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Social Sustainability Components & Improving the Physical Quality of Contemporary Residential Complexes

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Abstract

The paradigm of social sustainability in contemporary literature has always been widely proposed to solve the problems and inefficiencies of the physical environment in various scales of the urban space. Hence, addressing the concept of social sustainability on a micro-scale, such as residential complexes that have been less discussed, can improve the socio-physical quality of these areas. In this research, because social sustainability indicators have complex dimensions,evaluation and prioritization of the components and indicators that are affecting social sustainability in Shiraz's residential complexes have been done from the viewpoints of professionals in the field of architecture and urban planning. The strategy of the current study is correlational and quantitative in terms of methodology; the collected data of 33 selected professionals whose research and the professional area is focused on residential complexes was examined and evaluated using a multi-criteria decision-making process (DANP technique). The findings of this study showed that the physical component serves as a grounding criterion that affects the component of social sustainability. The following indicators, according to experts, are effective in improving the physical quality of residential complexes: indicators A) social interactions, B) security and safety, and C) place attachment and sense of place have higher rankings, whereas the indicator E) housing density has the lowest. Finally, policies and strategies for planning and designing residential complexes in both social and physical dimensions are suggested for decision-makers and planners to adopt based on the findings and results.

Keywords: Place Sustainability; Physical Quality, Social Sustainability; Expert Evaluation; Contemporary Residential Complexes of Shiraz

1. Introduction

Housing, particularly the social sustainability of residential complexes, has always been a topic that has been researched by professionals on a variety of levels. In residential complexes, sustainability, particularly social sustainability, is important because it improves the quality of living by providing an appropriate physical environment in which the residents' social aspirations and conditions are considered. To put it another way, building a link between the physical environment and the notion of social sustainability is critical for environmental planning because the quality of the living environment is determined by the 'needs' and 'culture' of individuals in the community (Cilliers, 2018).

In addition to improving the physical dimensions of residential complexes, addressing the components that explain social sustainability provides the possibility of improving residents' quality of life; applying the dimensions of social sustainability can be considered the main issue that leads to placemaking. This study aims to use expert opinions to evaluate the components and effective indicators of social sustainability to improve the physical quality of residential complexes. Three questions will be addressed in this study, all of which are in line with the stated goal: A) What are the components and indicators that explain social sustainability in residential complexes? B) Which of the components and indicators of social sustainability in contemporary residential complexes has the highest influence and priority, according to expert opinion? Furthermore, C) What policies and strategies are in place to promote social sustainability in the planning and design of residential complexes and improve the physical environment's quality, and how may this be achieved?

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2. Literature Review

2.1 Social sustainability

In contemporary literature, social sustainability is the major pillar of sustainable development. Social sustainability is a process that always considers an individual's social realm, as well as concepts like 'quality of life,' 'happiness,' and 'well-being' (Colantonio & Dixon, 2011). It can be said that social sustainability is based on two major issues; the first is 'individual capacity', which is for the welfare of individuals as well as the welfare of communities, and the second is the 'capacity of communities,' which includes strengthening measures in which 'quality of life' is considered (Shirazi & Keivani, 2017). Social sustainability refers to the 'needs' and 'collective desires' of individuals in society (Manoochehri, 2018). In other words, social sustainability addresses people's individual and collective quality of life and well-being (Baldwin & King, 2018).

The availability and quality of facilities and services that pursue social goals locally can improve social sustainability (Manzi, 2010). Social sustainability evaluates the built environment's attributes in both 'physical' and 'nonphysical' dimensions, with the higher the perceived qualities in an environment, the greater the possibility of social sustainability in that area (Shirazi & Keivani, 2019b). Residents' impressions of concerns like 'environmental satisfaction,' 'relationships,' 'security,' and 'place attachment' make up the idea of social sustainability (Shirazi & Keivani, 2019a). From another perspective, there is a relationship between the physical environment and social sustainability through social interactions, thus whatever opportunities for residents to interact and communicate are supplied by the physical environment, social sustainability will be promoted (Karuppannan & Sivam, 2011).

2.2 Research background

Numerous studies have examined and evaluated the concept of social sustainability concerning urban space, which can be divided into two scales: city (Rashidfarokhi et al., 2018; Opp, 2017; Colantonio & Dixon, 2011; Chan & Lee, 2008) and neighbourhood (Shirazi & Keivani, 2021; Ali et al., 2019; Yoo & Lee, 2016). Most studies have examined either the urban context in line with social sustainability or the formed characteristics of social sustainability such as social participation, social interaction, community sense, and attachment in neighbourhoods. Also in other research, parallel arrays of social sustainability like social capital have been discussed as the main component. Among the most important studies in social sustainability and urban space are the following: Table 1 also lists some of the most important studies in this field.

Shirazi and Keivani (2021) proposed a general framework for measuring the social sustainability of neighbourhoods, based on which they evaluated four neighbourhoods in Berlin and London. Findings show that the most important indicators are 'quality of home,' 'access to facilities,' and then 'safety and security,' with 'participation' and 'interaction networks' being the least important. Stevenson (2021) also examines social sustainability through the concept of a social event in the neighbourhood based on components such as a) participation; b) interactions; c) social capital; d) the sense of place; and e) well-being. The researcher emphasizes examining social events on a local scale to attain social sustainability. Larimian et al. (2020) investigated urban social sustainability in five Dunedin neighbourhoods in New Zealand in another study. According to the findings, physical and individual components affect different dimensions of urban social sustainability. 'Duration of residency' in a neighbourhood has a stronger impact on urban social sustainability among the components evaluated in the individual criterion. In addition, there is a more effective association between dimensions such as participation and interaction and the individual component when compared to the physical component.

According to Santosa et al. (2020), social capital is the most important factor in determining the level of social sustainability. Researchers assessed the impact of social and housing policies on social capital in several Umea neighbourhoods in Sweden. The study's findings suggest that using social capital to plan and design neighbourhoods can help to promote social sustainability and health. Furthermore, in a study, Hamiduddin and Adelfio (2019) assessed the idea of social sustainability in the new neighbourhoods of Rieselfeld Freiburg, Germany, and Polvoranca Madrid, Spain. According to the findings, 'integration' and 'social sense' are fostered in Puloranca, Spain, by socializing open spaces, facilitating social interactions and providing 'local facilities,' and 'organizing activities by the residents' association.' The results also indicate that the studied samples provided adequate local services and facilities to the residents and that in planning, they have appropriately considered 'public transportation' to access other urban areas.

Ali et al. (2019) evaluated the urban form in two neighbourhoods in Irbid, Jordan, to improve social sustainability. Researchers studied and analyzed five components of urban form, including 'land-use distribution,' 'density,' 'building height,' 'housing type,' and 'accessibility,' in two key indicators of 'social justice' and 'community sustainability'. This study confirms that there is an effective relationship between urban form and social sustainability. Researchers identified the indicators of 'accessibility,' 'density,' and 'land-use' concerning the concept of social sustainability in the investigation.

Arundel and Ronald (2015) examined the relationship between urban fabric density and social sustainability in high and medium-density neighbourhoods in Amsterdam, the Netherlands; the study found no significant association between high density and indicators of social sustainability such as 'social capital,' 'sense of community,' and 'residents' satisfaction' in high and medium-density neighbourhoods in Amsterdam, the Netherlands. Other physical factors, on the other hand, such as 'scale,' the presence of 'local stores,' the level of 'automobile dominance,' and the 'construction time,' are more closely linked to the concept of social sustainability.

Karuppannan and Sivam (2011) investigated the impact of Delhi Indian neighbourhood form on social sustainability; the findings show that public and open spaces, as well as residential complexes, 'appropriate access to public areas,' 'mixed land use,' and 'social infrastructure,' are among the most effective indicators for promoting neighbourhood social sustainability. The findings also show a strong link between neighbourhood form and social sustainability and that 'cluster housing' will be a suitable design option for providing 'social interactions' because houses will be closer together.

Ancell and Thompson (2008) also examined the concept of social sustainability in Christchurch social housing in New Zealand. Scholars have examined social sustainability indicators such as housing affordability and quality, transportation, facilities, community communication, and neighbourhood quality. Based on the study sample, the results show that medium-density social

housing does not provide residents with social sustainability.

Iranian researchers have also looked into the concept of social sustainability in the physical environment, as evidenced by Razzaghi Asl et al. (2017), who evaluated social sustainability indicators in regenerating the dilapidated fabric of Tehran's Shiva neighbourhood from the perspective of residents. According to the study's findings , indicators such as 'equality of rights' and 'quality of life' have the biggest impact on the study area's social sustainability, according to residents' judgments. Jomepour and Ebrahimi (2015) examined social sustainability on a complex residential scale, reporting that the study's findings show that 'crime prevention' and 'social justice' have the greatest impact on social sustainability, while 'social participation' and 'environmental quality' have the least impact. Sajjadi Ghaem Maghami et al. (2011) examined the principles of social sustainability in complex residential , citing 'comfort in the house' and 'playability of open and multi-purpose spaces for children' as two of the most important indicators of social sustainability by experts.

Table1
Social sustainability literature review (key studies)

Result	Scale	Year	Title of Article/Thesis/Book	Author/s
Researchers have presented five components in the direction of urban social sustainability, which include the components of 'person', 'place', 'people', 'perception', and 'process'. Scholars have made their assessment based on the mentioned components in two residential areas of Izmir, Turkey. The obtained results indicate that the residents who value 'open spaces' in their neighborhoods are more important to indicators such as 'social relations', 'security' and safety'.	Neighborhood	2022	The Pentagon Model of Urban Social Sustainability: An Assessment of Sociospatial Aspects, Comparing Two Neighborhoods	Akcali & Cahantimur
This research have evaluated social sustainability in two old and new neighborhoods of Tehran, and the results indicate that the new neighborhood has a better situation in terms of social sustainability. In the new neighborhood, indicators such as 'sense of place' have the greatest impact and 'access to services' have reported the least impact on social sustainability.	Neighborhood	2021	Social sustainability between old and new neighborhoods (case study: Tehran neighborhoods)	Farhadikhah & Ziari
Zheng et al. (2020) assessed the 'sustainability perceived by residents' in three different neighborhoods of Chengdu China. The findings show that 'public participation' and 'infrastructure' are among the factors that contribute to the formation of the studied neighborhoods' sustainability.	Neighborhood	2020	Comparison of perceived sustainability among different neighbourhoods in transitional China: The case of Chengdu	Zhang et al.
In this study Larimian & Sadeghi (2019) investigated the relationship between design quality and social sustainability components in the five Dunedin neighborhoods of New Zealand; the results of the evaluation indicate that the quality of the designed environment of the neighborhoods has affected various dimensions of social sustainability and factors such as 'social interaction' as well as 'social participation' have the most relationship and 'social justice' have the least relationship with the quality of design in the studied neighborhoods.	Neighborhood	2019	Measuring urban social sustainability: Scale development and validation	Larimian & Sadeghi
This research examines the impact of the concept of social sustainability on the process of physical planning and tries to introduce the components that are effective in promoting social sustainability. The authors point out that based on the content analysis of the literature review, the six main components of social sustainability, including equality, social capital, social cohesion, social inclusion, social participation, and safety can be used in the planning process.	City	2018	Social sustainability tool for assessing land use planning processes	Rashidfarokhi et al.
Baldwin & king (2018) express the dimensions of social sustainability for the resilience of neighborhoods in 9 components, the most important of which are relationship and social interaction, as well as attachment to the neighborhood.	Neighborhood	2018	Social Sustainability, Climate Resilience and Community-Based Urban Development What About the People?	Baldwin & King

In this study, the meta-analysis method was used to qualitatively explain the dimensions of social sustainability, followed by policies to achieve social sustainability. The researchers point out that the study of the relationship between urban form and social sustainability and the effectiveness of each of them is very much dependent on the context under study and that social sustainability is process-oriented in essence therefore, it should be considered in urban environmental planning and policies.	City	2017	Critical reflections on the theory and practice of social sustainability in the built environment – a meta-analysis	Shirazi & Keivani
In his research, Opp (2017) provided a framework that includes four indicators of the notion of social sustainability for American cities, including a) 'equal access and opportunity.' b) 'environmental justice' c)'society and spatial values,' d) 'basic human needs'.'	City	2017	The forgotten pillar: a definition for the measurement of social sustainability in American cities	Opp
Yoo & Lee (2016) investigated the relationship between the components of social sustainability and social capital in the physical environment of Seoul neighborhoods. The research results confirm the relationship between the mentioned variables and show that the 'perceived quality of the environment' is one of the important factors that affect social sustainability.	Neighborhood	2016	Neighborhood Built Environments Affecting Social Capital and Social Sustainability in Seoul, Korea	Yoo & Lee
Kyttä et al. (2015) examined two areas in the urban context and suburban of Helsinki, Finland; findings indicate that access to services in the urban context has been related to the well-being of residents. The results indicate that environmental quality is significantly associated with well-being and that dense urban neighborhood, perform better in terms of social sustainability.	Neighborhood	2015	Urban happiness: a context-sensitive study of the social sustainability of urban settings	Kyttä et al.
In this study, 'urban interventions' in the important neighborhoods of Lisbon Portugal, and Oslo Norway are examined based on two components of social sustainability: a) social capital and b) participation and governance. The findings show that resident participation in the decision-making of physical interventions is recognized as an effective factor in Lisbon. Also, the decision-making of local institutions in Oslo neighborhoods by improving 'housing conditions', 'public services', and 'educational and cultural activities' are aimed at achieving social sustainability.	Neighborhood	2012	A question of social sustainability: Urban interventions in critical neighbourhoods in Portugal and Norway	Søholt et al.
This study investigated the relationship between urban form and social sustainability, which introduces the components of 'equaled access' and 'community sustainability' based on its explanatory indicators to achieve social sustainability at the neighborhood level.	Neighborhood	2011	The Social Dimension of Sustainable Development: Defining Urban Social Sustainability	Dempsey et al.
Colantonio & Dixon (2011) have divided the components of social sustainability into two general categories according to theories and field literature: 'traditional' and 'new emerging'; in the new emerging category components such as a) demographic change b) social mixing and cohesion; c) identity and sense of place; d) participation and access to health and safety; e) social capital; f) well-being, happiness, and quality of life have been mentioned.	City	2011	Urban Regeneration & Social Sustainability Best practice from European cities	Colantonio & Dixon
Dave (2011) examined the relationship between urban form and social sustainability in 11 Mumbai neighborhoods. The findings show that 'population density' has no detrimental impact on social sustainability' and that 'the urban shape' of the investigated neighborhoods is a key component in achieving social sustainability. findings indicate that 'physical density' and 'perceived density' have a negative effect on the 'satisfaction' of neighborhood residents. In addition, social criteria such as 'family income,' social statute,' and physical factors such as 'building shape,' and 'mixed land use,' are deemed to be effective in achieving social sustainability in the researched neighborhoods.	Neighborhood	2011	Neighbourhood Density and Social Sustainability in Cities of Developing Countries	Dave

Bermley et al. (2009) investigated social sustainability and urban form in five UK cities' neighborhoods. Researchers have studied two indicators including social equality and community sustainability. The results show that in high-density places 'satisfaction' and residential 'safety,' have lower rates. In medium-density places 'interaction' and 'social participation,' and in low-density, 'pride and attachment', 'stability' and 'safety' have a significant share among the indicators of social sustainability in neighborhoods.	Neighborhood	2009	Social sustainability and urban form: evidence from five British cities	Bramley et al.
The effective factors of social sustainability in Hong Kong city renovation projects were evaluated from the perspectives of citizens and professionals in this study; the results show that 'access to open spaces' is one of the most important criteria reported in the sustainability assessment.	City	2008	Critical factors for improving social sustainability of urban renewal projects	Chan & Lee

According to the literature review, few studies have evaluated the components and indicators of social sustainability from the perspective of experts, especially since the studies mentioned have focused on the scale of the neighbourhood and have only considered residential complexes as an indicator alongside other features. The current study will look at the components and indicators of social sustainability to develop appropriate policies and methods for planning and designing contemporary residential complexes, based on expert prioritization.

2.3 Components and indicators

A conceptual model based on studies has been presented (Figure 1) to explain the components and indicators of social sustainability in residential complexes. This conceptual model examines social sustainability on a micro-scale (residential complexes) according to the context conditions and a) physical and b) social sustainability indicators. In physical indicators, housing characteristics, public spaces, mixed land use, and local facilities and services have all been identified as key contributors in the formation of social sustainability indicators. In addition, social interactions and participation among residents, justice and equity in society, security, safety, and ultimately place attachment and a sense of place are among the criteria that affect social sustainability. Social sustainability indicators with the physical environment (expressed indicators) can provide the possibility of achieving the physical and social sustainability of residential complexes. This conceptual model considers social sustainability as a process-oriented issue in which the balance of environmental indicators plays a key and fundamental role.

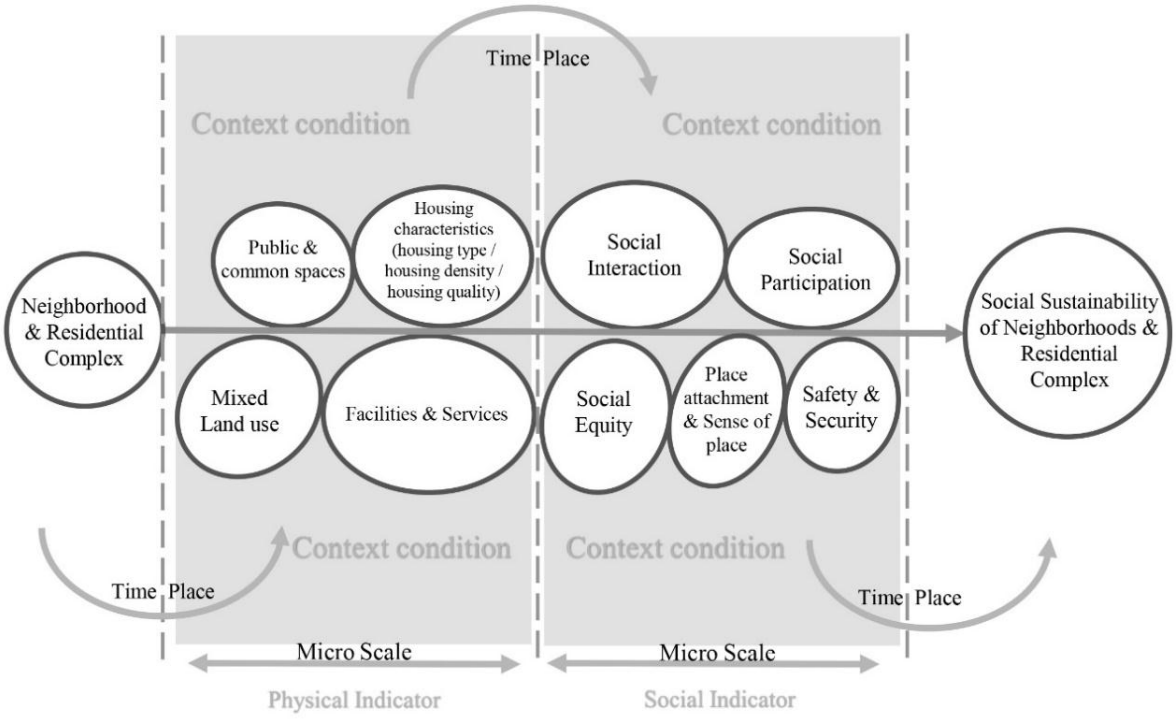

Fig 1. Conceptual model of social sustainability of residential complexes

The following physical characteristics of residential complexes are characterized in the current study, based on the literature review, to evaluate the concept of social sustainability in residential complexes using an expert

method: a) housing characteristics that include sub-indicators such as housing type, density, and quality of housing; b) mixed land use; c) access to open spaces and public spaces, d) facilities and services that are available to residents of residential complexes on a neighbourhood level. The degree of interaction of the indicators mentioned above with social sustainability indicators such as a) security and safety; b) place attachment and sense of place; c) social interactions; d) social participation; and e) equity and social justice will be measured from an expert's perspective. Table (2) lists the studies that were used to explain the indicators of social sustainability of residential complexes.

Table 2
Components and indicators of social sustainability based on literature review

Component	Indicators	Researcher/s
Physical (P)	Housing characteristics (housing type / housing density / housing quality) / (P1, P2, P3)	Arundel & Ronald, 2015; Ancell & Thompson, 2008; Shirazi & Keivani, 2019b; Ali et al., 2019; Shirazi & Keivani, 2021.
	Access to open spaces & public spaces (P4)	Hamiduddin & Adelfio, 2019; Chan & Lee, 2008; Opp, 2017; Dave, 2011; Ali et al., 2019; Karuppannan & Sivam, 2011; Yoo & Lee, 2016; Rashidfarokhi et al., 2018; Akcali & Cahantimur., 2022.
	Access to facilities and services (P5)	Kyttä et al., 2015; Hamiduddin & Adelfio, 2019; Dempsey et al., 2011; Yoo & Lee, 2016; Zhang et al., 2020; Shirazi & Keivani, 2019b; Shirazi & Keivani, 2021; Chan & Lee, 2008; Dave, 2011; Ali et al., 2019; Farhadikhah & Ziari., 2021; Akcali & Cahantimur., 2022.
	Mixed land use (P6)	Karuppannan & Sivam, 2011; Yoo & Lee, 2016; Shirazi & Keivani, 2019b; Shirazi & Keivani, 2021; Larimian et al., 2020; Akcali & Cahantimur., 2022.
Social (S)	Security & Safety (S1)	Karuppannan & Sivam, 2011; Larimian et al., 2020; Shirazi & Keivani, 2017; Shirazi & Keivani, 2019b; Larimian & Sadeghi, 2019; Ali et al., 2019; Opp, 2017; Dave, 2011; Chan & Lee, 2008; Rashidfarokhi et al., 2018; Hamiduddin & Adelfio, 2019; Shirazi & Keivani, 2021; Yoo & Lee, 2016; Dempsey et al., 2011; Bramley et al., 2009; Baldwin & King, 201; Fatourehchi & Zarghami., 2020; Farhadikhah & Ziari., 2021; Akcali & Cahantimur., 2022.
	Place attachment & Sense of place (S2)	Karuppannan & Sivam, 2011; Larimian et al., 2020; Shirazi & Keivani, 2017; Shirazi & Keivani, 2019b; Larimian & Sadeghi, 2019; Ali et al., 2019; Shirazi & Keivani, 2021; Stevenson, 2021; Colantonio & Dixon, 2011; Hamiduddin & Adelfio, 2019; Dempsey et al., 2011; Baldwin & King, 2018; Arundel & Ronald, 2015; Bramley et al., 2009; Farhadikhah & Ziari., 2021; Akcali & Cahantimur., 2022.
	Social interaction (S3)	Karuppannan & Sivam, 2011; Larimian et al., 2020; Shirazi & Keivani, 2017; Shirazi & Keivani, 2019b; Larimian & Sadeghi, 2019; Ali et al., 2019; Shirazi & Keivani, 2021; Zhang et al., 2020; Stevenson, 2021; Hamiduddin & Adelfio, 2019; Baldwin & King, 2018; Arundel & Ronald, 2015; Bramley et al., 2009; Rashidfarokhi et al., 2018; Fatourehchi & Zarghami., 2020; Akcali & Cahantimur., 2022.
	Social participation (S4)	Larimian et al., 2020; Shirazi & Keivani, 2017; Shirazi & Keivani, 2019b; Larimian & Sadeghi, 2019; Rashidfarokhi et al., 2018; Shirazi & Keivani, 2021; Yoo & Lee, 2016; Stevenson, 2021; Dempsey et al., 2011; Colantonio & Dixon, 2011; Hamiduddin & Adelfio, 2019; Baldwin & King, 2018; Bramley et al., 2009; Søholt et al, 2012; Fatourehchi & Zarghami., 2020; Farhadikhah & Ziari., 2021; Akcali & Cahantimur., 2022.
	Equity & Social justice (S5)	Larimian et al., 2020; Larimian & Sadeghi, 2019; Dempsey et al., 2011; Colantonio & Dixon, 2011; Opp, 2017; Shirazi & Keivani, 2017; Shirazi & Keivani, 2019b; Rashidfarokhi et al., 2018.

3. Research Method

The current study's strategy is correlational in terms of quantitative methodology and descriptive-analytical approach. The study is divided into four sections: The first stage provides a conceptual framework, components, and indicators of social sustainability using information sources. the second stage evaluates components of social

sustainability from the perspective of selected experts (closed comparative-type questions) in the field of architecture and urban planning using the items collected in the first stage. The third stage analyses based on expert evaluations using multiple criterion decision-making methods; finally, practical policies and strategies for planning and designing residential complexes to improve the physical environment will be discussed.

Few studies have evaluated the components and indicators of social sustainability in residential complexes from the experts' point of view in the field of architecture and urban planning, as mentioned in the review of the research background. The reason for selecting experts for evaluation is that their complete mastery of different and complex dimensions and criteria of social sustainability can provide a suitable basis for adopting planning and design strategies. To gather data for this study, a questionnaire based on social sustainability indicators was developed, which comprised an 11 * 11 matrix. questionnaire was then sent to 39 selected professors in the field of architecture and urban planning, 33 of whom responded to questionnaire. It should be noted that two necessary preconditions for evaluation were observed when selecting specialists: the first is that the field of study and professionalism of the specialists chosenwere considered according to the subject of the research. the second point was that the experts were chosen based on their knowledge and lived experience of Shiraz. For three weeks, experts were given questionnaires and asked to rate the impact of each of the social sustainability indicators on each other, which are divided into two categories: physical and social. Respondents were asked to rate the influence of each row's indicator on each column on a scale of 0 to 4, with 0 indicating no effect and 4 indicating very effective. Assistant professors made up 46% of the respondents and professors made up 3% (Figure 2), with 42 percent being men and 58 percent being women. In addition, the highest age rate of experts' in this research with 46% is between the age range of 30-39 and the lowest age rate with 3% is in the range of 50-59 (Figure 3).

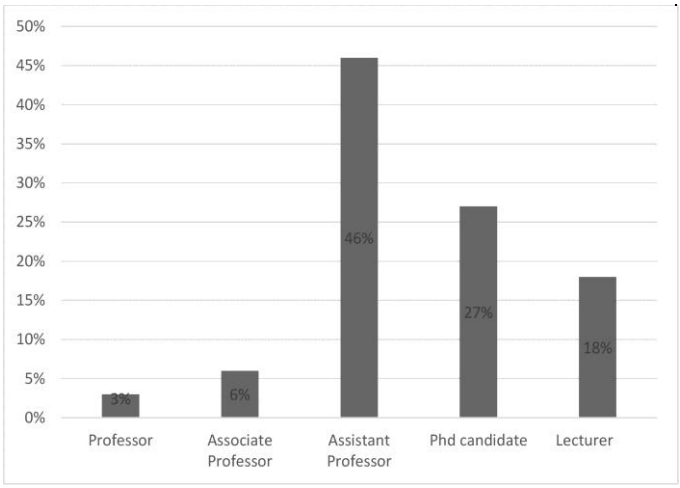

Fig 2. The rate of experts' participation according to academic rank

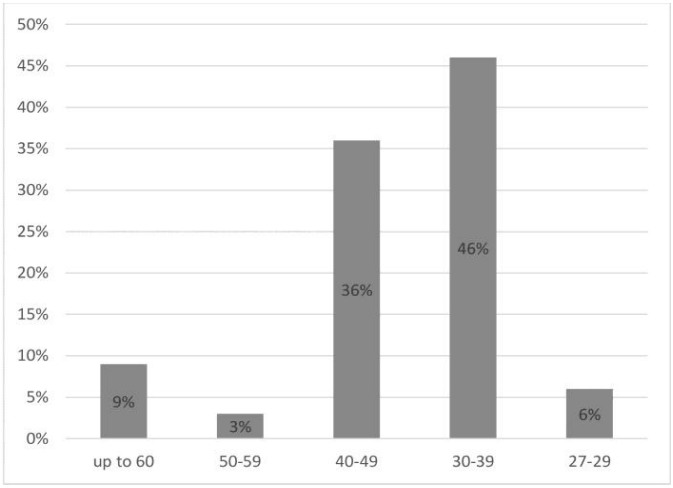

Fig 3. The rate of experts' age

As stated, considering that the identified indicators of social sustainability have complex dimensions. To evaluate the impact and importance of each indicator , the DANP technique, which is a suitable tool to solve this issue, has been raised. This technique is more accurate in the evaluation based on reality (Hsu et al., 2013 & Chiu et al., 2013) and can create a more appropriate understanding of the provided data (Yen & Tsao., 2020).

The DANP technique is a combination of the Dematel technique and Analytic Network Process. In Dematel, the relationships between indicators and the intensity of each effect are examined and obtained through the process of network analysis of weight and ranking of components and indicators; in Network Analysis Process, the relationships between indicators and the intensity of each effect are examined and obtained through the process of network analysis of weight and ranking of components and indicators (Hsu et al., 2020). The technique (DANP) is one of the techniques for determining cause-and-effect relationships between components and indicators, and the weights of each indicator and component may be determined using this technique (Chiu et al., 2013).

3.1 Data analysis

Data from experts was analyzed in seven key steps by technique (DANP); it should be emphasized that all seven processes are based on the formulas provided in Hsu et al. (2020) study's. Before beginning the data analysis process, all the experts' questionnaires were imported into Excel software, and a direct relation matrix was generated using the arithmetic mean. In addition, the incompatibility rate was estimated from the outset to assess the data's reliability. The direct relation matrix's incompatibility rate was calculated (0.0082). The number specified to confirm questionnaire's reliability should be less than (0.005); hence, questionnaire's reliability has been approved.

- **Step 1:** The relation matrix is normalized in this step; the sum of the rows and columns is

calculated and divided by the largest number (30.3939) to normalize the direct relation matrix (Table 3).

Table 3
Normalized direct relation matrix

N	P1	P2	P3	P4	P5	P6	S1	S2	S3	S4	S5
P1	0/0000	0/0997	0/0947	0/0897	0/0668	0/0738	0/0927	0/1027	0/0907	0/0768	0/0768
P2	0/0967	0/0000	0/1067	0/1027	0/0818	0/0847	0/1027	0/0748	0/0977	0/0867	0/0818
P3	0/0718	0/0808	0/0000	0/0778	0/0698	0/0578	0/0967	0/1107	0/0738	0/0668	0/0818
P4	0/0828	0/0877	0/0957	0/0000	0/0828	0/0718	0/0957	0/1007	0/1196	0/1067	0/0917
P5	0/0489	0/0728	0/0818	0/0788	0/0000	0/1027	0/0907	0/0907	0/0987	0/0917	0/1067
P6	0/0668	0/0768	0/0798	0/0728	0/1047	0/0000	0/0937	0/0798	0/0957	0/0897	0/0867
S1	0/0748	0/0907	0/0987	0/0808	0/0758	0/0688	0/0000	0/1077	0/1087	0/1017	0/0927
S2	0/0818	0/0708	0/0997	0/0768	0/0688	0/0628	0/1007	0/0000	0/1037	0/1137	0/0808
S3	0/0728	0/0798	0/0678	0/0957	0/0847	0/0828	0/1107	0/1127	0/0000	0/1216	0/0957
S4	0/0668	0/0718	0/0678	0/0887	0/0738	0/0768	0/1017	0/1137	0/1186	0/0000	0/0997
S5	0/0877	0/0828	0/0847	0/0917	0/1037	0/0758	0/1027	0/0897	0/0927	0/1007	0/0000

- **Step 2:** The second stage involved creating a singular matrix and subtracting it from the normalized direct connection matrix; the resulting matrix was then inverted and multiplied by the original matrix to obtain the total relation matrix of the indices (Table 4).
- **Step 3:** The complete relationship between the physical component and social sustainability, as well as the intensity and direction of their impact, is discussed in this step; at this stage, the total relation matrix of the indicators obtained in the previous step is employed. The total relation matrix of the components was created by averaging each of the numbers placed at the intersection of the physical component and social stability, and then putting these numbers together (Table 5). It has also been done so that a set of columns (abbreviated C) and matrix rows (abbreviated R) have been calculated to calculate the direction and intensity of the effect. It should be noted that to calculate the direction of the effect (R-C) and its intensity (R + C), the following information should be considered: If the number (R-C) is negative, the component is impressible; if the number obtained is positive, the component is effective (Table 6). The physical component, based on the expert's view, was effective. the component of social sustainability was impressible, according to the acquired numbers. We obtained a threshold (average of the numbers of the total relationship matrix of the components) of (0.6394) in this stage to determine the cause-and-effect relationships between the components, and numbers that exceed this threshold indicate the relationship between the components (Fig 4).

Table 4
Total relation matrix of indicators

	P1	P2	P3	P4	P5	P6	S1	S2	S3	S4	S5
P1	0/4247	0/6030	0/6368	0/6212	0/5750	0/5478	0/7019	0/7091	0/7073	0/6742	0/6338
P2	0/5388	0/5419	0/6778	0/6630	0/6175	0/5850	0/7454	0/7214	0/7488	0/7167	0/6708
P3	0/4551	0/5440	0/5045	0/5658	0/5347	0/4941	0/6537	0/6645	0/6411	0/6159	0/5913
P4	0/5338	0/6319	0/6787	0/5805	0/6283	0/5835	0/7522	0/7556	0/7799	0/7465	0/6906
P5	0/4721	0/5795	0/6245	0/6117	0/5141	0/5735	0/7006	0/6990	0/7145	0/6879	0/6604
P6	0/4800	0/5740	0/6132	0/5971	0/5993	0/4720	0/6919	0/6790	0/7008	0/6749	0/6336
S1	0/5100	0/6144	0/6602	0/6343	0/6024	0/5621	0/6409	0/7373	0/7463	0/7188	0/6693
S2	0/5076	0/5797	0/6413	0/6117	0/5779	0/5398	0/7105	0/6189	0/7202	0/7070	0/6394
S3	0/5195	0/6191	0/6491	0/6614	0/6245	0/5875	0/7575	0/7582	0/6665	0/7527	0/6878
S4	0/4943	0/5883	0/6232	0/6303	0/5914	0/5597	0/7213	0/7302	0/7431	0/6160	0/6645
S5	0/5279	0/6155	0/6565	0/6512	0/6339	0/5759	0/7427	0/7311	0/7425	0/7264	0/5932

Table 5
Total relation matrix of components

TD	P	S
P	0/5689	0/6921
S	0/5950	0/7017

Table 6
Matrix of intensity and direction of components

TD	R	C	R+C	R-C
P	1.2610	1.1639	2.4248	0.0971
S	1.2967	1.3938	2.6905	-0.0971

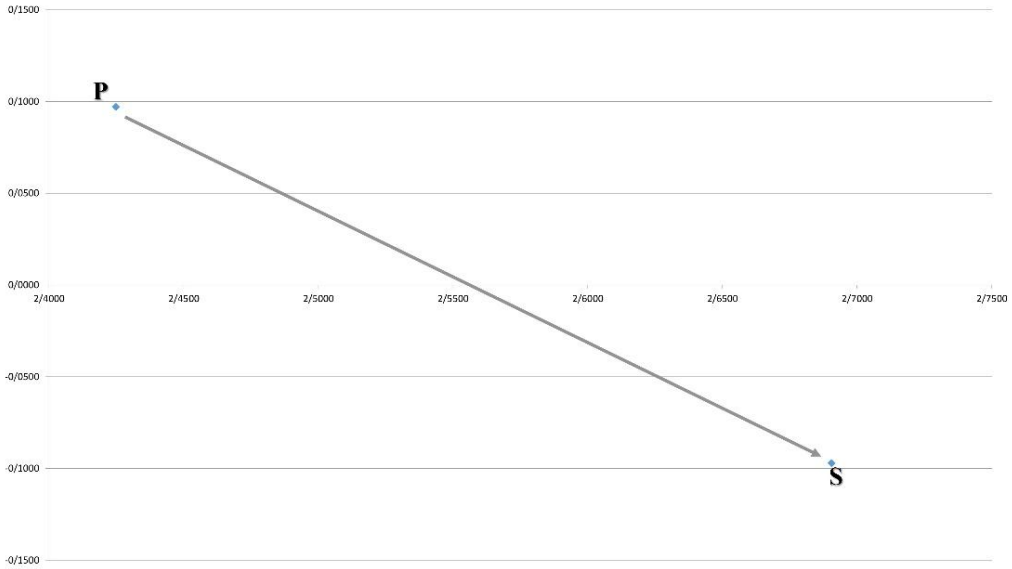

Fig 4. Cause-and-effect relationships of components

- **Step 4:** We acted as the third step in this step to show the direction of the effect of each of the indicators (Table 7) and also to determine the cause-and-effect relationship between each of the indicators (Fig 5 and 6); it is worth noting that the physical component (0.5689) and the social sustainability component (0.5689) were the thresholds (0.7017). According to the analysis shown in Fig 3 and 4, access to open spaces and public space, as well as access to facilities and services, are the most impressible indicators in the physical component, and housing density is the most effective indicator; however, among the indicators of social sustainability, social interactions are the most effective and social participation, security and safety is the most impressible.

Table 7
Matrix of intensity and direction of indicators

TD	R	C	R+C	R-C	Essence of indicator
P1	3/4087	2/9045	6/3132	0/5042	Effective
P2	3/6240	3/4742	7/0982	0/1497	Effective
P3	3/0983	3/7356	6/8339	-0/6373	Impressible
P4	3/6368	3/6394	7/2762	-0/0026	Impressible

P5	3/3753	3/4690	6/8443	-0/0937	Impressible
P6	3/3356	3/2560	6/5916	0/0797	Effective
S1	3/5126	3/5729	7/0855	-0/0604	Impressible
S2	3/3960	3/5756	6/9716	-0/1796	Impressible
S3	3/6227	3/6185	7/2412	0/0041	Effective
S4	3/4751	3/5208	6/9959	-0/0458	Impressible
S5	3/5359	3/2543	6/7902	0/2816	Effective

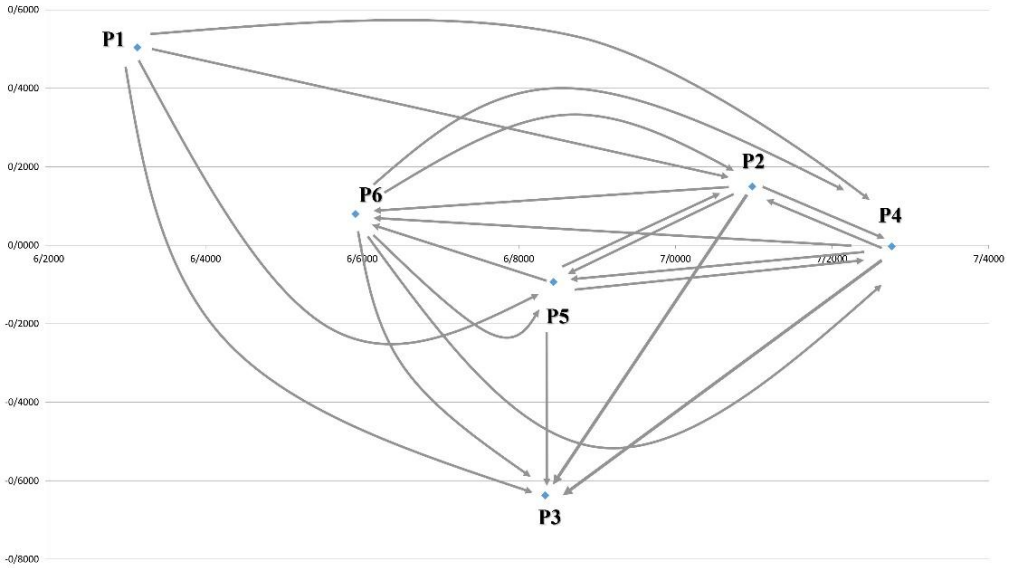

Fig. 5. Cause-and-effect relationships of physical indicators

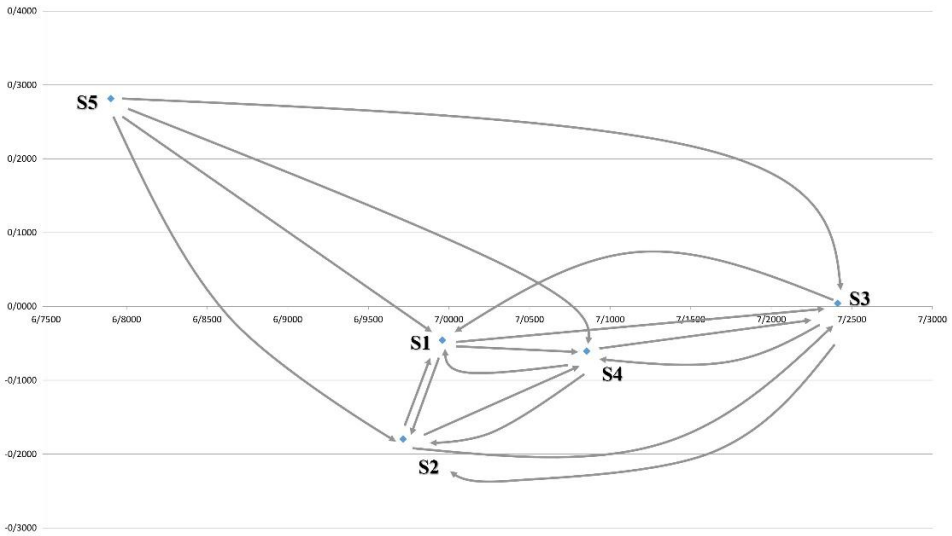

Fig. 6. Cause-and-effect relationships of social sustainability indicators

- **Step 5:** To prioritize the components, we first normalized the indicators, which means dividing each value by the sum of its rows in the total relationship matrix of the

components, then transposing the newly created matrix and calculating the average of the rows to determine the component's rank. According to the above, the social sustainability component (0.5450) is the most important, followed by the physical sustainability component (0.4550).

- **Step 6:** In this step, the indicators are completely normalized; we considered the numbers in each component separately, added the row numbers in each component separately, and then divided the result by the numbers in the same line; the resulting matrix was the normalized total relation matrix of the indicators, then we transposed the normalized total relation matrix of the indicators as in the fifth step, yielding an unweighted supermatrix.
- **Step 7:** To normalize, we multiplied the unweighted supermatrix by itself in multiple steps until all the rows had the same number, or until the convergent matrix is obtained; the weight and rank of each of the indicators were obtained as a result of this step (Table 8). According to the experts, the social interaction indicator (0/11244) is the most important, followed by security and safety (0/11111), place attachment and sense of place (0/11094), and participation (0/10867). Other indicators, such as mixed land use (0.07223) and housing type (0.06507), are also included in the latest ranking of experts for the social sustainability of contemporary residential complexes.

Table 8
Convergent matrix

W	P1	P2	P3	P4	P5	P6	S1	S2	S3	S4	S5
P1	0/06507	0/06507	0/06507	0/06507	0/06507	0/06507	0/06507	0/06507	0/06507	0/06507	0/06507
P2	0/07713	0/07713	0/07713	0/07713	0/07713	0/07713	0/07713	0/07713	0/07713	0/07713	0/07713
P3	0/08257	0/08257	0/08257	0/08257	0/08257	0/08257	0/08257	0/08257	0/08257	0/08257	0/08257
P4	0/08115	0/08115	0/08115	0/08115	0/08115	0/08115	0/08115	0/08115	0/08115	0/08115	0/08115
P5	0/07719	0/07719	0/07719	0/07719	0/07719	0/07719	0/07719	0/07719	0/07719	0/07719	0/07719
P6	0/07223	0/07223	0/07223	0/07223	0/07223	0/07223	0/07223	0/07223	0/07223	0/07223	0/07223
S1	0/11111	0/11111	0/11111	0/11111	0/11111	0/11111	0/11111	0/11111	0/11111	0/11111	0/11111
S2	0/11094	0/11094	0/11094	0/11094	0/11094	0/11094	0/11094	0/11094	0/11094	0/11094	0/11094
S3	0/11244	0/11244	0/11244	0/11244	0/11244	0/11244	0/11244	0/11244	0/11244	0/11244	0/11244
S4	0/10867	0/10867	0/10867	0/10867	0/10867	0/10867	0/10867	0/10867	0/10867	0/10867	0/10867
S5	0/10149	0/10149	0/10149	0/10149	0/10149	0/10149	0/10149	0/10149	0/10149	0/10149	0/10149

4. Result & Discussions

Experts have assessed physical indicators as a dimension affecting the component of social sustainability, as mentioned in the data analysis; this viewpoint considers physical criteria as a platform and a prelude to strengthening the component of social sustainability and, ultimately, its promotion in contemporary Shiraz residential complexes. Experts in component prioritization have identified the component of social sustainability as a top priority for promoting social sustainability. Some factors and indicators discussed in this section, such as equity and social justice, are affected by social decisions in other areas, such as economic, cultural, and institutional ones. This is reflected in social sustainability, particularly at micro-scales such as communities and housing complexes. The degree of participation and social interaction in residential complexes is affected by various factors, including physical conditions and broader social contexts.

From the perspective of experts, social interactions are the most effective indicator among the indicators of social sustainability. In theory, creating places for people to interact will lead to the connection and strengthening of other indicators of social sustainability, such as social participation, safety, and security, which can be referred to as the most effective indicators in this field. However, experts consider housing density to be an effective indicator in the physical component, as it affects other physical aspects that underpin social sustainability in residential complexes. However, in a comparison between the results obtained in this research and recent articles, we can mention two studies that were based on the experts' point of view. Fatourehchi and Zarghami (2020), point out, that the indicators such as 'safety' is the most important. the 'site and equipment considerations' as the least important factor in the social sustainability of residential buildings in Iran from the experts' point of view. In another research, Allaei et al. (2020) evaluated the components affecting housing's social sustainability in accordance with expert opinions, with results indicating that 'physical desirability', as well as 'social and cultural life,' has the greatest impact on increasing the level of social sustainability, according to experts. To achieve social sustainability, the index of 'security', and 'participation and social interactions' in the component of 'social and cultural life', are deemed more significant than other characteristics.

According to data analysis, effective indicators are related to other indicators. They can be used as a complementary factor to improve the physical quality and social sustainability of residential complexes through the use of design techniques. Strategies for planning and design can be presented in two dimensions based on the ranking that experts have made of the components and indicators of social sustainability to improve the physical quality of residential complexes in Shiraz: a) social; b) physical.

A) Social dimension

People's presence in residential complexes can be increased by providing public and semi-private spaces; it appears that defining motion sequences and circulations in the complex, which integrates and connects with collective spaces, can help to strengthen this group of spaces and residents' socialization.

Providing a favorable environment in the formation of which residents' participation is considered, both during the design phase and after residents' occupancy, has increased the individual's relationship with the physical environment. As a result, one can expect a sense of attachment to the place in which it has intervened and participated.

B) Physical dimension

On the other hand, strengthening the soft edges as well as the visibility of collective spaces in residential complexes, in addition to being able to establish a visual connection between the residential complexes and the surrounding environment, provides the complexes with security. In addition to increasing the desirability of space among residents, strengthening open public spaces in residential complexes, such as using children's playgrounds, neighborhood spaces, and green roofs, which allow residents to socialize in daily interactions and provide social and cultural events together, will also ensure residents' mental and physical health.

The proper location of residential complexes in the neighborhood can be considered a planning strategy that, in addition to providing adequate access to local facilities and services such as neighborhood parks, religious centers, and shops (paying attention to the dimension of equity), also leads to social interactions on a scale that extends beyond residential complexes.

Planning and adjusting the spatial structure of residential complexes according to residents' lifestyles, i.e., the proper connection of public, semi-private, and private spaces, can lead to increased communication between people and the physical environment around them, as well as proper communication with neighbors.

In addition to guaranteeing individual safety in residential complexes, considering the quality of housing construction (including the quality of structural elements) can also extend inhabitants' optimal operating time.

Establishing and implementing barrier-free spaces in residential complex design strategies can boost the presence of physically challenged and older people in the complex while also ensuring that all residents have equal access to all the complex's spaces.

5. Conclusion

The social sustainability of a place, particularly the social conditions of people in residential environments, can impact its long-term sustainability. The current study, like several others, argues that the physical environment's quality is important in promoting the concept of social sustainability (Shirazi & keivani, 2019b; Ali et al., 2019; Larimian & Sadeghi, 2019). Based on previous studies, this study presents a two-dimensional model that includes a) a physical component and b) a social sustainability component. Social sustainability is viewed as a process-oriented issue that requires a degree of balance between the indicators that shape social sustainability. The physical component has been defined in this model as a contextual criterion for forming social sustainability and promoting it in residential complexes. According to the research findings and as evidenced by experts, the physical component has been highlighted as an effective dimension that affects the component of social stability, which supports the suggested model.

To determine the role of social sustainability in improving the physical quality of residential complexes social indicators such as a) social interaction; b) security and safety; c) place attachment and sense of place; and d) Social participation has been prioritized in this study from the perspective of experts. One of the reasons for such professional assessments is that the indicators mentioned above, which are all social indicators, can play a bigger role in the place's long-term sustainability than the physical components. Each of the examined indicators appears to have a complementary effect on the context conditions.

Other components, such as institutional, economic, and cultural components that covertly affect the concept of social sustainability and the physical quality of residential complexes, can certainly be considered to improve the physical quality of the complexes, according to the concept of social sustainability. The lack of attention to the impact of institutional, economic, and cultural components was one of the research's limitations, which may be explained by the expansion of research criteria as well as diverse assessments and analyses based on the field of specialists.

It is suggested that in future studies, more variables be added to the model presented in the theoretical literature of the research and analyses be conducted using it. It should be noted that different studies might be conducted to acquire practical results by focusing on two topics. To begin, social sustainability approach can be tested on current residential projects, i.e., after the complexes have been occupied; to what extent have the investigated projects been effective in achieving social sustainability due to their physical dimensions? The indicators used in this study, on the other hand, can be employed in contemporary residential projects in two different geographical contexts through deductive and comparative researches. Despite Even though several studies have looked at the relationship between social sustainability and the physical environment, there is still a need to assess and investigate the cause-and-effect relationships between these two issues. These investigations must take into account both time and spatial factors.

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