Transformability in Post-Earthquake Houses in Iran: with Special Focus on Lar City

M. Parva, K. Dola, F. Pour Rahimian

***Abstract*—**Earthquake is considered as one of the most catastrophic disasters in Iran, in terms of both short-term and long-term hazards. Due to the particular financial and time constraints in Iran, quickly constructed post-earthquake houses (PEHs) do not fulfill the minimum requirements to be considered as comfortable dwellings for people. Consequently, people often transform PEHs after they start to reside. However, lack of understanding about process, motivation, and results of housing transformation leads to construction of some houses not suitable for future transformations, hence resulting in eventually demolished or abandoned PEHs. This study investigated housing transformations in a natural bed of post-earthquake Lar. This paper reports results of the conducted survey for comparing normal condition housing transformation with post-earthquake housing transformation in order to reveal the factors that affect post-earthquake housing transformation in Iran. The findings proposed the use of a combination of 'Temporary' and 'Permanent' housing reconstruction models in Iran to provide victims with basic but permanent post-disaster dwellings. It is also suggested that needs for future transformation should be predicted and addressed during early stages of design and development. This study contributes to both research and practice regarding post-earthquake housing reconstruction in Iran by proposing new design approaches and guidelines.

***Keywords*—**Housing transformation, Iran, Lar, post-earthquake housing.

I. Introduction

EARTHQUAKE is one of the most catastrophic disasters the hazards of which are very serious within both short-term and long-term. The aim of post-earthquake housing constructions has always been to mitigate or minimize these hazards. Residential buildings have always been of the highest importance in dealing with earthquakes [1]. In essence, Alexander [2] asserted that previous experiences in the field of human-earthquake interaction can be categorized into two groups: 1) reducing the risks and 2) mitigating the hazards. Baradan [3] argued that although most of previous attempts mitigated the risks, they all failed in addressing people's future needs. In other words, due to the time and fund constraints of planning and constructions in force major post-earthquake circumstances, there is a risk of getting unsatisfactory results in every project [4]. This problem is further magnified in context of Iran due to its particular cultural and financial conditions [5]. Consequently, the occupants of such houses in Iran often try to transform their houses after a short occupancy period. The intention of this transformation is to adjust PEHs for fulfilling minimum life requirements. If anticipated well, the transformation process could convert these 'semi-temporary' shelters into preferable houses for people. In other words, a thoughtful initial design could leverage the latter transformations in term of adapting the semi-impermanent PEHs with residents' needs and lifestyle. Currently, the lack of information, motivation, and completed samples in Iran, usually lead to construction of some houses, which are not suitable for future transformations. Consequently, this makes the residents of such houses eventually demolish (or abandon) their PEHs. This causes various social and economic crises in the future of post-earthquake housing process.

This study investigated the final product of post-earthquake housing transformation in Lar-Iran in order to map the problems of these transformations during a long-term occupancy. This paper reports the findings of the conducted questionnaire survey study in order to investigate three core issues of post-earthquake housing transformations in Iran: 1) the details of post-earthquake housing transformation, 2) peoples' motivations in transforming their PEHs, and 3) the influencing factors on the specifications of post-earthquake housing transformations..

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II. Background of Study

A. Post-Earthquake Housing, Process, Planning and Assessment

Barkat [6] asserted that the success of post-earthquake housing is often dependent on the seven key factors: 1) Safety and security of land; 2) human resources in terms of unskilled and skilled labor, foremen, contractors etc; 3) institutional resources; 4) community resources and capacities; 5) availability of building materials; 6) level of available technology; and 7) financial resources. Baradan [3] categorized these seven factors as technology-based and community-based factors. According to Baradan [3], technology-based factors focus on building material, human resources, and technology whilst community-based factors concentrate on institutional resources and community resources.

Turan [7] discussed two stages of housing reconstruction after disaster: 1) urgent shelters, and 2) permanent houses. During the first short-term stage of reconstruction, usually tents are setup in relief campuses [7]. In the second stage, normal houses are constructed for a long-term inhabit. Cole

[8] developed Turan's classification by identifying two additional stages. The resultant four categories for post-earthquake housing were as follows: 1) emergency sheltering, 2) temporary sheltering, 3) temporary housing, and permanent housing. According to this category, emergency and temporary shelters are occupied during the relief period (for less than one month), temporary houses are occupied during reconstruction period (for less than two years), and permanent houses are formed in order to provide normal life for people. Arsalan developed Cole's [8] category by adding the fifth stage which is called "temporary housing transformation" [9]. This model proposed a method for reusing temporary houses after occupancy. This means that temporary houses are transitional dwellings that, eventually, should be transformed into other kinds of buildings or even completely replaced by new constructions.

From a different point of view, Esin and Cosgun [10] asserted that controlling the constructional wastes could play a very important role in making a post-earthquake reconstruction process successful. In this regard, Arsalan and Cosgun [11] proposed use of some kinds of recyclable and reusable temporary houses in post-earthquake area. They identified two types (passive and active) of after occupancy usage for the post-earthquake temporary houses; in "passive measures", temporary houses are changed into permanent houses or to any other functions until the end of lifetime, whilst in "active measures", temporary houses or their material are sent to another area or stored for case of another disaster. Lizarralde and Root [12] defined two types of 'passive' reuse: 1) when a low-income family uses a temporary house with no additional part, even after construction of permanent houses; 2) residents transform temporary dwellings into permanent houses during occupancy period.

B. Post-Earthquake Housing Problems

The urgent need of shelter for the survivors is the main issue that should be taken into account by governments and public departments [13]. The situation is even worse when there is a shortage of fund and a limited time to help the victims. Temporary houses can partly mitigate this risk [11]. However, the households never feel the sense of ownership and social safety living in this kind of temporary shelters. Consequently, these might cause some social problems in post-earthquake area if used for a long period of time [14]. Long-term post-occupancy problems also could appear when household try to improve their living conditions but the house is not good enough to address their *'new'* needs [14]. This problem is further magnified when the PEHs are constructed by contractors without any contribution from the households [15]. This study posits that long-term problems of post-earthquake area could be minimized by making PEHs capable to be modified based on households' prospective needs.

C. Post-Earthquake Housing Transformation

Transformation in architectural studies refers to changing and modifying building into a better condition during occupancy period. It consists of changing form, function, and pattern of buildings. Mostly, building transformation takes place in residential buildings [16]. According to Shiferaw [17], residential buildings are transformed more efficiently compared to the other forms of buildings. In this process, the houses are adjusted to households' life style [17]. It is often difficult to distinguish housing transformation from some other activities such as housing extension, housing renovation, and housing alteration [18]. Votava [19] defined housing transformation as some indoors and outdoors changes that are based on households' requirements. According to Votava [19], housing transformation process promotes temporary shelters into the permanent homes.

D. Housing Transformation as a Socio-Economical Opportunity

Tipple [20] asserted that housing transformation could contribute to sustainable developments in the urban and rural environments. According to Tipple [20] housing transformation could always contribute to architectural qualities of the houses, so that it could increase households' attachment to their houses and leverage their sense of belonging. Form a different perspective, Habraken [21] argued that housing transformation could develop the quality of housing spaces and adjust social and economic conditions of living spaces. Tipple [20] argued that any improvement in the quality of living environment needs to be done during a long-term and based on the needs, interests and socio-economic status of households. Habraken [21] asserted that studying housing transformations could reveal the households' viewpoint about their life environments which could be developed into lifestyle approaches for designing affordable houses [22]. Al-Naim [23] categorized the socio-economic factors which could affect the housing transformation process as follows:

- factors that are formed by housing supply systems,
- factors that have significant impacts on existing housing resources, e.g. land, infrastructure and construction materials, and
- factors that could save social resources.

E. Types of Housing Transformation

Brand [16] identified two types of housing transformation, namely "add-In" and "add-On". In add-In transformation, the changes are done inside the existing building without constructing any additional space whilst add-On comprises of additional constructions. Consequently, add-On transformation system has the potential to expand the built area of the building [24]. According to Tipple [20], in add-In building transformation, internal walls are capable to be modified based on households' requirements so it gets hold of adjusting indoor spaces into new condition, whilst add-On transformation is done for getting larger indoor spaces.

In another classification of housing transformation, Salama [25] categorized housing transformation into two categories namely exterior and interior transformations. According to Nguluma [26], exterior transformation consists of changing

façade, windows, and housing extensions, whilst, interior transformation refers to modifications of indoor spaces by only relocating internal walls and changing room sizes.

F. Levels of Transformation Housing

Mahmud [27] developed Brand's [16] findings in order to categories housing transformation into four levels: *slight adjustment, addition and division, total conversion,* and *reconstruction*. Latter, Okatay and Orcunoglu [28] added '*Rebuilt'* as one more level, where the houses are changed fundamentally; normally, for transforming courtyard and terrace-houses into apartments.

G. Motivations for Housing Transformation

Rapoport [29] claimed that socio-cultural aspirations are the main motivators for constructing the houses. Shiferaw's [17] developed this model and explained common motivation of housing transformation as: 1) socio-culturally determined aspirations, 2) changes in households' structure, comprising the size and structure of the family, 3) desire to generate income (by modifying the function of housing to a commercial building), 4) reply to harsh climatic conditions, 5) desire to copy prevalent housing forms, 5) new aspiration to change traditional housing forms. Hojrup[30] developed this theory based on lifestyle theories. Salam [22] added the idea of housing motivators and chaining houses to Hojrup's[30] theory, by analysing the impacts of lifestyle models on housing transformation. Salam [22] further analyzed all aforementioned categories of housing transformations based on three lifestyle models: *work-based, attitude-based,* and *status-based.* The common part of all these theories that have never changed was that all of them considered housing transformations as a result of three types of factors: *1) architectural factors, 2) socio-cultural factors,* and *3) economic factors*.

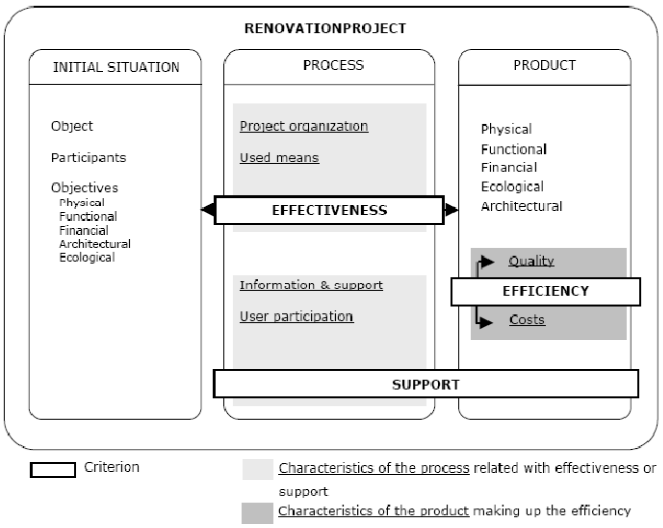

Fig. 1 Housing transformation framework [31]

H. Housing Transformation Process

Housing transformation process determines the actual relationship among initial housing quality, transformation period, and final product (Fig. 1) and the determinant factors during this process could be categorized as: *1) physical, 2)* functional*, 3) financial, 4) architecture,* and *5) ecological factors* [31].

I. Housing Transformation in Iran

Housing transformation is a very common phenomenon in the cities of developing countries [27]. This phenomenon is more highlighted in the countries with free hold residential property ownerships. However, the highest rate of housing transformation is in the countries in which houses is considered as wealth [32]. Notwithstanding the traditional housing transformation system in Iran which was a continual activity controlled by the household size [33], modern housing transformation has become an emerging issue due to the recent huge increase in housing prices [34]. As such, Mirmoghtadaee [35] chronologically categorized housing transformations of Iran into three groups: *traditional, transitional,* and *modern* transformations. According to this model, in the traditional period the changes were very slow and it was controlled by the changes in the size of household. In transitional period, the traditional typology of the houses has been transformed into modern houses. Finally, by influence of economic factors, the modern transformation transforms the traditional courtyard houses into apartments.

The traditional housing transformations in Iran were continuously performed during occupancy period and following the traditional housing patterns of *"Inward-looking"* courtyard houses [33]. In essence, a traditional house in Iran transformed in two stages: 1) first it expanded horizontally around the courtyard, and 2) then the house expanded vertically. As such, in this transformation the original dwellings (initial housing plan) were always preserved. In contrast, through transitional and modern transformations which commenced since 1970s (only in Tehran and the other four other large cities of Iran: *Tabriz, Isfahan, Mashhad,* and *Shiraz)* courtyard houses started to transform into modern houses; and it demolished the initial housing plan of the original doweling. Notwithstanding the risks, the Modern housing transformation in Iran is considered as a predominant policy for leveraging Iranian housing development [36] for addressing the need for 600000 new residential units in Iran [35]. This makes it necessary to take these transformations into account as an indispensable fact of housing in Iran. This paper claims that a well-defined plan for these transformations could significantly mitigate all types of prospective risks resulted by these transformations. Table I compares traditional transformations with the new methods of housing transformations in Iran.

TABLE I
TYPOLOGY OF HOUSING TRANSFORMATION IN IRAN [35]

	Initial housing plan	Process of transformation	Motivation of housing transformation	Final result of housing transformation
Traditional housing transformation	Protect	Continually	Adapting house to household changing	A courtyard houses(based on the Iranian traditional housing)
New housing transformations	Demolish	Suddenly	Getting profits	Residential complex

III. RESEARCH METHODOLOGY

A. Context of the Study, Lar City

Lar city was chosen as the context of this study for three reasons as follows: 1) completing a full lifecycle for PEHs since 1960, 2) similarity between climatic and geographical conditions of Lar and those for high-risk zones of central parts of Iran, and 3) homogeneity in original dwellings in PEHs of Lar city.

1. Typology of Houses in Lar

Of the main characteristic of Lar city is being divided into two parts (Fig. 2) which were founded in different times. While the old part of Lar is a historic area the history of which backs to more than 1000 years ago, the new part has been founded only after the earthquake of 1960 destroyed a main part of the city.

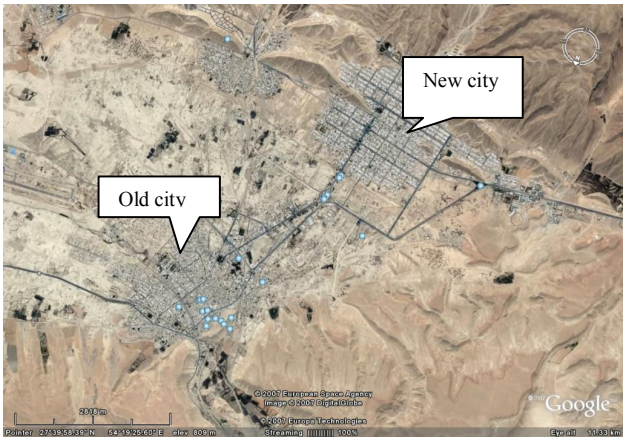

Fig. 2 Airplane view of old city and new city of Lar

In overall, Lar's pre-earthquake houses could be categorized into two different types: 1) pure-residential buildings and 2) residential-commercial buildings. Pure residential per se could be categorized into two different types, namely single-courtyard and multi-courtyard houses. Usually, in Lar's single-courtyard houses which are built in one or two stories, all of spaces are organized around a central courtyard [37]. In the meantime, multi-courtyard houses which are more developed than the first group of the houses, there is a distinction between *"introvert"* and *"extrovert"* courtyards. In such houses, the introvert courtyards are dedicated to service activities, e.g. traditional kitchen (Matbakh), however, extrovert courtyards are surrounded by the spaces which are designed for serving guests or attending strangers [33]. Residential-commercial buildings are located besides the main roads and comprise some shops as well as residential spaces. In some residential-commercial houses which belong to rich merchants, there are also some stores for storing incoming goods.

Fig. 3 Hajj Moayedi's House (1880), Lar, Old Town

Aesthetical values and decorations of interior spaces are the integral parts of Iranian introvert architecture [33]. This claim can be generalized to architecture of all cities of Iran, including Lar (Fig. 3). Besides, due to thermal comfort considerations, white is *de facto* colour (Fig. 4) of the houses in Lar [37].

Fig. 4 Hajj Mahmoudi's House (1880), Lar, Old Town

After the 1960 earthquake (Fig. 5), the government decided to construct a new town near to Lar, rather than reconstruction of the disaster site. There were two main reasons behind this decision: 1) the original city was located on a high-risk zone and 2) it was very difficult to rehabilitate the exhausted old site; consequently, the new city was founded on a land which

was 4km from southern border of the original city (Fig. 6) [38].

Fig. 5 Lar eartquake-1960, Source: Iranian Red Crescent Society

Fig. 6 Post-earthquake housing Lar-1961, Source: Iranian Red Crescent Society

New Lar city comprises of 48 urban blocks including 20 residential lands each. Every residential land is a 15m by 35m rectangle (Fig. 7). During the first phase of this project, the government developed 375 residential units dispersed in all over the city to further motivate people to come and reside there [39]. Initially, the built area of every house was 35 m^2 and the houses were delivered by prefabricated construction system. Due to the particular constructional system of this city, every two houses shared a single structural system (Fig. 8). As it will be discussed in the next sections, this became one of the main barriers of housing transformation in this city [37].

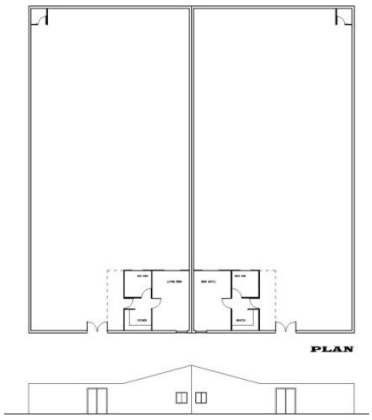

Fig. 7 The floor plan and the elevation of the typical houses in New Lar city

Fig. 8 Twin prefabricated houses in New Lar city

Due to the time and financial constraints in designing and constructing the new city, people faced various post occupancy problems. The main problems which were initially claimed by the people were as follows: 1) the design was not addressing the minimum thermal comfort requirements of the area; 2) the road system was very inconvenient for the users; 3) the city was very far from the original downtown and there was not any substitute facilities in the new city; and 4) the design of the houses was very alien for people of Lar [38]. These problems led to substantial transformations in PEHs in Lar.

2. Housing Transformation in Lar

Lar's houses could be considered as very particular cases due to their very high prices [39]. Average of house prices in 2000 was 1200000000IIR, it was 19% more than average of house price in a similar city in Iran [37]. According to the master plan of Lar [40], Lar has two kinds of housing transformations. While the slow and traditional transformation in old town of Lar follows the changes in the size of households, transformations in the new city of Lar and post-earthquake area has much higher rate and impact. Although this high speed transformation process could be considered as an opportunity for documentation of the experience for future reference, there is no formal study to investigate Lar's housing transformation process [40]. As a result of these arbitrary transformations, the share of built area in residential properties of Lar has recently increased by more than 320%. Although the existing roads are sufficient to support the new population, there are still many problems due to unplanned transformations [38].

Taking into account the aforementioned needs, this study conducted a questionnaire survey in order o investigate people's perceptions towards housing transformations in Lar's PEHs based on four factors: 1) advantages and problems of the PEHs compared to the traditional houses in Lar, 2) advantages and problems of the transformed houses compared to the original PEHs in Lar, 3) people's expectations that are not addressed in PEHs, and 4) motivations of people for transforming their PEHs.

B. Research Variables

The variables of this research could be categorized into two groups: 1) building oriented, and 2) human oriented variables. Building oriented variables which explained housing state before and after transformation were analyzed in three stages: pre-earthquake-1960 housing process, post-earthquake-1960 housing process, and post-transformation housing process. However, the human oriented variables explained the residents' ability to perform housing transformations and their needs for transformations.

Building oriented variables could be categorized as independent and dependent variables. In this research, independent variables which represent some specifications of the buildings are as follows: 1) specifications of PEHs, 2) location of PEHs, 3) specifications of pre-earthquake houses, 4) climatic conditions. On the other hand, the dependent variables of this research are: rate of transformation, time of transformation, morphology of transformation, typology of transformation, pre- and post-earthquake facilities.

Human oriented variables, however, comprise of all socio-cultural and economical parameters of the households. These variables which can be categorized as independent and dependent variables may affect building variables too. The independent human variables of this study are as follows: household size, household's preferences about pre-earthquake house, household income, and households' viewpoint about PEH, pre- and post-earthquake facilities. However, households' perceptions towards the housing transformations are the only dependent human variables of this study. Consequently, the developed questionnaire in this study consisted of nine parts and 68 questions (see Table II).

C. Controlling the Measurement Error, Validation and Reliability

There is a potential of error in every study in which data is collected via questionnaire survey. According to true space theory, true score of a research could be calculated as summation of truth and measurement errors [41]. In below equation, **var*(X)*, var(*T*),** and**var(E_X)** respectively represent observation score, trough ability, and random error.

$$\text{var}(X) = \text{var}(T) + \text{var}(E_X)$$

In space theory, measurement errors comprise of random error and systematic error. Consequently, the equivalent equation could be defined as follows:

$$X = T + Er + Es$$

In true score theory **Er** means Random error and **Es** means systematic error. Therefore, random error and systematic error should be minimized in order to get more accurate result. The random error of the conducted survey was controlled by selecting an appropriate sample size. With regard to the controlling systematic error, three factors can facilitate the reliability of the findings in conducting questionnaire survey: 1) designing clear questionnaire for testing actual perception of people about research constructs, 2) employing different indicators with similar intention and running reliability test among the similar indicators, and 3) conducting pre-test. This research employed native people for adjusting the terms of questionnaires with local terms of Lar. Moreover, some purposive repetitions have been embedded in the questionnaire in order to facilitate future reliability tests. Finally, a pre-test survey was conducted for refining the questionnaire and reconsidering all vague questions. Cronbach's alpha value was calculated for all groups of questions and when the value was less than 0.6, problematic questions were detected and reformatted. Consequently, as reported in different parts of Results and Analysis section, Cronbach's alpha values of all groups of the final test were greater than 0.6; which is the significant level for showing the reliability of questionnaire survey. In addition to considering these factors, this research also relies on the clarifications by trained distributers during the data collection phase. The distributers were architectural students who are quite familiar with this research and PEHs of Lar. This consideration was motivated by low educational background of majority of people of Lar who were not able to read and understand the questions properly. Finally, triangulation among different theories from literature review and findings of survey further assured the construct validity and internal validity of this study (please refer to the discussion section for more details).

TABLEII
SUMMARY OF THE DESIGNED QUESTIONS

	Topic of the section	Number of Subsections	Number of Questions	Purpose
1	Household particulars	-----	8	To identify the characteristics of the household
2	House particulars	-----	4	To identify the specifications of the houses
3	PEH particulars	-----	12	To survey people's perception of PEHs
4	Post-Earthquake Housing transformation particulars	----	9	To survey people's perception of post-transformation houses
5	Influencing factors on the transformation of post-earthquake housing	3	18	To get affirmation of theories derived from literature
6	Motivation of on the transformation of post-earthquake housing	----	7	To get affirmation of theories derived from literature
7	Rate and type of transformation	----	5	To analyse quality and level of the transformations
8	Determine the degree of importance of the following actor/factors in designing PEHs	----	3	To get affirmation of theories derived from literature
9	Respondents will fill this part of questionnaire	----	2	To integrate the results of the questionnaire with findings of the systematic observation

D. Data Analysis Strategies

The collected data through the conducted survey was stored in an SPSS file. SPSS version 17.0 was employed to carry out all the data visualization and hypothesis testing tasks. The employed tests included basic Descriptive Statistics (Mean, Standard Deviations etc), Examination of Reliability Scale, and Hypothesis testing scales (e.g. Correlation Analysis and Regression, Variance Analysis (ANOVA), and Chi square).

IV. Results and Analysis

Overall, 190 questionnaires were distributed among respondent. Following sections describe the results in detail.

A. Determining People's Motivations in Transforming Lar's Post-Earthquake Houses

Fig. 9 provides descriptive overview for people's main 7 motivations in transforming their PEHs in Lar. Based on this result, the most predominant motivations for transformations are *"to adjust physical-living comfort"* and *"Growing household size"*. The results also show that *"Increasing income"* and *"Thermal comfort considerations"* have the least impacts in motivating people.

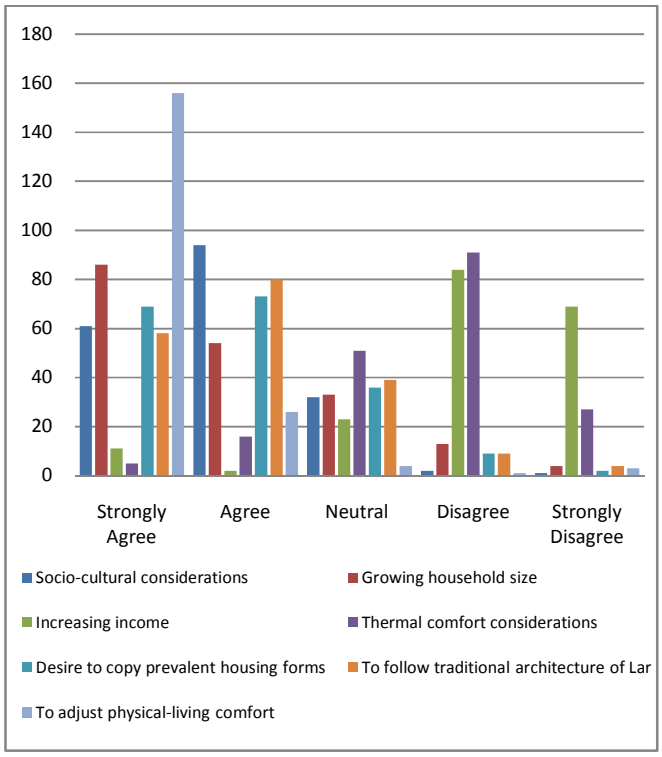

Fig. 9 Descriptive analysis of people's motivations for transforming Lar's PEHs

1) Inferential Statistics for People's Motivations in Transforming PEHs in Lar

This section firstly reports on the results of testing the hypotheses related to people's motivations in transforming PEHs in Lar, then it further justifies the impacts of each factor by conducting factor analysis. Since housing transformations are dependent on motivations for overcoming shortcomings of original dwellings, this paper looks for significant relationships between specifications of initial PEHs and people's motivations for changing them. In other words, the assumption is that the shortcomings of original dwellings motivate the transformations. Therefore, this study tested five related hypotheses:

H1. There is significant relationship between total specification of PEHs and motivation of socio-cultural considerations for transforming PEHs.

H2. There is a significant relationship between location of PEHs and motivations for transforming PEHs in order to increase household's income.

H3. There is a positive significant relationship between growth in household size and increment in people's motivation for transforming their PEHs.

H4. There is a significant positive relationship between inappropriate spatial organizations in PEHs and level of socio-cultural considerations for housing transformations.

H5. There is a significant positive relationship between desire for applying traditional architecture of Lar in PEHs and motivations for housing transformations in Lar's PEHs.

In order to test each hypothesis, this study conducted *"Pearson Product-Moment Coefficient"* for testing relationship between dependent and independent variables. For testing the first hypothesis, the study first investigated the consistency among all independent variables which are PEH specifications. The conducted reliability test revealed that the increment and decrement of the variables related to qualities of PEHs are aligned together (Cronbach's alpha value=.72). Therefore, this study combined all those variables into one single variable so called PEH specifications. The study then conducted Pearson Product-Moment Coefficient Test for testing the relationship between PEH specifications and socio-cultural considerations for transformations (H1). The conducted test confirmed the asserted hypothesis ($r = -.13$, $n = 189$, and $p < .05$). The second hypothesis evaluated the relationship between the location of the houses and emergence of motivations for increasing household's income via housing transformations. In other words, as increasing household's income is possible by converting the function of PEHs from residential into commercial buildings, this is assumed that this tendency is higher in the houses which are located in vicinity of commercial site. The result of the conducted Pearson Product-Moment Coefficient test confirmed this hypothesis ($r = .157$, $n = 189$, and$p < .05$). The third hypothesis of this section asserts that the increment in household size is a stimulus for transformations in PEHs in Lar. The result of the conducted Pearson Product-Moment Coefficient test confirms this hypothesis too ($r = .243$, $n = 189$, and$p < .05$). In a same manner the conducted Pearson Product-Moment Coefficient test confirmed H4 and H5 as well. In other words, the tests revealed the existing significant positive relationship between the levels of people's complains against the inappropriate spatial planning of PEHs and also impacts of socio-cultural considerations in order to transform the PEHs ($r = .124$, $n = 189$, and$p < .05$). The respective test also confirmed that there is a significant positive

relationship between desires to follow vernacular architecture of Lar and increment in motivations for transformations in Lar's PEHs ($r = .238,\ n = 189,\ \text{and} p < .05$).

2) Factor Analysis for Evaluating the Impacts of Each Transformation Motivation

"Linear regression analysis" was conducted in order to determine how much each motivational factor affects the formation of housing transformations in Lar's PEHs. The results revealed that only *"socio-cultural considerations"* significantly affected the formation model of housing transformations. Therefore, this study further traced the impacts of all sub-categories of PEH specifications in forming the category of socio-cultural considerations. Fig. 10 illustrates the impact level of each sub-factor of PEHs specifications in forming transformation motivations. In this diagram, R^2 represents the impact level of each factor. The diagram shows that the impact of PEH specifications on formation of socio-cultural motivations for transformations is 8.5% (R^2=0.084). In other words, 8.5% of model of socio-cultural motivations for transformations is determined by PEH specifications. Based on this result, the most influencing factor in forming PEH specifications is the quality of spatial planning (R^2=0.512) whilst the lowest impact in this formation belongs to the quality of ornamental elements (1%).

Pearson Product-Moment Coefficient test was also conducted among all factors of post and pre earthquake houses and all motivations of transformations. The purpose of this test was to reveal the relationships between housing specifications and motivations for transformations with further details.

Fig. 10 summarizes logical relationships among specifications of post and pre earthquake houses and motivations of transformations comprising of *socio-cultural considerations, to follow traditional architecture of Lar,* and *to adjust physical-living comfort*. Table III reveals that there is a significant relationship between PEHs specifications and 2 of transformation motivations comprising of socio-cultural considerations and thermal comfort considerations. On the other hand, three of motivations including socio-cultural considerations, to follow traditional architecture of Lar, and to adjust physical living comfort are controlled by conditions of pre-earthquake houses.

This study also conducted linear regression test in order to analyze impacts of each of aforementioned factors on forming the motivational model of housing transformations. The results are shown in Fig. 11. According to Fig. 11, the model of motivations for housing transformations is independent from the specifications of PEHs and is only shaped by 4 out of 9 specifications of pre-earthquake houses. In the meantime, the diagram shows that the mentioned 4 characteristics significantly influence the formation of only two motivations namely socio-cultural considerations and to follow Lar's traditional architecture.

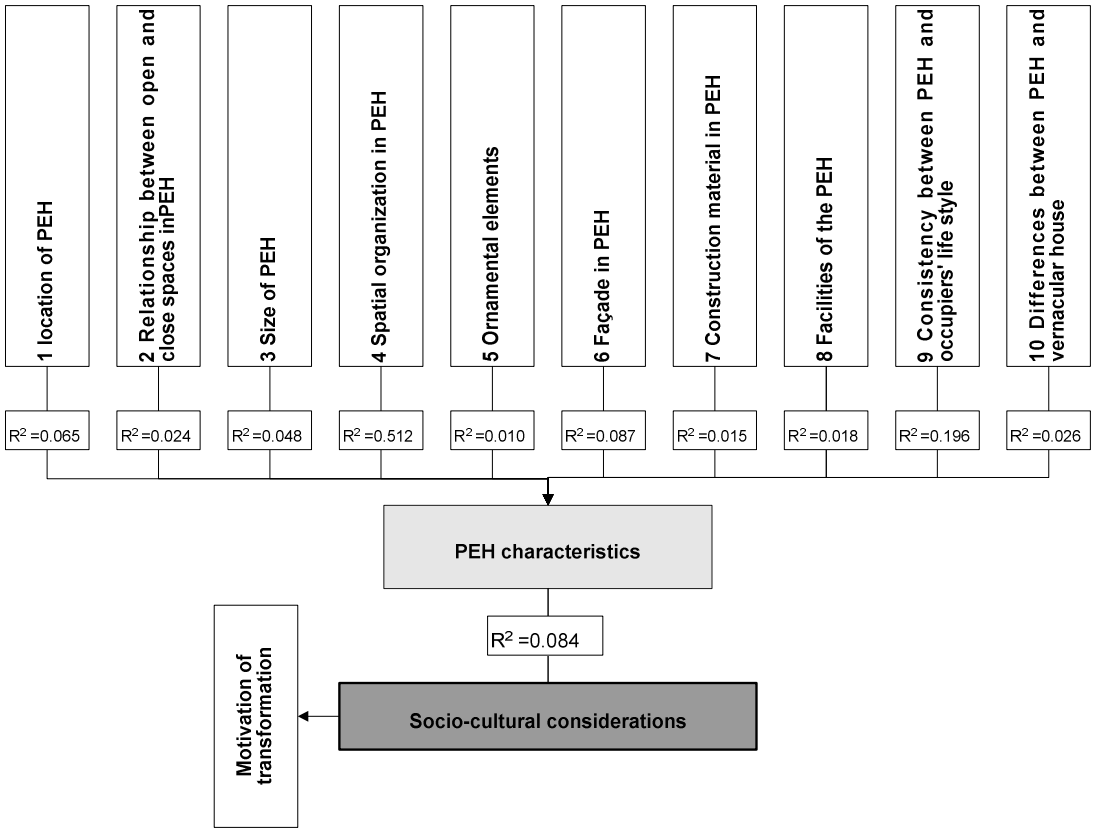

Fig. 10 Analysis of impacts of post-earthquake houses characteristics on emergence of motivations for post-earthquake house transformations

TABLE III
RELATIONSHIPS BETWEEN HOUSING SPECIFICATIONS AND MOTIVATIONS FOR TRANSFORMATIONS IN LAR'SPEHS

		Socio-cultural considerations	Growing household size	Increasing income	Thermal comfort considerations	Desire to copy prevailing house forms	To follow traditional architecture of Lar	To adjusted physical-living comfort
PEH specifications	Pearson Correlation	-.130 (*)	.106	-.018	-.118 (*)	-.033	.047	.042
	Sig. (1-tailed)	0.037	0.074	0.403	0.05	0.329	0.262	0.282
	N	190	190	189	190	189	190	190
Pre-earthquake housing specifications	Pearson Correlation	.250(**)	.055	-.005	.041	.034	.340**)	.178(*)
	Sig. (1-tailed)	0.001	0.227	0.474	0.287	0.325	0.000	0.008
	N	186	186	185	186	185	186	186

* Significant relationship exists between two variables
** Very significant relationship exists between two variables

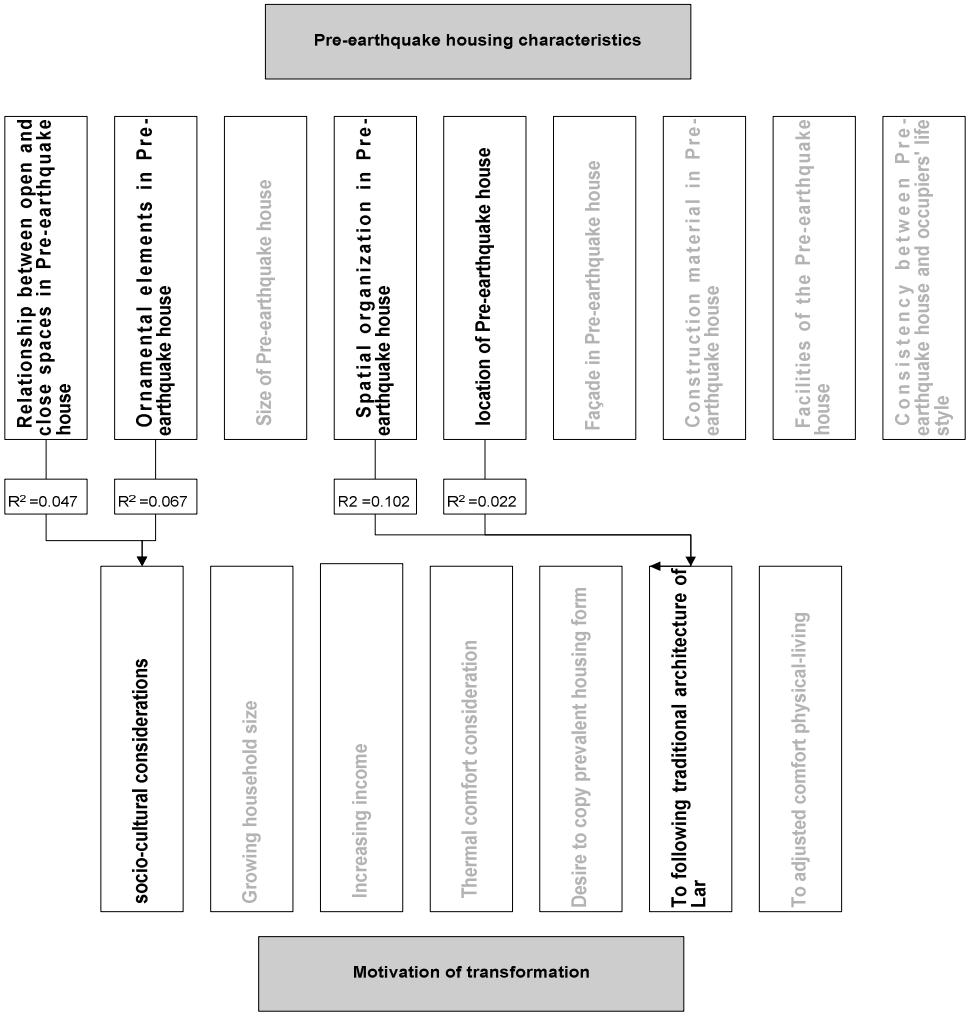

Fig. 11 Analysis of impacts of pre and post-earthquake housing characteristics on forming the motivational model of housing transformations

B. Motivations for Transformations and Their Impacts on Emergence of Housing Transformations in PEHs in Lar

In order to examine the impact degree of each of motivations studied above in performing the transformations in Lar's PEHs, this study conducted a Pearson Product-Moment Coefficient test for tracing the relationships among

the motivations and the appeared transformations. According to the results presented in Table IV, typological transformations are significantly stimulated by socio-cultural considerations and desire to follow the prevailing international housing forms. The results also show that changes in built up are triggered by desires to follow the prevailing international housing forms. However, functional transformations are stimulated by targeting more income and desire to follow traditional architecture of Lar. Finally, the results show that the transformations in materials and facades are caused by desire to copy prevalent housing formsand desire to follow traditional architecture of Lar.

C. Analysis of Influencing Factors on PEH Transformations

In order to analyze housing transformations, this section first explores the architectural specifications of housing transformations then justifies independent variables (factors) which influence these transformations. The studied factors in this section are as follows: 1) tenure form, 2) original dwelling (initial housing plan), 3) financial resources, 4) employable labor, and 5) infrastructure.

The architectural factors that could affect housing transformations are as follows: 1) transformations in morphology, 2) transformations in built up area, 3) transformations in functions, 4) transformations in construction material, and 5) transformations in façades. The conducted reliability test among all these 5 factors reveals that the rate of changes is consistent for all variables (Cronbach's alpha value= .7825). Therefore, the study generated a new variable entitled *"Rate of transformations"* through collating above 5 variables in order to represent the average amount of transformations in PEHs. The study further analyzed the impact of each of these factors on housing transformations by conducting factor analysis. The results of the conducted linear regression test for above mentioned purpose are presented in Fig. 12. It could be concluded from Fig. 12 that the highest impact on forming the model of transformations was made by transformations of built up area (70%). The impact of each of the other 4 factors is also illustrated in this figure.

TABLE IV
RELATIONSHIPS BETWEEN PEOPLE'S MOTIVATIONS FOR TRANSFORMATIONS AND THE HOUSING TRANSFORMATIONS IN LAR

		Socio-cultural considerations	Growing household size	Increasing income	Thermal comfort considerations	Desire to copy prevalent housing forms	To follow traditional architecture of Lar	To adjusted comfort physical-living
Typology	Pearson Correlation	.203(**)	-.015	.029	.070	.207(**)	.010	.113
	Sig. (2-tailed)	.005	.832	.695	.338	.004	.888	.120
	N	189	189	188	189	188	189	189
Built area	Pearson Correlation	.025	.067	-.039	.049	.199(**)	-.080	.103
	Sig. (2-tailed)	.736	.362	.593	.506	.006	.276	.158
	N	189	189	188	189	188	189	189
Function	Pearson Correlation	-.029	-.164	.435(**)	.064	.057	-.150(*)	-.094
	Sig. (2-tailed)	.692	.025	.000	.385	.441	.040	.197
	N	188	188	187	188	187	188	188
Constructional Materials	Pearson Correlation	-.093	.035	-.029	.067	.233(**)	-.168(*)	.048
	Sig. (2-tailed)	.204	.629	.689	.359	.001	.021	.516
	N	189	189	188	189	188	189	189
Façade	Pearson Correlation	-.077	.065	.002	-.021	.281(**)	-.154(*)	.048
	Sig. (2-tailed)	.291	.377	.977	.778	.000	.035	.517
	N	188	188	187	188	187	188	188

* Significant relationship exists between two variables
** Very significant relationship exists between two variables

Although according to the reviewed literature tenure form might affect housing transformation, this study assumed that this impact should be negligible in Lar's PEHs. This is because in Lar's PEHs, majority of houses (94.7%) have the same tenure form which is freehold ownership. The conducted Pearson Product-Moment Coefficient test confirmed this assumption ($r = .013,\ n = 189,$ and$p > .05$).

Consequently, this study posited that housing transformations in Lar's PEHs is independent of the tenure type.

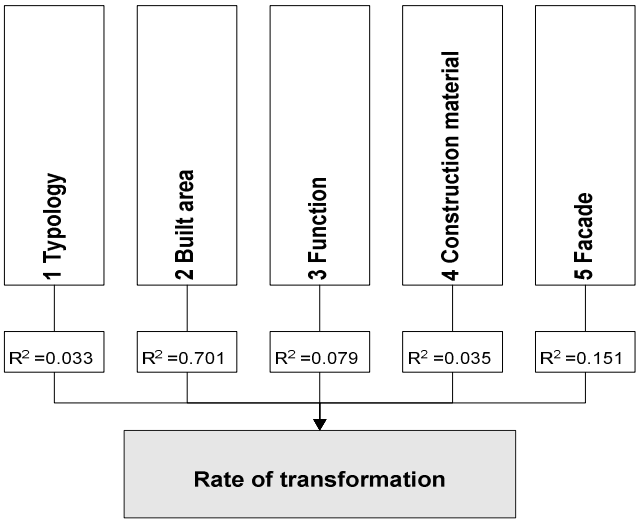

Fig. 12 Analysis of the impacts of influencing factors on housing transformations

The specifications of the original dwellings were detailed in Section 10 of the distributed questionnaire. The specifications covered 1) Location of PEHs, 2) Ratio of open and closespaces in PEHs, 3) Size of PEHs, 4) Spatial organization in PEHs, 5) Ornamental elements in PEHs, 6) Façades of PEHs, 7) Construction material in PEHs, 8) Facilities of the house in PEHs, 9) Consistency between PEH and occupiers' life style, and 10) Differences between PEHs and vernacular houses. This study first evaluated the consistency among above factors. The conducted reliability test confirmed this consistency (Cronbach's alpha value=.721). Therefore, a new variable entitled post-earthquake housing specification has been formed by collapsing the 10 variables listed above. However, based on the results of the conducted Pearson Product-Moment Coefficient test, the study posited that the rate of transformations in PEHs is not determined by average quality of those houses($r = .019,\ n = 189,\ \text{and} p > .05$).

With respect to the impacts of financial resources on the quality and quantity of PEH transformations, this study took two facts into account: 1) Lar's PEHs were initially the only choices of the households; 2) there were various households with different wealth level that initially resided at the similar houses but not necessarily were going to live in the same conditions for ever. The assumption therefore was that the households will transform the houses up to the level that they could afford. The conducted Pearson Product-Moment Coefficient test confirmed that the rate of transformations in PEHs is significantly dependent on the wealth and income level of households($r = .216,\ n = 188,\ \text{and} p < .05$).

All transformations in Lar's PEHs were the result three indicators namely Consultancy services, Local labor, and Local Constructional materials [9], [42]. The conducted preliminary observations revealed that 98.8% of transformations were performed by householders, local workers, or local contractors. Therefore, this study intended to define a new variable entitled "low level facilities" which is a combination of Local labor and Local Constructional materials. Based on the results of the conducted Pearson Product-Moment Coefficient test it could be concluded that the rate of transformations in PEHs is significantly dependent on the availability of low level facilities ($r = .4453,\ n = 189,\ \text{and}\ p < .05$).

This study examined the impacts of infrastructures on Lar's PEH transformations by investigating the influences of six factors: 1) Accessibility of commercial centers, 2) Usability of current roads, 3) Accessibility of public transportation system, 4) Accessibility of governmental offices, 5) Accessibility of public urban facilities, and 6) Accessibility to employment/work. The study combined all these factors of in order to form a new variable entitled *"Infrastructural Factors"*. The conducted Pearson Product-Moment Coefficient test confirmed the rate of transformations in PEHs is significantly dependent on the accessibility of infrastructures($r = .191,\ n = 189,\ \text{and}\ p < .05$).

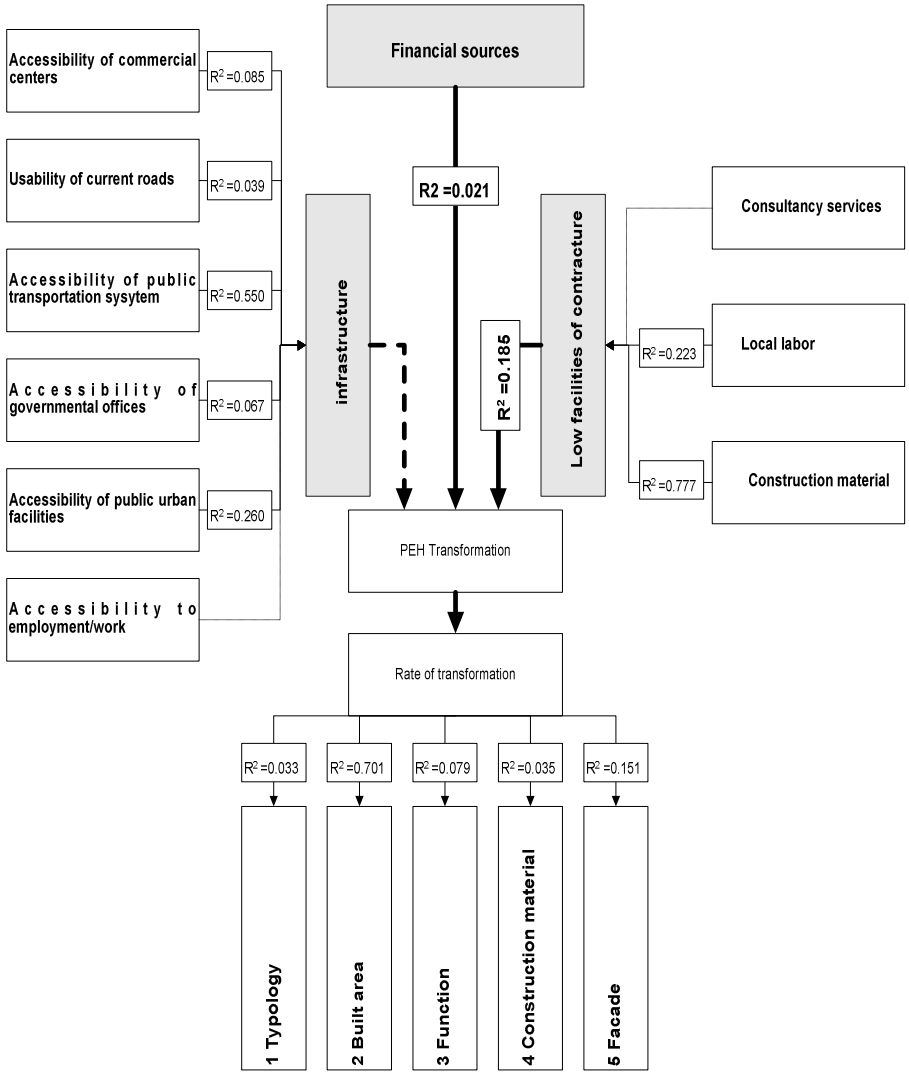

Fig. 13 Impacts of all five influencing factors and their sub-factors on formation of housing transformations in Lar's post-earthquake houses

D. Analysis and Comparison of Impacts of All Influencing Factors on Lar's PEHs Transformations

Fig. 13 illustrates the impacts of all five major influencing factors on Lar's PEHs transformations and their sub-factors on formation of housing transformations in Lar's PEHs. The Figure reveals that 18.5% (R^2=0.185) and 2.1% (R^2=0.021) of model of PEH transformations are respectively determined by facilities of construction and Financial sources. However, the impact of infrastructural factors in forming the model of Lar's PEH transformations is negligible. To conclude, out of these five factors, only three factors have significant impact on forming Lar's PEHs transformations: 1) Household financial resources, 2) Accessibility of infrastructures, and 3) Accessibility of low-level facilities.

V. Discussion

A. Discussion on People's Motivations in Transforming Post-Earthquake Houses in Lar

The strongest motivation for Lar's post-earthquake housing transformations was the willingness to adjust physical-living comfort conditions to most occupants. This is evident from this research that Lar's PEHs were uncomfortable. At the same time, the least important motivation was leveraging natural thermal comfort conditions. Initially, this fact might look somehow odd as Lar is located in arid zone of Iran. However, since currently people in Iran are being subsidized in terms of prices of electricity, they still have no attempt for replacing active thermal conditioning (air condition) systems (Fig. 14) with passive techniques (e.g. wind catcher).

Fig. 14 An instance for the applied electrical active air-conditioning system in Lar

B. Discussion on Influencing Factors on People's Motivations for Transforming Lar's PEHs

The conducted analysis in this study revealed that there is a positive significant relationship ($r = -.13,\ n = 189,$ and $p < .05$) between the development of all transformational factors in Lar's PEHs and people's four major transformational motivations which target socio-cultural considerations, increasing income, growing household size, and rehabilitating the qualities of Lar's traditional architecture. It could be concluded from this finding that changing housing specifications in PEHs will precede socio-cultural considerations. This could counter Alexander [2] and Fallahi's [43] idea that preparing urgent shelter for victims should be the main policy in PEH constructions. In other words, this study claims that since in a developing country like Iran PEHs are considered as semi-permanent residential units rather than mere temporary shelters, socio-cultural considerations must be taken into account just during the initial planning phase in order to prevent serious future problems.

Another important verified hypothesis in study explained the existing significant positive relationship between growth in household size and increase in motivation for PEH developments ($r = .243,\ n = 189,$ and$p < .05$). Indeed, this finding verifies Habraken's [21] idea that any changes in household size definitely will be accompanied by changes in house size. On the other hand, Friedman [44], when mentioning that the majority of housing developments are triggered by household size growths verified this idea. Parva and Dola[45]categorized these types of issue into long-term and short-term developments. They ascertained that short-term developments of Lar's PEHs are due to shortage of the living spaces in initial PEHs, whilst long-term developments follow the normal conditions of growth in household size. This idea also supports previous literature published in this field [e.g., 17, 22, 30].

The other verified hypothesis in this study described the existing significant relationship between spatial organization in PEHs and socio-cultural motivations for transformations ($r = .238,\ n = 189,\ and p < .05$). This hypothesis was initially supported by Kashefy [39] and Alizadeh [42]. They asserted that sudden changes in PEHs may precede many socio-cultural problems for the residents. It also verified Salam's [22] idea that those inconsistencies in pre and post-earthquake lifestyle may trigger motivations for transformations in PEHs. The verified hypothesis here reaffirmed all above theories, and also highlighted the importance of considering socio-cultural issues during PEH design phase.

Finally, the last verified hypothesis in this section explained the significant relationship between comprehensive changes in spatial organization of PEHs and internments in motivations for transformations ($r = .238,\ n = 189,$ and $p < .05$). This study interprets that this was due to people's tendency for following vernacular architecture of Lar which can be considered as an instance of socio-cultural issues.

Finally, it could be concluded that there are three groups of factors intensifying people's motivations for transforming PEHs in Lar. The first group which follows pre-earthquake architecture of Lar comprises of materials, built-up area, and spatial organization between open and closed spaces. The second group which relates to post-earthquake housing specifications explains all shortcomings of PEHs as motivations of transformations. The explained shortcomings are as follows: materials, location of PEHs, and sizes of both land and built-up area. Finally, the third group relates the current prevalent architecture of Lar or neighbor cities which is considered as a motivation for changes in façades and materials.

C. Discussion on the Results of Factor Analysis for Evaluating the Impacts of Each Transformational Motivation

Socio-cultural issues in developing PEHs are frequently supported by the published literature. For instance, Barakat [6] asserted that rehabilitation of socio-cultural qualities should be taken into account in constructing and designing PEHs in the same degree of importance as for rehabilitation of the buildings. Besides, as supported by Comprehensive Plan of Lar [37] improvements in people's attachment to Lar's PEHs after transformation period is another instance of importance of socio-cultural issues. Therefore, this research studied specifications of both conditions of housing in Lar in order to trace the roots of the motivations for transformations. The results also showed that socio-cultural issues are so strong motivations for transforming PEHs. It revealed that more than 8% of transformational motivations is rooted on socio-cultural issues (R^2=.084). This finding verified Kashefy's [39] idea that socio-cultural issues triggered by inconsistencies between pre and PEHs led people towards transforming their PEHs.

On the other hand, the conducted factor analysis revealed that socio-cultural motivations and motivations for following traditional architecture of Lar follow the housing specifications of pre-earthquake houses in Lar. Moreover, among all mentioned motivations, two motivations namely "*adjusting relationship between open and close spaces in pre-earthquake houses* (R^2=0.047)" and "*re-applying ornamental elements of pre-earthquake houses* (R^2=0.067)" are the most important factors in determining the model of socio-cultural motivations. This finding supported Alizadeh's [42] claim that spatial planning and ornamental elements of pre-earthquake

houses play a big role in determining people's expectations of PEHs.

D. Transformational Motivations and the Applied Changes in PEHs

Although people are not necessarily able to apply all the transformations that they desire, there could play a big role in determining the quality of housing transformations. Depending of the five verified hypotheses, this section discusses the impacts of transformational motivations on the quality of the transformations in PEHs.

First of all, it should be noted that the quality of transformations in houses are dependent on the occupiers' perceptions and preferences [44]. Based on the results of this study, every motivation could cause a different transformation in PEHs. The study also revealed that changes in typology, built-up area, constructional materials, and façades are mainly motivated by desire to copy prevalent housing forms. This finding verified Al-Naim [23] and Shiferaw's [17] idea.

Besides, the findings showed that converting function of PEH for improving income is accelerated by location of the houses. The results show that this type of motivation appears only when the houses are located besides the main roads. Moreover, the results of this study explained contrary influences of two motivations namely "*desire to copy prevalent housing forms*" and *"desire to follow traditional architecture of Lar"* on determining quality of constructional materials. In other words, the utilized materials in constructing initial PEHs are adjusted neither with traditional housing of Lar nor with the prevailing architecture of the region [37]. Consequently, the occupiers try to convert the materials into either a traditional or a modern style that they are familiar with; however, as discussed earlier, the utilized alien material in construction of Lar's PEH caused some serious difficulties during housing transformations.

Façade transformations are often guided by the patterns of current prevailing architectural style of the region. However, according to the results of this study, façade changes in Lar were guided by the motivation to follow traditional architecture of Lar as well as motivation to model the prevalent housing style. This was an interesting finding that during early stages of post-earthquake housing, people are attached to their past memories from their previous lifestyle rather than widespread lifestyles of the time being. This paper asserts that this is because of historical value of architecture and culture in central parts of Iran. This finding which explains a socio-psychological aspect of living in PEHs has been ignored in the previous publications. Fig. 15 summarizes the motivations and the applied changes in post-earthquake housing transformation within the context of Lar.

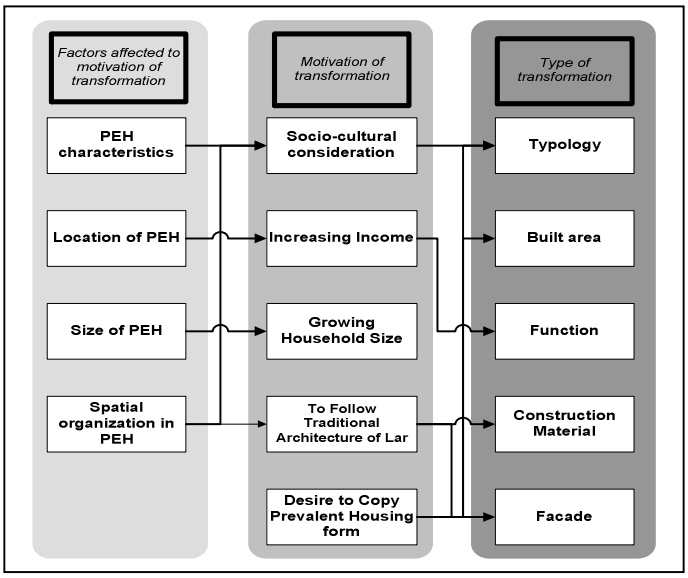

Fig. 15 Motivations and the applied changes in post-earthquake housing transformation

E. Rate of Transformations in Lar's Post-Earthquake Houses and Its Influencing Factors

Rate of transformations in PEHs is dependent of the changes in the architectural specifications of the PEHs. According to Shiferaw [17], this rate of housing transformations in PEHs are dependent on five architectural factors including; morphology, built-up area, functions, construction material, and façades. The results of this study revealed that the most influencing factor in Lar's post-earthquake housing transformations rate comprises of changes in built-up area which determine more than 70% of transformations (R^2=0.701). This finding supports Miromogtadaee's [35] earlier idea that transformations of Iranian houses are dependent on the changes in constructional materials and built-up area only.

F. Discussion on the Impacts of Each Influencing Factors on Transformations of Lar's Post-Earthquake Houses

The influencing factors on housing transformations are as follows: 1) Tenure form, 2) original dwelling (initial housing plan), 3) financial resources, 4) employable labor, and 5) the infrastructures. According to Shiferaw [35], those factors could affect both quality and quantity of the transformations even though Dychtwald [46] asserted that transformations are also dependent on people's creativity in changing their houses. Nevertheless, according to Jha and Barenstein [47], there are some constraints by governments which may affect the transformations of PEHs. Following sections explain those mentioned factors in detail.

1) Influences of Tenure Form on Transformations of PEHs in Lar

Although according to Shiferaw [17] and Portnov and Odish [48] tenure form have a significant impact on the quality of housing transformations, testing h6 in this study did not support the pervious theories ($r = .013$, $n =$

$189, \text{and} p > .05$). In other words, the findings of this study did not provide any strong evidence for revealing the relationship between tenure forms and housing transformations in Lar's PEHs. This paper interprets that this is because of the same tenure form of all PEHs in Lar that is freehold. Therefore, according to the results coming from the selected sample the transformations of Lar's PEHs are independent from tenure forms of them.

2) Impacts of Original Dwelling (Initial Housing Plan) on Housing Transformations

According to Tipple [20] and Makachia [49], transformations of PEH follow the specifications of the original dwellings. This is because of two reasons as follows: 1) limitations of the original dwelling which make the occupants change the conditions and 2) the influence of the specifications of the original dwelling on people's decisions for transformations.

Concerning the limitations, since the original construction only covered a small part of the land, people were able to develop their houses in any way that they desired. On the other hand, sloped roof system of the original dwellings was a constraint to transform the PEHs, as it was not easy to integrate a new part with that type of construction. However, with regards to impacts of original dwelling on determining the quality of the transformations, since Lar's initial PEHs were not acceptable in the beginning their architectural style have never been followed by people during latter transformations. As a result of all above discussions, failure in verification of h7 could be an acceptable finding($r = .019$, $n = 189$, and $p > .05$) even though the hypothesis was initially supported by the previous publications [e.g., 3, 17].

3) The Impacts of Financial Resources on Post-Earthquake Housing Transformation

According to Shiferaw [17] and Dündar [50], financial resources are very important factors in determining the quality of housing transformations. Although in Lar's PEHs all initial financial funds have been provided by the government or NGOs, these were people's capitals which facilitated the latter transformations. Therefore, in asserting H8 the initial assumption was that there is a significant relationship between household income and the level and quality of housing transformations. Indeed, the results supported this hypothesis ($r = .216,\ n = 188,\ \text{and} p < .05$). In other words, the results show how 84.7% of transformations happened from 1980 to 1990 when the economic conditions of the city suddenly improved due to people's emerging trades with UAE's merchants. Fig. 16 and 17 Fig. 17illustrate the differences between transformations of two PEHs belong to the families with different income range.

Fig. 16 A transformed PEH belonging to household with monthly income lesser than USD400

Fig. 17 A transformed PEH belonging to household with monthly income more than USD2300

4) Discussions on the Impacts of Available Technical Facilities and Local Labor on Transformations of PEHs

According to Shiferaw [17], employable labor is one of important factors determining the quality of transformations in PEHs. On the other hand, Friedman [44] asserted that accessibility of technical services can improve adaptability of houses. Since transformations on Lar's PEHs have been done by only consultancy services or local contractors, the results of this study show that transformations of Lar's PEHs are independent from high-level engineering services. In other words, they only depend on availability of consultancy services or local contractors and on local constructional materials ($r = .4453,\ n = 189,\ \text{and}\ p < .05$). Therefore, use of those constructional materials and systems which are available and familiar for local workers and contractors should be taken into account in planning and design of PEHs. The conducted direct observations provided evidence for this claim when it highlights the problems of local workers with the unfamiliar constructional system of roofs applied in Lar's PEHs (Fig. 18 and 19).

Fig. 18 Workers are demolishing some parts of an original PEH due to heterogeneity of local materials and those applied in original PEHs

Fig. 19 Difficulties in attaching new parts to the employed alien roof system in original PEHs

In conclusions, this section has two recommendations for improving latter transformations in PEHs: 1) employing some constructional systems during construction of initial PEHs that are understandable for local workers and 2) training local workers to be more familiar with the applied systems in constructing original PEHs.

5) The Impacts of Infrastructures on Transformations of Lar's PEHs

Verification of h10 reveals the existing significant relationship between the quality of infrastructures and emergence of transformations ($r = .191,\ n = 189,$ and$p < .05$). This confirms Shiferaw [17] and Al-Naim's [23] theory regarding the impacts of infrastructures on housing transformations. However, this research did not detect any evidence for effects of accessibility to employment/work on housing transformations of Lar. Nevertheless, previous works recognized this [e.g., 17, 23] as a highly influencing factor for determining the qualities of housing transformations. One of the reasons could be due to lack of formal employments in New-City of Lar and most of the people still go to the old-town to work. Therefore, the condition is the same for all people and not influencing the process significantly. In conclusions, the study proposes providing higher level of infrastructure than the need of the time being in development of similar PEHs.

G. Discussion on the Results of Analyzing Influencing Factors on Post-Earthquake Housing Transformations

This study explained the existing logical relationship between three influencing factors on the quality of post-earthquake housing transformations, namely infrastructure, local labor and contractor, and financial resources. These are three factors which determine the level of housing transformations. Nevertheless, based on what discussed in this paper, original dwelling and tenure form are two factors which are not significantly affecting housing transformations in Iran even though their importance has been highlighted in previous researches. In other words, the findings of this study show that expediting transformations in Iranian PEHs is dependent on availability of infrastructures, funds, and finally professional and non-professional workers. Table V explains above mentioned factors and their recourses. According to this table transformation in PEHs is a process which starts concurrently with initial planning for those houses and lasts for a long time during occupancy period. In other word, financial sources influences on long-term after occupancy and availability of infrastructure influences on short-term after occupancy.

TABLE V
INFLUENCING FACTORS ON TRANSFORMATION OF PEHS AND THEIR RESOURCES

Factor	Facilitated by	Time to be effective
Availability of Financial resources	Occupiers	In long-term during occupancy period
Availability of Professional and non-professional workers	Training programs conducted by government	After finishing reconstructions
Availability of Infrastructures	Governmental sectors who are in charge of reconstructions	As soon as starting for the occupancy

VI. CONCLUSION

Reconstructed post-earthquake shelters in Iran are usually not suitable due to the limited time and funds. In addition, victims (or residents) usually need to transform initial temporary shelters in order to use them for permanent occupancy purposes. This study introduced new approaches for increasing housing transformability in PEHs in Iran. This study looked at housing transformation as a result of collaboration among government, designers, and occupants. The study posits that leveraging transformability in PEHs could promote temporary houses into permanent homes in post-earthquake area. In other words, the results of this study could contribute towards creating some post-earthquake housing reconstruction policies, which could help the society achieve the following four main objectives:

- To enable occupants to modify PEHs based on their requirements and needs
- To reduce PEHs reconstruction expenditure by designing PEHs for a long-term occupancy so that they are not demolished after occupancy
- To provide the PEH residents with a high quality living area
- To enable the residents for adapting their PEHs based on the changes in household structures

This study proposes that the above objectives must be achieved through three phases: Pre-earthquake phase, Reconstruction phase and Post-occupancy phase

Pre-earthquake phase: (for new houses to be built in high-risk earthquake area)

- Study of vernacular architecture in high-risk earthquake area
- Understanding the household's idea about their house in high-risk earthquake area

Reconstruction phase :(PEHs)

- The design should consider the vernacular architecture in post-earthquake area
- The design should consider the original dwelling (initial housing plan) and can be transformed
- The planning of infrastructure of post-earthquake area should be the ability of initial housing extension

Post-occupancy phase :(for new houses to be built in high-risk earthquake area)

- The municipality should provide law and regulation for transformation of PEHs. (based on defending initial house)
- Training of local labours and contractors for housing transformation
- Occupancy should transform (renovate) their PEHs based on municipalities' regulation.

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