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# Economic Value of Urban Landscapes

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## Abstract

To support decision-makings in landscape management and related policies, an objective methodology for evaluating urban landscapes is necessary. In particular, it is anticipated to show the economic value of urban landscapes so that the social benefits of regulations on landscapes can be verified. This paper developed a three-step framework for assessing the economic value of urban landscapes, i.e. conducting standardized landscape survey, extracting critical evaluation factors, and identifying the marginal effect of the factors with a hedonic approach. Using Tokyo and Kitakyushu city data, which are typical of large metropolitan areas and local cities, it was empirically demonstrated that the compatibility of buildings and the greenery of neighborhood are distinctively perceived factors, and in both cities, compatibility and greenery were significant determinants of land prices. Although Tokyo and Kitakyushu city differ in landscape features and many other ways, the economic impacts of urban landscapes were very alike. These results empirically confirmed the usefulness of the three-step approach for evaluating urban landscapes, and because the improvement of compatibility and greenery require for the collaboration of residents, the results, in a general sense, implied the importance of coordination at neighborhood level.



**Keywords:** urban landscape, economic value, compatibility, greenery

## 1. Introduction

In recent years, there is a growing concern for the beauty of urban landscapes. Improving urban landscapes is taken as an effective way for enhancing the competitive ability of cities and a way for revitalizing old dilapidated areas. A variety of public policies have been made to fulfill this purposes, e.g. land use regulations on the height and appearance of buildings, landscape controls on views and advertisement, and designation of conservation areas (Nishimura et al., 2000). An example in Japan is the implementation of 'Landscape Laws' in 2004. The laws provided legal foundation for the protection of the rights of urban landscapes, and through a so-called 'landscape certification' program, human judgments on the comprehensive quality of landscapes were legitimated. It is widely accepted that the above policies have deep influences on urban planning and landscape management. However, in practice, the evaluations of urban landscapes are often mixtures of personal views, and there is still no formal framework of evaluation. For these reasons, the effectiveness of the policies is potentially limited. Therefore, it is of critical significance to establish an objective methodology for evaluating urban landscapes.

In particular, since planning regulations on the heights, shapes, or locations of buildings out of landscape reasons will inevitably limit the development right of land, it is strongly anticipated to clarify the social benefits of regulations and quantitatively show the benefits. This necessitates analyses on the economic values of urban landscape.

So far, quite a few frameworks for landscape evaluation have been raised. For example, Gómez-Sal et al. (2003) proposed to evaluate landscape from ecological, productive, economic, social and cultural perspectives and defined scenarios in comparison with which particular landscape planning or management projects can be evaluated. Prato (2000) proposed to evaluate the sustainability of landscape management plans by considering the biophysical and economic attributes of plans emphasized differently by private and public decision-makers. Angileri and Toccolini

(1993) assessed the visual quality of rural landscapes for which they defined five aspects in landscape perceptions, i.e. relief, vegetation, density of built-up areas, size of cultivated fields and presence of character elements such as hedgerows or small woods. Based on field survey, they drew landscape evaluation maps for study areas. These works strongly suggest that empirical studies are indispensable in landscape evaluations.

In the literature, a big variety of approaches were employed in empirical works, for example, evaluations for the physical space and compositions of specific historical sites (Carter and Bramley, 2002; Coeterier, 2002; Lichfield, 1988), evaluations of urban landscapes with semantic differential technique in terms of human perceptions (Garcia-Mira et al., 1997; Green, 1999; Imamoglu, 2000), evaluations for the quality of design with respect to physical criteria of landscape (Fukahori and Kubota, 2003; İpekoğlu, 2006), and so on. In addition, some addressed the economic values of landscapes, for example, with psychological experiment (Fukahori and Kubota, 2003), contingent valuation method (Willis and Garrod, 1993), etc. Methodologically speaking, the above approaches have been well established.

However, although these approaches allow for evaluations from specific aspects, it is not easy to use these methods to comprehensively evaluate urban landscapes, and the results are sometimes not easy for understanding. On the other hand, widely used methodologies for evaluating the economic impact of environmental goods such as hedonic approach was rarely used in the present literature of urban landscape.

In this paper, we attempt to bridge this gap. The main concern of this study is twofold. The first is to identify evaluating structure of urban landscape, and to empirically investigate whether the values of urban landscape are reflected by land market. This requires for a framework for objectively measuring the ‘beauty’ of urban space, as well as an analytical framework for associating the perceptions for physical environments with economic values. The second concern relates to the generalization of the evaluation method. Since the perception of urban landscape is likely to differ among cities, districts, and individuals with different preferences, to what degree a methodology is valid and applicable is a critical issue. Through this work, we want to establish an empirical approach for assessing urban landscape.

We selected Tokyo and Kitakyushu city for investigation, which are typical of large metropolitan areas and local central cities, respectively. The two cities have well-managed data on planning and urban environment, most of which are integrated with GIS.

A sample of residential sites was chosen in each city. We conducted standardized surveys on the landscape of these areas, i.e. in the survey subjective factors that may lead to diverse results were controlled as much as possible. Upon analysis, it was identified that compatibility and greenery are most distinctively perceived factors in urban landscapes, and in addition, they are significant determinants of residential land prices. Comparison analysis of the Tokyo and Kitakyushu samples revealed that their evaluation structures are quite alike, though the two cities have very different geographical and social economic conditions. This strongly suggests the objectivity and usefulness of the developed method for assessing urban landscapes.

## 2. Methodology

A three-step approach was developed.

First, design a framework, by which one can qualitatively catch the physical characteristics of urban landscapes, and then survey on sample sites and their surrounding areas to collect objective data.

Second, extract critical factors for landscape evaluation by employing principal component analysis (PCA).

Lastly, adopt a hedonic approach to examine if the principal characteristics of urban landscape are critical determinants of land prices.

### 2.1 Sample and data

In Tokyo, the sample sites were drawn from 1996-97 issues of *Weekly Housing Information*, which provided information on a large amount of houses and lands for sale. The sample was limited to transacted vacant land properties in western part of the 23 wards of Tokyo. The study area covers nine wards (Suginami, Nerima, Shinjuku, Shibuya, Nakano, Setagaya, Meguro, Ota, and Shinagawa). We chose only a part of Tokyo for the convenience of survey, and because transacted sites were relatively densely distributed in this area. In addition, the sample sites were confined to land use zones designated mainly for residential use. The size of sample with complete data is 272. Among them, 203 sites are in low-story residential zones, 37 in high-medium residential zones and 32 in residential zones.

The sample in Kitakyushu city was drawn from an administration survey database for 1333 properties purchased in fiscal year 2003. Similar criteria were used as that in Tokyo, which yielded a sample of 187 vacant sites distributed across the whole city. The proportion of samples in low-story residential zones, high-medium residential zones and residential zones is approximately 2:1:2.

The databases for the two samples were carefully constructed. First, both include the price of the sites. For the Tokyo sample, *Weekly Housing Information* provided the final list prices of each. The administration survey data of Kitakyushu city provided the prices given by purchasers in questionnaire. Since they are not real prices, the accuracy is a bit low, but we assumed that they were close to real prices. Besides, the data on the Tokyo sample from the database of Gao et al. (2005) was used. They included detailed information on sample lots such as sizes, shapes, the width and direction of front roads, locations and accessibility to public transportation, a variety of neighborhood environmental attributes, as well as land use and social economic indices of *chome* (i.e., district) such as building density, gross floor-area-ratio, population density, proportion of wooden-made structures, and so on. For Kitakyushu city, the living environment data provided by Kitakyushu city, including the ratings on 18 aspects of living environment of 1488 *chomes*, were used in addition to the administrative survey data.

A list of the above data can be found in Appendix 1.

## 2.2 Landscape survey

Table 1 shows the landscape survey sheet. With regard to the content, we learned from Arai (2001), which proposed to evaluate urban landscape from three aspects: neighborhood scene, street scene and planning activities (e.g. public involvement in local affairs and the implementation of 'district planning' and covenant).

In this survey, we focused more on evaluations of neighborhoods and streets, with specific interest on the physical aspect of urban environment and for which data are easy to be collected by observation. Along this line, we designed an 11-factor evaluation system shown in Table 1. The factors beginning with 'A' are indicators of neighborhoods and those with 'B' are indicators of streets. Furthermore, each factor has several specific items, each rated with points (+1, 0, -1, etc.). The indices of the 11 factors were aggregated from the points.

**Table 1** Factors for evaluating urban landscape

| Factors | Items | Point |
|---|---|---|
| A1 Continuity of external walls (+1, 0, -1) | Continuous | +1 |
| | Average level | 0 |
| | Not continuous | -1 |
| A2 Conformity in colors and materials (+1, 0, -1) | Harmonious | +1 |
| | Average level | 0 |
| | not harmonious | -1 |
| A3 Compatibility of buildings styles (+1, 0, -1) | Sharing common features | +1 |
| | Average level | 0 |
| | Little common features | -1 |
| A4 Beauty of skylines constructed by buildings (+3, +2, +1, 0, -1) | Building height in order | +1 |
| | Similar roof shape | +1 |
| | beautiful rhythm with other buildings | +1 |
| | Skylines in disorder | -1 |
| A5 Openness and the scale of buildings (+1, 0, -1, -2) | Open and relaxed | +1 |
| | Compressed street space | -1 |
| | Dull without change | -1 |
| A6 Visually nice and continuous greenery (+2, +1, 0) | forming network | +1 |
| | Visual continuous | +1 |
| B1 Greenery of walls and trees (+1, 0, -1) | Continuously greened walls | +1 |
| | Average level | 0 |
| | Mostly concrete blocks walls | -1 |

| | | |
|---|---|---|
| B2 Greenery of open pedestrian spaces (+2, +1, 0, -1) | Having well-greened parks and playgrounds | +1 |
| | Many trees along street | +1 |
| | Deserted land scattered by garbage | -1 |
| B3 Favorable pedestrian space (+1, 0, -1, -2, -3) | Pleasant streetscape | +1 |
| | Chaotic scenes with garbage bins or bicycles | -1 |
| | Advertises in disorder | -1 |
| | Illegal parking that disturb pedestrian use | -1 |
| B4 Friendly outdoor space (+1, 0, -1) | Friendly street space | +1 |
| | Isolated street without living atmosphere | -1 |
| B5 Decorations and street furniture (+2, +1, 0) | Street furniture, sculpture, waterscape, etc. | +1 |
| | Well-designed lightening, etc. | +1 |

To keep objectivity in the survey, a detailed manual was made. The evaluations were based on neighborhood areas within 20-25 m from the borders of each sample site. Detailed criteria for giving points are provided, including both verbal descriptions and pictures for reference. For an instance, the criteria for A1 (the continuous of external walls) are shown in Appendix 2. Besides, a 1-hour training was delivered to investigators, who came from two local investigation companies and had no professional experience on architecture and urban design.

The site surveys were conducted for the Tokyo sample in May 2004 and for the Kitakyushu sample in March and April of 2005. The investigators were instructed to work on each site for 15 to 20 minutes, and finish about 10 sites every day. For each sample site, two people implemented the evaluation. The second was asked to confirm the points given by the first. In case that they cannot agree with each other, the scores given by each were recorded. In addition, they were asked to take six to eight pictures and a 15-second video for each sample area. These were later used to justify whether the evaluation results were biased and in case of different opinions appeared, which of the investigator’s result was better. In fact, 94% of the points given by the investigators were unanimous and reasonable, and no significant difference was detected between the results in two cities. A member in one of the 15 groups of Tokyo investigators tended to rate landscape lower than his colleague. This tendency and other discrepancies in the survey were justified with the pictures and videos.

As results, the databases of urban landscapes in Tokyo and Kitakyushu city were established. Figure 1 shows the means of the indices of the 11 factors. The figures in bracelets are *t*-values of the differences between the two cities.

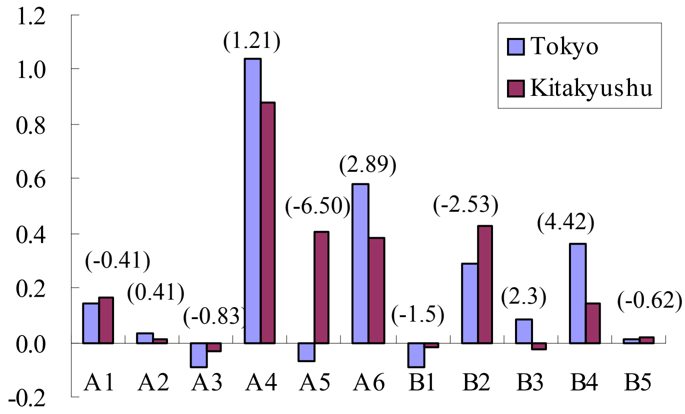


**Figure 1** Comparison of the survey results in two cities

A screening of the data shows that the average levels are similar in factors such as A1 (continuity of external walls), A2 (conformity in colors and materials), A3 (compatibility of building styles), A4 (beauty of skylines constructed by buildings), B1 (greenery of walls and trees) and B5 (decorations and street furniture) but significantly different in other factors such as A5 (openness and the scale of buildings), A6 (visually nice and continuous greenery), B2 (greenery of open pedestrian spaces), B3 (favorable pedestrian space), and B4 (friendly outdoor space). The mostly varied factor A5 had reflected the fact that many samples in Kitakyushu city were located in newly developed areas with many vacant lands. As a whole, the results reasonably suggested the characteristics of large metropolitan areas as compared to local cities, where building density is generally higher and residential areas are featured by less open space and greenery.

**2.3 Principal Component Analysis (PCA) of landscape data**

It was found that many of the 11 variables on urban landscape were significantly correlated. We performed a PCA in the second step to alleviate the correlation problem while to understand the evaluation structure better.

For the Tokyo data, the 11 factors were firstly classified into four categories according to their correlations with a graphical modeling method. As a result, we have four groups of variables, (A1, A2, A3, A4), (B1, B2, B6), (B3, B4, A5), and (B5). From the features they represented, we could tell that they relate to the compatibility of buildings, greenery, sense of familiarity, and the effort in blocks to preserve or create unique characteristics, respectively. Then, PCA was conducted within each category. This generated one principal component with eigenvalue larger than 1 for each of the former three categories, which were named *compatibility*, *greenery* and *familiarity*.

They accounted for 72.8%, 66.6% and 58.2% of the classified variables, respectively. B5 in the fourth category was omitted because eigenvalue of the factor strongly correlated to this variable in the whole data is very small. The variables were classified prior to PCA because the two variables signified in later discussed hedonic modeling kept more information of original data (44.7%) than the one significant variable did if principal components without classification were input to hedonic model (41.4%).

In parallel, three principal components with eigenvalues larger than 1 were generated with the Kitakyushu data. Table 2 details the results.

**Table 2** Principal components of landscape factors

| | Tokyo | | | Kitakyushu city | | |
|---|---|---|---|---|---|---|
| Principal Component | 1 | 2 | 3 | 1 | 2 | 3 |
| Eigenvalue | 4.436 | 1.313 | 1.035 | 4.317 | 1.4369 | 1.016 |
| Percent (%) | 40.33 | 11.93 | 9.41 | 39.24 | 13.06 | 9.23 |
| Cum Percent (%) | 40.33 | 52.26 | 61.68 | 39.24 | 52.31 | 61.54 |
| Evaluation concept | Compatibility | Greenery | Familiarity | Compatibility | Greenery | Decoration |
| A1 Continuity of external walls | 0.336 | -0.208 | -0.306 | 0.372 | -0.234 | -0.004 |
| A2 Conformity in colors and materials | 0.370 | -0.298 | -0.155 | 0.392 | -0.269 | -0.068 |

| | | | | | | |
|---|---|---|---|---|---|---|
| A3 Compatibility of buildings styles | 0.381 | -0.158 | -0.204 | 0.388 | -0.221 | -0.028 |
| A4 Beauty of skylines constructed by buildings | 0.383 | -0.206 | -0.207 | 0.397 | -0.235 | 0.079 |
| A5 Openness and the scale of buildings | 0.231 | -0.073 | 0.361 | 0.280 | 0.056 | -0.002 |
| A6 Visually nice and continuous greenery | 0.305 | 0.476 | -0.097 | 0.220 | 0.608 | -0.055 |
| B1 Greenery of walls and trees | 0.249 | 0.491 | -0.197 | 0.322 | 0.289 | 0.032 |
| B2 Greenery of open pedestrian spaces | 0.275 | 0.487 | 0.037 | 0.226 | 0.548 | 0.144 |
| B3 Favorable pedestrian space | 0.280 | -0.086 | 0.479 | 0.246 | 0.084 | -0.203 |
| B4 Friendly outdoor space | 0.287 | -0.221 | 0.383 | 0.236 | -0.056 | -0.079 |
| B5 Decorations and street furniture | 0.119 | 0.187 | 0.492 | 0.048 | -0.051 | 0.957 |

In both samples, the three principal components explained for about 40%, 12%, and 9% of the variances of the 11 variables. In total, they keep 62% of the total information of each dataset. The eigenvectors (lower part of Table 2) revealed that the structures of the first and two components were fairly alike in Tokyo and Kitakyushu city. Since the first principal component strongly correlates to factors representing the compatibility of buildings (A1, A2, A3, A4), we considered it to be a scale for *compatibility*. In the same way, the second principal component was deemed to be a scale of *greenery*. The third of the Tokyo sample, associated with B3, B4 and B5, was regarded as *familiarity*. That of the Kitakyushu sample with strong association with B5 was named *decoration*.

The results suggested that compatibility and greenery are the most distinctive features in the cognition of urban landscapes. Even in different cities, it has no much change. In metropolitan areas, familiarity is emphasized, probably because the flavor of people in large metropolitan areas is inversely affected by intense mixtures of industrial use, heavy traffic, and so on. In contrast, decoration in Kitakyushu city may have reflected the endeavors of local government and communities to preserve and create local characteristics.

### 2.4 Hedonic analysis on landscape factors in Tokyo

In the third step, we performed hedonic analyses with the datasets of Tokyo and Kitakyushu. In this process, the principal components of urban landscape were used as independent variables to identify, if any, their impact on land prices.

For the Tokyo sample, we used the following linear regression functions.

$$UnitP = \text{intercept} + \sum_i \alpha_i \times X_i + \sum_j b_j \times (X_j / S), \qquad (1)$$

where, *UnitP* is a vector of unit price derived by dividing total land prices by lot size, $X_i$ ($i$=1 to $m$) is a vector of the $i$-th independent variable with $m$ being the number of independent variables, $S$ is a vector of lot size, and $a_i$ and $b_j$ are regression coefficients. The dependent variable *UnitP* is approximately normally distributed. Terms $X_i$ and $X_i /S$ were both entered because we assumed that the influence of some variables may change with lot size.

The raw data of independent variables were transformed to suitable forms through postulating and validating various assumptions repetitively. For example, the width of the front road, $w_1$, was replaced by $\ln(w_1)$, thinking that as $w_1$ increases, its marginal influence on *UnitP* should decay. The width of second front road, $w_2$ ($w_2$=0 if second front road does not exist), was transformed to $\ln(w_2-1)$ so that the new variable is continuous even if a second front road does not exist. After transformation, the fitting of the model had been improved.

The specification in Equation (1) was tested against a variety of alternative functions such as linear model regressing on $X_i$, log-linear regression model on $X_i$, and so on. The fitting of the model in Equation (1) was satisfactory (highest $R^2$ and lowest AIC), and the prediction errors yielded by cross-validation test were smaller than other tested models.

As the result of incremental stepwise regression, a model with 21 variables was established (Table 3). The correlations of the 21 variables were weak except for that between *cul-de-sac* and *cul-de-sac/S*. This was easy to understand because they were integrated terms. However, statistical tests with some variables removed, and with random errors added to the correlated terms showed that the estimates of the model were stable. This suggests that this model has not suffered much from multi-collinearity problem.

**Table 3** Regression model for unit price (in Tokyo)

| | Variable | Definition | Impact on unit price (thousand Yen/m$^2$) | Std Error | *t* | P-value | Scope |
|---|---|---|---|---|---|---|---|
| | Intercept | | 734.5 | 0.0432 | 17.01 | <.0001 | |
| 1 | *Line-Seibu** | Along Seibu railway lines, 1; otherwise,0 | -120.2 | 0.0155 | -7.77 | <.0001 | Neighborhood |
| 2 | *Line-Keio* | Along Keio railway lines, 1; otherwise,0 | -40.2 | 0.0132 | -3.05 | 0.0025 | Neighborhood |
| 3 | *Line-Tokyutoyoko* | Along Tokyutoyoko railway lines, 1; otherwise, 0 | 64.2 | 0.0159 | 4.03 | <.0001 | Neighborhood |
| 4 | *Multiple line* | Close to multiple railway lines, 1; otherwise, 0 | 33.4 | 0.0120 | 2.78 | 0.0058 | Neighborhood |
| 5 | *UpFAR1* | If effective FAR of a site is between 60-100%, 1; between 110-270%, -1; otherwise, 0 | -60.3 | 0.0122 | -4.95 | <.0001 | Lot |
| 6 | *UpFAR2* | with effective FAR of a site less than 210%, 1; beyond 220%, -1 | -112.7 | 0.0234 | -4.84 | <.0001 | Lot |
| 7 | *UpFAR3* | with effective FAR between 110-160%, 1; between 170-210%, -1; otherwise, 0 | 18.9 | 0.0085 | 2.21 | 0.0279 | Lot |
| 8 | *t_station* | Time to the nearest train station (minute) | -9.5 | 0.0013 | -7.38 | <.0001 | Lot |
| 9 | *Irregular shape* | If for an irregular shaped site, $S$>=70m$^2$, ln($S$-70); otherwise, 0 | -24.3 | 0.0037 | -6.51 | <.0001 | Lot |
| 10 | *Frontage/S* | Frontage sharing with main front road (in meters)/S | 505.5 | 0.2092 | 2.42 | 0.0164 | Lot |
| 11 | *ln($w_1$)* | ln(width of main front road (in meters)) | 49.8 | 0.0168 | 2.96 | 0.0034 | Lot |
| 12 | *ln($w_2$-1)* | If width of the second main front road $w_2$>=2.0 m, ln($w_2$-1); otherwise, 0 | 50.0 | 0.0135 | 3.69 | 0.0003 | Lot |
| 13 | *Cul-de-sac/S* | Cul-de-sac dummy/*S* | 4998.3 | 2.0419 | 2.45 | 0.0151 | Neighborhood |
| 14 | *Cul-de-sac* | With a cul-de-sac front road, 1; otherwise, 0 | -100.2 | 0.0258 | -3.88 | 0.0001 | Neighborhood |
| 15 | *Chome-elevation/S* | Average elevation of chome (m) | 83.6 | 0.0357 | 2.34 | 0.02 | District |
| 16 | *Chome-popden* | Population density of chome (person/ha) | -0.4 | 0.0001 | -3.03 | 0.0027 | District |
| 17 | *Chome-BCR<=40%/S* | with average building coverage ratio less than 40%, 1/S; otherwise, 0 | -4243.1 | 1.4081 | -3.01 | 0.0029 | District |
| 18 | *Chome-wooden* | Proportion of wooden structure buildings in chome (%) | -2.0 | 0.0009 | -2.21 | 0.0283 | District |
| 19 | *Unpleasant facility* | with unpleasant facility in neighborhood, 1; otherwise, 0 | -119.9 | 0.0284 | -4.23 | <.0001 | Neighborhood |
| 20 | *Compatibility* | First principal component of landscape | 7.9 | 0.0033 | 2.4 | 0.0171 | Neighborhood |
| 21 | *Greenery* | Second principal component of landscape | 8.4 | 0.0040 | 2.1 | 0.0368 | Neighborhood |
| | **$R^2$** | **0.699** | | | | | |
| | **Adj. $R^2$** | **0.672** | | | | | |
| | ***N*** | **232** | | | | | |

* Dummy variables for railway lines were based on JR Chuo line.

It was found that the determinants of land price include railway lines (*line-Seibu*, *line-Keio*, *line-Tokyutoyoko*), accessibility to multiple railway lines (*multiple line*) and time to the nearest train station (*t-station*). For example, properties along Tokyutoyoko line, where is famous for wealthy residents and high-class houses, are 64 thousand Yen/$m^2$ more expensive than standard residential areas along Chuo line (based on which the dummy variables of railway lines were generated).

Significant variables also include attributes of land such as frontage (frontage/S), irregularity (*flag*) and floor-area-ratio regulated by planning controls (*upFAR1*, *upFAR2*, *upFAR3*), the attributes of front roads such as width ($ln(w_1)$ and $ln(w_2\text{-}1)$) and *cul-de-sac*, as well as the attributes with regard to blocks, which involve average elevation (*chome-elevation/S*), population density (*chome-popden*), building coverage ratio (*chome-BCR<=40%*), the proportion of wooden structure buildings (chome-wooden), and the presence of unpleasant facilities.

The estimates of the above variables as well as their signs are reasonable and the results are of interest from many viewpoints. However, detailed explanations are omitted to leave space for the investigation of variables on landscape.

Two principal components were significant. One is *compatibility*, and the other is *greenery*. Land prices increase for 7.9 thousand Yen/$m^2$ if the value of compatibility increases for one point and for 8.4 thousand Yen/$m^2$ if the value of greenery increases for one point. These results have some important implications. First, they demonstrated the positive effect of landscapes on land prices since compatibility and greenery are positively associated with landscape factors as shown by the signs of eigenvectors in Table 2. Secondly, since the unit land price in Tokyo is averagely 600 thousand Yen/$m^2$ (specifically, the mean of this sample is 602.4 thousand Yen/$m^2$), the difference of one point in compatibility or greenery accounts for more than 1-1.5% of the total prices. We should say that the influence by landscape amenity on land price can not be ignored.

In addition, the results suggested the importance of cooperative activities for improving landscape qualities. According to the nature of the significant variables, they can briefly be classified to those associated with individual lots, those with neighborhoods, and those with even broader areas. This property is shown in the right-most column in Table 3. Because compatibility and greenery are attributes of building groups and neighborhoods, their improvement or management, to a large degree, depends on the efforts of whole residents rather than solely individuals.

### 2.5 Hedonic analysis of landscape factors in Kitakyushu city

A similar modeling procedure as above was followed with the Kitakyushu data. As a result, we got a log-linear regression model for unit land price.

$$\ln(UnitP) = \text{intercept} + \sum_i a_i \times X_i \,, \qquad (2)$$

By stepwise regression, a model with 25 variables was established (Table 4). This model explains for 63.8% of the variance of ln(*UnitP*). Statistical tests showed that there were no big multi-collinearity problems in this model and the estimates were stable. In addition, the signs and the estimates of the variables were consistent with expectation.

In this model, two principal components of urban landscape factors, *compatibility* and *greenery* were significant at 0.01 and 0.1 levels, respectively. This result again demonstrated the economic values of urban landscape. From the elastic coefficients, we know that land price can increase for 2.9% if *compatibility* is one-point higher, and for 2.7% if *greenery* is one-point higher.

**Table 4** Regression mode for ln(*UnitP*) in Kitakyushu city

| No. | Variable | Definition | Impact on ln(*UnitP*) | Std Error | *t* | P-value | Elastic coefficient (impact on unit price) | Scope |
|---|---|---|---|---|---|---|---|---|
| | Intercept | | 11.0167 | 0.1414 | 77.91 | <.0001 | | |
| 1 | *Away from main road* | Away from main road, 1; otherwise, 1 | -0.1399 | 0.0396 | -3.53 | 0.0005 | 0.869 | Neighborhood |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | *Away from commercial area* | Away from commercial area, 1;otherwise, -1 | -0.1175 | 0.0554 | -2.12 | 0.0355 | 0.889 | Neighborhood |
| 3 | *Road direction1* | Not in east, 1; otherwise, -1 | -0.0562 | 0.0296 | -1.9 | 0.0595 | 0.945 | Lot |
| 4 | *Road direction2* | In north, north-east or south, 1; in east, 0; otherwise, -1 | -0.0580 | 0.0194 | -3 | 0.0032 | 0.944 | Lot |
| 5 | *Road direction3* | In north, 1; in north-east or south, -1; otherwise, 0 | -0.0467 | 0.0316 | -1.48 | 0.1413 | 0.954 | Lot |
| 6 | *Without sidewalk* | Without sidewalk, 1; otherwise, 0 | -0.0565 | 0.0206 | -2.74 | 0.0067 | 0.945 | Neighborhood |
| 7 | *Road circulation* | No bad, 1; otherwise, -1 | 0.1478 | 0.0380 | 3.89 | 0.0001 | 1.159 | Neighborhood |
| 8 | *Line-not Chikuho* | Not along Chikuho line, 1; otherwise, -1 | 0.0657 | 0.0315 | 2.08 | 0.0389 | 1.068 | neighborhood |
| 9 | *Line-not Hitahikosan* | Not along Hitahikosan line, 1; otherwise, -1 | -0.1024 | 0.0431 | -2.38 | 0.0186 | 0.903 | Neighborhood |
| 10 | *Line-not monorail* | Not along monorail, 1; otherwise, -1 | -0.1329 | 0.0295 | -4.51 | <.0001 | 0.876 | Neighborhood |
| 11 | *t-bus stop* | Time to the nearest bus stop | -0.0004 | 0.0001 | -4.42 | <.0001 | 1.000 | neighborhood |
| 12 | *Solid land base* | Solid land base, 1; otherwise,-1 | 0.1729 | 0.0795 | 2.17 | 0.0311 | 1.189 | Lot |
| 13 | *regulated FAR* | FAR restricted by land use regulations | 0.0011 | 0.0003 | 3.71 | 0.0003 | 1.001 | Lot |
| 14 | *Regular shape* | Regular shape, 1; otherwise, -1 | 0.1046 | 0.0214 | 4.89 | <.0001 | 1.110 | Lot |
| 15 | *Distance-shopping* | Within 200-500 m to the nearest shopping center, 1; otherwise, -1 | -0.0432 | 0.0182 | -2.38 | 0.0187 | 0.958 | Neighborhood |
| 16 | *Chome-fire disaster* | In high degree of danger, 1, otherwise, -1 | -0.0452 | 0.0171 | -2.64 | 0.0092 | 0.956 | District |
| 17 | *Chome-fire prevention* | Well prepared for fire prevention, 1; otherwise, -1 | 0.0352 | 0.0192 | 1.83 | 0.069 | 1.036 | District |
| 18 | *Chome-public transportation* | Public transportation is bad, 1;average, 0, good, -1 | -0.1657 | 0.0378 | -4.38 | <.0001 | 0.847 | District |
| 19 | *Chome-medical facility* | Poor or average medical facilities, 1, good, -1 | -0.0490 | 0.0266 | -1.84 | 0.0672 | 0.952 | District |
| 20 | *Chome-home care* | Too few or too many home care facilities, 1, average, -1 | -0.0733 | 0.0212 | -3.46 | 0.0007 | 0.929 | District |
| 21 | *Chome-daily facility* | Insufficient daily facilities, 1;average or above, -1 | -0.1485 | 0.0406 | -3.66 | 0.0003 | 0.862 | District |
| 22 | *Chome-popden* | Population density in chome (person/ha) | 0.0029 | 0.0008 | 3.76 | 0.0002 | 1.003 | District |
| 23 | *Housing density* | Density of houses in chome (house/ha) | -0.0048 | 0.0028 | -1.68 | 0.0947 | 0.995 | District |
| 24 | *Compatibility* | Principal component of landscape | 0.0286 | 0.0084 | 3.41 | 0.0008 | 1.029 | Neighborhood |
| 25 | *Greenery* | Principal component of landscape | 0.0262 | 0.0150 | 1.75 | 0.0827 | 1.027 | Neighborhood |
| | **$R^2$** | **0.686** | | | | | | |
| | **Adj $R^2$** | **0.638** | | | | | | |
| | ***N*** | **187** | | | | | | |

* Dummy variables for railway lines were based on JR Kagoshima line.

## 3. Comparison of the evaluation in two cities

The empirical results on the evaluation of urban landscapes in Tokyo and Kitakyushu city are quite identical. Both demonstrated that compatibility and greenery are mostly concerned attributes in landscapes, and in either case, they were significant determinants of land prices.

Although the evaluations for 11 factors being investigated were quite different (as shown in Fig. 1), *t*-tests showed that the levels of compatibility in the two cities did not have significant difference ($t$= -0.25), and neither did the levels of greenery in the two cities ($t$= 0.099).

In fact, the average unit price levels of the Tokyo and Kitakyushu samples are 602.4 and 73.2 thousand Yen/m$^2$, respectively. Accordingly, the impact of compatibility and greenery at the average unit price value in Kitakyushu city are 2.12 and 1.98 thousand Yen/m$^2$. The estimates are comparable in scale with the results in Tokyo, which are 7.9 and 8.4 thousand Yen/m$^2$. With respect to absolute values, the economic impacts of compatibility and greenery in Tokyo are higher, but with respect to the ratios to land prices, that in Kitakyushu city are a bit higher.

Because PCA factors were linear combinations of the product of eigenvectors and standardized landscape factors, we decomposed the estimates for *compatibility* and *greenery* in 11 dimensions. Thereby, the marginal effects of the 11 landscape factors on unit price were computed. Table 5 lists the results.

**Table 5** Comparison of the results in Tokyo and Kitakyushu city

| | Tokyo | | Kitakyushu city | |
|---|---|---|---|---|
| | Marginal effect on unit price (thousand Yen/m$^2$) | Elastic coefficient (impact on average unit price) | Average marginal effect on unit price (thousand Yen/m$^2$) | Elastic coefficient (impact on unit price) |
| A1 Continuity of external walls (1,0,-1) | +4.73 | 1.0079 | +0.44 | 1.0060 |
| A2 Conformity in colors and materials (1,0,-1) | +5.17 | 1.0086 | +0.41 | 1.0057 |
| A3 Compatibility of buildings styles (1,0,-1) | +5.78 | 1.0096 | +0.54 | 1.0074 |

| | | | | |
|---|---|---|---|---|
| A4 Beauty of skylines constructed by buildings (3,2,1,0,-1) | +2.76 | 1.0046 | +0.26 | 1.0035 |
| A5 Openness and the scale of buildings (1,0,-1,-2) | -* | 1.0000 | +1.00 | 1.0137 |
| A6 Visually nice and continuous greenery (2,1,0) | +6.10 | 1.0101 | +2.39 | 1.0326 |
| B1 Greenery of walls and trees (1,0) | +10.87 | 1.0180 | +2.85 | 1.0390 |
| B2 Greenery of open pedestrian spaces (2,1,0,-1) | +7.90 | 1.0131 | +2.407 | 1.0327 |
| B3 Favorable pedestrian space (1,0,-1,-2,-3) | - | 1.0000 | +1.62 | 1.0221 |
| B4 Friendly outdoor space (1,0,-1) | - | 1.0000 | +0.83 | 1.0113 |
| B5 Decorations and street furniture (2,1,0) | - | 1.0000 | +0.01 | 1.0002 |

* '-' means that the impact of the factor is not significant.

Table 5 confirms that the influences of landscape factors on land prices are significant, and that the absolute effects of landscape factors are generally larger in Tokyo while the effects with respect to unit price is somewhat higher in Kitakyushu city. For instance, solely by 1-point increase in A1 (continuous external walls), the unit prices can rise for 0.6-0.8%. The effects associated with greenery-related factors are even larger.

The results provide important policy implications. One of special interests, for example, is the results with B1 (greenery of walls and trees). In well greened areas in Tokyo, land price is 10.87 thousand Yen/m$^2$ higher than that of other areas. In Kitakyushu city, the marginal effect is 2.85 thousand Yen/m$^2$, which is also the largest among considered factors. Actually, in many Japanese cities, local governments encourage residents to greening their walls and fences along street by providing subsidies or reducing tax. There are more and more examples in enlightened areas where residents make agreements among themselves to green walls. Our analysis strongly demonstrates that these activities were valuable.

**4. Concluding remarks**

As more and more people pursue for the beauty of urban landscapes, understanding their economic values, especially their impact on land prices is valuable. It may substantially raise the incentives of residents for preserving or creating landscape beauty.

It also suggests that planning policies that purposefully encourage and induce people to do so are valuable. In addition, with the impact of landscape improvement or landscape destroy being clarified, it makes possible to adjust benefits among residents and others, and still, it may help public landscape management sectors to optimize their budget plans.

The analyses confirm the usefulness of the three-step procedure for landscape analysis, i.e., with standardized survey, PCA and hedonic analysis. Although Tokyo and Kitakyushu city differ a lot in geographical and social economic conditions, land prices levels, etc., their evaluation structures for urban landscape are amazingly similar. In both cases, the compatibility of buildings and the greenery of neighborhood are distinctly emphasized and in market, they are strongly evaluated. This implies the importance of keeping compatibility and greenery levels in a general sense.

Throughout the analyses, it is noted that landscape aesthetics could hardly be achieved solely by individual efforts; instead, collaborative efforts in neighborhood level are extremely important. Therefore, activities leading to collaborative improvement of landscapes, such as 'district planning' made by local government, or 'building and landscape covenant' made by residents should further be encouraged in landscape management policies.

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## Appendix 1 Data for two samples

| Tokyo (valid sample size: 272) | Kitakyushu city (valid sample size: 187) |
|---|---|
| Railway lines | Railway lines |
| Time to the nearest station | Time to the nearest station |
| Time to Yamanote line (railway line surrounding central areas) | Lot size |
| Lot size | Frontages |
| Frontages | Shape of lot (irregular or not) |
| Shape of lot (irregular or not) | Landform of lot |
| Landform of lot | Number of front roads |
| Number of front roads | Direction of front road |
| Direction of front road | Width and lanes of front road |
| Prerequisites of development | Right of road (public or private) |
| Gas | Pavement of road |
| Width and lanes of front road | Slope of road |
| Right of road (public or private) | Cul-de-sac |
| Pavement of road | Building setback along road |
| Slope of road | Fence and walls |
| Cul-de-sac | Adjacent land use (farmland, factory, parking lots, etc.) |
| Building setback along road | Unpleasant facilities |
| Fence and walls | Mixture of land use |
| Noise and vibrations | Mixture of different height buildings |
| Adjacent land use (farmland, factory, parking lots, large open space, etc.) | Distance to public facilities (park, school, hospital, shopping center, *etc.*) |
| Unpleasant facilities (waste treatment, cemetery, etc.) | Land use zone |
| Mixture of land use | FAR and building coverage ratio designated by zoning |
| Mixture of different height buildings | Evaluation of chome on vulnerability to fire disasters |
| Distance to public facilities (park, school, hospital, shopping center, etc.) | Evaluation of chome on activities against fire disasters |
| Available sunshine duration (delimited by surrounding buildings) | Evaluation of chome on dangers to natural disasters |
| Land use zone | Evaluation of chome on hazard |
| FAR and building coverage ratio designated by zoning | Evaluation of chome on criminal-prevention |
| Effective FAR | Evaluation of chome on pollution and noise |
| Beauty area designated by planning | Evaluation of chome on public transportation |
| Requirement for building setback | Evaluation of chome on accessibility to artery roads |
| Economic rank of chome | Evaluation of chome on welfare facilities |
| Planning activities (district plan) | Evaluation of chome on medical facilities |
| High criminal occurrence area | Evaluation of chome on daily facilities |
| Average elevation of chome | Evaluation of chome on education facilities |

| | |
|---|---|
| Population density in chome, changing rate of population | Evaluation of chome on commercial facilities |
| Proportion of road in chome | Evaluation of chome on parks and public space |
| Proportion of vacant land in chome | Evaluation of chome on coverage of greenery |
| Building coverage ratio in chome | Evaluation of chome on open space |
| Density of wooden structure buildings | Evaluation of chome on planning regulations in terms of landscape beauty |
| Density of dilapidated old buildings | Evaluation of chome on sustainability of environment |
| | Evaluation of chome on balance of population |

**Appendix 2 Evaluations on A1 (continuity of external walls)**

This factor focuses on the walls and external walls of buildings that are higher than 1.5 m (above eye-line) to see if they are well-aligned along street. Three situations are separated.

+1 point: Most walls and buildings along street are well-aligned. They account for more than 4/5 of the total in each side of the street. An example is shown in the left of Fig. 2.

0 point: More than half of walls and buildings are well-aligned but no more than 4/5. An example is shown in the middle of Fig. 2.

-1 point: There are many vacant lands, parking lots, houses without gate-walls, or large buildings such as apartments or office buildings in the neighborhood. Specifically, less than 1/2 of walls are aligned along street. An example is shown in the right of Fig. 2.

+1 point 0 point -1 point

**Figure 2** Pictures for reference in landscape survey

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