupants about energy saving behaviors must be raised with the help of pamphlets, posters, emails, and some appropriate guidelines. Second, regular live updates of energy use to the users of building and third briefing to the newly employed staff.	This is very necessary for daily interaction of building users with their building with respect to energy use. These strategies change the occupants perspective and develop their energy-saving behavior.
The energy-aware intelligent facility management system [21]	In this system at first knowledge, the database was developed including basic information on common daily work request and work instructions. Secondly, the artificial intelligent model was proposed which could automatically analyze and then prioritize the future work requests by keeping the focus on energy consumption impact, safety and occupant satisfaction. The validity of the system was checked with the help of case study on campus.	This system helps occupants by prioritizing tasks. The focus of this paper was on HVAC, further work should be done on other aspects of energy consumption as well.
Green Building management practices [23]	Five clusters of management practices were identified after an extensive review of green building practices. These five clusters included: Sustainable Procurement, Sustainable operation, Resource management, Repair and Maintenance Management, and Environmental Health. The clusters cover society, economy and environmental dimensions.	These are the most general set of practices and are addressing to achieve sustainability work from the initial phase of building is necessary. It also emphasizes that every person from the design phase of the building to the demolish phase must keep in focus these practices.

Table 4. No. of publications against the type of buildings

Building Type	No. of publications
Academic Institute	3
Office	2
Residential Building	6
Commercial	2
Total	13

In addition to all these explored benefits of greening of occupants, there is lack of diversification in studies such as, certification type (in papers one to three types are discussed at a time), building type (only one building type is concerned), energy use type (if electricity is taken as variable then many common machines like computer and mobile are omitted from the study), research context (studies are case studies, or are for one city, or for one country only). There is a need of more primary work on different building types for the development of the generalized framework. As the literature shows only two studies are conducted on office type settings. Another issue is lesser sample size, in many cases not even fulfilling the criteria of statistical analysis. The possible reason behind this issue could be the lesser number of green buildings in second and third world countries. Trash management and incentive program for occupants are the hot topics which must be explored by researchers. These issues conclude that this area is quite understudied, and this is the right time for researchers to take the initiative for this work.

5. Discussions

The study reviews the literature about the resolution of energy efficiency issues in achieving sustainability with the help of green buildings. An important point of key interest is to understand the forgiveness factor. It is the extent to which the occupant ignores unfavorable conditions and compromise with the building attributes. Green buildings perform efficiently when occupants offer this factor [18]. For example, the famous attribute of the green building is wide openings for the utility of clean air and sunlight. Anyhow, this attribute causes so many problems, such as disturbances due to excess dirt in case of a storm, heat in case of summer, cooling in case of winter and rainwater. If occupants tolerate such problems only then the wide opening could provide a healthy environment in the building and save energy by using sunlight and air. Considering this factor and facts provided in the review section we classified four classes as depicted in Figure 1.

First class is of green occupants living in the green buildings. The occupants offer forgiveness factor and have sound knowledge of green practices (use of automated HVAC systems, water, and energy efficient systems etc.). Green buildings are designed by keeping in view the sustainability, constructed by using recycled materials, and operated with the help of automatic and energy efficient systems which makes it best. While the trained or certified green users are supposed to use the provided systems yielding the highest efficiency. Also according to research this set makes the building the most efficient in the use of resources especially energy and is the best solution for the sustainable environment [18].

The second class consists of brown occupants and green buildings. In this set, occupants offer low to zero forgiveness factor and have negligible knowledge of green practices, which leads to the less efficient building. The main cause is that they could not use the systems as they are not trained or showing non-seriousness. Even in some cases, such green buildings use more energy than conventional buildings of the same size and use. There is also a reason that sometimes occupants think that the green certified building is itself doing sustainable actions. While this is not the case and the matter, in reality, cause drastic effects on the energy efficiency of the building. This is one of the main reasons behind the low performance of green buildings.

The third class includes green occupants and brown buildings, which makes a low impact on the sustainability of the environment. This class is very important, and we recommend it for existing buildings and in developing and underdeveloped countries as well. The literature shows that a number of green buildings are very low in these regions and their implication is also full of barriers [32]. For example, in Pakistan a nuclear country there are only 24 green buildings according to Pakistan Green Building Council. Thus, there is a need for this class in such countries to aware people about greening by generating impact with the help

of green occupants. Moreover, this is also the need of time because existing buildings are large in number and will serve for decades. This class will help us to reduce their impact on the sustainability of the environment.

The fourth class comprises of brown occupants and brown building. This is the worst scenario and has a high negative impact on the sustainability of the environment. Brown buildings are not equipped with energy efficient systems, have a conventional design, a material with high-value negative impact on the environment is used during construction. It depicts the real-time situations of many countries. Besides, the occupants are brown with no knowledge of green practices, no training and even not aware of the concepts like sustainability, green buildings, and environmental issues and impact.

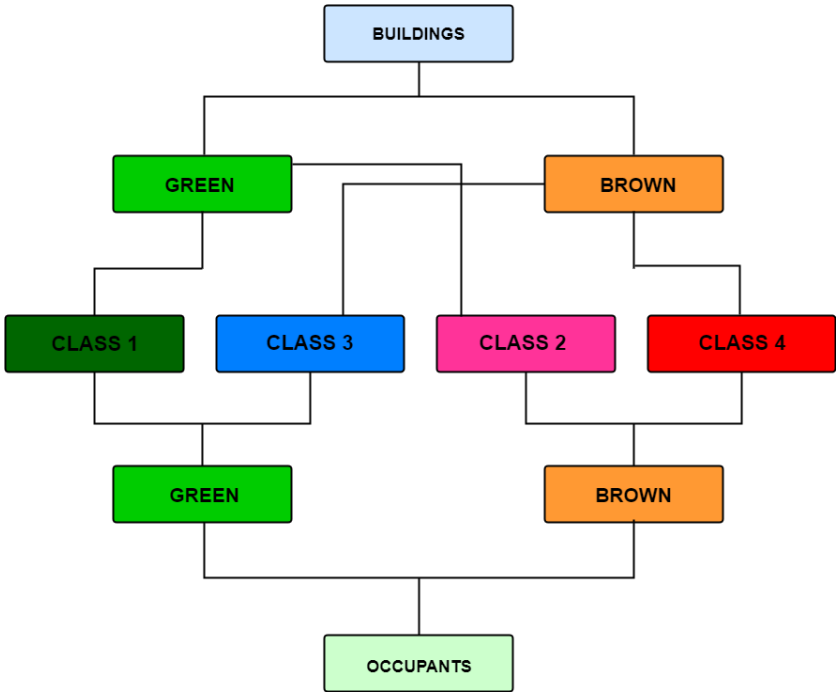

Figure 2. Relation of occupants with buildings

This relationship of occupants and type of buildings could also be better understood by developing the relationship of the efficiency of buildings, occupants, and the type of building in a matrix. Figure 2 shows that we could make four possible combinations. The first combination in this matrix consists of green buildings and green occupants. It is the most effective solution set for the sustainable environment and have the highest efficiency. The second combination is of brown occupants with green buildings it yields high to low efficiency. The third combination is of green occupants and brown buildings which yields low to high efficiency. Here it is worth noting that both second and third combinations result in medium level efficiency. Anyhow, the second class reduces the performance of green building from high to low while the third class increases the performance of brown building from low to high in the positive manner. The fourth combination is of brown buildings and brown occupants which yield the lowest energy efficiency. Figure 3 shows the building efficiency matrix.

We contribute to the literature by recommending a suitable class for high energy efficiency without changing the building type. That class consist of green occupants and brown buildings. Converting the conventional buildings to green one and developing green buildings results in high costs to the investors. Anyhow, greening the occupants is relatively less costly for the organizations. This paper is categorically helpful for the underdeveloped economies as they usually cannot afford high budget strategies to cover the deficiencies.

Our keen observations made us able to deal with some major flaws in the literature. First, the methodology portion of most of the papers is somewhat inappropriate. Second, their applicability is challengeable as they just discussed the techniques. There is no detail about impact of occupants on greening, benefits of the green practice discussed in respective paper. Third, in survey studies the sample size is low and in many cases secondary data was processed. There is high need in the field to introduce primary data studies.

It has been observed that some greening techniques of occupants are under practiced and need validation. For example, trash management and incentive for occupants for compliance of green practices which could be a driving factor for occupants to behave green need more research.

Figure 3. Building efficiency matrix

Our study is significant in the following manners. The paper provides the complete overview on the topic from 2000 to 2018. No review on this topic has been conducted yet according to our best knowledge. Thus, the study concludes that the green buildings can be more energy efficient by greening the occupants. Second, we developed a relationship among occupants, buildings and efficiency in the form of a matrix. This matrix contributes in green building literature by providing a clear picture of various combinations of buildings and occupants. We discuss four different classes by the pairing of occupants and buildings. It provides synthesized results about the greening of occupants and helps the managers to increase the efficiency of brown buildings by implementing the greening occupants' practices.

6. Study implications

The study is inherited with practical implications for the managers, investors, and governments. First, the findings suggest that the building management must start greening their inhabitants using the suitable technique provided in the literature. The change in the occupants' behavior will help both green and brown building management in long run to save energy, to play their role in the sustainable environment and to save money.

Second, the population of developing and underdeveloped countries is larger than the developed ones. Thus, it is necessary for governments to work on their nation as their impact regarding energy use on the environment will be very high. This is also necessary as due to global linkages they also commute to other parts of the world. The education of occupants' energy saving behavior will develop their positive energy consumption behavior which will be fruitful to the world. After discussing pros and cons of available techniques we selected the most feasible technique for the greening of occupants. This solution lies in educating and training the occupants regarding green practices and to use automated systems in green buildings. The education provides a broader sense of situations, able to modify decision power and develop thinking. Like switching off light, fan or any other electrical appliance when not in use, is a green practice. A prodigious list could be prepared for this purpose. On the other side training generates a sense of competition in occupants, help them to face real time situations, also boost their confidence and as return increase their energy efficiency.

Third, these steps will also help to reduce overall electricity consumption. Nowadays this is very important issues especially in underdeveloped and even in developing countries, to meet the demands of electricity. Another case is also observed that where there is no load shedding per unit rates are quite high. Careful use of electricity by green occupants will also reduce per unit cost of available electricity. Fourth, greening can also be done by working on trash management at the individual level. This will help to reduce pollution and other garbage related costs. Fifth, these approaches will also make healthy ecosystems due to low carbon production, excessive greenery, clean air and the availability of clean water.

7. Limitations and future directions

Our study does not provide the historical perspective of green buildings rather it aims to cover the elements that can help in gaining energy efficiency through their occupants. The study also does not cover the other elements that may help in achieving high green building efficiency. Future research should incorporate these elements for the review.

8. Conclusion

The review shows that the green buildings are not performing up to the mark and the cause could be their occupants. Previous research proposed numerous solutions for greening of occupants, but their synthesis was absent, and our research fulfilled the purpose. After systematic literature, we developed a relationship between occupants and building with respect to energy efficiency, identified four classes, and discussed their relation and effect on energy saving of building. A robust solution for sustainability issues of second and third world countries is the introduction of class three (green occupants & brown buildings). The best strategy to green the occupants is the early education of occupants regarding green practices. The greening of occupants not only enhances the energy efficiency of buildings but also helps the environment by reducing garbage and rehabilitation of ecosystems. We provide recommendations for future research by enhancing demographic variety, diversification of context and external validity elements

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References

[1] International Energy Agency. Directorate of Sustainable Energy Policy. (2013). *Transition to sustainable buildings: strategies and opportunities to 2050*. Organization for Economic.

[2] Ashuri, B., & Durmus-Pedini, A. (2010). An overview of the benefits and risk factors of going green in existing buildings. *International Journal of Facility Management*, *1*(1), 1–15.

[3] Cohen, R., Bordass, W., & Leaman, A. (2007). Evaluations and comparisons of the achieved energy and environmental performance of two library buildings in England and Sweden. *Transactions-American Society Of Heating Refrigerating And Air Conditioning Engineers*, *113*(2), 14–26.

[4] Howe, J. C., & Gerrard, M. B. (2010). *The Law of Green Buildings: Regulatory and Legal Issues in Design, Construction, Operations, and Financing.* Columbia Law School–Columbia University, New York.

[5] Scofield, J. H. (2009). Do LEED-certified buildings save energy. *Not reallyĚ. Energy and Buildings*, *41*(12), 1386-1390.

[6] Menezes, A. C., Cripps, A., Bouchlaghem, D., & Buswell, R. (2012). Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap. *Applied energy*, *97*, 355-364.

[7] Turner, C., & Frankel, M. (2008). Energy performance of LEED for new construction buildings. *New Buildings Institute*, *4*, 1-42.

[8] Yudelson, J. (2010). *Greening Existing Buildings*. McGraw-Hill Education.

[9] Lakeridou, M., Ucci, M., Marmot, A., & Ridley, I. (2012). The potential of increasing cooling set-points in air-conditioned offices in the UK. *Applied Energy*, *94*, 338-348.

[10] Masoso, O., & Grobler, L. J. (2010). The dark side of occupants' behaviour on building energy use. *Energy and Buildings*, *42*(2), 173-177.

[11] Azar, E., & Menassa, C. C. (2012). A comprehensive analysis of the impact of occupancy parameters in energy simulation of office buildings. *Energy and Buildings*, *55*, 841-853.

[12] Pisello, A. L., & Asdrubali, F. (2014). Human-based energy retrofits in residential buildings: A cost-effective alternative to traditional physical strategies. *Applied Energy*, *133*, 224-235.

[13] Hutter, M. (2020). *Experiencing Cities.* Routledge.

[14] Stovold, E., Beecher, D., Foxlee, R., & Noel-Storr, A. (2014). Study flow diagrams in Cochrane systematic review updates: an adapted PRISMA flow diagram. *Systematic Reviews*, *3*(1), 1-5.

[15] Koehler, M. (2008). Green facades-a view back and some visions. *Urban Ecosystems*, *11*(4), 423-436.

[16] Steinberg, D., Patchan, M., Schunn, C., & Landis, A. (2009). Developing a focus for green building occupant training materials. *Journal of Green Building*, *4*(2), 175-184.

[17] Mirel, D. (2010). Certifiable Green. *Journal of Property Management*, *75*(5), 35-37.

[18] Deuble, M. P., & de Dear, R. J. (2012). Green occupants for green buildings: The missing link? *Building and Environment, 56*, 21-27.

[19] Milenkovic, M., & Amft, O. (2013). Recognizing energy-related activities using sensors commonly installed in office buildings. In E. M. Shakshuki (Ed.), *4th International Conference on Ambient Systems, Networks and Technologies* (Vol. 19, pp. 669-677)

[20] Hope, A. J., & Booth, A. (2014). Attitudes and behaviours of private sector landlords towards the energy efficiency of tenanted homes. *Energy Policy, 75*, 369-378.

[21] Cao, Y., Song, X., & Wang, T. (2015). Development of an Energy-Aware Intelligent Facility Management System for Campus Facilities. In W. O. Chong, J. Chang, K. Parrish, & U. Berardi (Eds.), *Defining the Future of Sustainability and Resilience in Design, Engineering and Construction* (Vol. 118, pp. 449-456).

[22] Mokhtar, A., Wilkinson, S., & Fassman, E. (2015). Strategies for improving energy saving behaviour in commercial buildings in Malaysia. *Engineering, Construction and Architectural Management, 22*(1), 73-90.

[23] Aghili, N., Bin Mohammed, A. H., & Sheau-Ting, L. (2016). Key Practice for Green Building Management In Malaysia. In S. N. B. Kamaruzzaman, A. S. B. Ali, N. F. B. Azmi, & S. J. L. Chua (Eds.), *4th International Building Control Conference 2016* (Vol. 66).

[24] Huebner, G., Shipworth, D., Hamilton, I., Chalabi, Z., & Oreszczyn, T. (2016). Understanding electricity consumption: A comparative contribution of building factors, socio-demographics, appliances, behaviours and attitudes. *Applied Energy, 177*, 692-702.

[25] Aulia, D. N., Marpaung, B. O. Y., & Suryani, L. (2017). Identification of Increasing Green Behaviour in Citraland Bagya City, Medan. In A. G. Abdullah, A. B. D. Nandiyanto, & A. A. Danuwijaya (Eds.), *1st Annual Applied Science and Engineering Conference* (Vol. 180).

[26] Chukwuka, C., Enegbuma Wallace, I., & Kenley, R. (2018). Energy efficiency practices for Malaysian green office building occupants. *Built Environment Project and Asset Management, 8*(2), 134-146.

[27] Field, K. (2006). Breaking New Ground. *Chain Store Age, 82*(13), 106-114.

[28] McConnell, M. C. P. M. (2007). Talking Trash. *Journal of Property Management, 72*(4), 54-55.

[29] Koehler, M. (2008). Green facades-a view back and some visions. *Urban Ecosystems, 11*(4), 423-436.

[30] Cole, R. J., Brown, Z., & McKay, S. (2010). Building human agency: a timely manifesto. *Building Research and Information, 38*(3), 339-350.

[31] Lee, I. Y. L., Chen, H., & Tiong, R. L. K. (2015). An Investigation Into Tenant Organizations' Willingness-To-Pay For The Intangible Value-Added Benefits Of Sustainable Buildings: Case Study In Singapore. *Journal of Green Building, 10*(3), 191-213.

[32] Azeem, S., Naeem, M. A., Waheed, A., & Thaheem, M. J. (2017). Examining barriers and measures to promote the adoption of green building practices in Pakistan. *Smart and Sustainable Built Environment, 6*(3), 86-100.