

A STUDY ON A RELATIONSHIP BETWEEN COGNITION OF GREENERY ENVIRONMENT IN RESIDENTIAL AREA AND ENERGY-SAVING LIFESTYLE IN JAPAN

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1. Introduction

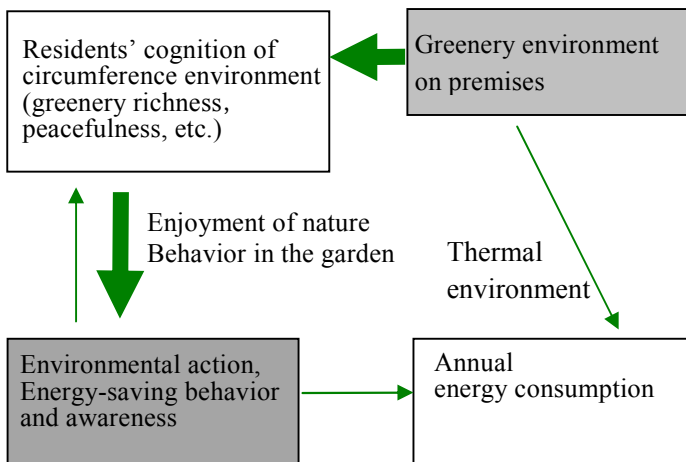
In order to solve the problems of global warming risks and natural resource depletion, it is necessary for people to combine comfort and an energy-saving lifestyle, particularly in residential areas. In Japan, to achieve this, research has focused on the implementation of passive design houses, showing that re-vegetation is an effective passive cooling method [1],[2]. Miyamichi et al. showed the effects of a water-sprinkled green pallet on temperature suppression [3]. Fukuda et al. showed the thermal influence of roof gardening for apartments on the top-most floor [4]. Furthermore, Hoyano et al. and Todo et al. showed the thermal influence of green walls and developed prediction models [5],[6]. There are many findings on the thermal influence of the re-vegetation of houses.

On the other hand, in Japan “greenery” refers not only to plants such as trees and flowers, but also to mountains and forests. People can see the cycle of seasons through the change in greenery, such as fall foliage or fresh leaves, and it holds a major significance for the Japanese on an emotional level. In this reflection of the Japanese background, research on the relationship between greenery and energy-consumption behavior indicates the possibility of greenery also affecting the feeling, awareness, and actions of residents, as well as the environment. Yamamoto et al. indicated that people feel coolness in seeing a green space in summer [7], and Kakuta et al. suggested those who raise greenery in their gardens or rooms are more inclined to save energy for heating [8]. We focused on how residents’ behavior of position changing followed the natural rhythm of the four seasons and day-and-night in their houses [9],[10]. We found out that people with this behavior were more inclined to live in houses with gardens, decks, or roof terraces connected to their living room and were more likely to have more greenery in these spaces. From those results, it was shown that there is a possibility of a

relationship between greenery and residents’ behavior.

In order to analyze the relationship between residents’ energy consumption and greenery, and to achieve both comfort and energy saving in houses, it is necessary to consider the factors of circumference temperature, a resident’s feelings and environmental awareness, and their energy-consumption behavior. Asawa et al. examined the presence or absence of window-opening or air-conditioning actions and how they related to circumference temperature in a greenery-rich environment [11],[12]. They found that living in greenery-rich environments encouraged people to open windows and let air into their houses. We showed that the amount of greenery cognized from the living room window correlated with residents’ energy-saving behavior and annual energy consumption in their houses [13]. However, the extent to which the amount of greenery-richness cognized by residents determines their energy-saving behavior has not yet been analyzed.

This research is aimed at clarifying the effects of greenery environment on energy-saving lifestyle. The relationship between energy-saving lifestyle and factors such as type and amount of greenery on the premises, residents’ cognition of circumference environment, and behavior in their gardens, decks, and roof terraces is investigated from the perspectives of residents’ feelings and awareness. Figure 1 presents the framework of this research. The arrows in the figure indicate a causal relationship. In this research, the results of the analysis on this relationship are indicated by thick arrows. It is shown that the richness of the greenery environment on the premises can influence the residents’ cognition of circumference environment briefly. Similarly, it is shown that their cognition also effects their environmental action, energy-saving behavior, and awareness through



※ In this study, the results of the analysis on the causal relationship are indicated by thick arrows.

Figure1 Framework of this research.

their enjoyment of nature and activities in gardens. It is believed that there are both a direct correlation and an indirect correlation between them. An indirect correlation refers to the effects of the space in which the greenery exists. In this study, we do not distinguish between direct and indirect correlation.

The investigation is outlined in Section 2, and results are presented in Section 3, specifically the respondents' attributes in 3.1. The relationship between the respondent group in greenery-rich residences and energy-saving lifestyle is presented in 3.2. The relationship between residents' energy-saving lifestyle and the characteristics of their surrounding green environment is presented in 3.3 and 3.4, and the relationship between residents' energy-saving lifestyle and their outdoor behavior is presented in 3.5. The frequency that residents experience nature is presented in 3.6. Further, the effects of greenery-richness cognized by residents on their energy-saving lifestyle is presented in 3.7.

2. Investigation

2.1 Investigation method

This study investigated residents' feelings toward their outdoor environment, residents' energy-saving behavior, and the greenery environment of both their previous and current residences. Similarly, it investigated residents' energy consumption. In order to eliminate the confusion regarding the respondents' attributes that have not been included in this study, respondents

Table 1 Investigation summary

Items	Contents	
Period	2010/9/3~24	
Surveyed	Residents living in detached houses built within the previous one to three years in warm urban areas	
Method	Questionnaire on the website	
Effective replies	Questionnaire	482 [rate 10.2%]
	Energy consumption	95

Table 2 Content of the investigation

Questionnaire	
a) Usual behavior	
Energy-saving behavior at home	Cooling & Heating, Bathing, Lightings & Electric appliances, Environmental actions
Air-conditioner, window opening	Frequency of using air-conditioners, opening windows (at previous and present premises)
Behavior in the gardens	Behavior in the gardens, decks, roof terraces Frequency of looking the garden etc.
Behavior reflecting enjoyment of nature	Bell-ringing crickets, sunsets, sunrises etc.
b) Feelings and awareness	
Feeling of the outsides surrounding and belonging to premises	Coolness, Steamy heat, Greenery richness, Season changing etc, (in previous and present residence)
Environment issue & Energy-saving	Awareness of environment issues, Actions toward energy-saving (in previous and present residence)
c) Greenery environment on premises	
Premises	Type of greenery, Ground-covered material outside of living room, Greenery viewing from living room window, Type of abuttal paling etc.
Surrounding Area	Type of greenery within 10 minutes of premises (in previous and present premises)
d) Attributes	
Respondent	Age, Gender, Occupation
Family	Number of family members
House	Floor space, Site areas, Configuration of rooms, etc.
Energy consumption	
Monthly consumption and charges (electricity, gas) in Apr 2010~Mar 2011	

were selected from people living in detached houses of their own in a warm urban area *1). In order to be able to compare houses in which they live now with houses in which they lived before, respondents

needed to have built their houses within the past one to three years.

The investigation was conducted by e-mail, which was titled “Questionnaire on greenery environment.” When respondents clicked the URL they were lead to the questionnaire on our website. The investigation implementation period was from September 3–24, 2010. We received 482 effective replies. Some cooperative respondents were also sent the questionnaire on energy consumption by normal mail (Table 1).

2.2 Items

The questionnaire investigation form comprised the following sections: a) respondents’ usual behavior, b) feelings and awareness of greenery environment, and views on environmental issues and energy saving, c) greenery environment of residence, d) attributes (Table 2). In this form, “greenery” meant not only plants such as trees and flowers, but also mountains and forests. Concrete choices on the form served as indication for respondents on this definition.

3. Results

3.1 Respondents’ attributes

The respondents’ attributes are presented in Fig. 2. Respondents included mostly males in their 30s. Average household size in the detached houses (owned houses) was 3.0 people and average residential floor space was 128m² in the 2005 national census. In contrast, respondent’s average household size was 3.7 people and average residential floor space was 122.1m². Annual energy consumption of the respondents’ family was 75.1GJ (respondents’ number, n = 95) on average*²). In a previous paper [13], annual energy consumption was 83.4GJ. Compared with that, annual energy consumption in this investigation was lower, and this was likely to be related to respondents’ age and residential floor space.

3.2 Greenery richness of residence and energy-saving behavior

(1) Primary focus of this investigation:

In this paper, respondents with energy-saving lifestyles were focused on for analysis. Fig. 3 depicts the relationship between cognized greenery-richness of premises, and the respondents’ actions toward energy saving. Respondents with

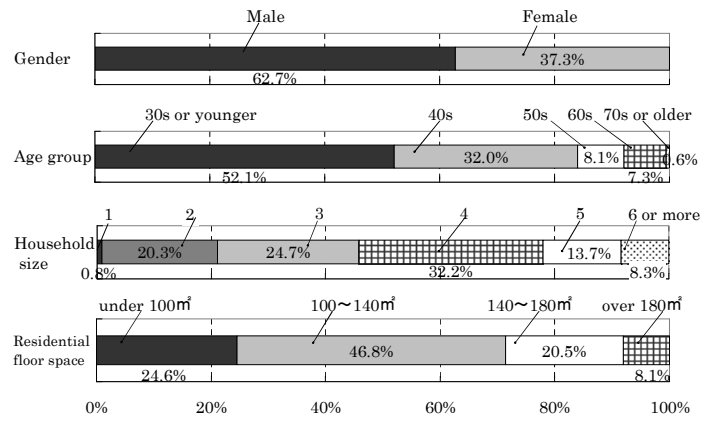


Figure 2 Respondents’ attributes.

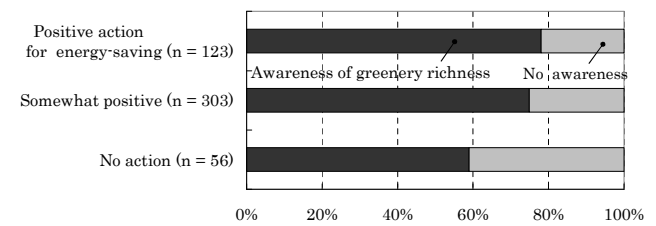


Figure 3 Cognized greenery of premises and residents’ energy-saving actions.

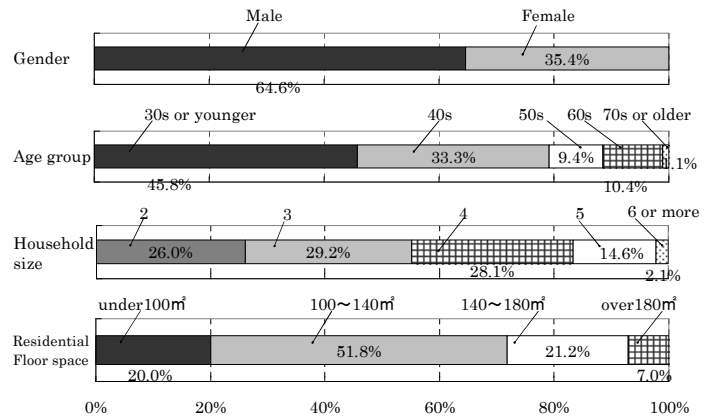


Figure 4 Attributes of “green-rich and energy-saving positive group.”

positive attitudes toward energy saving were more likely to rate their residence as rich in greenery. In the following sections, this group is referred to as the “green-rich and energy-saving positive” group (n = 96).

(2) Attributes of the “green-rich and energy-saving positive” group:

Fig. 4 presents the attributes of the “green-rich and energy-saving positive” group. The attributes of this group are very similar to averaged attributes of all respondents in this investigation (Fig. 2). Average household size was 3.4 people and average residential floor space was 122.9m².

3.3 Energy-saving lifestyle and greenery-viewing rate:

This section presents the amount of greenery on the premises for the “green-rich and energy-saving positive” group.

(1) Residents’ actions toward energy saving and greenery-viewing rate:

Fig. 5 presents the relationship between greenery-richness cognized from the largest window in the living room (referred to as the “greenery-viewing rate” hereafter)^{*3)} and the groups categorized by cognized greenery richness on the premises and residents’ actions towards energy saving. Respondents who cognized their premises as greenery-rich (hereafter referred to as the “green-rich” group) had a higher greenery-viewing rate than respondents who did not (hereafter referred to as the “green-poor” group). The “green-rich and energy-saving positive” group had the largest greenery-viewing rate among them.

(2) Measured greenery-viewing rate:

The greenery-viewing rate shown in the previous figure was the result of respondents answering the questionnaire in view of the largest window in their living room. In addition to this greenery-viewing rate, the measured greenery-viewing rate was used. In order to clarify the relationship, pictures were taken from respondents’ living room window (n = 295)^{*4)} and green pixels were counted and calculated to form the “measured greenery-viewing rate.”

The values of both greenery-viewing rates correspond with each other for 42% of respondents. Fig. 6 shows that the “green-rich and energy-saving positive” group has the largest greenery-viewing rate of all groups, similar to Fig. 5.

The relationship between the greenery-viewing rate of the questionnaire and the measured greenery-viewing rate is presented in Fig. 7. Both correspond at <20.0%. This result was consistent with the results in Figs. 5 and 6, which also correspond at <20.0%.

3.4 Energy-saving lifestyle and features of greenery environment from living room

This subsection shows the features of the greenery environment seen from the living room of the “green-rich and energy-saving positive” group. Fig. 8 indicates the relationship between the type of greenery that residents can see from their living room windows and the groups categorized by the

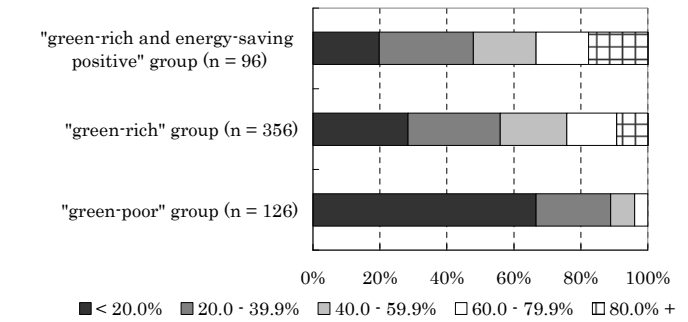


Figure 5 Energy-saving lifestyle and greenery-viewing rate.

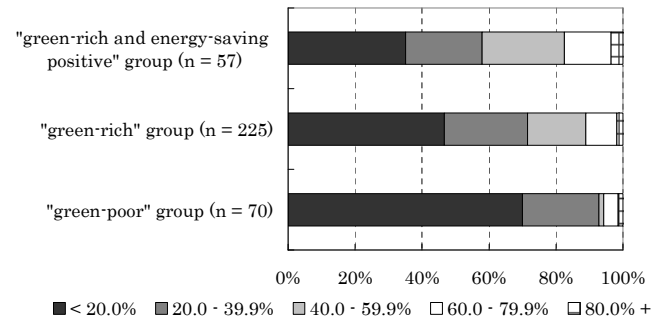


Figure 6 Energy-saving lifestyle and measured greenery-viewing rate.

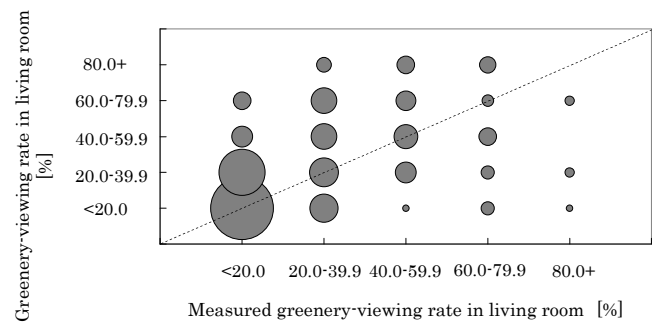


Figure 7 Greenery-viewing rate from living room (answered and measured).

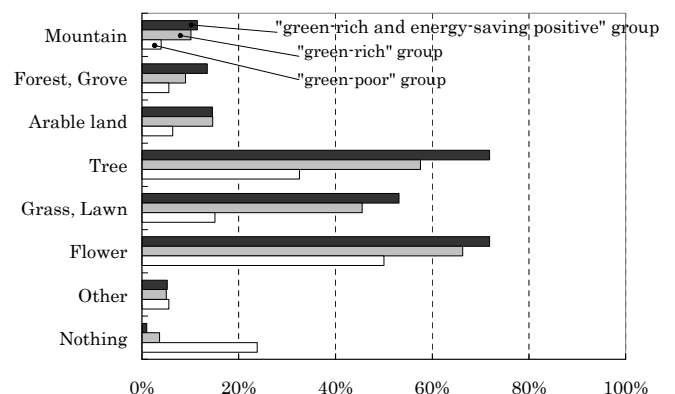


Figure 8 Type of greenery residents can see from their living room windows.

cognized greenery richness of the premises, and residents’ energy-saving actions. Compared with the respondents belonging to the “green-rich” group, the

respondents belonging to the “green-rich and energy-saving positive” group had more of each type of greenery, particularly trees.

Fig. 9 depicts the relationship between the types of greenery of the residence in front of the living room, and the groups are categorized by cognized greenery richness of the premises and the residents’ energy-saving actions. Among the greenery types, trees are subdivided by planting method and height *5). Compared with the respondents belonging to the “green-rich” group, the respondents belonging to the “green-rich and energy-saving positive” group had more of each type of tree and flower; particularly, middle-height trees, lower-height trees, and ground-coverage trees. This signifies that the respondents belonging to the “green-rich and energy-saving positive” group had considerably more than just flowers in front of the living rooms, possibly indicating why their greenery-viewing rate tended to be higher than other groups.

Fig. 10 presents the relationship between the type of material of the ground outside the living room, the groups categorized by cognized greenery richness of the premises, and residents’ energy-saving actions. Compared with the respondents belonging to the “green-rich” group, the respondents belonging to the “green-rich and energy-saving positive” group were more inclined to have “soil, lawn, or underbrush” as the surface outside their living rooms. This was consistent with the result in Fig. 9.

3.5 Energy-saving lifestyle and usual outdoor behavior

This subsection presents usual outdoor behavior of the respondents belonging to the “green-rich and energy-saving positive” group.

(1) Energy-saving lifestyle and behaviors for experiencing nature:

As the Japanese have always enjoyed four seasons, it is natural for them to frequently engage in behavior oriented around experiencing nature. Since the Edo period, people have enjoyed the *mushi-kiki*, or the festival of listening to the sound of bell-ringing crickets, and the *tsuki-mi*, or moon-viewing festival, as annual events [16]. Fig. 11 shows the relationship between the frequency with which the respondents enjoy everyday representatives of nature, the groups categorized by cognized greenery richness of the premises, and

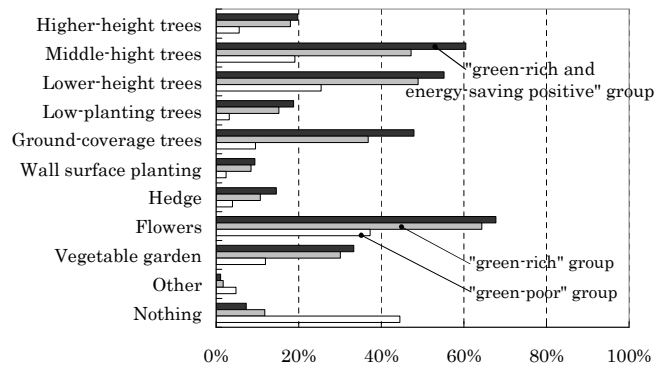


Figure 9 Energy-saving lifestyle and type of greenery of residence in front of living room.

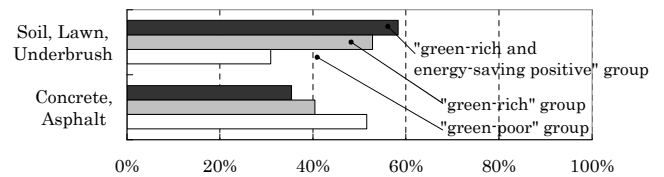


Figure 10 Energy-saving lifestyle and type of material of the ground outside of living room.

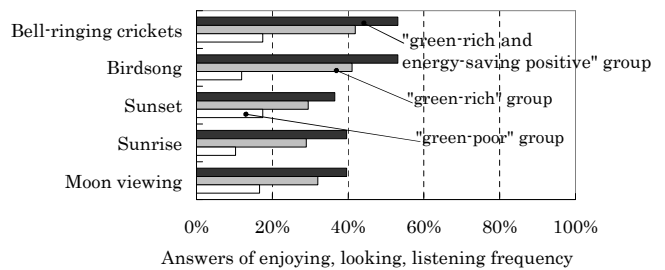


Figure 11 Energy-saving lifestyle and frequency of experiencing nature.

residents’ energy-saving actions. Respondents belonging to the “green-rich and energy-saving positive” group answered that they frequently listened to bell-ringing crickets and birdsong, and enjoyed sunsets, sunrises, and moon viewings. The results suggest that the respondents belonging to the “green-rich and energy-saving positive” group are more aware and more likely to engage in outdoor activities than other groups.

(2) Energy-saving lifestyle and outdoor activities in the garden, deck, and roof terrace:

In order to clarify if the respondents belonging to the “green-rich and energy-saving positive” group did have a greater tendency toward being outdoors, their behavior in their gardens, decks, and roof terraces was also surveyed. Fig. 12 represents the relationship between the frequency of the respondents’ activities in those places, the groups categorized by cognized greenery richness of the

Table 3 Outdoor behavior on premises

Behavior	Numbers of answers	Percentages of "often and sometimes"
a) Taking care of flowers and trees	384	79.7%
b) Eating a meal or snack	143	29.7%
c) Enjoying events like fireworks display	167	34.6%
d) Playing with or taking care of children, grandchildren, or pets	253	52.5%
e) Sitting in the sun	190	39.4%
f) Spending with family or friends	180	37.3%
g) Relaxing	272	56.4%
h) Talking with neighbors	179	37.1%

premises, and residents' energy-saving actions. Table 3 presents the activities in those places depicted in Fig. 12. Respondents of the "green-rich" group performed each activity more frequently than those of the "green-poor" group. Respondents

belonging to the "green-rich and energy-saving positive" group most frequently engaged in a) "taking care of flowers and trees," d) "playing with or taking care of children, grandchildren, and pets," e) "sitting under the sun," and g) "relaxing."

In order to clarify the relationship between the residents' activities in these places and the size of the gardens, Fig. 13 indicates the relationship between the frequency of the respondents' activities in these places, the size of their outdoor areas, and the groups categorized by cognized greenery richness of the premises. Respondents who felt that their premises were greenery-rich more frequently engaged in the activities shown in Fig. 13 despite the distance from their living room to the site boundary. On the other hand, respondents who did not feel that their area was particularly greenery-rich (other) engaged less frequently in these activities, and the longer the distance from their living room to site boundary was, the more frequently they engaged. These results indicate that richness of the greenery on the premises encourages residents' activities regardless of the size of the space in front of the living room.

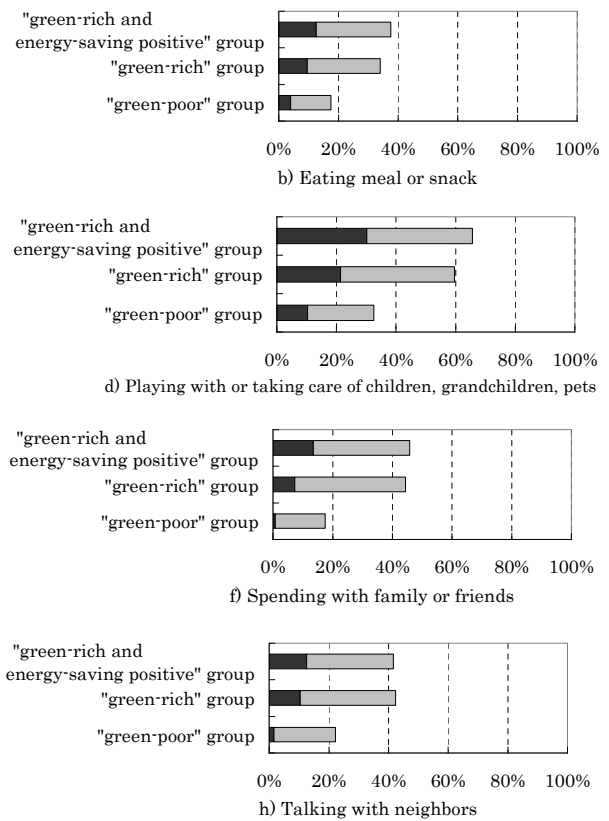
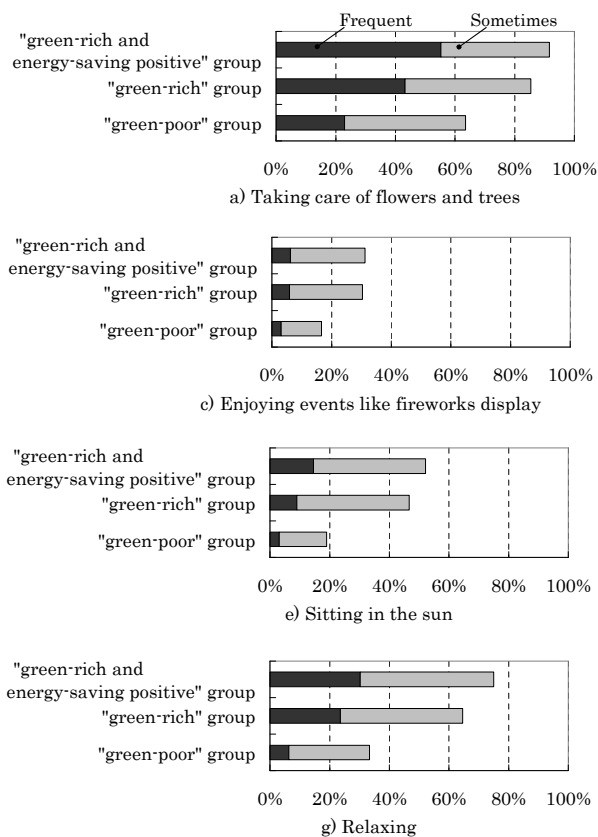


Figure 12 Energy-saving lifestyle and outdoor behavior around residence.

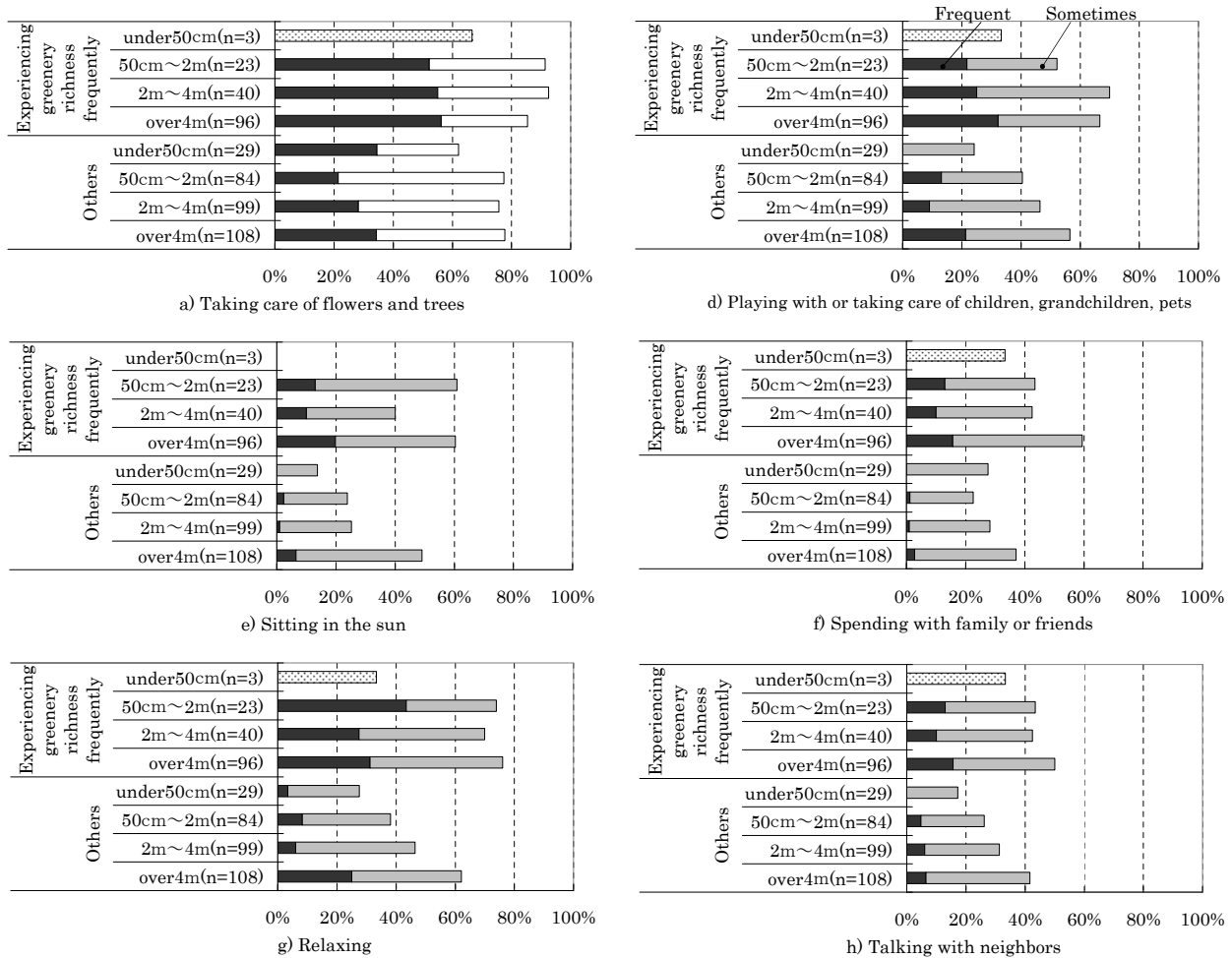


Figure 13 Greenery richness of premises, distance from living room to site boundary, and outdoor behavior around premises.

3.6 Effects of greenery environment on energy-saving lifestyle

In this section, the effects of greenery richness on residents' energy-saving lifestyle are presented.

(1) Analysis of the comparison of previous premises in which residents lived, and present premises:

The respondents were divided by the richness of the greenery cognized in their "previous premises" and their "present premises" shown in Table 4. This analysis was conducted by respondent data, whose "present premises" were different from their "previous premises." It presents whether the differences in greenery richness from the "previous premises" to "present premises" affected residents' behavior and awareness. The amount of increased changes [%] of the residents' behavior and awareness, shown in Table 5, when moving from the "previous premises" to the "present premises" are presented in Fig. 14 and Table 6. The group whose

Table 4 Classification by greenery environment of premises at previous and present premises

Greenery environment of premises			Number of responses	Percent -ages
Previous premises	Present premises	Change category		
Feel richness	Feel richness	rich→rich	93	28.5%
Not feel	Feel richness	poor→rich	145	44.3%
Feel richness	Not feel	poor	89	27.2%
Not feel	Not feel			

"previous premises" were greenery poor but whose "present premises" were greenery-rich (referred to as the "poor --> rich group" hereafter) is compared with the group whose "previous premises" and "present premises" were both greenery-rich (referred to as the "rich --> rich group" hereafter) and the group whose "present premises" are

Table 5 Residents' behavior and awareness

Behavior and awareness	Percentages at present premises			
	Often	Some times	Rarely	Never
A)Frequency of looking at the garden	50.8%	28.7%	14.1%	6.4%
B)Frequency of opening living room windows in summer (Except when rainy)	57.2%	27.2%	11.3%	4.3%
C)Energy-saving action	24.2%	62.7%	11.6%	1.5%
D)Environmental awareness	24.2%	65.4%	9.8%	0.6%

Table 6 Increased percentages of residents' behavior and awareness

Behavior and awareness	Response	Differences of greenery richness of premises from the previous to present premises		
		Rich→rich group	Poor→rich group	Poor group
A)Looking at the garden	Often	34.4% up	55.2% up	5.6% up
B)Opening living room's windows in summer	Often	2.2% up	13.8% up	3.4% down
C)Energy-saving action	Often and Sometimes	23.7% up	39.3% up	30.3% up
D) Environmental awareness	Often and Sometimes	15.1% up	31.0% up	25.8% up

greenery-poor (referred to as the “poor group” hereafter). A) “frequency of looking at the garden,” B) “frequency of opening windows in summer,” C) “energy-saving action,” and D) “environmental awareness” increased the most for the “poor → rich” group. This suggests that the greenery on the premises helped encourage an increase in those behaviors and awareness. The results of 3.4 emphasize that the behavior and awareness in C) “energy-saving action” related to the greenery richness of the outdoor area in front of the living room, which again suggests that the richness of greenery on the premises affect how residents’ react to a more energy-efficient lifestyle.

(2) Covariance Structure Analysis

A covariance structure analysis was conducted in order to clarify the relationship between how residents feel about the greenery richness on their premises, and their “environmental action and energy-saving behavior.”*6) “How residents feel about the outdoor environment of the premises” was used as a latent variable generated from the

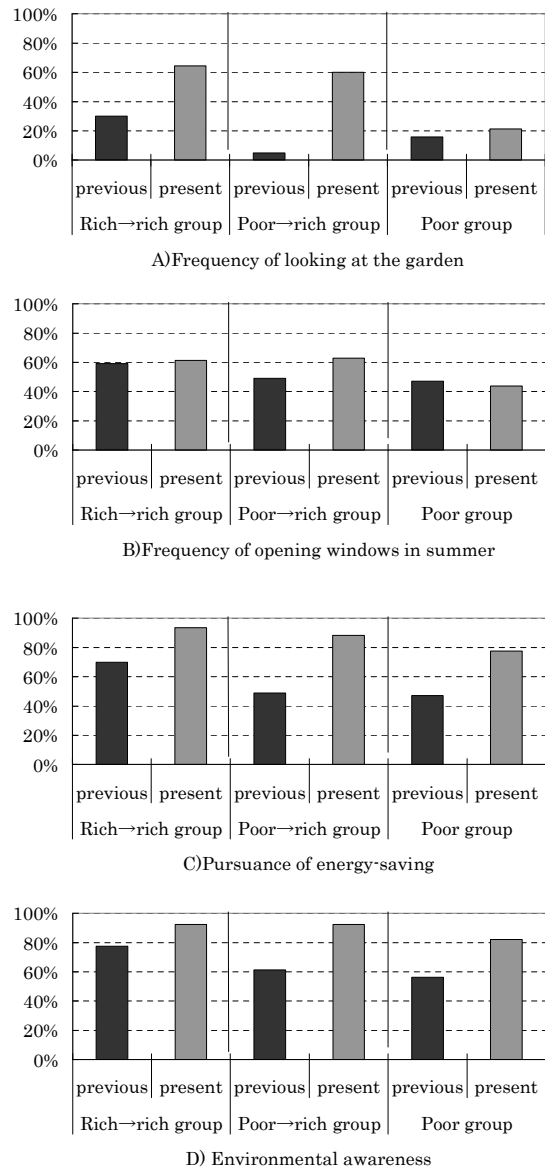
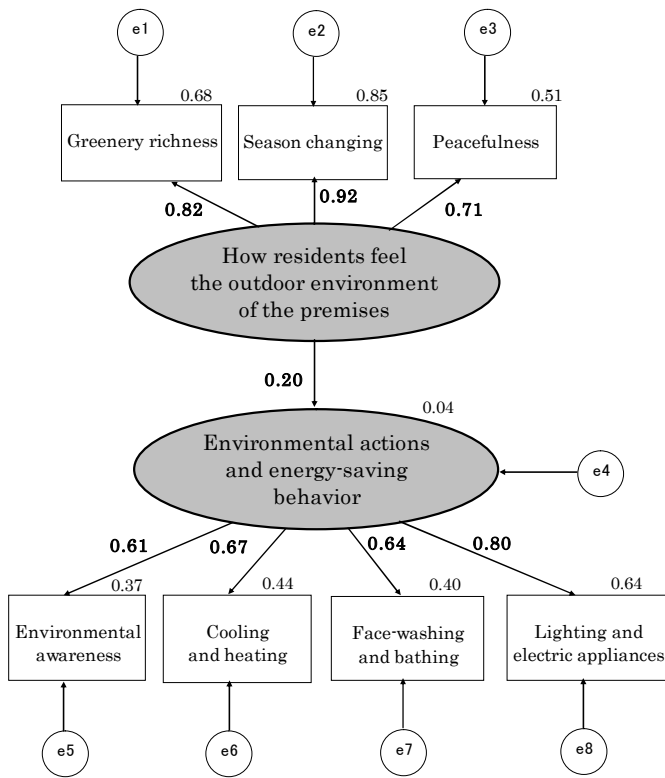


Figure 14 Frequency of behavior and awareness corresponding to greenery richness of premises at previous and present premises.

variables of “greenery richness”, “season changing,” and “peacefulness” and was comprised of a four-item evaluation (often, sometimes, rarely, never). “Environmental actions and energy-saving behavior” was a latent variable generated from 48 actions related to “environmental awareness,” “cooling and heating,” “face washing and bathing,” and “lighting and electrical appliances.” Fig. 15 shows that the standardized coefficient from “how residents feel about the outdoor environment of the premises” to “environmental actions and energy-saving behavior” is 0.20. “How residents feel about the outdoor environment of the premises” determined the extent of “environmental actions



CFI : 0.987 GFI : 0.983 AGFI : 0.964 RMSEA : 0.50

※ Figures in bold represent standardized coefficients. Text on right side of variable is dispersion." e1-e8" are other effects.

Figure 15 CSA of the relationship between "how residents feel outdoor environment of premises" and "energy-saving lifestyle".

and energy-saving behavior" 20% of the time. This indicates that how the residents feel about the outdoor environment of the premises may have some effect on residents' environmental actions and energy-saving behavior.

3. Conclusion

In this study, the investigation was conducted with people living in detached houses of their own in warm urban areas. We analyzed the type and amount of greenery belonging to the premises, residents' cognition of the environment surrounding the houses, residents' behavior in their gardens, decks and roof terraces, and energy-saving behavior. Results showed that cognized richness of the greenery environment on the premises did have some effects on residents' environmental awareness and energy-saving behavior. Specifically, the following conclusions were obtained:

■ In 3.2, the respondents who were positive about energy-saving were more inclined to cognize that their premises were greenery-rich. The respondents who answered that they cognized their premises as greenery-rich and were positive towards energy saving were determined the "green-rich and energy-saving positive" group.

■ In 3.3, respondents who were positive about energy saving, compared to the other respondents, were more inclined to have a large greenery-viewing rate in their living room. The "green-rich and energy-saving positive" group that was the focus group of this study had the largest greenery-viewing rates. Two types of greenery-viewing rates were explained; one was based on respondent's answers from the view of a window, and another was measured from pixel amount in a picture of that same window. The "green-rich and energy-saving positive" group had the highest greenery-viewing rates for both kinds. The percentage of respondents at which both rates correspond was 42%; both greenery-viewing rates corresponded at <20%.

■ In 3.4, the respondents belonging to the "green-rich and energy-saving positive" group were more likely to see more trees from the windows in their living rooms. Their gardens in front of the living rooms had more middle-height trees (single planting, approximately 1.5~3 meters height), lower-height trees (single planting, approximately less than 1.5 meters height) and ground-coverage trees (less than 0.1 meters height) than other groups. They were also more likely to have "soil, lawn, and underbrush" as the ground surfaces outside their living rooms, and this is consistent with the other results.

■ In 3.5, the respondents belonging to the "green-rich and energy-saving positive" group answered that they listened to bell-ringing crickets and birdsong, and enjoyed sunsets, sunrises, and moon viewings more frequently as compared to other groups. They were also more likely to "take care of flowers and trees," "play with or take care of children, grandsons and pets," "sit in the sun" and "relax" in their gardens, decks, and roof terraces. Similarly, residents who cognize their premises as greenery-rich engaged in those behaviors unconcerned with size of the outdoor spaces in front of their living rooms.

■ In 3.6(1), respondents from whose "previous premises" were greenery-poor and whose "present

premises” were greenery-rich engaged in an increased frequency of looking at their gardens, opening windows in summer, and engaging in energy-saving and environmental actions after their move. This indicates that the greenery of the premises partially encouraged an increase in those behaviors and awareness.

■ In 3.6(2), a covariance structure analysis was conducted with the latent variables of “how residents feel about the outdoor environment of the premises” and “environmental actions and energy-saving behavior.” The standardized coefficient from the former to the latter variables was 0.20. This signifies that how the residents feel about the outdoor environment of their premises does have some effects on residents’ environmental actions and energy-saving behavior, if we assume that there is causal relationship between them.

In the future, we will analyze the direct and indirect effects of greenery environment on energy-saving lifestyle. This would be useful for the designing of houses and gardens that achieve both energy-saving and comfort.

References:

- [1] Urano Y: Passive Cooling of Dwellings, Morikita Publishing,1991 in Japanese
- [2] Kodama Y: Nature in Housing, Maruzen, 2008 in Japanese
- [3] Miyamichi S, Otsuka M, Takeda H, Sankai T: Study of Passive Cooling System: Thermal Performance of Roof Planting Using Pallet and Calculation of Mass Transfer Coefficient, Summaries of Technical Papers of Annual Meeting Architectural Institute of Japan D-2, pp.347-348, 2004.7 in Japanese
- [4] Fukuda A, Ogusu Y, Nakamura S, Kato N: Thermal Effect by Roof Garden on Top Floor of Residence Complex, Journal of the Japanese Society of Revegetation Technology, 27(1), pp.209-210, 2001.8 in Japanese
- [5] Hoyano A, Chatani M, Yagi K: Experimental Study on Solar Control by an Ivy Covered Wall, Journal of Architecture, Planning and Environmental Engineering (Transactions of Architectural Institute of Japan), No351, pp.11-19, 1985.5 in Japanese
- [6] Todo K, Ogura D, Hokoi S, Kotani H: Reduction of Thermal Impacts on Indoor and Outdoor Environment by Greening Walls, Journal of Environmental Engineering (Transactions of Architectural Institute of Japan), No631, pp.1109-1116, 2008.9 in Japanese
- [7] Yamamoto S, Masuda N, Shimomura Y, Abe D, Sakata K : Study on the Existing Effects of Green Space in Residential Environment, Journal of the Japanese Institute of Landscape Architects, 56(5), pp259-264, 1993.3 in Japanese
- [8] Kakuta H, Matsubara N, Kurazumi Y, Yamato Y: The Study on the Relationship between Green and the Way of Living in Summer and Winter : Results of the Investigation in Winter, Journal of Kinki affiliate of Architectural Institute of Japan. Environmental Engineering, (41), pp.45-48,2001.5 in Japanese
- [9] Shimokawa M, Ito K: Survey on Passive Lighting, Cooling, Heating Measures and Their Relations to the Ecologically-sound Lifestyle: Part 5. The relationship between ecologically-sound lifestyle and housing space, Summaries of Technical Papers of Annual Meeting Architectural Institute of Japan D-2, pp.465-466, 2009.8 in Japanese
- [10] Ito K, Shimokawa M: Survey on Passive Lighting, Cooling, Heating Measures and Their Relations to the Ecologically-sound Lifestyle: Part 4. Passive Cooling Measure and Exterior Space by the Ecologically-sound Lifestyle, Summaries of Technical Papers of Annual Meeting Architectural Institute of Japan D-2, pp.463-464, 2009.8 in Japanese
- [11] Asawa T, Hoyano A, Takezawa H, Shimizu K: Analysis of the Behavioral Characteristics of Both Window Opening and Air Conditioning Use at Detached Houses: Relationship between outdoor microclimate and residents' living open to outdoor Part 2, Journal of Environmental Engineering (Transactions of Architectural Institute of Japan), No593, pp.87-94, 2005.7 in Japanese
- [12] Asawa T: The Characteristics of Living-style Regarding Window Opening from the View Point of Indoor and Outdoor Microclimates and Resident's Consciousness: Relationship between Outdoor Microclimate and Residents' Living-style Regarding Window Opening Part 3, Journal of Environmental Engineering (Transactions of Architectural Institute of Japan), No623, pp.115-122, 2008.1 in Japanese
- [13] Shimokawa M, Tezuka T: A Study on a Relationship between Cognition of Outdoors Greenery Environment and Energy Consumption of a Residential House: From the Viewpoints of Residents' Behavior for Cooling, Perception of Outdoors Environment and Energy Consumption Style, Journal of Environmental Engineering (Transactions of Architectural Institute of Japan), No662, pp.325-333, 2011.4 in Japanese
- [14] Statics Bureau, Ministry of Internal Affairs and Communications: 2008 Housing and Land Survey, Website of Statics Bureau, <http://www.stat.go.jp/data/jyutaku/2008/index.htm>, (accessed on 2011-9-10)
- [15] Statics Bureau, Ministry of Internal Affairs and Communications: 2010 Population Census, Website of Statics Bureau, <http://www.stat.go.jp/data/kokusei/2005/index.htm>, (accessed on 2011-9-10)
- [16] Sugiura H:Oedo-de-gozaru ~wisdoms of Edo-city desirable to our age~, Wani Books, 2003 in Japanese

Notes:

- *1) Detached houses are in Tokyo, Kanagawa, Chiba, Saitama, Tochigi, Ibaraki, Gunma, Shizuoka, Shiga, Kyoto, Osaka, Hyogo, Nara, and Wakayama and are built by “house maker A” and others.
- *2) The adopted energy conversion factor in this paper is 8.81MJ/kWh for electric power, gross heating value 44.8MJ/m³ for town gas, 110.3MJ/m³N for LPG.
- *3) Respondents were not given instructions on the positions from which they looked out the windows. They answered about the greenery-viewing rate from the most usual position because there were various patterns of space and layouts of furniture in their living rooms.
- *4) Respondents were requested to take pictures from positions that would include all window frames.
- *5) Higher-height trees (single planting, approximately more than 3 meters height), middle-height trees (single planting, about 1.5~3 meters height), lower-height trees (single planting, about less than 1.5 meters height) and ground-coverage trees (less than 0.1 meters height). These were complimented by illustrations.
- *6) CSA (Covariance Structure Analysis) was conducted by using the Amos ver18 software.