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Analyzing the Interactions among Barriers to the Use of Solar Energy for Heating in Residential Buildings in Van, Türkiye

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Abstract: In terms of environmental sustainability, the barriers—and interactions between these barriers—to the use of solar energy for active and passive heating in residential buildings stem from location-specific housing production patterns and the actors involved in these patterns. A clear definition of hierarchies and priorities between barriers helps managers set strategic priorities and action plans to find solutions. After the earthquake in Van in 2011, 6000 hectares of land were opened for new development, and research using the sampling method discovered that the most common type of housing production in the city is the build-to-sell housing production method. The actors involved in build-to-sell housing production are technical staff, local–central administrations, entrepreneurs, end users, landowners, financial companies, non-governmental organizations, and building inspection institutions. This article examines the barriers to the use of solar energy for active and passive heating purposes, the interactions between these barriers using ISM and MICMAC methods, and the build-to-sell housing production method and actors. Barriers were identified through a literature review and semi-structured interviews. The barriers were further categorized under eight main headings according to their subject matter. The hierarchies of barriers in creating problems and solutions were determined using ISM and MICMAC methods and the findings were interpreted. In the City of Van, with regard to the houses produced via the build-to-sell production method, the barriers against the use of solar energy for heating purposes in houses considering active and passive methods are ranked in order of priority in creating the problem and the solution. Barriers caused by political and administrative issues are ranked first; barriers caused by social awareness and end users are ranked second; barriers caused by social and sociological events are ranked third; barriers caused by laws and regulations are ranked fourth; barriers caused by the knowledge, skills, and awareness of designers are ranked fifth; barriers caused by deficiencies in technical issues are ranked sixth; and barriers caused by economic and financial issues are ranked seventh. Even though the barrier caused by the working mode of build-to-sell productions is the largest in creating the problem, it is the least effective barrier to solving the problem in the ISM hierarchical and MICMAC schemes. The research process is presented in the Methods section.

Keywords: solar energy; active and passive solar heating; barriers; interpretive structural modeling (ISM); Cross-Impact Matrix Multiplication Applied to Classification (MICMAC); mode of housing production

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1. Introduction

In Türkiye, the primary energy source used for heating dwellings is still fossil fuels with 34.9% being natural gas and 28.6% being coal (200 kWh/m^2 per year) [1,2]. Since the use of solar energy in the heating of houses via active and passive methods reduces fossil fuel consumption and greenhouse gas emissions, the use of solar energy in heating newly produced houses with active and passive design methods is an important goal in the field of architecture [3–5].

Since the world energy crisis in the 1970s, the importance of using renewable energy sources has been recognized, and publications on the use of solar energy have been produced worldwide and in Türkiye [5–15].

Although Türkiye has a high solar energy potential and there is information about the use of solar energy in the literature, its use in houses via active and passive methods is not widespread [1] (p. 2), and there are few examples. Two examples include Durusu Park Houses [16,17] (p. 89) (Figure 1), built of timber, where renewable solar energy is used via the passive solar heating, and Datça Summer Wind Houses [18] (Figure 2), built of timber (passive cooling), where wind is used for cooling, which received the 2018 Passive Cooling Systems for Sustainable Architecture/Sign of the City Award. Therefore, the scarcity of and reasons for the use of solar energy for heating houses in Türkiye and the barriers to its use constitute the problem addressed in this study.



Figure 1. Durusu Park Smart Houses, İstanbul, Türkiye (passive solar heating) [16].



Figure 2. Datça Summer Wind Houses: 2018 Sign of the City Award (passive cooling), Datça, Türkiye [18].

In the context of sustainability, the issues that generally come to the fore in the publications examined include the following: the use and adoption of renewable energy sources; the use of the sun in heating houses with active and passive design methods, low-energy buildings, energy-efficient buildings, and zero-energy buildings; and barriers to the use of energy-efficient technologies. These issues can be grouped under three headings:

- Investigation of the barriers to energy-efficient construction through housing production forms;
- Finding and analyzing the barriers to energy-efficient construction using local data;
- The choice and importance of the methodology used to analyze the relationships between barriers to energy-efficient construction [19–30].

Barriers to energy-efficient construction should be investigated through different local forms of housing production. Accordingly, different problems are encountered in different forms of housing production [23,26,31].

The most important reason for conducting the study locally in the City of Van is that the barriers to energy-efficient construction in the context of sustainability and the use of solar energy in the heating of houses via active and passive methods have location-specific physical, social, and economic reasons [19,20,29,32,33].

In addition to the literature review, common to all studies, the identification and analysis of barriers in different countries and regions was conducted using three different methods: semi-structured interviews [21,23,26], surveys [19,20,29], and the interpretive structural model [24,25,27].

In a study conducted on construction companies in Switzerland using semi-structured interviews, the most important barrier to the building of energy-efficient buildings was shown to be a lack of demonstration that low-energy buildings are feasible [23]. The same method was used to investigate the barriers to the construction of sustainable buildings in Finland, and it was found that the most important barriers were a lack of affordability of sustainable technologies, a lack of awareness and demand among end users, technological deficiencies, and deficiencies in building regulations [21].

In studies carried out using the survey method, which investigated the barriers to implementing energy-efficient technologies in residential buildings in eight countries in the European Union, the barriers differing from country to country and the importance of local action were emphasized. The most effective barrier among EU countries was economic arguments, and the least effective barrier was the lack of a legal framework [19]. In a survey conducted in 14 European countries, the barriers to integrating thermal collectors and photovoltaic panels in buildings were investigated. The barriers differed between countries, and the most important barriers were those caused by economic issues [20].

The barriers to constructing zero-energy buildings in Türkiye were investigated through a literature review of the barriers faced by Mediterranean countries. The review found that there is a lack of a climate-specific approach, knowledge, and experience in constructing zero-energy buildings, along with financial barriers, legal barriers, etc. [30].

In a study of barriers to the use of energy-efficient measures in buildings in Türkiye, which was carried out using the survey method, it was emphasized that the study did not reflect the generality of the country. The most effective barrier was the reluctance of contractors to use designs and technologies that reduce energy consumption in buildings. The second most effective barrier was the difficulties in implementing energy-efficient measures and the lack of importance given to energy-efficient technologies and applications by managers. The weakest barrier was the reluctance of construction workers and civil engineers toward energy-efficient construction [29].

Studies using the interpretive structural modeling method have shown that the main barrier to implementing energy-saving policies in buildings in China is a lack of awareness about energy savings [24]. Another study conducted in China using the same method investigated the barriers that cause the difference between the designed building and the measured building energy performance. A lack of an effective inspection system and time cost were the most effective barriers [25].

In a study conducted in India using the ISM method, the barriers to adopting solar energy in energy production were investigated nationwide. The strongest barrier was the perceived functional benefits. The second-strongest barrier was the perceived ease of use, and the weakest barrier was user experience and familiarity [27].

Sakınç et al. [12] emphasized that the lack of development of solar energy-efficient systems as a design element is a barrier to energy-efficient construction, the application of energy-efficient systems should become widespread shortly, and buildings are expected to become areas of energy production rather than energy consumption [12]. The failure to achieve the expectations of energy-efficient construction predicted by Sakınç et al. [12]. shows the need to investigate the barriers to the use of solar energy for heating purposes in housing with active and passive methods.

Within the scope of this article, the barriers to energy-efficient construction and the use of solar energy for heating in residential buildings in Türkiye have been investigated by reviewing the studies conducted under the title of energy-efficient construction. As a result of the research, a study investigated the barriers to the construction of zero-energy buildings in Türkiye through a literature review on the barriers faced by the countries

around the Mediterranean, and a total of two publications investigating the barriers to the use of energy-efficient measures in buildings using survey methods were found [29,30].

In other publications, it has been observed that the barriers to energy-efficient construction are limited to the topic of the study, and other possible barriers are briefly mentioned. No study analyzes the barriers to the use of solar energy for active and passive heating purposes and the relationships between the barriers through local housing production patterns, which is the subject of this study. Barriers to the use of renewable energy in buildings have been identified using available national and international sources, and identifying the barriers of the place has been suggested [19,20,29,32].

What is missing in the literature is the need to define barriers through site-specific forms of housing production and to identify the relationships between barriers in order to prioritize barriers in problem creation and solution. This article offers some innovations in the framework of this requirement compared to existing studies.

The first novelty of the study is that it is conducted in the City of Van, which has not been studied before. It has a high solar energy potential and is being built rapidly through the local housing production form.

Secondly, by choosing a more specific topic compared to other studies, this study investigated the barriers to the use of solar energy in residential buildings with active and passive methods. Thus, the study results are prevented from being affected by different barriers that may be encountered within the broad content of the concept of energy-efficient construction.

Thirdly, there are different modes of production and roles for actors in each mode of production [31]. Accordingly, each type of housing production involves different barriers. For this reason, this research focused on the type of housing production that produces the most housing, analyzed it, and identified its actors.

Fourthly, similar studies have found the barriers that constitute the problem through a literature review [24,25,27]. In this study, in addition to the literature review, barriers were found by using semi-structured interviews with the actors who produce the most housing and are involved in housing production. Thus, barriers found in the literature were supported, and new barriers were found at the same time.

Fifthly, unlike other studies using ISM and MICMAC methods, this study shows the direct and indirect interactions of barriers in a table and evaluates them as ranking criteria for creating and solving the problem. The ISM and MICMAC table and the direct and indirect interaction findings are shown in a table, and a ranking criterion is created to prioritize the barriers to solving the problem by evaluating these three findings together.

Sixthly, this study focuses on the use of solar energy in residential buildings through active and passive methods. This study innovates by proposing an eight-step methodology for identifying the existence of the problem, finding the type of housing production to investigate the barriers that constitute the problem, investigating and finding the barriers that constitute the problem, and ranking the barriers in order to clearly identify and solve the problem (Figure 3).

The barriers to the use of knowledge generated in energy-efficient building design, active and passive methods, and solar heating of houses with solar energy in housing production arise from the forms of housing production and the actors involved in the housing-production process. These barriers can be derived and analyzed through the actors involved in housing production.

A survey conducted in Van after the 2011 earthquake found that most houses were produced using the build-to-sell housing production method (p. 7).

The relationship between the barriers involves determining the hierarchies and impact of said barriers in creating the problem through their interaction. Determining the hierarchies and impact strengths of the barriers in creating the problem will enable us to prioritize the barriers to solving the problem and suggest the points to start solving the problem.

In order to achieve the objective of the study, the interpretive structural model (ISM) and Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) methods were

selected to find, classify, and analyze the barriers to the use of solar energy in the production of housing with active and passive heating methods in Van, where the number of sunny days is sufficient and new and safe construction areas have been opened due to the 2011 earthquake. These two methods have been used to find, interpret, and propose solutions to the barriers encountered in the process of installation of Enterprise Resource Planning (ERP) [34]; the main barriers to the implementation of energy-saving practices implemented by the Chinese government throughout the country; and the barriers to the implementation of Building Information Modeling (BIM) in the prefabricated housing sector in China [24]. The ISM and MICMAC methods have shown that they can be used to find and analyze the barriers to the use of solar energy for heating with active and passive methods in prefabricated houses and to prioritize and rank the barriers in order to solve the problem.

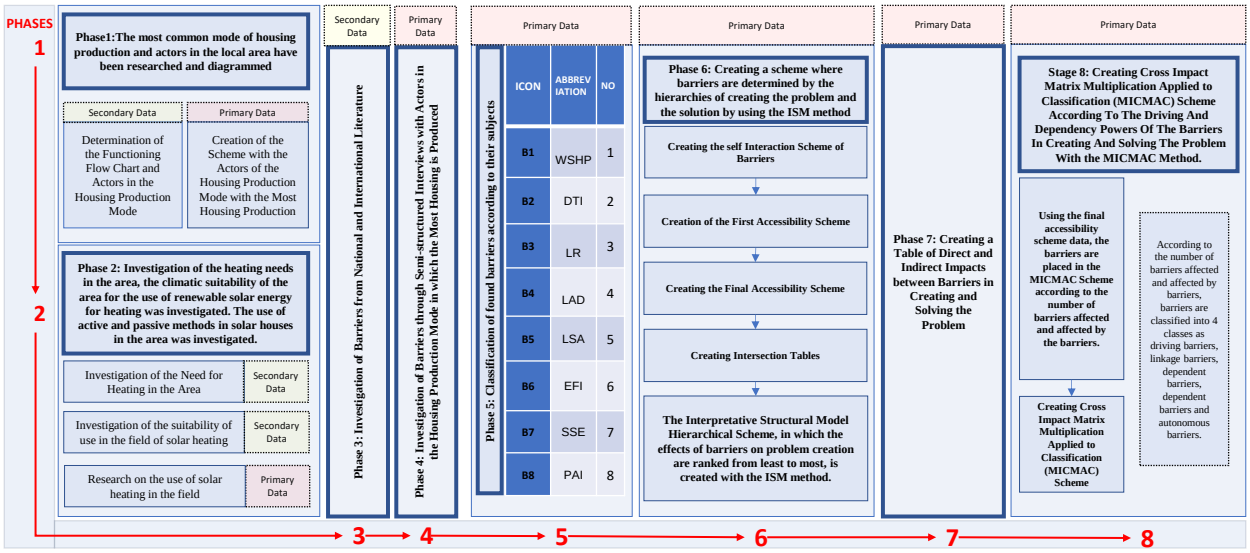

Figure 3. Table of the stages of the method used for identifying barriers to using solar energy for heating purposes in houses with active and passive methods in the City of Van and analyzing the relationships between solution-oriented barriers. The table presented in this study is an original creation and has not been previously published elsewhere.

As a result of the study, the barriers to the use of solar energy in housing production with active and passive methods were identified through semi-structured interviews with the actors involved in the builder housing production method, where most housing is produced in the City of Van, and a literature review, and 124 barriers were classified under eight headings according to their themes.

Among the barriers to the use of solar energy for heating purposes in housing construction in the City of Van, those with the highest impact power in creating the problem and those with the highest strategic priority in solving the problem were identified and ranked according to their priority in producing solutions.

2. Materials and Methods

In the City of Van, using solar energy for heating in newly built houses with active and passive methods will reduce the demand for fossil energy by 30–50% [35].

The aim of this study is to identify the barriers to the use of solar energy for heating purposes in newly produced houses through active and passive methods using ISM and MICMAC methods, to create a method that enables us to prioritize the interaction between the barriers in terms of the hierarchies of their effects on the problem and solution, and to prioritize the solution to the problem by finding the driving and dependency forces according to the influence of the barriers on each other. Figure 3 shows the stages of the study.

Phase 1: The most common mode of housing production. Actors in the local area were researched and diagrammed.

Phase 2: Investigation of the heating needs in the area. The climatic suitability of the area for the use of renewable solar energy for heating was investigated. The use of active and passive methods in solar houses in the area was investigated.

Phase 3: The barriers to the use of solar energy in houses with active and passive heating methods were investigated using the mode of housing production that produces the most housing in Van. This was performed by reviewing the literature from national and international sources.

Phase 4: The barriers to the use of solar energy in housing for active or passive heating were investigated through semi-structured interviews with the actors involved in the mode of housing production.

Phase 5: The barriers identified from the literature review and structured interviews were classified according to their themes.

Phase 6: Interpretive structural model hierarchical scheme. The hierarchies of barriers in creating the problem were determined, and the barriers were solved using the interpretive structural model method. The creation of hierarchies was performed by questioning the barriers' influence on each other.

Phase 7: A table of the total, direct, and indirect interaction between the barriers in creating the problem and the solution was created.

Phase 8: The barriers were placed in the MICMAC table according to their driving and dependency powers using the number of barriers affected and those affected by each other.

At the end of the study, the results were analyzed, and recommendations were made (pp. 20–30).

2.1. PHASE 1: Research on the Mode of Housing Production and Actors

The main forms of housing production in Türkiye and the City of Van, with a population of 1,127,612, are individual production, building cooperatives, built-to-sell, social housing, and squatter housing (Figure 4).



Figure 4. Building examples in Van according to the mode of housing production.

In the City of Van, which was selected as the study area, 6 buildings were examined in the sample taken with a 300 m interval on the 1800 m long İkinisan Street, which was demolished and rebuilt after the 2011 Van earthquake in the İpekyolu district, which was selected using the sampling method (1800/300 = 6; the sampling interval is 6 in this study). All the buildings examined were produced using the build-to-sell housing production method (Figure 5). Thus, the most common mode of housing production in the İpekyolu District of Van City was the build-to-sell housing production mode [36], so this production mode was analyzed.

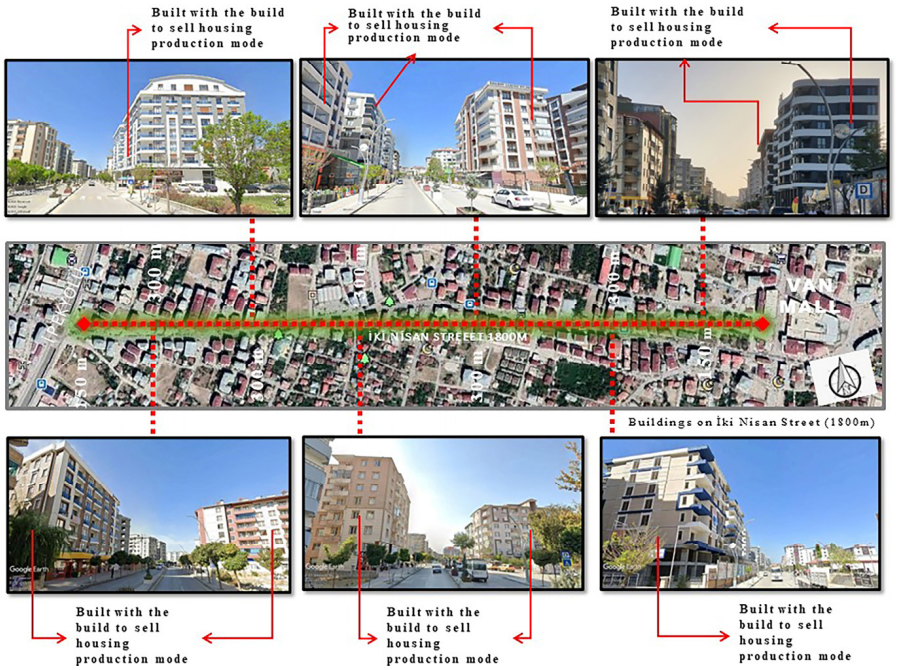

Figure 5. Buildings selected using the sampling method on İkinisan Street in Van City and research on the mode of housing production.

The build-to-sell housing production mode consists of three main headings, including decisions, project design, and construction and use. By specifying the actors involved in each heading, a diagram of the housing production mode and the actors involved was created (Figure 6). Technical personnel, local central administrations, entrepreneurs, end users, land owners, financial companies, non-government organizations, and construction inspection companies are effective in the system [31,37] (Figure 6).

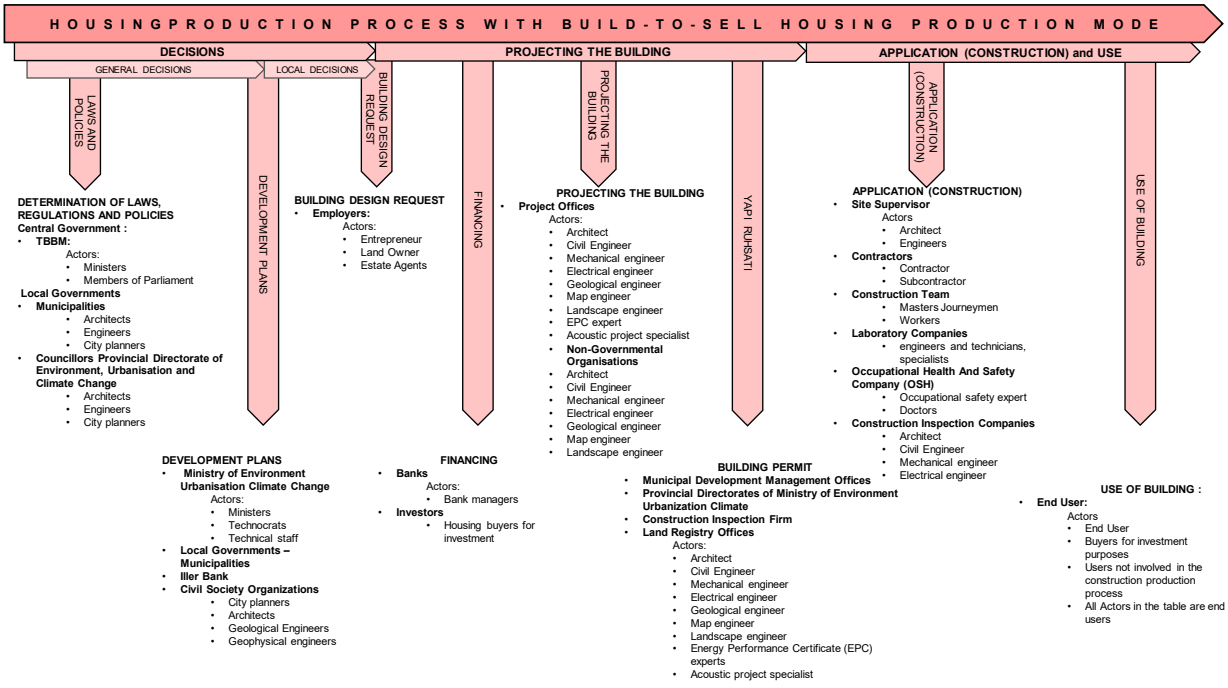

Figure 6. Scheme of housing production process and actors involved in housing production using the build-to-sell housing production mode. The table presented in this study is an original creation and has not been previously published elsewhere.

The role of the entrepreneur is more important in the build-to-sell housing production mode. The entrepreneur plays an important role in finding the land on which the block is to be built, obtaining the necessary building permits, designing the building, raising finance, constructing the building, and selling the houses (Figure 7).

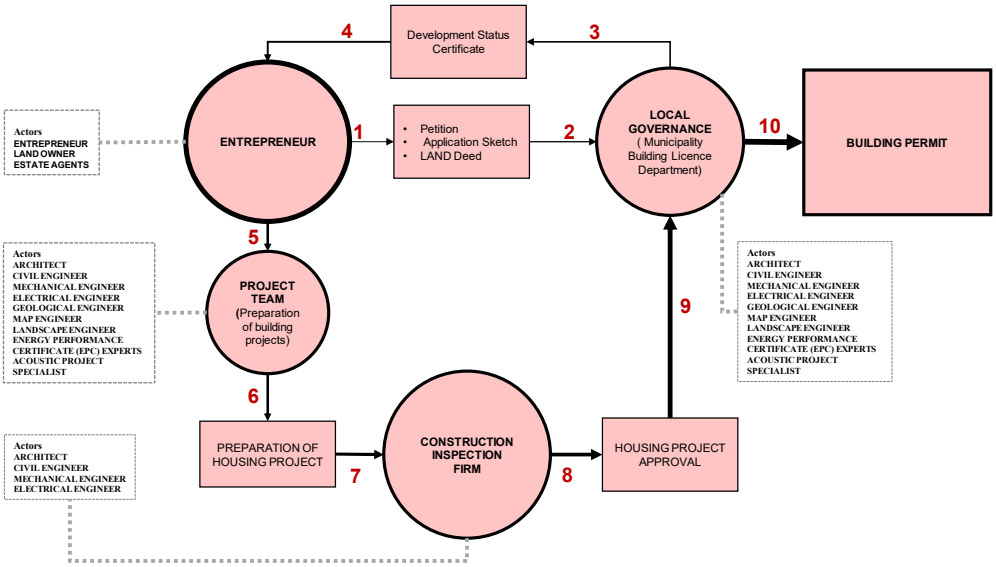

Figure 7. Flowchart of the stages in preparing building permits using the build-to-sell housing production mode. The figure presented in this study is an original creation and has not been previously published elsewhere.

2.2. PHASE 2: Research on the Need for Residential Heating in the City of Van/Solar Energy Potential and the Use of Solar Energy for Residential Heating in Van

The climatic data of the City of Van, which was selected as the study area, show that it has a high solar potential and is the 3rd-ranked city in Türkiye in terms of insolation [38]. Studies have shown that solar energy can be used for residential heating in Van City with active and passive methods [39,40]. In the City of Van, which is located at an altitude of 1654 m above sea level, there is a need for heating for 8 months between October and May [41]. According to climate data and statistics, the average air temperature in October is 11.3 °C, while the average air temperature in May is 13.1 °C [42] (Figure 8).

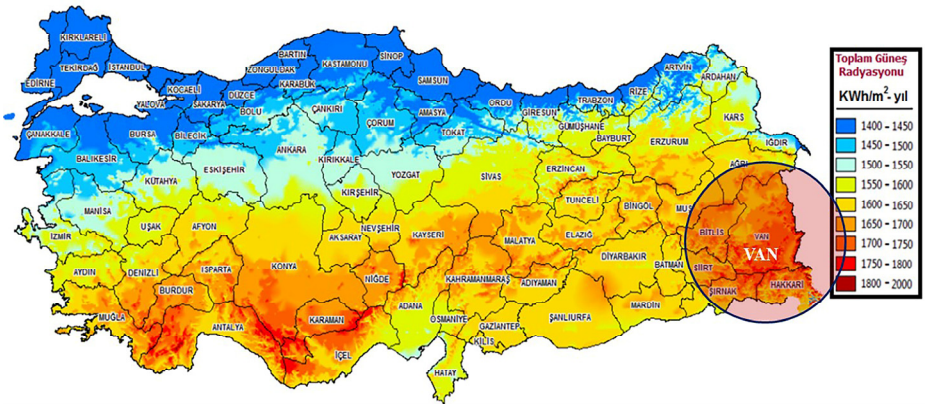

Figure 8. Solar radiation distribution map of Türkiye [43].

According to 2022 data from the TÜİK (Turkish Statistical Institute), 3360 building licenses (building permits) for residential purposes were issued between 2012 and 2021 [44]. After the earthquake in Van in 2011, a revised urban plan was made in 2016. In this revised urban plan, 6000 hectares of unbuilt land in the southwest of the City of Van were newly opened for settlement [45].

On the 1800 m long İkinisan Street, 6 buildings with a 300 m interval were selected using the systematic sampling method. In the selected houses, whether solar energy was used for heating purposes with active and passive methods was investigated (1800/300 = 6; the sampling interval is 6 in this study). This examination was performed by questioning the presence of the 14 criteria given below. It was found that solar energy was not used for active and passive heating purposes in the houses examined in the research (Figure 9).

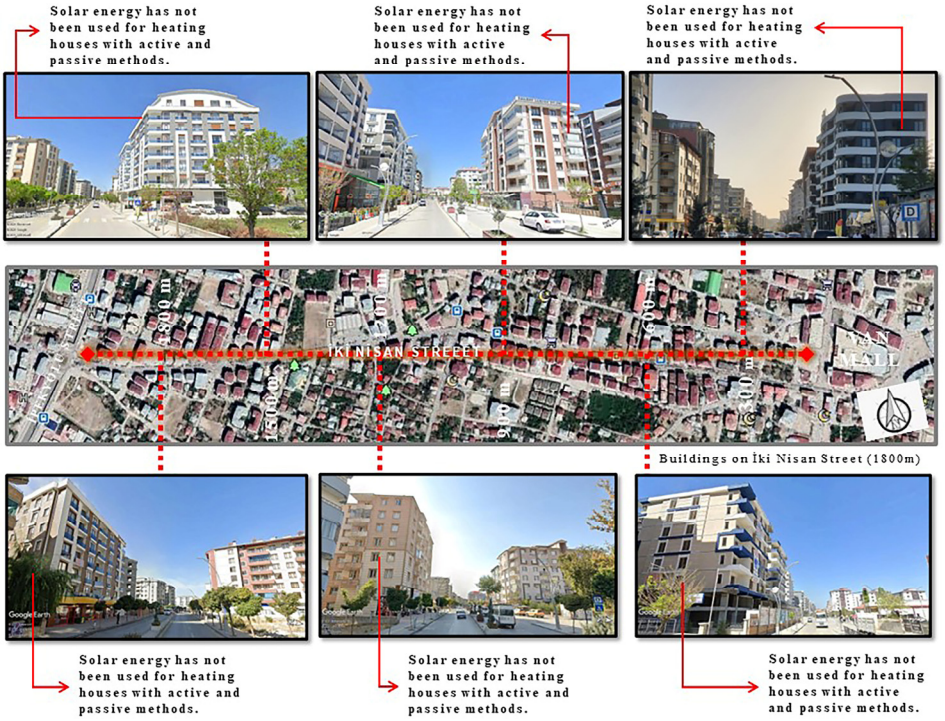

Figure 9. Buildings on İkinisan Street, where the use of solar energy is questioned.

The 14 criteria used in the research on whether solar energy was used for heating in houses were as follows: the placement of the house on the topography according to climate data, the form of the building, the determination of building spacing, orientation, space organization, building envelope, material selection, greenhouse and winter garden, the presence of trumpet walls, the presence of convectional channels, the presence of terrace roof pools, the presence of remote openings, and the use of photovoltaic panels.

2.3. PHASE 3: Investigation of Barriers to the Use of Solar Energy to Heat Homes Using Active and Passive Methods through a Literature Review

In the literature review, more than 30 databases provided by the Yıldız Technical University Library, including Google Scholar, Scopus, and WoS, were used, with the following keywords: energy-efficient buildings—housing, energy identity certificate, energy-efficient construction—barriers, ecological design, energy-efficient building parameters, energy efficiency in buildings, solar energy and heating, and barriers. The national and international literature review identified 74 barriers to the use of information produced for the use of solar energy for heating in houses with active and passive methods from 20 sources.

2.4. PHASE 4: The Investigation of Barriers through Semi-Structured Interviews with Actors Involved in the Build-and-Sell Housing Production Mode in Van

Semi-structured interviews were conducted with 10 professionals with 8 years of professional experience residing in the City of Van, who were involved in housing production via the build-to-sell housing production mode.

There were a total of 6 architects, 1 architect from the Chamber of Architects, 1 mechanical engineer from the Chamber of Mechanical Engineers, 1 urban planner from the

Chamber of Urban Planners, 1 architect from the Municipality of İpekyolu District, Van Province), and 1 entrepreneur: 1 person involved in housing production via the build-to-sell housing production mode (the persons selected for the interview were selected from the actors involved in the housing production system using the build-to-sell housing production mode).

In semi-structured interviews, information was given about the use of solar energy for heating houses with active and passive methods. Participants were asked whether solar energy was used for heating houses with active and passive methods in Van City, whether it could be used, and the barriers to its use. As a result of the interview, 50 barriers were found.

A total of 124 barriers were identified, 74 in the literature review and 50 in the face-to-face interviews. Repeated barriers were eliminated. The barriers found were categorized according to their themes and grouped under 8 headings for use in the interpretative structural modeling method (Table 1).

Table 1. Barriers to using solar energy with active and passive methods in houses produced using the build-to-sell housing production mode.

ICON	Abbreviation	Barrier
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode (internal dynamics of housing production)
B2	DTI	Barriers Caused by Deficiencies in Technical Issues
B3	LR	Barriers Caused by Laws and Regulations.
B4	LAD	Barriers caused by lack of knowledge, skills and awareness of the designer (project team).
B5	LSA	Lack of Social Awareness (Sensitivity, Lack of Consciousness Level)
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)
B7	SSE	Barriers caused by Social and Sociological Events.
B8	PAI	Barriers Caused by Political and Administrative Issues

In this study, each barrier found in the literature review and interviews with the actors was listed and grouped regardless of the frequency of encounter.

2.5. PHASE 5: Classification of the Barriers According to Their Subject

Barriers caused by high construction costs, the desire for low construction costs, limited time, the high speed of housing production, the use of standard projects and symmetrical plans in housing production, the expectation to build as many houses as possible using the housing plot with the aim of profit, no additional profit for the entrepreneur (investor), barriers arising from the entrepreneur's reluctance to invest in something that is not commercial and does not bring profit, a reluctance to cooperate with the actors involved in housing production, a reluctance to receive support from institutions and organizations involved in technological production, and the use of conventional housing production techniques were categorized under the heading of (B1) WSHP: barriers caused by the working system of the build-to-sell housing production mode (the internal dynamics of housing production).

Barriers caused by the lack of prioritization of energy in architectural design, energy-conscious design being mostly limited to building scale and insulation, building energy consumption control being left to mechanical engineers, residential areas being insufficiently evaluated in city plans to benefit from solar energy, zoning parcels being unsuitable for orientation in terms of solar energy, barriers caused by leaving the utilization of solar energy to chance, a lack of consideration of solar collectors and photovoltaic panels as design elements and conception that they cause visual pollution, and a lack of reliable data supporting architectural design were categorized under the heading of (B2) DTI: barriers caused by deficiencies in technical issues.

Barriers caused by the lack of a legal framework (the lack of necessary laws); a lack of laws, regulations, and certification; institutional authority and responsibility conflicts in the laws; incompatibility of the legal infrastructure with international commitments; the issue of energy consumption being handled at a single-building scale and aiming more toward insulation in legal regulations for zoning legislation; the lack of targets to minimize heat losses and gain from renewable energy sources, such as solar energy; a lack of a scientific approach in this regard, and the issue being left to chance; the lack of a legal legislation on collectors and photovoltaic panels; no building standards; deficiencies in terms of solar energy use in the urban plan and plan regulation; no pre-certification legislation in terms of energy-efficient building design criteria for buildings in the architectural design phase; barriers arising from the lack of criteria for the utilization of solar energy for heating purposes in laws and regulations; the lack of a control system; the limitation of the distances between buildings to the minimum distances stipulated by the urban development plan; inadequate inter-building distances; and the lack of legislation to prevent their shading were categorized under the heading of (B3) LR: barriers caused by laws and regulations.

Barriers caused by a lack of knowledge, skills, and training of the architectural designer; a lack of awareness of the architect and designer; a lack of awareness (environmental awareness) of the professionals; and willingness of the designer and project team to use conventional techniques were categorized under the heading of (B4) LAD: barriers caused by a lack of knowledge, skills, and awareness of the designer (project team).

Barriers caused by a lack of social awareness and consciousness, a lack of knowledge and awareness of the society, a lack of training activities, a lack of demand for housing that uses solar energy for heating purposes (no demand from the end user), a lack of awareness of the end user on this issue, a lack of a demand from landowners in this direction, end-user comfort, and rebound effect were categorized under the heading of (B5) LSA: lack of social awareness (sensitivity, lack of consciousness).

Barriers caused by a lack of incentives and supports (financial, precedent increase, exemption from legal fees), a lack of credit, a lack of government support (costs), high initial investment cost (foreign dependency), initial investment in collectors and photovoltaic panels, a lack of sufficient utilization of engineering and architectural knowledge, the selection of conventional solutions instead of ready-made profitable and fast solutions that provide maximum profit, and regular maintenance and repair costs were categorized under the heading of (B6) EFI: barriers caused by economic and financial issues (incentives).

Barriers caused by unplanned urbanization and land use due to uncontrolled population growth and migration to the city and a lack of awareness of "City Ownership" were categorized under the heading of (B7) SSE: barriers caused by social and sociological events.

Barriers caused by a lack of importance and priority in central and local governments, a lack of effort of local governments to create sustainable living environments, leaving the issue of solar energy use to the inclinations of the architect, the use of solar energy not being a priority issue of policymakers, a lack of public awareness of it being possible, public administrations not constructing exemplary buildings that use solar energy for heating purposes to pioneer and set an example, a lack of consultancy units, a lack of information of the benefits of solar energy (end users, managers, and legislators), and a lack of guidance and supervision on the use of solar energy in houses to be built through the creation of energy boards (such as urban aesthetic boards) were categorized under the heading of (B8) PAI: barriers caused by political and administrative issues (Table 1).

2.6. PHASE 6: Creation of the ISM Hierarchy Scheme, in Which the Problem and Solution Creation Hierarchies of the Barriers Are Determined Using the ISM Method

The interpretive structural modeling (ISM) method was used to find the hierarchies of the barriers to the use of solar energy for heating purposes in the housing built with the build-to-sell housing production mode and to prioritize where to start the solution of the problem. This method has been used in the literature to overcome the barriers that form the problems encountered in the application areas of socio-economic and technical

systems [24,25,46]. In Phases 6 and 7 of the study, information about the ISM and MICMAC methods is given, and the application stages of the two methods are explained in detail.

The interpretive structural model (ISM) was first developed by John N. Warfield. The interpretive structural model (ISM) is used as a method that can correctly identify the direct and indirect interactions between the factors (barriers) and prioritize, represent, and analyze their effects on the system in a hierarchical model [46–48]. The application flowchart of the interpretive structural model is given below to analyze the barriers to the use of solar energy for active and passive heating in residential buildings. The flowchart was reorganized for this study from the flowchart developed by Wang et al. in 2008 [24], (Figure 10).

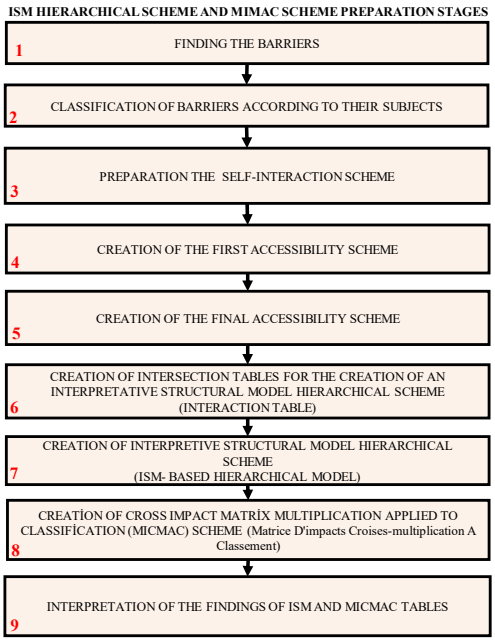

Figure 10. ISM hierarchical scheme and MICMAC table preparation flowchart. Adapted for this study from the scheme prepared by Wang et al. in [24].

In the literature, barriers were only found through a literature review of studies using the interpretive structural modeling method [34,46,49]. However, in this study, barriers were found through semi-structured interviews with the actors involved in the construction of housing production in addition to the literature review.

In order to create the interpreter structural model, the self-interaction matrix was first created. In order to create the scheme, the interactions of the barriers were examined. Bilateral interactions of barriers were analyzed. There may be mutual interaction between barriers, unidirectional interaction, or no direct interaction between barriers.

The relationships between the barriers were identified through structured interviews with experts in the field of energy performance certificates. The professional experience of 5 architects who are "Energy Performance Certificate (EPC) experts" was 8 years or more. Four symbols (V, A, X, O) were used in the self-interaction matrix created to investigate the interaction between the barriers. In the relationship between two barriers, if Barrier I affects Barrier J but Barrier J does not affect Barrier I, the symbol V is used. If Barrier I does not affect Barrier J but Barrier J affects Barrier I, the symbol A is used. The symbol X is used when the crossing barriers interact. If there is no direct interaction between the barriers, the symbol O is used (Figure 11).

According to the answers given by the energy performance certificate (EPC) experts in the interviews using the above criteria, the self-interaction matrix was created. The answer given by the majority or unanimously was accepted (Figure 12).

V : Barrier i affects barrier j (one-way effect from i to j)
A : Barrier j affects barrier i (there is a one-way effect from j to i),
X : Barriers i and j mutually influence each other (there is a two-way effect between i and j),
O : There is no interaction between barriers i and j

Figure 11. Interaction criteria table of barriers [24].

BARRIERS		J						
		B8 (PAI)	B7 (SSE)	B6 (EFI)	B5 (LSA)	B4 (LAD)	B3 (LR)	B2 (DTI)
I	B1 (WSHP)	A	A	A	A	A	A	O
	B2 (DTI)	A	O	O	O	X	A	
	B3 (LR)	A	O	V	X	V		
	B4 (LAD)	A	O	O	A			
	B5 (LSA)	X	X	V				
	B6 (EFI)	O	O					
	B7 (SSE)	A						

Figure 12. Self-interaction scheme of barriers.

After creating the self-interaction scheme, the first accessibility scheme was created in the second row. The first accessibility scheme was created by converting the letters used in the barrier interaction scheme into numerical values. This was performed in one direction. If Barrier I affects Barrier J, the number 1 should be written; if Barrier I does not affect Barrier J, the number 0 should be written. As the query is one-way, the entire first accessibility diagram is filled in. As each barrier interacts with itself, the interaction of each barrier with itself takes the value 1 in the diagram (Figure 13).

After creating the first accessibility scheme, the final accessibility scheme was created in the third row by applying the transitivity rule between the barriers. Here, if Barrier A affects Barrier B and Barrier B affects Barrier C, then Barrier A is considered to affect barrier C [48] (Figure 14). The values of 0 in the initial accessibility scheme were converted to 1 for the barriers that satisfy this rule (Figure 15).

Using the final accessibility scheme, the accessibility cluster–primary cluster and the driving force dependencies of the barriers were also found and determined.

The barriers affected by each barrier were grouped into an accessibility cluster (on the right-hand side of the table), and the driving force of the barrier was calculated accordingly. The driving force of a barrier (including itself) is equal to the number of elements in its accessibility cluster (Figure 15).

Example: Barrier B1 is the only barrier in the accessibility cluster. This is because this barrier cannot affect other barriers. Since only Barrier B1 is in the accessibility cluster, the driving force of Barrier B1 is set to 1 (Figure 15).

The barriers that affect the barrier were grouped under the primary cluster (at the bottom of the table), and the dependency force of the barrier was calculated accordingly. The dependency force of a barrier (including itself) is equal to the number of elements in the primary cluster of that barrier.

BARRIERS		J							
		B1 (WSHP)	B2 (DTI)	B3 (LR)	B4 (LAD)	B5 (LSA)	B6 (EFI)	B7 (SSE)	B8 (PAI)
I	B1 (WSHP)	1	0	0	0	0	0	0	0
	B2 (DTI)	0	1	0	1	0	0	0	0
	B3 (LR)	1	1	1	1	1	1	0	0
	B4 (LAD)	1	1	0	1	0	0	0	0
	B5 (LSA)	1	0	1	1	1	1	1	1
	B6 (EFI)	1	0	0	0	0	1	0	0
	B7 (SSE)	1	0	0	0	1	0	1	0
	B8 (PAI)	1	1	1	1	1	0	1	1

Figure 13. First accessibility scheme.

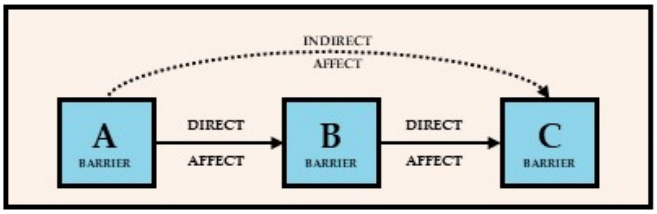

Figure 14. Schematic representation of the transitivity rule in interaction between barriers.

BARRIERS		J								DRIVING FORCE	BARRIERS AFFECTED BY THE BARRIER (ACCESSIBILITY CLUSTER)
		B1 (WSHP)	B2 (DTI)	B3 (LR)	B4 (LAD)	B5 (LSA)	B6 (EFI)	B7 (SSE)	B8 (PAI)		
I	B1 (WSHP)	1	0	0	0	0	0	0	0	1	B1
	B2 (DTI)	1	1	0	1	0	0	0	0	3	B1,B2,B4
	B3 (LR)	1	1	1	1	1	1	1	1	8	B1,B2,B3,B4,B5,B6, B7,B8
	B4 (LAD)	1	1	0	1	0	0	0	0	3	B1,B2,B4
	B5 (LSA)	1	1	1	1	1	1	1	1	8	B1,B2,B3,B4,B5,B6, B7,B8
	B6 (EFI)	1	0	0	0	0	1	0	0	2	B1,B6
	B7 (SSE)	1	0	1	1	1	1	1	1	7	B1,B3,B4,B5,B6,B7, B8
	B8 (PAI)	1	1	1	1	1	1	1	1	8	B1,B2,B3,B4,B5,B6, B7,B8
DEPENDENCE FORCE		8	5	4	6	4	5	4	4		
BARRIERS AFFECTED BY THE BARRIER (PRİMARY CLUSTER)		B1,B2, B3,B4, B5,B6, B7,B8	B2, B3,B4, B5,,B8	B3,B5, B7,B8	B2, B3,B4, B5, B7,B8	B3, B5 B7,B8	B3, B5,B6, B7,B8	B3, B5, B7,B8	B3, B5, B7,B8		

1 The Boxes Marked In Yellow Have Been Modified From The First Accessibility Scheme According To The Transitivity Rule.

Figure 15. The final accessibility scheme shows the accessibility cluster–primary cluster driving force–barrier dependency forces.

Example: The primary cluster of Barrier B1 includes itself and all other barriers because this barrier is affected by all other barriers. Since the primary cluster of Barrier B1 includes Barriers B1, B2, B3, B4, B5, B6, B7, and B8, the number of elements in this cluster is 8, and the dependency strength of Barrier B1 is determined to be 8 (Figure 15).

In the fourth row, an intersection table was created to determine the levels of barriers in the hierarchical scheme of the interpretive structural model (Figures 16–18). In the intersection table, the accessibility cluster of each barrier is formed, i.e., the accessibility cluster consisting of all the barriers affected by the barrier, including the barrier itself, and the primary cluster consisting of the barriers affected by each barrier, including the barrier itself. If the primary cluster includes the accessibility cluster, i.e., all barriers in the accessibility cluster are included in the primary cluster, the level of that barrier is determined. To find the level of the next barrier, the barrier whose level was determined in the first step is removed from the table, the intersection is checked again, and the process continues until all barriers have been removed from the list.

Figure 16 compares the elements in the accessibility cluster and the elements in the primary cluster. It can be seen that the primary cluster (P) only covers the accessibility cluster (A) (P $\supseteq$ A) B1, and this coverage is not provided in other barriers. Therefore, Barrier B1 has been placed at level I in the interpretive structural model hierarchical scheme (Figure 14).

In Figure 17, the accessibility cluster and the primary cluster were compared by removing Barrier B1 from the whole table. The primary cluster (P) covered the accessibility cluster (A) at 3 barriers (P $\supseteq$ A) in B4, B2, and B6. This coverage was not provided at other barriers. For this reason, Barriers B4, B2, and B6 were placed at level II in the interpretive structural model hierarchical scheme (Figure 17).

BARRIERS	ACCESSIBILITY CLUSTER (BARRIERS AFFECTED BY THE BARRIER)								PRİMARY CLUSTER (BARRIERS AFFECTED BY THE BARRIER)								ACCESSIBILITY CLUSTER INTERSECTION OF THE PRIMARY CLUSTER (ALL ELEMENTS OF THE ACCESSIBILITY CLUSTER MUST BE COVERED BY THE PRIMARY CLUSTER)	LEVEL
B1 (WSHP)	B1								B1	B2	B3	B4	B5	B6	B7	B8	B1	I
B2 (DTI)	B1	B2		B4						B2	B3	B4	B5			B8	NO COVERAGE	
B3 (LR)	B1	B2	B3	B4	B5	B6	B7	B8			B3		B5		B7	B8	NO COVERAGE	
B4 (LAD)	B1	B2		B4						B2	B3	B4	B5		B7	B8	NO COVERAGE	
B5 (LSA)	B1	B2	B3	B4	B5	B6	B7	B8			B3		B5		B7	B8	NO COVERAGE	
B6 (EFI)	B1					B6					B3		B5	B6	B7	B8	NO COVERAGE	
B7 (SSE)	B1		B3	B4	B5	B6	B7	B8			B3		B5		B7	B8	NO COVERAGE	
B8 (PAI)	B1	B2	B3	B4	B5	B6	B7	B8			B3		B5		B7	B8	NO COVERAGE	

Figure 16. Interaction table (table of level I determination steps used to create an interpretive structural model hierarchical scheme).

BARRIERS	ACCESSIBILITY CLUSTER (BARRIERS AFFECTED BY THE BARRIER)								PRİMARY CLUSTER (BARRIERS AFFECTED BY THE BARRIER)								ACCESSIBILITY CLUSTER INTERSECTION OF THE PRIMARY CLUSTER (ALL ELEMENTS OF THE ACCESSIBILITY CLUSTER MUST BE COVERED BY THE PRIMARY CLUSTER)	LEVEL
B2 (DTI)		B2		B4						B2	B3	B4	B5			B8	B2,B4,	II
B3 (LR)		B2	B3	B4	B5	B6	B7	B8			B3		B5		B7	B8	NO COVERAGE	
B4 (LAD)		B2		B4						B2	B3	B4	B5		B7	B8	B2,B4	II
B5 (LSA)		B2	B3	B4	B5	B6	B7	B8			B3		B5		B7	B8	NO COVERAGE	
B6 (EFI)						B6					B3		B5	B6	B7	B8	B6	II
B7 (SSE)			B3	B4	B5	B6	B7	B8			B3		B5		B7	B8	NO COVERAGE	
B8 (PAI)		B2	B3	B4	B5	B6	B7	B8			B3		B5		B7	B8	NO COVERAGE	

Figure 17. Interaction table of level II determination steps used to create an interpretive structural model hierarchical scheme.

BARRIERS	ACCESSIBILITY CLUSTER (BARRIERS AFFECTED BY THE BARRIER)								PRİMARY CLUSTER (BARRIERS AFFECTED BY THE BARRIER)								ACCESSIBILITY CLUSTER INTERSECTION OF THE PRIMARY CLUSTER (ALL ELEMENTS OF THE ACCESSIBILITY CLUSTER MUST BE COVERED BY THE PRIMARY CLUSTER)	LEVEL
B3 (LR)			B3		B5		B7	B8			B3		B5		B7	B8	B3,B5,B7,B8	III
B5 (LSA)			B3		B5		B7	B8			B3		B5		B7	B8	B3,B5,B7,B8	III
B7 (SSE)			B3		B5		B7	B8			B3		B5		B7	B8	B3,B5,B7,B8	III
B8 (PAI)			B3		B5		B7	B8			B3		B5		B7	B8	B3,B5,B7,B8	III

Figure 18. Interaction table of level III determination steps used to create an interpretive structural model hierarchical scheme.

As seen in Figure 18, Barriers B4, B2, and B6 were removed from the table, and the accessibility cluster and the primary cluster were compared. The primary cluster (P) covered the accessibility cluster (A) B3, B5, B7, B8 (P ⊇ A). Therefore, Barriers B3, B5, B7, and B8 were located at level III (Figure 18).

In the fifth row, the interpretive structural model hierarchical scheme (ISM-based hierarchical model) was created. The levels of all the barriers were found (Figures 16–18). The barriers were located in a three-level hierarchical scheme. In the hierarchical scheme of the interpretive structural model, barriers at level III were considered the most effective barriers in creating the problem. Barriers at level I were considered less effective in creating the problem than barriers at levels III and II, respectively (Figure 19).

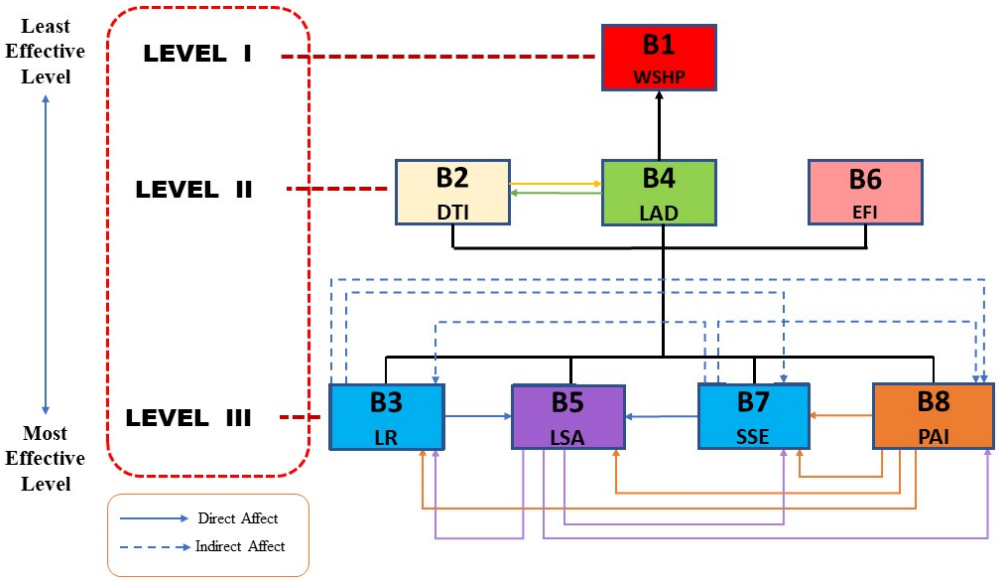

Figure 19. Interpretive structural model hierarchical scheme.

The barriers in the hierarchical scheme of the interpretative structural model (ISM) were included in a hierarchical scheme with 3 levels. There were 4 barriers at level III, which is the most important level in the creation and resolution of the problem. Barriers B3, B5, B7, and B8 were found at level III.

There are 3 barriers at level II. At level II, there are barriers B4, B2, and B6. In the interpretative structural model hierarchical scheme, there is 1 barrier at level I. At level I, there is a B1 barrier.

Sixth, the hierarchical scheme of the interpretative structural model and the self-interaction scheme of the barriers were compared and found to be conceptually compatible, thus achieving conceptual consistency (Figures 12 and 19).

2.7. PHASE 7: Questioning Direct and Indirect Interaction between Barriers in Creating and Solving the Problem

Figure 20 presents a diagram of barriers that a barrier affects and is affected by in total, indirectly and directly. It also shows the interaction of barriers with other barriers in detail by name and numerical data.

BARRIER			←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)				
ICON	ABBREVIATION	BARRIER	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier	
				Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1
B2	DTI	Barriers Caused by Deficiencies in Technical Issues	3	B2,B4	2	B1	1	5	B2,B3,B4, B8	4	B5	1
B3	LR	Barriers Caused by Laws and Regulations.	8	B1,B2,B3,B 4,B5,B6	6	B7,B8	2	4	B3,B5,B8	3	B7	1
B4	LAD	Barriers caused by lack of knowledge, skills and awareness of the designer (project team).	3	B1,B2,B4	3		0	6	B2,B3,B4, B5,B8	5	B7	1
B5	LSA	Lack of Social Awareness (Sensitivity, Lack of Consciousness Level	8	B1,B3,B4,B 5,B6,B7,B8	7	B2	1	4	B3,B5,B7, B8	4		0
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2
B7	SSE	Barriers caused by Social and Sociological Events.	7	B1,B5,B7	3	B3,B4,B6,B 8	4	4	B5,B7,B8	3	B3	1
B8	PAI	Barriers Caused by Political and Administrative İssues	8	B1,B2,B3, B4,B5,B7, B8	7	B6	1	4	B5,B8	2	B3,B7	2

Figure 20. Table of total and direct and indirect impacts of barrier-affected barriers and their numbers.

(B1) (WSHP) Barriers caused by the working system of the build-to-sell housing production mode are directly affected by 7 barriers—B1, B3, B4, B5, B6, B7, and B8—and any impact on these 7 barriers directly affects B1. Barrier B2 indirectly affects B1. An effect on B2 will indirectly affect B1. Barrier B1 can only directly affect itself and cannot directly or indirectly affect any other barrier. Figure 20 shows the interactions with other barriers.

2.8. Step 8: Create the MICMAC Table (Cross-Impact Matrix Multiplication Applied to Classification) and the Driving and Dependence Force of Barriers in Creating and Solving the Problem

Once interpretive structural modeling (ISM) was carried out, the MICMAC table was created using the data obtained from the ISM. Barriers can be analyzed using both the ISM and MICMAC methods. The MICMAC method is an analysis method used by Duperrin and Godet in 1973 to find the driving and dependency force of the factors affecting a system [24,50].

MICMAC allows us to analyze the dependency and driving force of each barrier to clearly understand the interactive relationship between barriers. Each barrier is classified into four categories according to its driving and dependency force.

The driving force of a barrier indicates the total number of barriers that are affected by it, while the dependency force indicates the total number of barriers that affect it (Table 2).

Autonomous barriers: These barriers have weak driving and dependency forces. They have little connection with the system to which they belong, which means that they are not easily influenced by other barriers in the system or other barriers. They need to be addressed in isolation. These barriers are not effective barriers in creating and solving the problem. These barriers are in zone I of the MICMAC table [24].

Table 2. Driving force-dependent forces of barriers table (generated from the final accessibility scheme).

Icon	Abbreviation	Driving Force of Barrier	Dependence Force of Barrier
B1	WSHP	1	8
B2	DTI	3	5
B3	LR	8	4
B4	LAD	3	6
B5	LSA	8	4
B6	EFI	2	5
B7	SSE	7	4
B8	PAI	8	4

Dependent barriers: These barriers are unlikely to affect other barriers. However, they are likely to be affected by other barriers. Dependent barriers have weak drivers and high dependency. Dependent barriers are strongly influenced by linkage barriers and driving barriers. Therefore, if the driving and linkage barriers are addressed and worked on, the dependent barriers will also be indirectly affected. These barriers are in zone II of the MICMAC table [24].

Linkage Barriers: These barriers have both driving and dependent forces at a medium level. At the same time, they are dependent on some other barriers and have a driving force on some other barriers. Any work on these barriers will affect other barriers as well as themselves. Linkage barriers are important barriers because they have the power to increase the effect of previous barriers on subsequent barriers. These barriers are in zone III of the MICMAC table.

Driving barriers: These barriers have a low dependency on other barriers but a very high driving force. Driving barriers can strongly influence other barriers but are not or are only slightly influenced by other barriers. With these characteristics, driving barriers are important barriers that should be addressed first in solving the problem. These barriers are in Region IV of the MICMAC table [24,50–52].

The driving and dependency powers of the barriers were generated from the final accessibility scheme. As seen in Table 2, the barrier with the highest driving power in creating the problem and solution is B8, and the barrier with the highest dependency power is B1 (Table 2).

The barriers were placed in the MICMAC table according to their driving and dependent forces. The table shows that the barriers are grouped in the fourth region, the driving barriers region, and the second region, the dependent barriers region (Figure 21).

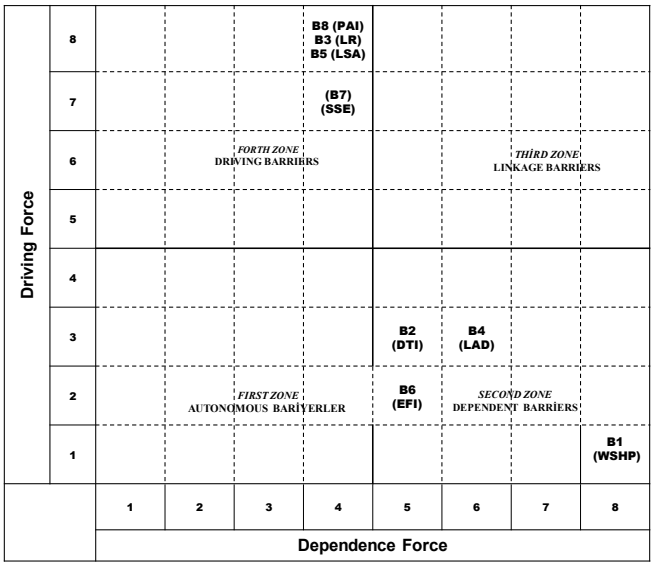

Figure 21. Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) scheme.

3. Phase 8: Findings and Recommendations

The table of the barrier ranking criteria is shown in Figure 22; the three-level hierarchical scheme was obtained as a result of the hierarchical scheme of the interpretative structural model (ISM) (Figure 19). The barriers were located in two regions in the ranking Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) scheme (Figure 21). They resulted from the total, direct, and indirect barriers affected by other barriers.

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)					THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LevelII	Leve II	Leve I	DRIVING BARRIERS (FORTH ZONE)	DEPENDENT BARRIERS (SECOND ZONE)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier		
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count	
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW
B2	DTI	Barriers Caused by Deficiencies in Technical Issues		II			Dependent Barriers	3	B2,B4	2	B1	1	5	B2,B3,B4, B8	4	B5	1	6TH ROW
B3	LR	Barriers Caused by Laws and Regulations.	III			Driving Barrier		8	B1,B2,B3,B 4,B5,B6	6	B7,B8	2	4	B3,B5,B8	3	B7	1	3RD ROW
B4	LAD	Barriers caused by lack of knowledge, skills and awareness of the designer (project team).		II			Dependent Barriers	3	B1,B2,B4	3		0	6	B2,B3,B4, B5,B8	5	B7	1	5TH ROW
B5	LSA	Lack of Social Awareness (Sensitivity, Lack of Consciousness Level	III			Driving Barrier		8	B1,B3,B4,B 5,B6,B7,B8	7	B2	1	4	B3,B5,B7, B8	4		0	2ND ROW
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)		II			Dependent Barriers	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2	7TH ROW
B7	SSE	Barriers caused by Social and Sociological Events.	III			Driving Barrier		7	B1,B5,B7	3	B3,B4,B6,B 8	4	4	B5,B7,B8	3	B3	1	4TH ROW
B8	PAI	Barriers Caused by Political and Administrative Issues	III			Driving Barrier		8	B1,B2,B3, B4,B5,B7, B8	7	B6	1	4	B5,B8	2	B3,B7	2	1ST ROW

Figure 22. Ranking criteria table of barriers (barriers and full findings).

A methodology and flowchart were developed to analyze the findings and prioritize and rank the barriers regarding problem creation and resolution (Figure 23).

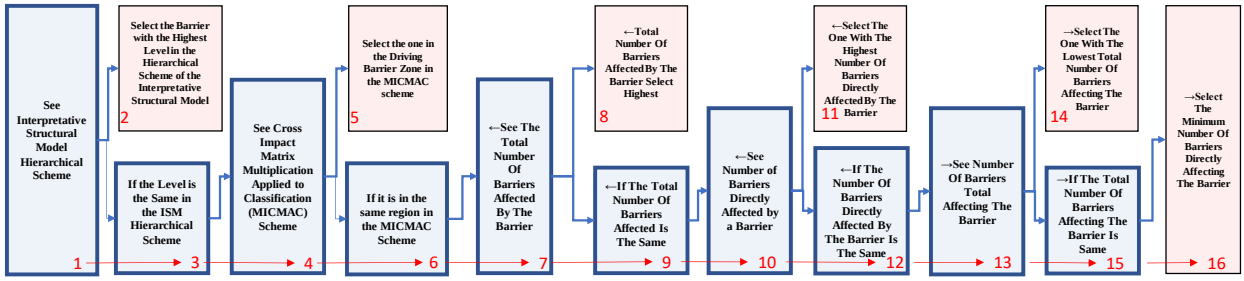

Figure 23. Methodology flowchart for prioritizing the barriers to problem creation and resolution. The figure presented in this study is an original creation and has not been previously published elsewhere.

In order to rank and prioritize the barriers in terms of creating and solving the problem, firstly, the hierarchical scheme of the ISM was examined. From the barriers, the barrier with the highest level (level III) was selected. If the barriers were at the same level in the ISM hierarchical scheme, the MICMAC table was examined.

In the MICMAC table, the barriers in the driving barrier zone, connection barrier zone, dependent barrier zone, and autonomous barrier zone were selected, respectively. In cases where the barriers were in the same region in the MICMAC table, the total number of barriers affected by the barriers was analyzed. The barrier with the highest total number of barriers was selected. If the total number of barriers affected by the barrier was the same, the number of barriers directly affected by the barrier was analyzed. The barrier with the highest number of directly affected barriers was selected. In order to rank the barriers with the same number of directly affected barriers, the total number of barriers affecting the barriers was analyzed. Among the barriers, the barrier with the lowest number of barriers affecting the barrier in total was selected. For the barriers with the same total number of

barriers, the barrier with the least number of barriers directly affecting the barrier was selected. Thus, the barriers were ranked in terms of creating the problem and solution. A flowchart of the methodology for prioritizing barriers to creating and solving the problem was produced (Figure 23).

4. Barriers

4.1. B8 Barrier Findings

B8 (PAI) Barriers Caused by Political and Administrative Issues

- Barrier B8 (PAI) is located at level III in the ISM hierarchical scheme, which is the most effective for creating and solving the problem (Figure 19).
- B8 (PAI) directly affects seven barriers, namely B1, B3, B4, B5, B6, B7 and B8, and indirectly affects barrier B2; in total it affects eight barriers. Among the barriers, B8 (PAI) is one of the three barriers (B3, B5, B8) with the highest total number of barriers affected. B8 (PAI) is directly affected by two barriers, B5 and B8, and it is indirectly affected by two barriers, B3 and B7, totaling four barriers. B8 (PAI) is the least-affected barrier in terms of the number of barriers directly affected and one of the four least-affected barriers in terms of the number of barriers affected in total (Figure 20).
- B8 (PAI) has a driving force score of 8 and a dependence force score of 4 (Table 2). It is located in the fourth region, the driving barriers region, in the MICMAC table. The fourth driving barriers region, where the most effective barriers are located in creating and solving the problem in the MICMAC table, is the region where the barriers that need priority intervention are located (Figure 21).
- In the hierarchical scheme of the interpretative structural model, B8 (PAI) is located at the same level, level III, with B3, B5, and B7. Therefore, the MICMAC table was analyzed. In the MICMAC table, B8 is located in the region of driving barriers with B3, B5, and B7. The total number of barriers it affects was analyzed. Here, it affects the same number of barriers as B3, B5, and B7. In order to rank them, the number of barriers directly affected by the barriers was analyzed, and B8 directly affected the same number of barriers as B5. Therefore, the number of barriers affected in total was analyzed, and B8 was affected by the same number of barriers as B5. Then, in order to rank them, the number of barriers directly affected by the barriers was analyzed. B5 was directly affected by four barriers; B8 was directly affected by two barriers; and B8, which was directly affected by the lowest number of barriers, was selected as the first-ranking barrier in creating and solving the problem (Figure 24).

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)					THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LeveIII	Leve II	Leve I	DRIVING BARRIERS (*FORTH ZONE*)	DEPENDENT BARRIERS (*SECOND ZONE*)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier		
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count	
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW
B2	DTI	Barriers Caused by Deficiencies in Technical Issues		II			Dependent Barriers	3	B2,B4	2	B1	1	5	B2,B3,B4, B8	4	B5	1	6TH ROW
B3	LR	Barriers Caused by Laws and Regulations.	III			Driving Barrier		8	B1,B2,B3,B 4,B5,B6	6	B7,B8	2	4	B3,B5,B8	3	B7	1	3RD ROW
B4	LAD	Barriers caused by lack of knowledge, skills and awareness of the designer (project team).		II			Dependent Barriers	3	B1,B2,B4	3		0	6	B2,B3,B4, B5,B8	5	B7	1	5TH ROW
B5	LSA	Lack of Social Awareness (Sensitivity, Lack of Consciousness Level	III			Driving Barrier		8	B1,B3,B4,B 5, B6,B7,B8	7	B2	1	4	B3,B5,B7, B8	4		0	2ND ROW
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)		II			Dependent Barriers	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2	7TH ROW
B7	SSE	Barriers caused by Social and Sociological Events.	III			Driving Barrier		7	B1,B5,B7	3	B3,B4,B6,B 8	4	4	B5,B7,B8	3	B3	1	4TH ROW
B8	PAI	Barriers Caused by Political and Administrative Issues	III			Driving Barrier		8	B1,B2,B3, B4,B5,B7, B8	7	B6	1	4	B5,B8	2	B3,B7	2	1ST ROW

Figure 24. The prioritization of problem creation and solution flowchart for B8.

Recommendations for B8:

When the findings are analyzed, B8 (PAI) (barriers caused by political and administrative issues) ranks first in the creation and solution of the problem and is the barrier that needs priority intervention to solve the problem.

B8 (PAI) is at level III in the interpretive structural model diagram, which is the most effective barrier in creating and solving the problem. It is one of the three barriers with the highest total number of barriers it affects. It is the barrier least directly affected by other barriers, and it is located in the most effective barriers region in the MICMAC table. These results show that this barrier is the most effective in solving the problem.

The sub-headings of B8 (PAI) should be analyzed first. B8 (PAI), which appears to be the most important barrier in solving the problem in the study, directly and indirectly affects all barriers. Any work performed on B8 (PAI) with this power of influence will affect all barriers.

4.2. B5 Barrier Findings

B5 (LSA) Lack of Social Awareness (Sensitivity, Lack of Consciousness)

- B5 (LSA) is located at level III in the ISM hierarchical scheme, which is the most effective in creating and solving the problem (Figure 19).
- B5 (LSA) directly affects seven barriers, namely B1, B3, B4, B5, B6, B7 and B8. It also indirectly affects barrier B2. It affects eight barriers in total. It is one of the two highest-ranking barriers in terms of the number of barriers it directly affects, and it is also one of the three highest-ranking barriers in terms of the number of barriers it affects overall.

B5 (LSA) is directly affected by four barriers, B3, B5, B7, and B8, and it is indirectly affected by zero barriers, totaling four. B5 (LSA) is directly affected by more barriers than B8 and B3. In terms of the total number of barriers affected, it is one of the four least-affected barriers (Figure 20).

- B5 (LSA) has a driving force score of 8 and a dependence force score of 4 (Table 2). It is located in the fourth region, which is the driving barriers region in the MICMAC table. In the MICMAC table, the fourth region—where the most effective barriers in creating and solving the problem are located—is the driving barriers region and where the barriers that need priority intervention are located (Figure 21).
- B5 (LSA) is located at level III in the hierarchical scheme of the interpretative structural model at the same level as B3 and B7. Therefore, the MICMAC table was analyzed. In the MICMAC table, B5 (LSA) is located in the region of driver barriers with B3 and B7. Then, in order to rank them, the total number of barriers it affects was analyzed. B7 affects seven barriers, but B3 and B5 (LSA) both affect eight barriers. In order to rank B3 and B5 (LSA), the number of barriers directly affected by the barriers was analyzed. The number of barriers directly affected by B3 was six. The number of barriers directly affected by B5 (LSA) was seven, and B5 (LSA) was selected as the second-ranking barrier in creating and solving the problem (Figure 25).

Recommendations for B5:

The barriers included in B5 (LSA), a lack of social awareness (sensitivity, lack of consciousness), rank second in the creation and solution of the problem and need to be addressed second to solve the problem.

B5 (LSA) is ranked as the most effective level, level III, in creating and solving the problem in the interpretive structural model scheme. It is one of the two barriers with the highest number of barriers that it directly affects, and it is one of the three barriers with the highest number of barriers that it directly affects in total. It is the third-ranking barrier in being least directly affected by other barriers. It is one of the four barriers that are least affected in terms of the total number of barriers that it affects, and it is ranked in the most effective barriers region in the MICMAC table. It is one of the four least-affected

barriers in terms of the total number of barriers affected and is located in the most effective barriers region in the MICMAC table. These results show that this barrier is among the most effective barriers to solving the problem.

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)				THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LevelII	Leve II	Leve I	DRIVING BARRIERS (FORTH ZONE)	DEPENDENT BARRIERS (SECOND ZONE)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier		
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count	
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW
B2	DTI	Barriers Caused by Deficiencies in Technical Issues		II			Dependent Barriers	3	B2,B4	2	B1	1	5	B2,B3,B4, B8	4	B5	1	6TH ROW
B3	LR	Barriers Caused by Laws and Regulations.	III			Driving Barrier		8	B1,B2,B3,B 4,B5,B6	6	B7,B8	2	4	B3,B5,B8	3	B7	1	3RD ROW
B4	LAD	Barriers caused by lack of knowledge, skills and awareness of the designer (project team).		II			Dependent Barriers	3	B1,B2,B4	3		0	6	B2,B3,B4, B5,B8	5	B7	1	5TH ROW
B5	LSA	Lack of Social Awareness (Sensitivity, Lack of Consciousness Level	III			Driving Barrier		8	B1,B3,B4,B 5,B6,B7,B8	7	B2	1	4	B3,B5,B7, B8	4		0	2ND ROW
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)		II			Dependent Barriers	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2	7TH ROW
B7	SSE	Barriers caused by Social and Sociological Events.	III			Driving Barrier		7	B1,B5,B7	3	B3,B4,B6,B 8	4	4	B5,B7,B8	3	B3	1	4TH ROW

Figure 25. The prioritization of problem creation and solution flowchart for B5.

The sub-headings of B5 (LSA) should be analyzed second. B5 (LSA), which appears to be the second most important in solving the problem in the study, directly and indirectly affects all barriers, and any work on B5 (LSA) with this power of influence will affect all barriers.

4.3. B3 Barrier Findings

B3 (LR) Barriers Caused by Laws and Regulations.

- B3 (LR) is the most effective barrier in creating and solving the problem and is located at level III in the ISM hierarchical scheme (Figure 19).
- B3 (LR) directly affects six barriers, B1, B2, B3, B4, B5, and B6, and it indirectly affects two barriers, B7 and B8, totaling eight barriers. It is the third highest-ranking barrier in terms of the number of barriers it directly affects. In terms of the total number of barriers it affects, it is one of the three highest barriers.

B3 (LR) is directly affected by three barriers, B3, B5, and B8, and it is indirectly affected by one barrier, B7, totaling four barriers. B3 (LR) is one of the four least-affected barriers in terms of the number of barriers affected in total (Figure 20).

- B3 (LR) has a driving force score of 8 and a dependence force score of 4 (Table 2). It is located in the fourth region, which is the driving barriers region in the MICMAC table as well as where the most effective barriers in creating and solving the problem are located. In addition, it is also the region where the barriers that need priority intervention are located (Figure 21).
- B3 (LR) is located at level III in the hierarchical scheme of the interpretative structural model, which is at the same level as B7. Therefore, the MICMAC scheme was analyzed. In the MICMAC scheme, B3 is located in the region of driving barriers with B7. In order to rank it, the number of barriers it affects in total was analyzed. B7 affects seven barriers, but B3 (LR) affects eight barriers. B3 (LR) was selected as the third-ranking barrier in creating and solving the problem (Figure 26).

Recommendations for B3:

When the findings are evaluated, barriers gathered under the title of B3 (LR), barriers caused by laws and regulations, are the barriers that need to be addressed third to solve the problem.

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)					THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LevelII	Leve II	Leve I	DRIVING BARRIERS (FORTH ZONE)	DEPENDENT BARRIERS (SECOND ZONE)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier		
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count	
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW
B2	DTI	Barriers Caused by Deficiencies in Technical Issues		II			Dependent Barriers	3	B2,B4	2	B1	1	5	B2,B3,B4, B8	4	B5	1	6TH ROW
B3	LR	Barriers Caused by Laws and Regulations.	III			Driving Barrier		8	B1,B2,B3, B4,B5,B6	6	B7,B8	2	4	B3,B5,B8	3	B7	1	3RD ROW
B4	LAD	Barriers caused by lack of knowledge, skills and awareness of the designer (project team).		II			Dependent Barriers	3	B1,B2,B4	3		0	6	B2,B3,B4, B5,B8	5	B7	1	5TH ROW
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)		II			Dependent Barriers	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2	7TH ROW
B7	SSE	Barriers caused by Social and Sociological Events.	III			Driving Barrier		7	B1,B5,B7	3	B3,B4,B6,B 8	4	4	B5,B7,B8	3	B3	1	4TH ROW

Figure 26. The prioritization of problem creation and solution flowchart for B3.

B3 (LR) is ranked at the most effective level, level III, in creating and solving the problem in the interpretive structural model diagram. It is ranked third regarding the number of barriers that it directly affects. It is one of the three barriers with the highest number of barriers it affects. It is the second-ranking barrier in being least directly affected by other barriers. It is one of the four barriers with the lowest total number of barriers it affects. It is also located in the most effective barriers region in the MICMAC table. Overall, these results show that this barrier is one of the most effective barriers to solving the problem.

The sub-headings of B3 (LR) should be analyzed third. B3 (LR), which appears to be the third most important barrier in solving the problem in the study, directly and indirectly affects all barriers, and any work on B3 (LR) with this power of influence will affect all barriers.

4.4. B7 Barrier Findings

B7 (SSE): Barriers Caused by Social and Sociological Events

- B7 (SSE), together with B5, B8, and B3, is located at level III in the ISM hierarchical scheme, which is the most effective in creating and solving the problem (Figure 19).
- B7 (SSE) directly affects three barriers, B1, B5, and B7, and it indirectly affects four barriers, B3, B4, B6, and B8. In total, it affects seven barriers. B7 (SSE) affects one barrier fewer than B5, B8, and B3 in terms of the total number of barriers affected. B7 (SSE) comes after B5, B8, and B3 in terms of the total number of barriers it affects.

B7 (SSE) is directly affected by three barriers, B5, B7, and B8, and it is indirectly affected by one barrier, B3, totaling four barriers. In terms of the number of barriers affected in total, it is one of the four least-affected barriers: B3, B5, B7, and B8 (Figure 20).

- Although B7 (SSE) is located in the fourth region, which is the driving barriers region in the MICMAC scheme, B7 (SSE) has a driving force score of 7 and a dependence force score of 4 (Table 2). It has 1 point less driving force than B8, B3, and B5. In the MICMAC table, the driving barriers region, which is the region where the most effective barriers are located in creating and solving the problem, is where the barriers that need to be addressed first are located (Figure 21).
- B7 (SSE) is located at level III in the hierarchical scheme of the interpretative structural model, and the other barriers are located at levels II and I. Therefore, B7 (SSE) was the fourth-ranking barrier in terms of creating and solving the problem (Figure 27).

Recommendations for B7:

When the findings were evaluated, the barriers gathered under the heading B7 (SSE), barriers caused by social and sociological events, ranked fourth in the creation and solution of the problem and need to be addressed fourth to solve the problem.

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)					THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LevelII	Leve II	Leve I	DRIVING BARRIERS (*FORTH ZONE*)	DEPENDENT BARRIERS (*SECOND ZONE*)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier		
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count	
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW
B2	DTI	Barriers Caused by Deficiencies in Technical Issues		II			Dependent Barriers	3	B2,B4	2	B1	1	5	B2,B3,B4, B8	4	B5	1	6TH ROW
B4	LAD	Barriers caused by lack of knowledge, skills and awareness of the designer (project team).		II			Dependent Barriers	3	B1,B2,B4	3		0	6	B2,B3,B4, B5,B8	5	B7	1	5TH ROW
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)		II			Dependent Barriers	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2	7TH ROW
B7	SSE	Barriers caused by Social and Sociological Events.	III			Driving Barrier		7	B1,B5,B7	3	B3,B4,B6,B 8	4	4	B5,B7,B8	3	B3	1	4TH ROW

Figure 27. Prioritization of problem creation and solution flowchart for B7.

B7 (SSE) is at level III, which is the most effective level in creating and solving the problem in the interpretative structural model scheme. It is the fourth most effective barrier after B8, B3, and B5 in terms of the number of barriers it affects in total. It is also located in the most effective barriers region in the MICMAC scheme. These results show that this barrier is the most effective after B8, B3, and B5 in solving the problem.

The sub-headings of B7 (SSE) should be analyzed fourth. B7 (SSE), which appears to be the fourth most important barrier in solving the problem in the study, directly and indirectly affects seven barriers. Thus, every study on B7 (SSE) with this impact power will affect seven barriers.

4.5. B4 Barrier Findings

B4 (LAD): Barriers caused by a lack of knowledge, skills, and awareness of the designer (project team).

- B4 (LAD), B2, and B6 are at level II in creating and solving the problem in the ISM hierarchical scheme. B4 (LAD) is located at level II after B3, B5, B7, and B8, which are the most effective at level III in creating and solving the problem in the ISM hierarchical scheme. It is one of the three barriers, B4 (LAD), B2, and B6, at level II (Figure 19).
- B4 (LAD) directly affects B1, B2, and B4 (three barriers) and it indirectly affects (-) zero barriers. In total, it affects three barriers. B4 (LAD) directly affects one more barrier than B2 and B6 with three directly affected in total.

B4 (LAD) is directly affected by five barriers, B2, B3, B4, B5, and B8, and it is indirectly affected by one barrier, B7, totaling six (Figure 20).

- B4 (LAD) is located in the second region, which is the dependent barrier region in the MICMAC scheme. The barrier has a driving force score of 3 and a dependency score of 6 (Table 2). In the MICMAC scheme, the second dependent barriers region, which includes barriers dependent on other barriers involved in creating and solving the problem, is where the barriers that need to be solved after the barriers in the driving barriers region are located (Figure 21).
- B4 (LAD) is located at level II in the hierarchical scheme of the interpretative structural model, which is at the same level as B2 and B6. Therefore, the MICMAC scheme was analyzed. In the MICMAC scheme, B4 (LAD) is located in the dependent barriers region with B2 and B6. Then, in order to rank it, the number of barriers it affects in total was analyzed. B6 affects two barriers, but B2 and B4 (LAD) affect three. In order to rank B2 and B4 (LAD), the number of barriers directly affected was analyzed. The number of barriers directly affected by B2 was two, and the number of barriers directly affected by B4 (LAD) was three. Overall, B4 (LAD) was the fifth-ranking barrier in creating and solving the problem (Figure 28).

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)					THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LevelII	Leve II	Leve I	DRIVING BARRIERS (*FORTH ZONE*)	DEPENDENT BARRIERS (*SECOND ZONE*)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier		
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count	
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW
B2	DTI	Barriers Caused by Deficiencies in Technical Issues		II			Dependent Barriers	3	B2,B4	2	B1	1	5	B2,B3,B4, B8	4	B5	1	6TH ROW
B4	LAD	Barriers caused by lack of knowledge, skills and awareness of the designer (project team).		II			Dependent Barriers	3	B1,B2,B4	3		0	6	B2,B3,B4, B5,B8	5	B7	1	5TH ROW
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)		II			Dependent Barriers	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2	7TH ROW

Figure 28. The prioritization of problem creation and solution flowchart for B4.

Recommendations for B4:

- When the findings were evaluated, the barriers included in B4 (LAD), barriers caused by a lack of knowledge, skills, and awareness of the designer (project team), ranked fifth in the creation and solution of the problem and need to be addressed fifth to solve the problem.
- B4 (LAD) is located at level II in the interpretive structural model scheme after the most effective level, level III, in creating and solving the problem. It ranks fifth in terms of the number of barriers it directly affects among the barriers. It is located in the dependent barriers region, which is the region of less effective and more dependent barriers in the MICMAC table. These results show that B4 (LAD) is the most effective barrier after B5, B8, B7, and B3 in solving the problem.
- The sub-headings of B4 (LAD) should be analyzed fifth. B4 (LAD), which appears fifth in solving the problem in the study, directly and indirectly affects three barriers and is affected by six barriers. Any work conducted on B4 (LAD) with this impact power will be effective on only three.

4.6. B2 Barrier Findings

B2 (DTI) Barriers Caused by Deficiencies in Technical Issues

- B2 (DTI) is at level II in creating and solving the problem in the ISM hierarchical scheme with B4 and B6. B2 (DTI) is located at level II after B3, B5, B7, and B8, which are located at level III, and it is one of the three barriers, B2 (DTI), B4, and B6, located at level II (Figure 19).
- B2 (DTI) directly affects B2 and B4 (two) and indirectly affects B1. In total, it affects three barriers. It comes after B5, B8, B7, B3, and B4 in terms of the number of barriers it directly affects. B2 (DTI) affects one barrier more than B6 in terms of the total number affected. This shows that B2 (DTI) is more effective than B6.

B2 (DTI) is directly affected by four barriers, B2, B3, B4, and B8, and it is indirectly affected by one barrier, B5, totaling five barriers (Figure 20).

- B2 (DTI) has a driving force score of 3 and a dependence force score of 5 (Table 2). It is located in the second dependent barriers region in the MICMAC table. In the MICMAC table, the second dependent barriers region, where the barriers dependent on other barriers in creating and solving the problem are located, is home to the barriers that need to be addressed after the barriers in the driving barriers region (Figure 21).
- B2 (DTI) is located at the same level, level II, as B6 in the hierarchical scheme of the interpretative structural model. Therefore, the MICMAC table was analyzed. In the MICMAC table, B2 is located in the dependent barrier's region with B6. Then, in order to rank them, the number of barriers they affected in total was analyzed. B6 affected two barriers, but B2 (DTI) affected three barriers. Thus, B2 (DTI) was the sixth-ranked barrier in creating and solving the problem (Figure 29).

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)					THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LeveIII	Leve II	Leve I	DRIVING BARRIERS (*FORTH ZONE*)	DEPENDENT BARRIERS (*SECOND ZONE*)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier		
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count	
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW
B2	DTI	Barriers Caused by Deficiencies in Technical Issues		II			Dependent Barriers	3	B2,B4	2	B1	1	5	B2,B3,B4, B8	4	B5	1	6TH ROW
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)		II			Dependent Barriers	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2	7TH ROW

Figure 29. Prioritization of problem creation and solution flowchart for B2.

Recommendations for B2:

When the findings are evaluated, barriers included as B2 (DTI), barriers caused by deficiencies in technical issues, are sixth in creating and solving the problem. Thus, it is the sixth barrier that needs to be addressed to solve the problem.

B2 (DTI): The TK barrier is located at level II in creating and solving the problem in the interpretive structural model scheme and in the dependent barrier region, which is the region of less effective and more dependent barriers in the MICMAC table. This means that this barrier is involved in the solution of the problem, along with B8, B5, and B7. This shows they are the most effective barriers after B3 and B4.

The barriers included under B2 (DTI) affect three barriers and are affected by five barriers. Any work conducted on B2 (DTI) with this impact power will be effective on only three barriers.

4.7. B6 Barrier Findings

B6 (EFI) Barriers Caused by Economic and Financial Issues (Incentives)

- B6 (EFI) is located at level II in creating the problem and solution in the ISM hierarchical scheme along with B4 and B2. B6 (EFI) is located at level II after B3, B5, B7, and B8, which are located at the level III, which is the most effective level in creating and solving the problem in the ISM hierarchical scheme (Figure 19).
- B6 (EFI) directly affects two barriers, B1 and B6, and it indirectly affects zero barriers. In total, it affects two barriers. In terms of the number of barriers that it affects directly, it comes after B8, B5, B7, B3, B4, and B2. In terms of the total number of barriers it affects (two), it affects one barrier fewer than B2.

B6 (EFI) is affected directly by three barriers, B3, B5, and B6, and it is indirectly affected by two barriers, B7 and B8, totaling five barriers (Figure 20).

- B6 (EFI) has a driving force score of 2 and a dependency score of 5 (Table 2). It is located in the second dependent barriers region in the MICMAC table. The second dependent barriers region, where the barriers dependent on other barriers in creating and solving the problem in the MICMAC table are located, is home to the barriers that need to be addressed after the barriers in the driving barriers region (Figure 21).
- In the hierarchical scheme of the interpretative structural model, B6 (EFI) is located at level II, and the remaining barriers for ranking are located at level I. Therefore, B6 (EFI) at level II was selected as the seventh-ranking barrier in creating and solving the problem (Figure 30).

Recommendations for B6:

According to the findings, in order to solve the problem, the barriers gathered under the heading B6 (EFI), barriers caused by economic and financial issues (incentives), should be addressed seventh, and the solution to the problem should be started in seventh place.

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)				THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LeveIII	Leve II	Leve I	DRIVING BARRIERS (*FORTH ZONE*)	DEPENDENT BARRIERS (*SECOND ZONE*)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier	
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW
B6	EFI	Barriers caused by Economic, Financial and Issues (Incentives)		II			Dependent Barriers	2	B1,B6	2		0	5	B3,B5,B6	3	B7,B8	2	7TH ROW

Figure 30. Prioritization of problem creation and solution flowchart for B6.

B6 (EFI) is located at level II in the interpretive structural model scheme after level III, which is the most effective in creating and solving the problem. It ranks seventh among the barriers in terms of the number of barriers it directly and indirectly affects. It is located in the dependent barriers region, which is the region of less effective and more dependent barriers in the MICMAC scheme. The facts that B6 (EFI) ranks seventh in terms of the number of barriers it directly and indirectly affects and that it is located in the dependent barriers region, which is the region of less effective and more dependent barriers in the MICMAC table, show that B6 (EFI) is seventh in effectiveness after B5, B8, B7, B3, B4, and B2 in solving the problem.

The barriers included under B6 (EFI), which ranks seventh in solving the problem in the study, affect two barriers and are affected by five barriers. Any work on B6 (EFI) with this impact power will affect only two barriers.

4.8. B1 Barrier Findings

B1 (WSHP) contains barriers caused by the working system of the built-to-sell housing production mode (internal dynamics of housing production).

- B1 (WSHP) is located at level I in the ISM hierarchical scheme of problem creation and problem solving. B1 (WSHP) is the only barrier at level I, the least effective level. It is influenced by the barriers at level III (B3, B5, B7 and B8), which is the most influential level, and by the barriers at level II (B6, B4 and B2). it is the least influential barrier among the barriers (Figure 19).
- B1 (WSHP) affects only one barrier directly and affects zero barriers indirectly, totaling one barrier. In terms of the number of barriers that it affects directly, it ranks after B8, B5, B7, B3, B4, B2, and B6. In terms of the total number of barriers it affects in total, it affects seven barriers fewer than B5, B8, and B3; six barriers fewer than B7; two barriers fewer than B2; and one barrier fewer than B6. B1 (WSHP) is the barrier with the lowest impact power in total.

B1 (WSHP) is directly affected by seven barriers, B1, B3, B4, B5, B6, B7, and B8, and it is indirectly affected by one barrier, B2. In total, it is affected by eight barriers. B1 (WSHP) is affected by all barriers with this feature. It cannot affect any barrier except itself (Figure 20).

- B1 (WSHP) has a driving force score of 1 and a dependency score of 8 (Table 2). It is located in the second dependent barriers region in the MICMAC scheme. In the MICMAC scheme, the second dependent barriers region, which is the region where the barriers dependent on other barriers in creating and solving the problem are located, is home to barriers that need to be addressed after the barriers in the driving barriers region. B1 (WSHP) has fewer driving forces than B6, B4, and B2 in the dependent barriers region and is more dependent on barriers other than these (Figure 21).
- B1 (WSHP) is located at level I in the hierarchical scheme of the interpretative structural model, and it is the only barrier located at this level. Therefore, B1 was the eighth ranking barrier in creating and solving the problem (Figure 31).

BARRIER			ISM Hierarchical Scheme			MICMAC Scheme		←Affected by the Barriers (totally, direct, indirect)					→ Affecting the Barrier (totally, direct, indirect)					THE ORDER OF THE BARRIER IN CREATING THE PROBLEM AND SOLUTION
ICON	ABBREVIATION	BARRIER	LeveIII	Leve II	Leve I	DRIVING BARRIERS (*FORTH ZONE*)	DEPENDENT BARRIERS (*SECOND ZONE*)	Total Affected by the Barriers	Directly Affected by the Barriers		Indirectly Affected by the Barriers		Total affecting the barrier	Directly affecting the barrier		Indirectly affecting the barrier		
									Barriers	Barrier Count	Barriers	Barrier Count		Barriers	Barrier Count	Barriers	Barrier Count	
B1	WSHP	Barriers caused by the working system of the built to sell housing production mode			I		Dependent Barriers	1	B1	1		0	8	B1,B3,B4, B5,B6,B7, B8	7	B2	1	8TH ROW

Figure 31. Prioritization of problem creation and solution flowchart for B1.

Recommendations for B1:

According to the findings, in order to solve the problem, the barriers gathered under the heading of B1 (WSHP), barriers caused by the working system of the built-to-sell housing production mode (internal dynamics of housing production), should be addressed eighth. The solution to the problem should be started in eighth (and last) place.

B1 (WSHP) is ranked at level I in the interpretative structural model scheme as the least effective barrier in creating and solving the problem. The facts that it ranks eighth in terms of the number of barriers that it directly and indirectly affects and that it is located in the dependent barrier's region, which is the less effective and more dependent barriers region in the MICMAC scheme, show that this barrier is the least effective barrier in solving the problem.

The sub-headings of B1 (WSHP) should be analyzed eighth. B1 (WSHP), which appears eighth in the solution to the problem of the study, directly and indirectly affects only one barrier and is affected by eight barriers. Any work on B1 (WSHP) with this impact power will be effective only on itself and will not affect other barriers. However, the work on each of the other barriers will be effective in analyzing B1 (WSHP). These findings show that B8, B3, B5, and B7 at level III and B6, B4, and B2 at level II affect B1 (WSHP) at level I. Further, B1 (WSHP) cannot be overcome without solving the barriers at levels III and II.

5. Conclusions

This study investigated the barriers to the use of solar energy for heating produced with active and passive methods in local housing production in Van City, the hierarchies of the barriers to creating and solving the problem, and the priority of the barriers in solving the problem. The barriers found in the study were categorized under eight headings (Table 1).

The barriers found were included in a three-level ISM hierarchical scheme for creating problems and solutions. In the hierarchical scheme, B8, B5, B7, and B3 are at the most effective level, level III; B4, B2, and B6 are at level II; and B1 is at the least effective level, level I (Figure 19).

The direct and indirect interactions between barriers in creating problems and solutions were tabulated (Figure 2). Among the barriers, the barrier that directly and indirectly affects other barriers the most is B8. The barrier most directly and indirectly affected by other barriers is B1.

The barriers were placed in the MICMAC table according to the number of barriers they affect and are affected by. Overall, B8, B5, B7, and B3 are located in the driving barrier region, and B4, B2, B6, and B1 are located in the dependent barrier region.

When the findings were evaluated, the most effective barrier to the use of solar energy for active and passive heating purposes in the houses produced via the build-to-sell housing production mode is Barrier B8. The second most effective barrier is B7, the third most effective barrier is B5, and the fourth most effective barrier is B3. The fifth most effective barrier is B6, the sixth most effective barrier is B4, and the seventh most effective barrier is B2. The B1 barrier is the least effective and can be mostly solved by solving the other barriers. It is the barrier that only needs intervention in the last stage.

In the study conducted by Yıldız [29] using the survey method in Türkiye, in which the barriers to the use of energy-efficient measures in buildings were investigated, the barrier "contractors' reluctance to use designs and technologies that reduce energy consumption

in buildings" was shown to be the most important barrier. This was also included under the title of B1 in our study. It was the least effective barrier, the barrier that should be addressed last to solve the problem, and it can be solved to a great extent via solving other barriers. The second most important barrier in the study conducted by Yıldız [29] is not giving enough importance to energy-efficient technologies and practices. This barrier was included under B8 in our study. The B8 barrier was shown to be the most effective in creating and solving the problem, and other barriers cannot be solved without solving this barrier. The study conducted by Yıldız [29] parallels ours in terms of local research on barriers to energy-efficient construction.

Sağlam [30] conducted a literature review on the barriers to the construction of zero-energy buildings in Türkiye and showed that there is a climate-specific approach, a lack of knowledge and experience in building zero-energy buildings, and financial and legal barriers. The study conducted by Sağlam [30] and ours are parallel in terms of the barriers found.

In a study conducted by Persson et al. [23] on construction companies in Sweden, the most important barrier to building energy-efficient buildings was the lack of demonstration that low-energy buildings are feasible. However, in our study, this barrier, under B5, was the third most effective. Hakkinen et al. [21] investigated the barriers to sustainable building in Finland and found that the most important barrier is the lack of affordability of sustainable technologies. However, in our study, this barrier, included under B1, was the least effective in creating and solving the problem. The barriers found in the study by Hakkinen et al. [21], such as a lack of end-user awareness and demand, technological deficiencies, and deficiencies in building codes, align with the barriers found in our study.

Camarasa et al. [19] investigated the barriers to the implementation of energy-efficient technologies in residential buildings in eight European Union countries, and Farkas et al. [20] investigated the barriers to the integration of thermal collectors and photovoltaic panels in buildings in 14 European countries. These authors showed that the most effective barrier is economic arguments, but in our study, this barrier, under the heading B6, was the fifth most important of the eight barriers.

Wang et al. [24] showed that a lack of awareness was the most important barrier to the implementation of energy-saving policies in China. However, in our study, this barrier, under the heading B5, was the third most important among the eight barriers.

This study seeks to answer why solar energy is not used to heat houses produced via the build-to-suit housing production mode. Our hypothesis was confirmed, and answers were reached by showing that the barriers to the use of solar energy in houses with active and passive heating are caused by the build-to-suit housing production mode and the actors involved. The barriers were analyzed using the methodological stages shown in Figure 3, the ISM and MICMAC methods, and a method was proposed to prioritize the barriers that pose a problem for the solution of the problem.

As a result, this study reveals the reasons for the insufficient utilization of solar energy as a renewable energy source and is supported by the problems discussed in the literature. Reducing fossil fuel consumption and building houses that require less energy is an important problem today. Considering the energy need and foreign dependency, the problem has more striking consequences. This study has succeeded by using scientific methods to reveal and analyze the problem of the use of solar energy for heating purposes in newly built houses and prioritizing the barriers to solving the problem.

This study is expected to guide future research and serve as a basis for decision makers by revealing the barriers to the use of solar energy for active and passive heating in houses produced via the build-to-suit housing production mode. This research should be repeated for each type of housing production in order to make progress in energy-efficient construction. Each barrier in this study should be studied in detail, and solutions should be produced. In this way, this study provides topics for future research.

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Abbreviations

ISM	Interpretive structural modeling
MICMAC	Cross-Impact Matrix Multiplication Applied to Classification
A	Accessibility cluster
P	Primary cluster
B1 (WSHP)	Barriers caused by the working system of build-to-sell housing production mode
B2 (DTI)	Barriers caused by deficiencies in technical issues
B3 (LR)	Barriers caused by laws and regulations
B4 LAD	Barriers caused by a lack of knowledge, skills, and awareness of the designer
B5 (LSA)	Lack of social awareness
B6 (EFI)	Barriers caused by economic and financial issues
B7 (SSE)	Barriers caused by social and sociological events
B8 (PAI)	Barriers caused by political and administrative issues

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