

# Factors Affecting Indoor Environmental Qualities of Social-Housing Projects in South Africa

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**Abstract.** The South African housing delivery plan faces various economic and social challenges, which include a high unemployment rate, low income, a huge housing backlog and a lack of infrastructure, particularly in rural areas. Indoor environmental quality (IEQ) is the ability of a building to deliver adequate indoor environment beyond occupant's expectation. These expectations include the occupant's health, wellbeing, and productivity among others which are often not considered during the design stages of social-housing projects. This paper presents the results of IEQ of social-housing projects in South Africa. The study adopted a quantitative, where a questionnaire survey was constructed and distributed to occupants of social-housing in the Gauteng province of South Africa. Analysis of the primary data collected was conducted using descriptive statistics procedures. The findings revealed that the major factors affecting IEQ of social housing occupants were indoor air quality parameters, level of privacy, acoustics sound between the units and level of visual comfort among other factors. Also, the occupants were not satisfied with the overall state of their IEQ which was driven by the above factors. Thus, creating a provision for IEQ aspects during the design and administration phases of social-housing projects will make social-housing more desirable in South Africa.

**Keywords:** Air quality, Occupant Satisfaction, Thermal comfort, Social housing.

## 1 Introduction

Following the democratic freedom that South Africa endured in 1994, providing adequate housing for the nation has been a constant challenge faced by the government. The department of housing [1] highlighted that challenge has been fueled by increased housing demands, amended housing scope and the social housing policy shortfall absorbed from the pre-democratic government. The need for practical solutions arose as various strategic policies related to housing projects and programmes required major revisions. Ironically, major housing problems still exist despite government's initiatives which were formulated to provide affordable housing projects for all [2].

There is a steady civil argument on the adverse impacts of inadequate indoor environmental quality (IEQ) on the wellbeing and occupant's satisfaction of their

38 indoor environment. Ibem [3] noted that the need to guarantee unwavering quality  
39 relating to social service delivery and housing provisions to the public had drawn the  
40 attention of the governing body together with the stakeholders of housing schemes in  
41 many developing economies. Also, contemporary literature has shown that across the  
42 globe, social-housing provision is regarded as an alternative to the privatised housing  
43 sector, which caters mostly for the middle to the high-class households. As a result,  
44 households of the lower class are found in an economic crisis that social-housing  
45 address [4]. Santamouris [4] further added that the economic crisis brings about  
46 inadequate IEQ of the lower-class households which the current study seeks to identify.

47 For this reason, more research is required to investigate occupant's satisfaction level  
48 with their IEQ within social-housing projects. Recent studies demonstrated that living  
49 in a reasonably planned indoor environment promotes more individual comfort and  
50 wellbeing of mental and the physical [5] [6]. It is therefore important to study the  
51 elements influencing the IEQ of social-housing projects. The study seeks to identify the  
52 factors that will contribute to the overall assessment of the challenges faced by the  
53 social-housing project scheme, in a bid to increase the demand for social housing in  
54 South Africa. The structure of the paper includes a credible literature review followed  
55 by a comprehensive write up of the adopted research methodology and the collection  
56 of empirical data through research findings. Subsequently, conclusions and  
57 recommendations relating to improving social-housing satisfaction are drawn using the  
58 findings of the paper.

## 59 **2 Indoor Environmental Quality: A Review of Literature**

60 Indoor environmental quality (IEQ) is a term which covers the environmental qualities  
61 within a building and is commonly linked to the well-being and comfort levels of the  
62 building's occupants. The phenomenon addresses the three main indoor environmental  
63 factors which mainly are; air quality (which is made up of humidity, temperature,  
64 pollutants and odours), light and acoustics quality. Aigbavboa and Thwala [7]  
65 mentioned that these factors should be the basis of any design when constructing social-  
66 housing units. Similarly, Sakhare & Ralegaonkar [8] emphasised that the most  
67 important function of a building or an enclosed structure is to provide ultimate user  
68 satisfaction through adequate IEQ. The following are known factors that influence the  
69 IEQ of occupants.

### 70 **2.1 Indoor Air Quality**

71 Indoor air quality (IAQ) is characterised as 'clean' air in an environment where the  
72 presence of air contaminants in the indoor space is significantly low. Similarly, indoor  
73 air exposure is dominant for occupants who spent over fifty per cent of their time  
74 indoors [9]. Sanni-Anibire [10] further defined IAQ as a mean or suitable level of  
75 tolerance with the indoor ventilation, humidity and biological air contaminants. IAQ is  
76 a component of IEQ that addresses two main indoor environmental aspects of air flow  
77 and humidity. Inadequate IAQ is common in the following indoor environments.

78 Mainly all major modes of transportation, institutional buildings, shopping outlets,  
79 workplaces, crèches, housing, hospitals and schools [9].

## 80 **2.2 Thermal comfort**

81 Thermal quality (TC) is defined as a perceived feeling linked to the overall fulfilment  
82 with the thermal environment relating to the temperature [11]. TC influences the level  
83 of IAQ in a building. Similarly, thermal comfort is affected by various mediation  
84 variables such as the season, age, gender, ethnicity, geographical climate and location  
85 [12].

## 86 **2.3 Acoustic comfort**

87 Acoustic comfort (AC) can be characterised as a condition of happiness with acoustic  
88 conditions [9]. The adoption of acoustic comfort is limited and providing for a decent  
89 acoustic environment can be a challenge for public spaces. The environmental element  
90 of the sound is naturally connected to various physical parameters. The physical  
91 properties of these parameters incorporate the sound source and the indoor  
92 environment. The sound weight level describes the sound recurrence and fleeting  
93 together with the duration period. The properties of an acoustic environment can  
94 influence the physical indoor space through the sound absorption and reflection,  
95 assimilation and resonation time which brings about indoor discomfort to the  
96 occupants.

## 97 **2.4 Visual Comfort**

98 Visual comfort is described as the light level of an area relating to light uniformity,  
99 color, glare control, luminance and illuminance together with the distribution of a light  
100 source [13]. Also, it was documented in a separate study that human sleeping patterns  
101 were influenced by the visual quality experienced during the day [14]. It is for this  
102 reason that visual comfort should be catered for in social housing projects among other  
103 IEQ parameters.

104 Moreover, the Leadership in Energy and Environmental Design (LEED) included  
105 IEQ as part of the five classes which deals with fabricating evaluation framework,  
106 created by the Green Building Council of the United States of America (USGBC).  
107 Thus, IEQ is mentioned to influence the occupant's fulfilment, building usage and  
108 overall efficiency. This can be achieved by guaranteeing high IEQ requirements of  
109 lighting, acoustics, clamour control, ventilation and thermal regulations.

110 In addition, Afacan and Demirkan [15] observed that constructing an acceptable and  
111 solid indoor environment is essential for tenants as it eliminates the need for  
112 reconstruction and renovation. According to Awabi [16], health, comfort and safety  
113 issues are particularly pronounced in the area of social housing, where the deterioration  
114 of the existing building creates a need for renovations to be prioritised. It is for this  
115 reason that a study aimed primarily on the factors that affected the qualities of social  
116 housing projects in South Africa with emphases on the indoor environment.

### 117 **3 Research Methodology**

118 The research study adopted a quantitative approach using a structured questionnaire  
 119 survey design that was distributed mainly to the occupants of social housing. The study  
 120 setting was mainly in the Ekurhuleni Development Company (EDC) and JOSHCO  
 121 (Johannesburg Social housing Company) which is found in the Gauteng province. The  
 122 occupants of these social housing companies were the targeted respondents. The  
 123 selection of the study area was prompted by the fact that most social housing projects  
 124 in South Africa are established in Gauteng due to the urbanisation of the working class.  
 125 A convenience sampling method guided the selection of a sample size of 70 occupants  
 126 who were selected due to the time and available respondents that were willing to  
 127 participate in the study. A close-ended questionnaire survey was designed with four  
 128 sections. The first section of the survey was designed to gather demographical data of  
 129 the respondents like the period of occupancy, age and gender. The second section  
 130 sought to gather the occupant's behavioral patterns or habits done in their units. The  
 131 third section sought to understand the type of control occupants had over the facilities  
 132 in their social housing units. The last part dealt with the factors affecting IEQ. A 5-  
 133 point Likert Scale was used to measure all factors associated with IEQ. Only 52 out of  
 134 70 distributed surveys were received back yielding a 71 per cent response rate which is  
 135 deemed adequate for analyses. In analyzing the data gathered, descriptive statistics was  
 136 done of each factor using mean item scoring (MIS), standard deviation (SD) and  
 137 ranking (R) respectively.

### 138 **4 Results**

#### 139 **4.1 Background Information**

140 The data analysis gathered demographical information of the respondents which  
 141 reflected that the occupant's gender was; 34% of the respondents were male, while 66%  
 142 were female. Also, the data showed the duration that the occupants have stayed in their  
 143 current unit; which revealed that 8% of the respondents have stayed in their units for 0-  
 144 6 months; 8% of the respondents have stayed in their current units for 7-12 years.  
 145 Similarly, 44% of the respondents have stayed in their current unit for 1-5 years; 40%  
 146 of the respondents have stayed in their current units for 6-10 years, 0% of the  
 147 respondents have stayed in their current units for 11-15 years, and 0% have stayed in  
 148 their current units for above 15 years. These demographical findings reveal a significant  
 149 influence and relationship to the impact of the IEQ factors by gender and the duration  
 150 of stay in their units similar to other studies [17-19]. The statistical findings of the study  
 151 are presented in Table 1 below were: (MIS) is the Mean item score, (SD) is the Standard  
 152 deviation, and (R) is the factor Ranking. The SD seeks to measure the variability of the  
 153 occupant's response to the mean data which reflected a higher margin.

154 **Table 1.** Factors affecting IEQ of Social Housing Units

Factors	MIS	SD	R
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The air quality of the unit (airflow, contaminates, stale air)	3.42	1.002	01
Sound privacy between the units (limit eavesdropping)	3.17	1.030	02
Temperature in the unit	3.09	0.961	03
Building sanitation and cleanliness	3.08	1.168	04
Level of privacy	3.01	0.898	05
Cardinal direction of the building	3.00	1.092	06
General maintenance of the building	2.58	1.216	07
The adjustability of unit furniture to personal preference	2.50	0.808	08
Amount of light in the unit	2.33	1.144	09
Properties of unit finishes (texture and color of walls, furniture and floors)	2.25	1.165	10
Comfort of furnishings	2.17	1.136	11
Visual comfort of the lighting (glare, reflections and contrast)	2.09	1.380	12
Availability of unit space (recreational and storage space)	2.08	1.126	13

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## 155 5 Discussion

156 In assessing the factor affecting IEQ, a five-point level of significance relating to  
 157 each factor would be recorded by the occupant, with five being strongly agreeing, four  
 158 being agreeing, three being neutral, two being disagreeing, and one being strongly  
 159 disagreeing. Table 1 shows the ranking of these factors by the occupants. Findings  
 160 show that 46% of the factors assessed were deemed significant by the occupants as they  
 161 have an MIS value above the 3.0. The main leading factors are; the air quality of the  
 162 unit, sound privacy between the units, temperature in the units, general cleanliness of  
 163 the building, and the level of privacy. These factors show an MIS value of 3.42, 3.17,  
 164 3.09, 3.08, and 3.01 respectively. Furthermore, 64% of the analysis informed us that  
 165 the occupants were neither neutral or satisfied with their IEQ as an MIS value between  
 166 2.08 until 3.0 was recorded.

167 The findings of the study are analogous with the findings of three similar studies  
 168 [20-22] that revealed that most household owners in their study cited concerns on the  
 169 air quality and general cleanliness of their homes as leading causes of inadequate IEQ  
 170 in their homes. On the other hand, the findings from this study are in contract with the  
 171 finding of Frontczak et al. [11] who mentioned that the least concerning factors  
 172 affecting the IEQ of open plan units was sound privacy. Also, Kamaruzzaman et al.  
 173 [19] observed that indoor glare and visual contrast related to visual comfort was the  
 174 least important factor that affected the IEQ of indoor occupants [19]. The current  
 175 findings of the study concurred with these results.

176 Further analysis of the results uncovered that the cardinal direction of the units that  
 177 the respondents occupied influenced the extent of lighting, and temperature present in

178 the unit. These findings were analogous with similar studies which identified that the  
179 climate elements of the indoor and surrounding environment affected the occupant's  
180 control and usage of sunlight and thermal satisfaction with their IEQ [20,23,24].  
181 Similarly, it has been observed that the occupant's level of satisfaction is further  
182 influenced by external factors such as the amount of time spent in the unit, the intensity  
183 of the activities conducted while in the unit and the ability to adjust or control facilities  
184 to suit the required temperature [25,19]. These findings also correlate with the  
185 perceptions of the current respondents of the study.

186 In addition, it was concluded that the absence of a mechanically driven IAQ system  
187 influenced the level of contaminants that were present in the indoor space [26,27,22].  
188 The same is true with the current study as windows allowed for continuous air flow and  
189 ventilation in their units which invited outdoor pollutant that contaminated the indoor  
190 air in their units. These pollutants entered the building through exhaust air, infiltration  
191 through cracks and openings from doors and windows. From this observation, it can be  
192 noted that the age of the building together with routine maintenance plays a vital role  
193 in ensuring adequate IEQ in social-housing projects. Likewise, the observations from  
194 this study are evident in other recent researches [28,29]. Moreover, the findings of  
195 Frontczak et al. [11] is in line with the beliefs of the study that maintaining adequate  
196 IEQ can be a profitable strategy for any public and private building investment.

## 197 **6 Conclusions**

198 The indoor environment is an outcome of the collaboration between the spatial matter,  
199 indoor climate and the occupants of the indoor space. The amount of complaints relating  
200 to the building stiffness, the increase in the usage of raw materials that devour natural  
201 resources, and the increasing amount of energy that is consumed to attain indoor  
202 comfort, has increased over the years. Based on literature and empirical data, the study  
203 investigated the factors affecting the IEQ of social housing projects in South Africa. It  
204 was noted through the survey data collected that the level of awareness regarding the  
205 indoor environmental condition and their qualities linked to social housing satisfaction  
206 was below expectation which raised concern among occupants. The study concludes  
207 that the main factors affecting IEQ of social housing projects were linked to the primary  
208 IEQ constituents which mainly were: IAQ, TC and AC. Moreover, the findings of the  
209 study cannot be generalised due to the limitation of the research scope.

210 It is therefore recommended that during the initial or retrofitting stages of a building,  
211 the provision of IEQ elements ought to incorporate to the design through a mechanical  
212 system that creates indoor proficiency and comfort. Also, social housing projects which  
213 are already established can create, implement and adopt an IEQ management system  
214 that seeks to maintain and improve the current qualities of social housing projects. An  
215 extension of the study can be conducted in other provinces to create a wider view of the  
216 research topic. Also, further research can investigate the benefits of a central IEQ  
217 management system in social housing units that can be adjusted to the occupant's  
218 preferred level of comfort.

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