

An Exhaustive Investigation of Green Building Certification on the Productivity and Mental and Physical Health of Buildings Occupants in Tehran, Iran

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Abstract—Since individuals spend the majority of their time indoors, this immediately affects their productivity and health. An essential factor in occupational health and public health is the influence of indoor environmental quality (IEQ) in buildings on occupant welfare and productivity. Since then, empirical data have been equivocal, indicating either that the studies are inaccurate or that the research has just scratched the surface of green buildings in offices, accommodation, and hospital settings and not taken the aforementioned holistically. This study compared three green-certified buildings — a residential green building, a green hospital, and a green school — with conventional structures in Tehran, Iran by means of a questionnaire spread among those utilizing these buildings, and assessing their productivity and health rate as opposed to the time they resided, worked in conventional buildings. The results demonstrated higher scores pertaining to productivity, physical and mental wellness as a consequence of better indoor environmental quality (IEQ), natural lighting, design, and sustainability of these building against non-green buildings. In addition, ancillary matters — environmental, financial, intellectual, emotional, social, spiritual dimensions of participants — were indirectly evaluated, and the same results are produced.

Keywords—Green building, Iran, productivity, physical and mental health, Tehran.

I. INTRODUCTION

GIVEN that buildings are explicitly designed for human occupation, it makes sense to prioritize the occupants' health and productivity from an ergonomic viewpoint. Issues of occupant health and productivity are prevalent in the many worldwide green building rating systems, often as a factor called indoor environmental quality (IEQ), which covers elements linked to employee well-being, contentment, and productivity to differing degrees. The influence of IEQ of green buildings on inhabitants' health, well-being, and productivity is a significant area of study in occupational and public health [1], [2]. Having said that, there are less articles and findings wherein productivity and health of people from diverse type have been taken into consideration, such as green hospitals, green offices, green residential buildings. This is why this study was conducted in order to investigate a larger scale compared to prior studies.

Green buildings, by definition, have a minimal effect on

human health, which is one of their primary characteristics. Not only are the materials used in green building development ecologically sustainable, but they are also healthier and cleaner for people. More and more companies and developers are relying on this type of information as they search for sustainable options for their real estate holdings that go beyond energy efficiency [3], [4]. Additionally, researchers truly believe that green building (GB) is a fundamental practical method for implementing sustainability and green construction in today's technologically advanced society [3], [4]. The GB movement aims to improve Indoor Air Quality (IAQ) and employee wellness by creating better buildings [1].

As a consequence of global industrialization, human beings are now subjected to a wide range of environmental hazards, including: noise pollution, water contamination, and motor vehicle pollution. Many ailments, including aging skin, hair loss, general weariness, forgetfulness and infertility as well as leukemia and cancer are directly linked to indoor pollution or poor IAQ [5]. Liquana et al. found that 37% of respiratory disorders are caused by indoor pollution. Indoor pollution is also to blame for 22% of all chronic diseases, 5% of all bronchial catarrhs, 5% of all malignancies, and 5% of all cases of leukemia [1]. Moreover, psychological health (e.g., sadness and stress) is harmed as a result of poor air quality, severe temperatures, excessive humidity, and inadequate ventilation. These workers are more likely to miss work, take longer absences and are less productive than their counterparts who do not suffer from similar health issues [6]-[8].

A little investment in the design process and operation of a building may have a large influence on an organization's employee productivity [3]. For example, improved ventilation systems; more fresh air, less recycled air; less glare from the sun, more sunlight, artificial lighting; and fewer volatile organic compounds (VOCs) will result from green buildings [2], [9]. Because of the emphasis on these factors, GBs are commonly thought (and often actively marketed) to be more pleasant, healthier, and more productive than conventional ones [2]. Furthermore, some studies substantiated the claim that GBs positively impact students' physical and mental health and ability and better off with learning and solving problems [10].

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Additional benefits include better acoustics and fewer concentrations of pollutants that may otherwise have a detrimental impact on students' productivity and well-being. Green schools also help to teach students about environmental sustainability [10]. Environmentally friendly buildings have a positive effect on employees' perceptions of asthma symptoms, respiratory allergy issues, and stress, as well as their ability to report absenteeism and work hours impacted, according to Leadership in Energy and Environmental Design (LEED) ratings, structures for offices [6], [11]. "Childhood asthma" is the leading cause of student absenteeism in the United States, accounting for 13.8 million lost school days per year according to [10]. Studies even pushed back the frontiers of knowledge. As an example, in a university context, an examination of occupant experiences in two LEED Platinum buildings on a college campus indicated that the GBs scored higher on people's health and performance. The productivity of each employee in GBs was on average 2.6% higher than the productivity of per employee in conventional structures [12], [13].

In healthcare settings, a correlation between IEQ and productivity was discovered. When compared to non-LEED hospitals, LEED platinum-certified hospitals had much reduced employee turnover [14]. Comparing two healthcare facilities on opposite sides of the street that are part of the same healthcare system demonstrates that the LEED-certified facility outperforms the non-LEED facility in terms of cleanliness, thermal comfort, safety, noise comfort, lighting comfort, overall comfort, perceived productivity. When a LEED-certified pediatric healthcare facility was compared to its prior, conventional equivalent, statistically significant gains in productivity, employee satisfaction, and quality of treatment were seen [14]. In essence, reduced environmental impact and responsibility for illness improvement are two of the hallmarks of a Green Hospital. Green hospitals understand the connection between public health and the environment and incorporate this understanding into their administration, strategy, and operations.

While researching GB performance, Birt and Newsham discovered that there were just a few publicly available studies. Environmentally friendly buildings have been shown to increase productivity, but the links between physical health and mental well-being have been less well studied. Studies of early examples of GBs found convincing evidence that GBs boosted productivity [2], [15].

Baird believes that it is logical to give priority to staff well-being and productivity financially, when considering building efficiency, since employee wages typically surpass the expenses associated with building design and usage (e.g., electricity, water, trash collection, etc.). Office workspace expenses are often broken down into four categories: labor, equipment, and maintenance and operations, with labor accounting for around 80% of total expenditures during a 10-year period [16]. To explore the relationship between the physical environment and organizational productivity in a single corporation, it is not necessary to engage in an expensive or invasive data-collection effort; instead, acquiring authorization to use existing data sources may suffice.

Employee retention and turnover, absences, and other aspects of employee health and well-being may already be stored in HR databases. Employee Opinion Surveys (EOSs) that contain information on health and organizational commitment are also conducted by many companies' HR departments on a regular basis [17].

Although there are several benefits to Green Building Technology (GBT), a number of hurdles, such as a lack of expertise and a lack of market demand, make implementation complicated. Typically, purchasers' value both the price and location of a GB. As a result, builders and planners will be unable to develop GBTs in the absence of consumer demand [3], [18]. Furthermore, knowledge, education, and teaching are essential for the development and expansion of employment in the clean energy industry. In their report, they observed that a lack of critical skills and competence might hamper advancement in this industry, as well as issues such as standards, price, product availability, and breaking with tradition [19], [20]; however, prior research has increased people's understanding that the use of GBs in building projects is a cost-effective choice [3], [21].

Other potential concerns with GBs may develop as a result of the use of LEED-certified lighting, noise, and thermal comfort. The reason LED lighting may cause headaches is because of a phenomenon called flicker. Standard LED lighting systems sometimes exhibit flicker at frequencies that might cause headaches and impair vision [17]. In terms of noise and heat, Fowler and Rauch [9] examined 12 GBs and reported that, although overall satisfaction with the indoor environment was high, noise and thermal comfort fell short of national criteria [10]. Although the study's findings suggested that LEED-certified healthcare facilities beat one non-LEED facility in most of the building performance characteristics (with the exception of controllability and its relevance), the majority of building performance characteristics of non-LEED healthcare facilities were found to be superior [16]. On balance, research exploring the relationship between productivity and wellbeing has seldom focused on the connection to various types of GBs. Additionally, the negative aspects listed above cannot have a detrimental effect on overall health and productivity. As a result, it is essential to assess the relationship between the aforementioned characteristics and their association with GBs [19].

II. RESEARCH METHODOLOGY

GBs (e.g., green schools, green hospitals, and green workplaces) were enlisted to aid in data collecting and evaluation. This study was conducted because these structures are uncommon in Tehran, Iran's capital, and Tehran faces several serious and unresolved issues, including population growth (approximately 17 million people) and significant environmental issues, including air, water, and soil pollution, noise pollution, traffic congestion, and resource use. Due to the fact that Tehran is the country's political capital, people have easier access to a range of economic, political, cultural, and educational institutions than residents of other cities [3]. Accordingly, in order to investigate physical and mental health

indices along with productivity index, a survey questionnaire and literature review were done.

Questionnaires encompass two sections: section 1 concerns people's background (Gender, Age, Education level, Job, Email). Section 2 concerns eight questions about eight dimensions of health in addition to three questions concerning overall status of physical, mental and productivity rate in accordance with a five-point Likert-scale ranging from very satisfied (5) to very unsatisfied (1) was used. Finally, five questions are related to people's preferences, and time spent in GBs through multiple-choice, and 5-point Likert-scale ranging from "1" (low) to "5" (high). Questionnaires were distributed via postal email to people who lived or worked in four GBs that had earned either the energy star label or LEED certification (at any level), including one residential GB, one green hospital, and one green school — they had previously lived and worked in conventional buildings — in order to estimate the aforementioned indices and, if the results were close, to encourage developers in Iran to convert traditional buildings to GBs. The questionnaire was credible, and it contributed to the credibility of the rest of the research. 150 questionnaires were e-mailed and delivered to participants, and 51 questionnaires were returned and found to be suitable after a one-month interval. Although subjects were not obligated to fill the questionnaire, they were reminded through email to partake in this research. The eight dimensions of wellness which are somehow linked to this study (e.g., environmental, financial, intellectual, emotional, social, spiritual, occupational, and physical dimensions) were analyzed to witness and assess the participant's health and productivity as a whole. As a consequence, their reactions and thoughts had a significant impact on the study's findings, in addition to validating the research's legitimacy. To respect participants' privacy in this study and principle of confidentiality all names are anonymous.

III. DATA ANALYSIS

Even though some of the aforementioned dimensions were not directly correlated to the purpose of this study, all of them were carried out so as to understand physical & mental health as well as productivity to measure productivity and health of GB's citizens in a comprehensive way. There were 22 males and 21 females among the sample. The participants were from a range of different GBs either working or living there (e.g., five green residential buildings, three green offices, and two green schools and one green hospital). Participants' age was between 21 and 67 years, with the average of 29.67 years (with a standard deviation of 8.61 years). The data were analyzed using statistical package (SPSS v.26). The reliability of a scale shows how free it is from inherently unpredictable errors. The most commonly used measurement for internal consistency or reliability is Cronbach's alpha coefficient. This statistic provides an indication of the average correlation among all of the items that make up the scale. Nunnally (1978) recommended that Cronbach's alpha coefficient scale should be above 0.7 [22]. As a result, the internal consistency method of checking the reliability of the scale was applied to this study. The first section of the questionnaire tests for reliability and is

deemed unnecessary [19]. The reliability test conducted for section two is recorded in Table II using Cronbach's alpha coefficient. According to these results, the alpha values for all sections were above 0.7. Therefore, these alpha values demonstrate that the sections can be considered highly reliable throughout the sample study. Indeed, The Cronbach's alpha for 16 items is shown at Table I.

TABLE I
RELIABILITY STATISTICS

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
980	990	16

It is worth mentioning that Table II on Item-Total Statistics demonstrates the reliability of Cronbach's alpha even when items are eliminated.

TABLE II
ITEM-TOTAL STATISTICS

Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q6	58.1	294.453	0.874	0.924	0.98
Q7	58.28	291.493	0.934	0.969	0.979
Q8	58.31	293.793	0.937	0.957	0.979
Q9	58.28	293.707	0.841	0.945	0.98
Q10	58.38	293.53	0.843	0.839	0.98
Q11	58.28	293.564	0.863	0.914	0.98
Q12	57.93	297.281	0.858	0.866	0.98
Q13	58.28	293.278	0.912	0.953	0.979
Q14	58.83	293.076	0.796	0.918	0.981
Q15	58.21	293.241	0.89	0.947	0.979
Q16	58.38	293.744	0.92	0.96	0.979
Q17	58.31	295.865	0.84	0.811	0.98
Q18	58	291	0.877	0.953	0.98
Q19	58.28	295.064	0.809	0.9	0.98
Q20	58.66	294.663	0.825	0.944	0.98
Q21	58.62	294.458	0.85	0.956	0.98

To corroborate findings, researchers often mix semi-structured interviews and formal questionnaires. Using a combination of qualitative and quantitative methodologies is often seen as a strategy to increase the rigor of approach. This study was conducted in order to ask conventional buildings owners (both for commercial and residential usage), conventional hospitals bosses along with conventional schools principles if their buildings are proportionate to GB foundations and indexes, how inhabitants', academics', students', and employees' mental and physical health, as well as productivity, would change. Finally, the results were compared to GBs on a similar, albeit global scale. The reason why this study was investigated is derived from the fact that people's wellness and productivity in Iran, that is Tehran, are in grave peril and GBs are scarcely seen in Tehran. In addition, the overall state of mental and physical health, along with their level of productivity, are shown in Figs. 1-3.

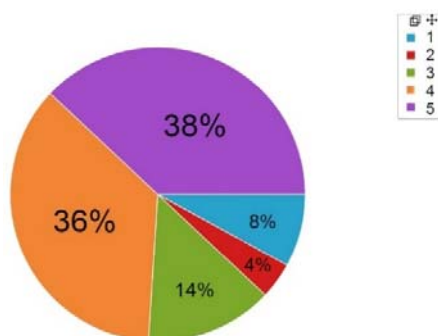


Fig. 1 Aggregate Physical Health in GBs

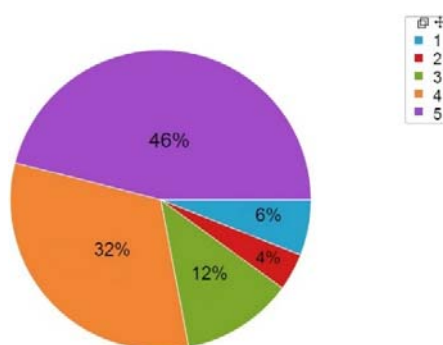


Fig. 2 Aggregate Mental Health in GBs

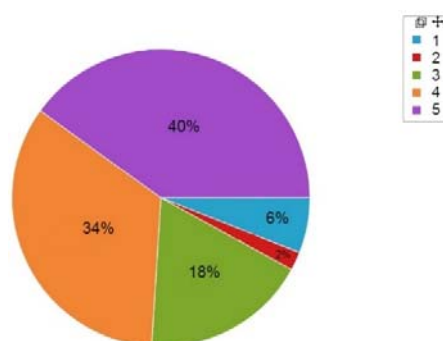


Fig. 3 Aggregate Productivity Rate in GBs

IV. DISCUSSION

Eight dimensions of health (e.g., environmental, financial, intellectual, emotional, social, spiritual, occupational, and physical dimensions) in addition to productivity rate of those who reside or work in GBs were examined by questionnaire to figure out whether the results are in or out of proportion with previous research. This case study includes green structures in Tehran, including two schools, one hospital, five residential buildings, and three green workplaces. The results are certainly consistent with prior expectations and significantly surpass previous global research. This is derived from the fact that air, lightening, noise, and aesthetics were optimized in comparison with traditional buildings wherein artificial light, noise pollution, and stuffy constructions got more in the way of reaching similar results. Other elements like greenery and aesthetics created a more productive and healthier environment for employees, occupants, students. In effect, in line with

hypotheses: firstly, there has been one well-recognized research that examined a sample of 33 green construction projects and concluded that present value advantages of \$37 to \$55 US dollars per square foot might be realized as a consequence of productivity gains from reduced sick time and increased worker productivity. Secondly, the most recent research looked at ventilation (at two levels) and illumination (at two levels) as interacting factors and showed that students' processing speed, focus, and math improved [23].

V. RECOMMENDATIONS AND LIMITATIONS

This research study has some limitations that indicate opportunities for additional exploration. Postal mail questionnaires were sent out as part of the study's methodology. Therefore, the responses received from the respondents served as the only valid source of information for substantiating the research findings. While the questions were designed to be straightforward and simple to comprehend in order to avoid misunderstandings and improve validity, it is feasible for respondents to respond carelessly to the questionnaire. Moreover, about half of respondents did not bring their answers back or perhaps look at the questionnaire. The data were rigorously confined to Tehran, with the goal of assisting in the validation of the paper's conclusions. Consequently, it proved difficult to locate GBs in Iran, since conventional structures outnumber them. Hence, interval occurred during this study to collect and to analyze essential data. In order to increase its generalizability, future study should also aim to address health and productivity rates in other areas of Iran and even beyond, that is, globally. Other elements, such as energy efficiency, satisfaction, and financial difficulties, should also be included all together to improve the research's reliability and validity. Indeed, owing to the fact that previous research and data were more one-dimensional, future studies should be multidimensional to get more concrete results. Finally, to measure reliability, it is recommended to conduct further studies by means of test-retest, inter-rater, parallel form, and split-half reliability so as to minimize the potential error and to have more reliable results.

V. CONCLUSION

Overall, the evidence given here indicates that buildings, whether non-green or green, can have an influence on the wellbeing and productivity of its residents. This study established a clear link between GB and increased productivity, as well as improved mental and physical wellness. This is due to increased natural light and fresh air ventilation, as well as improved Interior Environmental Quality (IEQ). GBs are regarded more highly by users than conventional buildings even in other areas like as temperature, noise, acoustics, overall satisfaction, and absenteeism reduction. Consequently, developers should invest more in the construction industry, and the media had better raise people's awareness on merits of green-certified buildings (or LEED-certified buildings) discussed in this research along with governors to enforce new laws and policies concerning greener and sustainable buildings

for greater good as the long-term effects of such buildings dominate in one way or another.

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