Visual Preferences for Slope Greening and Stabilization Techniques: the Case Study of Northern Part of Okinawa Island, Japan

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Abstract: Recently, the use of forest roads for recreational activities has been increasing. High scenic quality is considered important to visitors. Therefore, the visual quality of the roadside is one of the important aspects in managing forest roads in addition to the functioning and durability for slope stabilization. However, knowledge about public's visual preferences for different roadside management is scarce, even if it is important knowledge for designing slope greening in order to balance the function and aesthetic quality. In this study, we conducted an interview survey to explore public visual preferences towards various roadside solutions in Okinawa, Japan, which is increasingly becoming a popular tourist destination. A total of 143 survey responses were received and the non-parametric analyzes (chi-square test, gamma coefficient) were applied to examine the effect of socio-demographic characteristics (age, gender, marital status, employment status, income level, education level, birthplace, and the current residential place) on their preferences. Our results show that the public's favorite roadside scenery is a forest vegetation without any visible man-made structures. The preferences for some slope greening and stabilization interventions depend on the socio-demographic characteristics of the respondent. Results from the responses reveal that visual quality on slopes of forest roads is highly important, but the “safety” is even more crucial.

Keywords: forest roads, public perception, roadside slope greening, tourism, visual quality

1. Introduction

Forest roads play very important roles by providing access to forested areas through timber extraction, fire control, and wildlife habitat management. Due to unstable forest slope environments which are prone to landslides and erosion, obtaining mechanical stability on forest slopes and roads has been the main concern for forest managers (Kobayashi and Shiobara 1986; Ng et al. 2011).

Up to date, various roadside slope greening techniques have been developed and implemented (Barker 1995; Schiechtl 1980; Gray and Lieser 1982; Nishiyama 2000). Since stabilization of roadside slope is one of the most important goals, appropriate slope greening techniques are carefully applied depending on site conditions which can likely lead to instability (USDA 1994). The guide for choosing an appropriate slope greening techniques have been prepared for various regions (USDA 1994; GEO 2006; JSPA 2006). For example, installing rock bolting or applying cement concrete could be necessary in rock slope environment to reduce the risk of injury to the public and prevent road closures (USDA 1994). In Japan, it is recommended to combine vegetation method with conventional engineering techniques such as, a grid beam of concrete (slope framework), wire mesh netting and concrete blocks, on cut slope with greater than 45° slope angle (JSPA 2006). On the other hand, bio-stabilization with vegetation can be a useful technique for preventing surface erosion, especially on low slope areas. (USDA 1994). Although the surrounding man-made structures, such as a grid beam of concrete, are often revegetated to improve aesthetical value (Samaru and Sugiyama 2005), these techniques have been developed mainly based on

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the functioning and durability (Kobayashi and Shiobara 1986), with limited attention paid to roadside aesthetics (Ng et al. 2011).

Recently, the use of forest roads for recreational activities has been increasing (Christopher 2002; Town of Delta Bayfield County, Wisconsin 2004). Since sightseeing is one of the most popular recreation activities (USDA 2012), scenic quality is important to recreational visitors (USDA 2015). It is not surprising, therefore, to find an increasing interest in the visual quality of the roadside aesthetics by public (Akay et al. 2007; Ng et al. 2011). For improving the visual quality of forest roads, the management of roadside vegetation is important (McDonald and Litton 1987). Information on public’s preference on roadside aesthetics could help to design slope greening techniques which would balance the stabilization function, durability and aesthetic quality (Kobayashi and Shiobara 1986). However, only few studies have attempted to evaluate public’s visual preference on roadside aesthetics in Japan (Kobayashi and Shiobara 1986; Oku and Fukamachi 2000). Furthermore, there are few studies that have examined the relationships between visual preference on roadside aesthetics and the socio-demographic characteristics. It is important to consider the options, needs and preferences of landscape users and relate them to sociological and cultural features in developing a management plan (Atauri et al 2000; Filova et al. 2015). In this study, we conducted an interview survey to explore public preferences towards various roadside aesthetics in the northern part of the Okinawa Island. In this area, an increasing number of tourists take part in recreation activities such as walking and sightseeing in natural areas (Okinawa Prefectural Government, Department of Culture, Tourism and Sports 2019). This trend could be further accelerated due to the recent inscription of the site on the World Natural Heritage list along with Amami Oshima, Tokunoshima and Iriomote islands in 2021. Therefore, to promote sustainable nature-based tourism in this area, regional planners and local forest managers will be required to make difficult management decisions to achieve balance between recreation activities and safe slope stabilization.

2. Methods

2.1. The study area

Our study site is Okuni Forest Road located in the northern part of the Okinawa Island (Figure 1), where since ancient age the local people heavily rely on rich forest resources (Nakama 2010). This permanent forest road extends from Route 2 in Kunigami village to Route 331 in Ougimi village, for a total length of 35.5 km. This road has been facilitating easy access to the interior forest areas for visitors from urban areas (Nagamine 2020). For example, this road provides access to the entrance for a popular hiking trail to Mount Yonaha, where approximately 1,500 people visit per year (Ministry of the Environment Government of Japan 2017). Therefore, although the construction of Okuni forest road started in 1977 (and completed in 1994), with the aim of providing the basics for various forest management activities, its recreational use has been increasing in recent years (Yoshida 1999; Walker 2014). Forest roads in this area are now expected to provide the access for recreation in addition to primary use of the roads for forest resources by local people. However, it has been discussed that this road might also help facilitate the movement of introduced mammals such as cats to the interior forest areas (Nagamine 2020) which allows them to predate on Okinawa rails (Gallirallus okinawae), an endemic bird in Okinawa Island.
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(Ozaki et al. 2002).

Figure 1. Map showing the location of Okinawa Island and Okuni Forest Road.

2.2. Slope greening types and preparing photo questionnaires

We designed a questionnaire with pictures (photo-questionnaire) to identify visual preferences of the public for slope stabilization and greening techniques. Based on a detailed field observation, we selected 11 slope greening techniques which are representative for this area (Figure 2). We made sure that these selected photos cover both conventional engineering techniques (application of rock bolting, concrete cement) and bio-stabilization techniques with vegetation. All photos were taken with a D7000 Nikon® Digital Camera with a 18.0-105mm f/3.5-5.6 lens. It should be noted that each photo was presented to the respondents only with a brief title shown in Figure 2. We titled each photo carefully so that the use of man-made structure was identifiable. Also, if respondents raised a query about the photos and techniques used during questionnaire survey, we tried our best to describe each photo. The principal aim of the questionnaire was, however, to evaluate exclusively the visual quality of different slopes based on different management. Subsequently, the level of visual quality was linked with the particular management technique during the analysis and results’ interpretation.

Barroso et al. (2012) indicate that careful design of the survey especially with respect to the choice of photos is necessary for ensuring quality of our survey. In this study, as described in the study by Takahashi et al. (2021) we set the following guidelines for taking photos:
1. Balance proportion of sky and target vegetation;
2. Keep a constant view depth; and
3. Avoid any elements which are not in a study focus and might distract the respondents

To control factors other than vegetation affecting preferences of respondents, we used Adobe Photoshop CS6.

![Images of studied forest road vegetation types]

Figure 2. Studied forest road vegetation types.
2.3. Design of a photo-questionnaire and the procedure

The questionnaire included the following three parts: (i) demographic characteristics of the respondents (age, gender, marital status, employment status, income, education level, birthplace, current residential address); (ii) perception of forest roads; and (iii) visual preference.

The questionnaire was applied face-to-face and individually with each respondent. A completion of one questionnaire took approximately from 5 to 10 minutes. The respondents were informed that the information collected will remain strictly confidential and anonymous and will be used only for the purpose of this research.

After the collection of the socio-demographic characteristics of a respondent, he/she was asked few questions about their use of forest roads and their perception about functions of these roads. Then, a participant was asked to look at colored photographs printed on photo-quality papers and to rate each photo in terms of their preference using a 5-point rating scale, where the ends of the scale are 1 and 5 representing strongly dislike it and strongly like it respectively (additional option: don’t know).

Face to face questionnaire survey was conducted at “Bise Fukugi tree street”, “Yui Yui Kunigami” and “University of the Ryukyus, Senbaru campus” from August 2014 to November 2014. These sites were selected to obtain the data because they are a good catchment for people from Okinawa and people from other parts of Japan. At each site visitors were contacted randomly. In all, 143 visitors answered the questionnaire on site. In order to examine the perceptions of forest roads among public users, the following six questions assessed the respondents’ awareness about forest roads:

Q1. Have you ever used forest roads? (yes/no),

Q2. If your answer to Q1 was “yes”, mention the purpose of using forest roads. Mark any one of the five options (a) Access (to their own properties or other places), (b) Walking, (c) Evacuation, (d) Transportation and (e) Others (multiple answers allowed),

Q3. What function do you think is important for forest roads? Mark any one of the four options (a) “Safety”, (b) “Usability”, (c) “Aesthetics”, and (d) Others (multiple answers allowed)

Q4. Do you think aesthetics of forest road is important (yes/no)

Q5. Do you think that it is important to spend money on forest road construction and management (yes/no)

Q6. If your answer to Q5 was “yes”, Which features should you spend your budget on? Mark any one of the four options (a) “Safety”, (b) “Usability”, (c) “Aesthetics”, and (d) Others (multiple answers allowed)

2.4. Statistical analysis

In this study the data collected through the survey were categorical; ordinal and nominal. Nonparametric tests were carried out for analyzing the data. We used a statistical software R to conduct the statistical analysis. For investigating the relationship between preference scores and categorical variables, such as ‘gender’, ‘marital status’, ‘occupation’, ‘birthplace’ and ‘current residential address’, we performed the
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Chi-square test. Chi-square test is often used to test if there is a significant association in the crosstabulation where the categories for one variable are shown in rows, while the categories for the other variable are shown in columns. The number in each cell shows the frequency of cases for a specific pair of categories. In R, crosstabulation can be created using the command `table()` and the test statistics for the Chi-Square Test of Independence can be computed using the command `chisq.test()` (See Appendix for R scripts used in this study). When the calculated test statistics value is greater than the critical value, which is determined using the Chi-square distribution table with degrees of freedom and chosen significance level, the null hypothesis (row and column are independent) is rejected. Additionally, the p-values were reported.

To measure effect sizes of these tests, we also compute Cramer’s V, which is independent of sample size unlike p-values and allows us to compare the results to results from different studies (Sun et al. 2010; McLeod 2019). Chi-square test is inaccurate and not appropriate when a cross table contains cells with small counts. Since the original survey sheet contained a wide range of categories for employment status which often resulted in several empty cells of a cross table. Therefore, for statistical analysis employment status was further divided into following three categories; the employed, the unemployed and students.

To evaluate the relationship between preference scores and categorical variables, such as “age class”, “income”, and “education level”, we computed a Gamma coefficient which is frequently used to quantify the strength of dependence between two variables of ordinal data (Ruiz and Hüllermeier 2012). The Gamma-coefficient takes values between -1 and +1. When values are significantly different from zero it indicates a strong association between two variables. To compute Gamma coefficient in R, we first installed a package called “DescTools”, then use the command `GoodmanKruskalGamma()` (See Appendix for R scripts used in this study).

3. Results

3.1. Respondents’ socio-demographic characteristics

A total of 143 survey responses were collected. There were 65 male and 78 female respondents. Figure 3 shows the age distribution of the respondents. 65 respondents were married, while 78 respondents were single. Respondents varied in level of education, with the highest percentage having a high school degree (53%), while the lowest percentage had a middle school degree (1%). The birthplace of 58 respondents was Okinawa prefecture, while 85 respondents were born outside of Okinawa. With respect to current residential address, 91 respondents were Okinawa prefecture, while 52 respondents lived elsewhere. From all the respondents, the results revealed that 71 were employed (including self-employed and part-time employed), 10 were housewives, 42 were students, and 20 mentioned other occupation. In this study four income levels were defined (< JPY 3,000,000/year, JPY 3,010,000 – 5,000,000/year, JPY 5,010,000- 7,000,000/year, >= 7,010,000/year). Figure 4 depicts the distribution of income levels. It is worth noticing that there are 13 non-respondents for this particular question.

3.2. Perceptions of forest roads

Among a total of 143 respondents, 82 respondents have used forest roads, while 38 respondents have not used forest roads (there are 23 no-respondents). Among
the respondents who have used forest roads, 60 respondents have used them for access to their own properties or other places, 31 respondents have used them for walking, while 6 respondents have used them for transportation (5 respondents used for “Others”). We obtained 76 respondents who chose “safety” as the most important aspect for forest road building, 46 respondents who chose “Usability” as the most important aspect, and 84 respondents who chose “Aesthetics” as the most important aspect. 109 respondents agreed on the importance of “aesthetics” for forest roads. 96 respondents agreed on spending money on forest road construction and management (42 respondents did not agree on the importance of spending money for construction and management of forest roads). Among respondents who agreed on the importance of spending money for road construction and management, 69 respondents chose “safety” as the most important aspect for forest road building, while 34 respondents chose “aesthetics” as the most important aspect.

3.3. The ranking of preferred forest roads

Table 1 summarizes the results of the average score of the preferred forest road greening approaches. Results show that Evergreen broad-leaved forest (Photo 7) and Deciduous broad-leaved forest (Photo 11) received the highest average scores. On the contrary, Cement concrete (Photo 4) was the less appreciated. The less preferred
four photos either contains visible man-made structures (Photo 1, Photo 2 and Photo 4) or no vegetation (Photo 4, Photo 10).

Table 1. The ranking of preferred forest roads based on the preference average score.

<table>
<thead>
<tr>
<th>Rank (Photo ID)</th>
<th>Photo Description</th>
<th>Ave. Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st (Photo 7)</td>
<td>Evergreen broad-leaved forest</td>
<td>4.650</td>
</tr>
<tr>
<td>2nd (Photo 11)</td>
<td>Deciduous broad-leaved forest</td>
<td>4.585</td>
</tr>
<tr>
<td>3rd (Photo 6)</td>
<td><em>Pinus luchuensis</em></td>
<td>4.112</td>
</tr>
<tr>
<td>4th (Photo 3)</td>
<td><em>Dicranopteris linearis</em></td>
<td>3.957</td>
</tr>
<tr>
<td>5th (Photo 8)</td>
<td>Herbaceous</td>
<td>3.894</td>
</tr>
<tr>
<td>6th (Photo 5)</td>
<td>Japanese pampas grass</td>
<td>3.514</td>
</tr>
<tr>
<td>7th (Photo 9)</td>
<td>Epiphytic community</td>
<td>3.288</td>
</tr>
<tr>
<td>8th (Photo 1)</td>
<td>Rock bolting + Shrub</td>
<td>3.104</td>
</tr>
<tr>
<td>9th (Photo 2)</td>
<td>Rock bolting + Herbaceous</td>
<td>2.956</td>
</tr>
<tr>
<td>10th (Photo 10)</td>
<td>Vegetation free</td>
<td>2.727</td>
</tr>
<tr>
<td>11th (Photo 4)</td>
<td>Cement concrete</td>
<td>2.198</td>
</tr>
</tbody>
</table>
3.2. Relationships between landscape preferences and demographic characteristics

Tables 2 and 3 show the results from our statistical test for association between visual preferences and demographic characteristics for the respondents. Table 2 summarizes results for Chi-square test of Independence. The values of Cramer’s V, which measures the strength of association between two categorical fields, range from 0.043 to 0.230. One of the most widely applied guidelines for interpreting these values is the so-called Cohen’s rule and indicators; negligible association (< 0.10), small association (0.10 – 0.3), medium association (0.3 – 0.5) and large association (0.5 or more) (Cohen 1988; Sun et al. 2010; Fix et al 2013).

Table 3 summarizes the results of rank correlation measures with Gamma coefficient value. Rea and Parker’s rule of thumb (1992) has often been applied to interpret Gamma coefficient value (Vojíř and Rusek 2021). The values of Gamma coefficient range from 0.002 to 0.418 in absolute term. According to Rea and Parker (1992), 0 to 0.09 indicate no to negligible association, 0.1 – 0.29 indicate low association, and 0.3 – 0.59 indicate moderate association.
Table 2. Summary of Chi-square test of Independence. () below Chi-square shows degree of freedom.

<table>
<thead>
<tr>
<th>Photo ID</th>
<th>Discriptions</th>
<th>Gender Chi-square (4)</th>
<th>p-value</th>
<th>Cramer's V</th>
<th>Employment status Chi-square (8)</th>
<th>p-value</th>
<th>Cramer's V</th>
<th>Martial status Chi-square (4)</th>
<th>p-value</th>
<th>Cramer's V</th>
<th>Birthplace Chi-square (4)</th>
<th>p-value</th>
<th>Cramer's V</th>
<th>Current residential address Chi-square (4)</th>
<th>p-value</th>
<th>Cramer's V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo 1</td>
<td>Rock bolting + Shrub</td>
<td>0.298</td>
<td>0.990</td>
<td>0.046</td>
<td>5.834</td>
<td>0.829</td>
<td>0.117</td>
<td>5.664</td>
<td>0.226</td>
<td>0.199</td>
<td>1.968</td>
<td>0.742</td>
<td>0.117</td>
<td>5.492</td>
<td>0.240</td>
<td>0.196</td>
</tr>
<tr>
<td>Photo 2</td>
<td>Rock bolting + Herbaceous</td>
<td>1.805</td>
<td>0.772</td>
<td>0.112</td>
<td>16.662</td>
<td>0.082</td>
<td>0.197</td>
<td>4.219</td>
<td>0.377</td>
<td>0.172</td>
<td>6.562</td>
<td>0.161</td>
<td>0.214</td>
<td>4.527</td>
<td>0.339</td>
<td>0.178</td>
</tr>
<tr>
<td>Photo 3</td>
<td>Dicranopteris linearis</td>
<td>5.758</td>
<td>0.218</td>
<td>0.201</td>
<td>10.845</td>
<td>0.370</td>
<td>0.159</td>
<td>4.440</td>
<td>0.350</td>
<td>0.176</td>
<td>2.451</td>
<td>0.653</td>
<td>0.131</td>
<td>4.888</td>
<td>0.299</td>
<td>0.185</td>
</tr>
<tr>
<td>Photo 4</td>
<td>Cement concrete</td>
<td>1.540</td>
<td>0.820</td>
<td>0.104</td>
<td>5.998</td>
<td>0.648</td>
<td>0.118</td>
<td>4.353</td>
<td>0.360</td>
<td>0.174</td>
<td>1.867</td>
<td>0.760</td>
<td>0.114</td>
<td>1.337</td>
<td>0.855</td>
<td>0.097</td>
</tr>
<tr>
<td>Photo 5</td>
<td>Japanese pampas grass</td>
<td>7.555</td>
<td>0.109</td>
<td>0.230</td>
<td>9.183</td>
<td>0.515</td>
<td>0.146</td>
<td>4.709</td>
<td>0.318</td>
<td>0.181</td>
<td>1.931</td>
<td>0.748</td>
<td>0.116</td>
<td>5.725</td>
<td>0.221</td>
<td>0.200</td>
</tr>
<tr>
<td>Photo 6</td>
<td>Pinus luchuensis</td>
<td>1.589</td>
<td>0.662</td>
<td>0.105</td>
<td>7.033</td>
<td>0.318</td>
<td>0.128</td>
<td>0.267</td>
<td>0.966</td>
<td>0.043</td>
<td>5.882</td>
<td>0.118</td>
<td>0.203</td>
<td>2.737</td>
<td>0.434</td>
<td>0.138</td>
</tr>
<tr>
<td>Photo 7</td>
<td>Evergreen broad-leaved forest</td>
<td>1.280</td>
<td>0.734</td>
<td>0.095</td>
<td>11.888</td>
<td>0.065</td>
<td>0.166</td>
<td>6.376</td>
<td>0.095</td>
<td>0.211</td>
<td>2.421</td>
<td>0.400</td>
<td>0.130</td>
<td>4.028</td>
<td>0.258</td>
<td>0.168</td>
</tr>
<tr>
<td>Photo 8</td>
<td>Herbaceous</td>
<td>1.827</td>
<td>0.609</td>
<td>0.113</td>
<td>3.830</td>
<td>0.872</td>
<td>0.094</td>
<td>1.216</td>
<td>0.749</td>
<td>0.092</td>
<td>1.279</td>
<td>0.734</td>
<td>0.095</td>
<td>2.411</td>
<td>0.492</td>
<td>0.130</td>
</tr>
<tr>
<td>Photo 9</td>
<td>Epiphytic community</td>
<td>2.776</td>
<td>0.596</td>
<td>0.139</td>
<td>16.145</td>
<td>0.096</td>
<td>0.194</td>
<td>4.397</td>
<td>0.355</td>
<td>0.175</td>
<td>4.628</td>
<td>0.328</td>
<td>0.180</td>
<td>1.677</td>
<td>0.795</td>
<td>0.108</td>
</tr>
<tr>
<td>Photo 10</td>
<td>Vegetation free</td>
<td>5.466</td>
<td>0.243</td>
<td>0.196</td>
<td>15.744</td>
<td>0.107</td>
<td>0.192</td>
<td>1.015</td>
<td>0.907</td>
<td>0.084</td>
<td>1.168</td>
<td>0.806</td>
<td>0.106</td>
<td>6.526</td>
<td>0.163</td>
<td>0.214</td>
</tr>
<tr>
<td>Photo 11</td>
<td>Deciduous broad-leaved forest</td>
<td>3.943</td>
<td>0.268</td>
<td>0.166</td>
<td>7.681</td>
<td>0.465</td>
<td>0.134</td>
<td>5.308</td>
<td>0.151</td>
<td>0.193</td>
<td>2.103</td>
<td>0.551</td>
<td>0.121</td>
<td>2.579</td>
<td>0.461</td>
<td>0.134</td>
</tr>
</tbody>
</table>
The following results summarize relations between visual preferences of forest road aesthetics and socio-demographic characteristics of respondents, according to Tables 2 and 3.

In this study, our results for nominal data such as “gender”, “employment status”, “martial status”, “birthplace” and “current residential address” suggested no factors were associated with visual preferences of forest road aesthetics. On the other hand, our results for ordinal data such as such as “age class”, “income”, “education level” suggested a few factors were associated with visual preferences of forest road aesthetics. For example, the respondents’ ages had moderate positive association with the appraisal of Epiphytic vegetation community (Photo 9). Figure 5 shows the mosaic plot for visualizing association between two categorical variables; the respondents’ ages classes (in x-axis) and preference scores (in y-axis). Older people tend to prefer Epiphytic community. On the other hand, income levels had moderate negative appreciation with Cement concrete (Photo 4). Figure 6 shows the mosaic plot for visualizing association between two categorical variables; the respondents’ income levels (in x-axis) and preference scores (in y-axis). People with lower income tend to prefer Cement concrete.

4. Discussion

Our results show that evergreen broad-leaved forest is the most appreciated vegetation type for slope greening while cement concrete is the least favorite slope greening and stabilization approaches. Regardless of providing more safety, slope greening and stabilization approaches with man-made structures were generally less preferred. Our results show that “safety” is the most important aspect for forest road building followed by “aesthetics”. On the other hand, our results indicate that the public’s favorite roadside scenery is forest vegetation without man-made structures, which may not always provide enough safety.

These results mostly agree with the earlier findings by Kobayashi and Shiobara.
Figure 5. The mosaic plot for the association of the respondents’ ages and Epiphytic vegetation community.

Figure 6. The mosaic plot for the association of the respondents’ income levels and Cement concrete.
(1986) who showed that cement concrete without any vegetation is less preferred slope stabilization techniques than greening approach with tree and other plant species. Kobayashi and Shiobara (1986) also mentioned that the results from the study considering mechanical safety and stability are more likely to be different from their findings.

Our results showed that two types of broadleaved forest views are ranked 1st and 2nd followed by coniferous forest views. These results may not agree with the study by Oku and Fukamachi (2000) who indicate that forest-trail users in Kyoto, Japan, may prefer coniferous forest views over broadleaved forests ones for a certain specific view (the visual qualities of forest road from near view - interior view) because of their “orderlines”. It is possible that the photos used in present study may not best capture the distinguished characteristics of these two different forest types. Another explanation for our results deviating from the previous finding could be that coniferous forest views in Okinawa are quite different from those of other parts in Japan because of unique environment characterized by subtropical climate. Therefore, one of the common characteristics of coniferous forest, “orderlines”, in other part of Japan or other countries (Franklin et al.1986) may not represent the characteristic of coniferous forest in Okinawa.

5. Conclusion

This study attempts to identify visual preferences of roadside aesthetics for slope greening and stabilization approaches and to examine the effect of socio-demographic characteristics on the level of appreciation of forest road vegetation types. From the best of our knowledge, there is lack of published studies which have investigated visual preferences for roadside aesthetics in Okinawa Island. We applied the photo-questionnaire to identify the level of appreciation of various slope greening and stabilization approaches. Subsequently, we analyzed the collected data using non-parametric tests (i.e. chi-square test, gamma coefficient).

The results are specific to our study area. However, our study was motivated by the underlying issues that are common to many other places within and outside Japan. The discussion of the general findings, such as the impact of socio-demographic characteristics on roadside aesthetics appreciation, contributes to the existing empirical findings in literature.

The same limitations pointed out by Takahashi et al. (2021) apply in this study. First, we acknowledge the limitations of conducting a face-to-face photo questionnaire survey for exploring public preferences toward roadside aesthetics. Since photo questionnaire survey requires respondents to rate each roadside aesthetics without direct experience with them, the "representational validity" of photographs has been the subject of controversy (Hetherington et al. 1994; Daniel and Meitner 2001). Recently, an immersive virtual reality (VR) system which can provides users with more immersive and realistic experience through stereoscopic head-mounted displays, has been widely used in various fields (Loureiro et al. 2020). Therefore, in future studies VR system could provide useful surrogate for evaluating visual preferences of roadside aesthetics.

Secondly, our relatively small sample size could be the reason for the failure to detect a significant association between some of the demographic factors and preferences toward roadside aesthetics. Future studies should include more samples for validating the results from our case study, which in turn provides useful information for
designing, developing and implementing slope greening techniques for balancing the functioning, durability and aesthetic quality. Also, including more samples will allow us to conduct multinomial logistic regression analysis with an explanatory variable of preference ratings and explanatory variables of various demographic characteristics explored in this study.

Thirdly, like many other studies, the response rate for sensitive questions such as income level were low (Tourangeau and Yan 2007). The previous studies (Szolnoki and Hoffmann 2013; Heerwegh and Loosveldt 2008) indicate that the response rate for sensitive questions can be higher with computer assisted self-interview compared to face-to-face interviews. In future study, we may consider the internet as our medium for communicating with the respondents.

Despite these limitations, our study demonstrates that the relationship between level of roadside aesthetics appreciation and socio-demographic variables can be examined. Knowing the relationship between visual preferences and demographic variables as well as understanding people’s perception of forest roads is important for designing, developing, and implementing slope greening techniques for balancing the functioning, durability and aesthetic quality (Kobayashi and Shiobara 1986). Balancing the functioning, durability and aesthetic quality is necessary to achieve sustainable nature-based tourism in Okinawa, where an increasing number of tourists visit for participating in recreation activities such as walking and sightseeing in natural surroundings of Okinawa (Okinawa Prefectural Government, Department of Culture, Tourism and Sports 2019).

We believe that the present study brings to light some useful knowledge for future research, as well as help regional planners or local forest managers to apply appropriate slope greening and stabilization approaches.

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References


Polytechnic Institute and State Univ.


JSPA (Japan Slope Protection Association) (2006) Guidelines for slope greening techniques, 148p. (in Japanese, Title was translated by the authors of the present study)

Kobayashi, H., Shiobara, Y. (1986) The evaluation for the slope protection of the forest road with a psychometrical method from the view point of the landscape (I) – Case study on the cutting slopes of the constructed forest road – Bulletin of the Utsunomiya University Forests.


Appendix (R-code)

The following codes was used for the Chi-Square Test of Independence between “employment status” and the preference scores for “Photo 1”.

```r
> data_emp_p1 <- read.csv("Emp_p1.csv")
> tab_emp_p1 <- table(data_emp_p1[,2], data_emp_p1[,3])
> res_emp_p1 <- chisq.test(tab_emp_p1)
> res_emp_p1
```

The following codes was used for calculating the Gamma coefficient between “age” and the preference scores for “Photo 1”.

```r
> install.packages("DescTools")
> library("DescTools")
> data_age_p1 <- read.csv("Age-p1.csv")
> tab_age_p1 <- table(data_age_p1[,2], data_age_p1[,3])
> tab_age_p1
> GoodmanKruskalGamma(tab_age_p1, conf.level=0.95)
```