Identifying Visual Quality of Rural Road Landscape Character by Using Public Preference and Heat Map Analysis in Sabak Bernam, Malaysia

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Article

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Hangyu Gao [1,*], Shamsul Abu Bakar [1,*], Suhardi Maulan [1], Mohd Johari Mohd Yusof [1], Riyadh Mundher [1] and Khalilah Zakariya [2]

[1] Affiliation 1; Department of Landscape Architecture, Faculty of Design and Architecture, Universiti Putra Malaysia, Serdang 43400, Malaysia; suhardi@upm.edu.my (S.M.); m_johari@upm.edu.com (M.J.MY); gs54918@student.upm.edu.my (R.M.)

[2] Affiliation 2; Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia; khalilah@iium.edu.my (K.Z.)

* Correspondence: gs58413@student.upm.edu.my (H.G.); Shamsul_ab@upm.edu.my (S.A.B.)

Abstract: The rural road landscape is crucial in forming rural areas' landscape character (LC). As a platform for portraying the rural landscape, the rural roads demonstrate the area's unique natural and cultural characteristics to the visitors. However, with the continuous development of rural areas, the rural LC has been severely impacted, thus impacting visitors' visual experience. In order to preserve and protect the rural landscape, this study aims to assess the visual quality of rural road landscapes based on public preference and heatmap analysis. The results indicated that most of the participants had a higher level of preference for rural landscapes with open horizontal views represented by agricultural areas such as paddy fields. It was also found that different paddy field characters based on their planting stages can also positively affect the visual quality of rural road landscapes. The study also revealed that rural LCs with roadside settlements, commercial structures, mixed agricultural crops, and vegetation received low preference ratings. These characters negatively impact the visual quality of the rural road landscape. These findings provide significant insight for planners and decision-makers regarding protecting and preserving the essential rural road landscapes for the rural tourism experience.

Keywords: rural road landscape; landscape character; landscape visual quality; rural tourism experience

1. Introduction

Rural regions have very distinct landscape patterns due to the effect of the region's natural beauty, the style and form of the local architecture, and local cultural aspects [1]. In other words, the rural landscape is a particular sort of landscape that uses the countryside as the focal point and is characterized by a unique landscape [2]. The rural roads' landscape characteristics typically consist of various land cover types, landforms, land use, rural historical sites, and artistic features [3]. As an essential component of the rural road, the rural plays a crucial role in the scenic experience in the local tourism industry [4]. Rural roads not only serve as vital connectors between communities but also as potential tourist routes for rural life experiences, scenic landscapes tours, and other relevant tourist attractions [5]. To some extent, the rural road landscape could be considered a valuable resource that can be used to promote and enhance local tourism activities. It can provide visitors a quick, easy, safe, and scenic experience to explore the countryside. Studies have shown that the rural roads' landscapes could provide travelers with a positive experience through rural scenery and local cultural engagement [6-8].

However, in recent decades, rapid development and urban sprawl have changed and threatened the landscape's appearance in rural areas [9,10]. Although the modernization processes have improved the living quality and enhanced basic facilities in the rural environment, they have also altered the appearance of the rural landscape [11,12]. Primdahl et al. [13] have identified that these

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changes are perceived as a threat, a harmful development that could damage the richness and distinctiveness of the original landscape. Changes in nature and the original appearance of the landscape in rural areas, without reasonable control, may lead to a decrease in the visual quality of the rural landscape [1,14]. Meanwhile, the change of land in rural areas has accelerated the process of fragmentation of the rural landscape, further generating negative impacts on the characteristics and affecting visual comfort in rural areas [15,16]. These changes may also decrease rural population satisfaction and a reduction in the usefulness of the landscape [17]. Many countries also emphasize the significance of protecting cultural and natural landscapes in response to development pressure [18]. Because of the numerous environmental changes related to these pressures, the idea of LC has been enlarged to embrace not just extraordinary landscapes but also typical daily landscapes [19]. Therefore, it can be seen nowadays that the awareness to preserve the landscape in its original form has received more attention and become particularly important.

In Malaysia, rural tourism-related projects have been progressing in recent years, predominantly agricultural and agrarian tourism becoming popular, and the revenue from tourism gradually increasing [1]. However, along with development and other influences, the visual experience of Malaysia's rural landscape has declined [20]. During this time, large portions of the rural population migrated to the city, resulting in a loss of cultural identity that may impact how the rural LC develops [13]. Hence, Malaysia's rural visual experience and quality have become increasingly bleak. As mentioned earlier, the rural road is a significant component of rural areas and could indicate a place's identity. It not only provides visitors with a taste of the local conditions or culture as they pass through but could also allow emotional attachment to the rural landscapes. Hence, the rural road landscapes' visual quality has become a significant factor that can impact people's experience. However, in Malaysia, only a few studies have focused on the visual of rural road landscapes, leading to poor understanding among the decision-makers regarding its importance and future protection. Therefore, this study has three aims:

1. To classify and identify types of rural road LCs in Sabak Bernam in Malaysia.
2. To identify public preferences towards the visual quality based on rural road LCs in Sabak Bernam in Malaysia.
3. To identify preferred rural road landscape elements and socio-demographic factors that affect the preferences of rural road landscapes in Sabak Bernam, Malaysia.

1.1. Landscape Character

Landscape character (LC) is defined as "a distinct, recognizable, and consistent pattern of elements in the landscape that makes one landscape different from another, rather than better or worse" [21]. The physical elements of the scene vary from one another, and bringing them together in one distinctive scene is known as "character" [22]. Koç & Yılmaz [23] have highlighted that LC could be seen as a notion and a process of differentiation based on its diversity, organization, and layout, ultimately providing each area a distinct personality that distinguishes it from the surrounding landscape. Each LC area is made up of a unique set of variables that reflect the landscape's overall characteristics. LC may be defined as the landscape's overall expression, which is reflected in several features, such as natural, cultural, visual, or symbolic. The quantification of LC as an indicator could describe and identify the scene, further measuring human preferences using visual quality [24]. Nonetheless, nature and culture are the most fundamental in defining LC. For instance, Simensen et al. [25] pointed out that the natural and cultural character of the landscapes has been included as an essential factor within the landscape character assessment (LCA) framework. LCA is a collection of tools and processes used to classify and describe landscapes, as well as to comprehend and convert the evolution of their physical and cultural traits into the development of the related management or planning policy [26]. As a result, LCA lays the groundwork for several policies to balance the contradictions that arise when multiple sectors use landscape resources [27].

1.2. Landscape Visual Quality

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Landscapes' visual quality is determined by how an observer values the elements of the surrounding environment through their perception, emotional and psychological processes [28]. The landscape's visual quality is based on the perceptual interaction between visitors and the landscape; hence it can be subjectively quantified [29,30]. In contrast, some studies consider the landscape's visual quality depends on the intrinsic characteristic of the environment [31]. Therefore, the visual quality of a landscape could be seen as coming from two primary sources: one is the elements and combinations of the landscape itself, while the other is the observer's perception and perception of the landscape [14]. The first approach evaluates both the intensity of the characteristics and the objective and inherent beauty of the landscape itself [32,33]. These aspects can be evaluated quantitatively based on their physical or aesthetic components or other factors [34]. However, this approach ignores the observer's subjective feelings, personal preferences, and psychological components, i.e., it leaves out the underlying hidden qualities of the landscape [35]. The second is a more intuitive way of assessing the landscape, using respondents' preferences for the landscape, which means that each person needs to incorporate their understanding of the landscape into the assessment to reach a consensus [36]. Furthermore, certain authors have proposed a fusion of the two approaches [37,38], modifying the emphasis on integrating them based on practical considerations and aiming to establish a clearer relationship between landscape elements and the observer [39-42].

2. Materials and Methods

2.1. Study Area

The proposed study area is located within the Sabak Bernam district on the Malaysian Peninsular's west coast. It borders the Lower Perak District, Perak to the north, the District of Kuala Selangor to the south, and the upper Hulu District to the east. It takes approximately 2 hours from Kuala Lumpur, the capital of Malaysia, to the study area. The majority of the district land areas are occupied by agriculture (47%) and forestry (40.18%), with less than 5% of the land being settlements and known as one of Malaysia's major rice producer areas. Ibrahim et al. [43] mention that the road from Kuala Selangor to Sabak Bernam in the Malaysian government's planning could be an attractive tourism route demonstrating the local rural landscape, such as culture, heritage, paddy fields, rural settlements, and tourist attractions. In addition to this, the related tourist services are relatively well-equipped within the area. However, due to the conversion of paddy fields into commodity crops, housing, commercial and industrial, the acreage of paddy fields in Sabak Bernam has decreased over the past ten years, dropping from 26,645 hectares in 2000 to 13,375 hectares in 2013. Fortunately, due to food security and supply concerns, the government has recently started adopting measures and policies to protect the paddy field areas.

As one of the small towns in the district of Sabak Bernam, Sungai Besar, an area that retains its charms of rural character with traditional Malay architecture of "kampung houses," vast areas of paddy fields and coconut plantations [44]. Sungai Besar is also well renowned for its homestay programs, which continue to preserve the rural way of life for tourists to enjoy. This study was specifically conducted on the rural road in Sungai Besar, starting from the junction of Jalan Sungai Panjang and Jalan Parit Cabang until the junction of Jalan Sungai Panjang and the rural path near Maktab Rendah Sains Mara Sungai Besar (Figure 1). This rural road is approximately 18.0 km (11.18 mi) long and is rich in scenic views of the rural landscape on both sides of the road.

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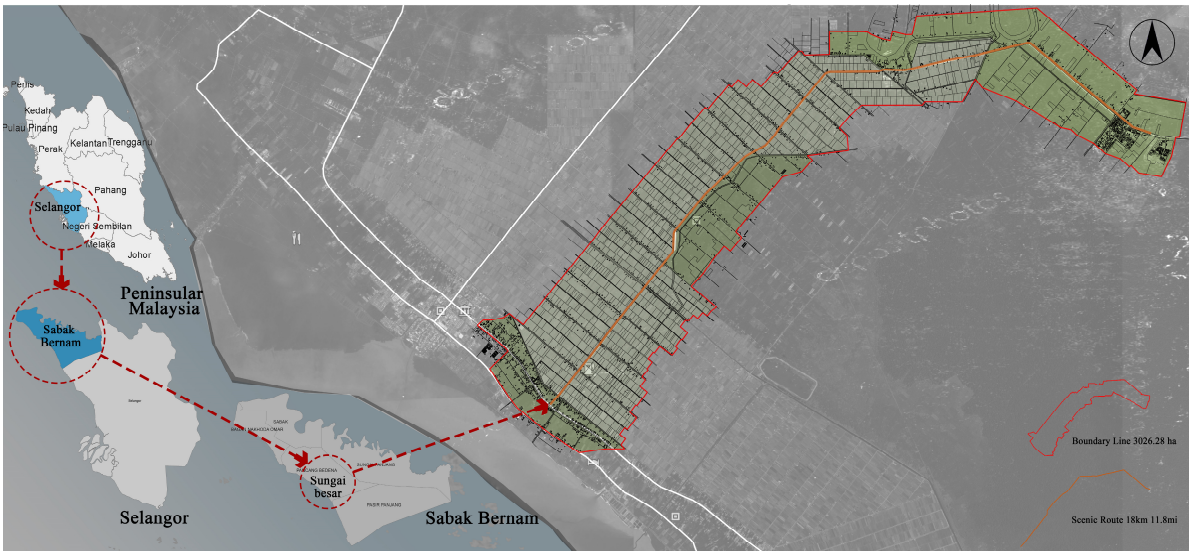

Figure 1. The location of the study area.

2.2. Methods of the Study

Studies examining visual aesthetics have asserted that public preference for a landscape is an interactive phenomenon that results from the interplay between the physical attributes of the landscape and the psychological responses of individuals who observe it [45,46]. This study proposes a user-centered evaluation method based on a public understanding of landscape preferences using the Likert scale technique. The Likert scale, widely employed in educational and social science research, is one of the most basic and extensively utilized instruments in psychological measurement [47]. In general, using the Likert scale often balances both positive and negative items, aiming to mitigate bias in the response set [48]. The participants utilize a bipolar scale, consisting of options such as, "strongly disagree, disagree, neutral, agree, strongly agree," to express their sentiments towards each item.

Furthermore, the photo survey method is one of the most direct approaches to assessing visual quality in the rural landscape [14]. The photo survey visually shows the scenic beauty of the landscape and allows the observer to assess its aesthetic appeal. Google Street View (http s://www.google.com/maps) provided the photos for this investigation because it employs more comprehensive and high-resolution panoramic photographs and could be more effective, quicker, and more convenient than field-based techniques [49]. Besides, the heatmap analysis allows respondents to understand which LCs and elements are preferred. Today, heatmap has gained popularity as a prevalent method of presenting information-rich data in 2D and 3D space. In terms of visualization, the graphical depiction of a heatmap provides a means of revealing coherent patterns within data by compressing a large amount of information into a small space [50]. Typically, two main categories of heatmaps exist the image-based heatmap and the data matrix heatmap [51]. The former refers to numerical data overlaid with an image, object, or geographic location, enabling visual information representation. The latter shows numerical information using a pseudo-color table or matrix format, presenting the information in a visual representation with specific color coding. Matrix heatmap finds extensive usage in the natural and biological sciences [52]. For this study, image-based heat maps are an appropriate means of demonstrating data visualization and emphasizing the visual impact of specific landscape elements.

2.3. The First Phase

- Collection of Photo

Photos along the rural road were captured through Google Street View at every 250m interval to cover the selected rural road (approximately 18.0 km long). The interval was decided based on the

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rural roads' 60 km/h speed restriction, equating to 60,000 meters in 60 minutes. A vehicle traveling at this speed would cover a distance of 250 meters in 15 seconds. The 15s interval was chosen assuming that it would be a reasonable duration for a visitor to experience the totality of the landscape offered by driving through the rural road. Based on this approach, 72 photos were captured. The details of capturing and classifying photos were be explained in the next section.

Figure 2. Examples of photos taken at a distance of approximately 250m.

- Landscape Character Identification

This study classified the LCs in the collected photographs based on land use, landform, land cover, vegetation, and human-made structures. Twelve categories of LCs were eventually identified, each including at least four images of the same LC. There were 12 groups, from A to L, using upper case letters in sequential sequence as a code. Each group was labeled based on a particular LC, such as Group A: "Barren paddy fields with roadside vegetation." To ensure that only dominant LC groups were selected for the survey, each group must have at least four photos. Based on this selection criteria, only 48 images were selected for this study after classification. (Appendix A). Table 1 shows the code and label for each group with one photo.

Table 1. Shows each group with their LCs.

Group.	Landscape Character	Code	Photo example
A	Barren paddy fields with roadside vegetation	A1	
B	Semi-barren paddy fields with irrigation canals	B1	

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C	Roadside oil palm vegetation	C1	
D	Semi-barren paddy fields with open horizon view	D1	
E	Roadside banana tree vegetation	E1	
F	A dense mix of roadside vegetation	F1	
G	Mix vegetation with settlements	G1	
H	Partial oil palm roadside vegetation	H1	

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I	Green paddy fields with irrigation canals	I1	
J	Partially grown paddy fields with roadside vegetation	J1	
K	Partially grown paddy fields and roadside vegetation with irrigation canals	K1	
L	Roadside settlements and commercial structures	L1	

2.4. The Second Phase

- Survey

This study's survey was administered and distributed online using a platform called Qualtrics. To avoid repetition of survey respondents' responses, the images were randomly organized, and no images from the same group were allowed to be placed consecutively. Besides, two additional images were added (one at the beginning and another at the end) to allow respondents to familiarize themselves s with the survey procedures and to avoid having a misled result. However, results from these two additional images were excluded from the analysis.

This online preference survey has two sections: (A) the demographic and (B) the photo survey. Section (A) contains 11 general questions: age, gender, income, educational background, experience with rural road landscapes, and other questions that are also important to the study. Section (B) contains two parts. One is the use of a 5-point Likert scale from 1 (least preferred) to 5 (highly preferred); participants were asked to view and evaluate a rural road landscape scene in the photo. Each photo was given a visual quality score ranging from -2 (least preferred scene) to +2 (highly preferred scene), where 0 value means moderate scene. Positive scores represent positive visual quality and vice versa. Using this categorization of the Likert scale, Wartmann et al. [53] successfully identified what the public considered an influential visual quality. Munder et al. [54] successfully utilized this Likert scale to classify landscape characters into negative and positive visual quality

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categories. Another section is to allow respondents to click and identify two elements of photos that they like the most in the rural road landscape. Heat map analysis will be automatically generated based on the recorded clicks' intensity. The Qualtrics heatmap analysis was utilized to identify the LC that impacts the visual quality.

The final survey was distributed through social media using purposive sampling, limiting people living in Malaysia as participants. The survey data were collected over 30 days beginning Feb 25, 2023. The SPSS V26 program was used to analyze the survey results and identify the variables that influence visual quality evaluation. Figure 3 provides an overview of the research methodology employed in this study.

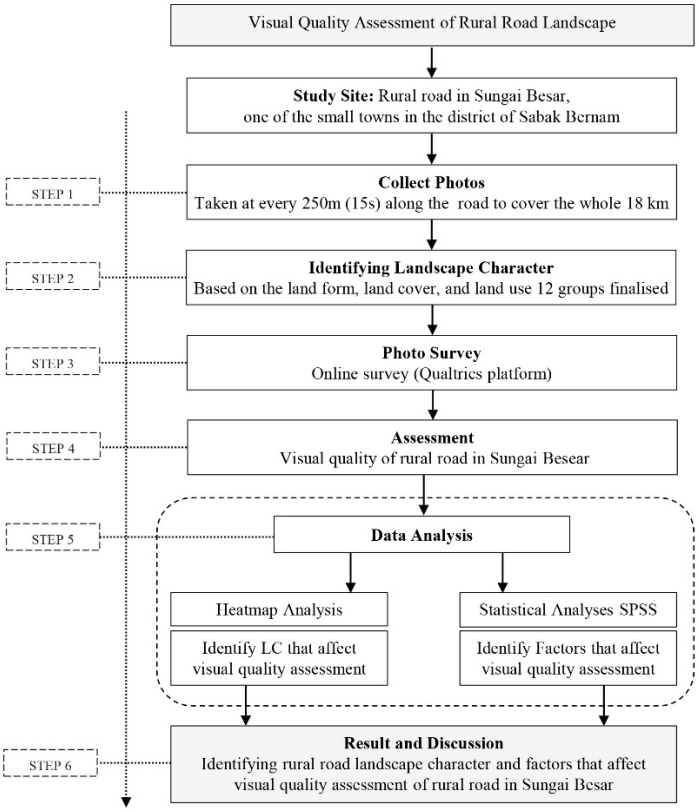

Figure 3. Overview of the research methodology.

3. Results

3.1. Demographic Statistics Description

As shown in Table 2, 250 respondents out of 282 completed the survey, with more females (N = 155, 62%) than males (N = 95, 38%). Most respondents (N = 105, 42%) and (114, 45.6%) were between 18 and 25 and 26 and 35, respectively. The remaining respondents (N = 31, 12.4%) were over 45. Additionally, 108 respondents were foreigners, making up 43.2% of the total respondents, while 142 were Malaysians. Among Malaysians, the majority were Malays (N = 65, 26%) and Chinese (N = 67, 26.8%), while Indians were the minority (N = 10, 4%). On the other hand, among the international respondents, there were significantly more Chinese respondents (N = 97, 38.8%) than respondents from other nations (N = 11, 4.4%). More than half of the respondents were students (N=131, 52.4%), which may indicate that their average monthly income was less than RM2500 (N=148, 48%). Moreover, over 80% of respondents (N = 222, 88%) in this group were educated higher than the high school level. Almost two-thirds of the (N = 160, 64%) respondents had a home in the urban area, but 64.8% (N = 164) visited the rural area more than twice or more. When the respondents were asked about the type of transportation they use when traveling to rural areas, the majority commented that the car (N = 216, 86.4%) was the primary means of transport when traveling to rural areas.

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However, only a relatively small number of respondents stated that they have been to Sungai Besar. This accounted for 47 samples representing 18.8% of the total respondents. Based on the results, it can be concluded that the respondents are predominantly female, students, and local, have a good education level, and are relatively familiar with rural areas but have limited information about the study area.

Table 2. shows the overall data of the demographic survey.

Variable.	Category	Frequency N	Valid Percent %
Gender	Male	95	49.6
	Female	126	50.4
Age	18 to 25	105	42.0
	26 to 35	114	45.6
	36 to 45	29	11.6
	46 to 55	2	0.8
	Above 55	0	0
Malaysian citizen	Yes	142	56.8
	No	108	43.2
Ethnicity	Malay	65	26.0
	Chinese	164	65.6
	Indian	10	4.0
	Others	11	4.4
Monthly income	Below RM 2500	120	48.0
	RM 2500 to 5000	66	26.4
	RM 5000 to 7500	38	15.2
	Above RM7500	26	10.4
Type of work	Student	131	52.4
	Self-employed	24	9.6
	Private	73	29.2
	Government	22	8.8
Educational level	High school	28	11.2
	Diploma-Bachelor degree	114	45.6
	Master degree	70	28.0
	Ph.D. or higher	38	15.2
Hometown	Urban area	160	64.0
	Suburban area	53	21.2
	Rural area	37	14.8
Frequency of visits to the rural area	Less than one a year	88	35.2
	2 to 4 times a year	95	38
	5 to 8 times a year	23	9.2
	More than 8 times a year	44	17.6
Type of transportation for the rural area	Train	18	7.2
	Bus	12	4.8
	Car	216	86.4
	Motorcycle	4	1.6
Visiting Sungai Besar or not	Yes	47	18.8
	No	203	81.2

- Statistics Description of Landscape Experience in Demographic Survey

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This part depicted the extent to which respondents were intrigued by the experience of the rural environment (Table 3). In general, respondents exhibited a higher interest in the natural landscape (AM = 3.75) compared to cultural ones (AM = 3.288), particularly demonstrating the highest interest in hill and mountain (IM = 3.83) in the natural landscape. However, traditional houses (IM = 3.67) and orchards (IM = 3.56) had a much higher average individual value in the cultural group than other LCs. Interestingly, the individual mean value for traditional houses (IM = 3.67) in the cultural LC variable was even higher than the forests (IM = 3.63) in the natural landscape variable. This result suggested that traditional rural houses could be of interest to some respondents because of their specific memories of their hometowns and their preference for traditional heritage. Paddy fields, mixed agricultural crops, and oil palm plantations were comparable within the cultural landscape, with oil palm plantations being the lowest at 2.94. This may be because planting large areas of oil palm has reduced respondents' experience of the diversity of the rural landscape.

Table 3. shows the respondent's landscape experience within the rural area.

Variable/Landscape Experience	Landscape Character	Individual Mean Value	Average Mean Value
Culture	Paddy field	3.12	3.288
	Mix agricultural crops	3.15	
	Traditional houses	3.67	
	Oil palm plantations	2.94	
	Orchard	3.56	
Nature	River	3.78	3.75
	Hill/Mountain	3.83	
	Forest	3.63	

3.2. Photo Survey

- Rating of Each Photo Survey

The Likert scale used in this visual photo survey ranged from negative two to positive two. According to this criterion, the mean value from the respondents' survey was analyzed for all 48 photos and ranked (refer to Table 4). The number of photos with positive visual quality was slightly less (N=21) than those with negative (N=27). Surprisingly, neither the positive nor the negative visual quality photos had a mean value greater than +1 or -1, with the highest mean value of +0.74 for positive visual quality and the lowest mean value of -0.53 for negative visual quality. These results could indicate that respondents for the rural road landscape were within their acceptable range. No specific landscape elements significantly influenced respondents' visual preferences as either exceptionally good or bad. Instead, the overall landscape of the rural road was perceived to be in relatively good condition and maintenance, suggesting a general satisfaction with the overall rural road landscape. Next, six images from the highest positive and lowest negative visual quality values were selected to provide a general overview of the visual quality trends (Table 5).

Table 4. shows the ranking of each photo's mean values.

Positive Visual Quality			Negative Visual Quality		
No.	Photos Codes	Mean Value	No.	Photos Codes	Mean Value
1	I3	+0.74	1	L3	-0.53
2	K2	+0.64	2	F4	-0.35
3	I1	+0.62	3	G2	-0.24
4	I4	+0.59	4	E2	-0.14
5	I2	+0.54	5	H3	-0.13
6	K4	+0.51	6	F2	-0.12
7	K3	+0.37	7	F3	-0.12
8	B4	+0.35	8	H1	-0.12
9	B1	+0.33	9	J4	-0.12
10	D3	+0.31	10	L1	-0.12
11	B3	+0.28	11	F1	-0.11

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12	A4	+0.26	12	E1	-0.10
13	B2	+0.24	13	G3	-0.10
14	J3	+0.17	14	L2	-0.07
15	D4	+0.14	15	E3	-0.06
16	A1	+0.14	16	A3	-0.05
17	J1	+0.08	17	H4	-0.05
18	H2	+0.07	18	C3	-0.04
19	J2	+0.06	19	C4	-0.04
20	K1	+0.05	20	L4	-0.04
21	D1	+0.01	21	C2	-0.02
			22	G1	-0.02
			23	A2	-0.01
			24	C1	-0.01
			25	D2	-0.01
			26	E4	-0.01
			27	G4	-0.01

Based on Table 5, notably in the positive visual quality category, four of six photos were from group I (I3 M = +0.74, I1 M = +0.62, I4 M = +0.59, I2 M = +0.54), which predominantly displayed the view with "green paddy fields with irrigation canals." Other photos were from group K (K2 M = +0.64, K4 M = +0.51), featuring "partially grown paddy fields" and "roadside vegetation with irrigation canals." It can be seen that the entire top six is only from groups I and K. These photos showed most likely similar LCs and elements that contribute to high visual quality and overall popularity among the survey respondents. Even the top 11 images fit this pattern (Table 4). However, the presence of water significantly enhanced the visual appeal to a certain degree, which has been consistently proven in many studies. Table 3 indicates that water experience was highly preferred in rural areas, while the experience of paddy fields was only the second least preferred among all the LCs. Thus, the element of water and its role can be considered vital in rural areas. However, most of the photos in the negative visual quality group also shared a similar LC of vegetation (F4 M = -0.35, G2 M = -0.24, E2 M = -0.14, H3 M = -0.13, F2 M = -0.12) except for L3 (M = -0.53), which had the poorest visual quality with "roadside settlements and commercial structures." The top four photos of the negative visual quality group showed a lack of coherence and a higher sense of complexity among elements within the scenes. In particular, L3, "human-made elements" without proper management, as the main LC, were more likely to result in the lowest preference for landscapes. The remaining two showed a slightly more orderly coherence, but the overall scene gave a sense of being enclosed, causing respondents to prefer this scene less.

Table 5. shows the top six positive and negative visual-quality photos.

	Photos	
Positive Visual Quality Photos		
	1. Mean = +0.74 (I3)	2. Mean = +0.64 (K2)
		

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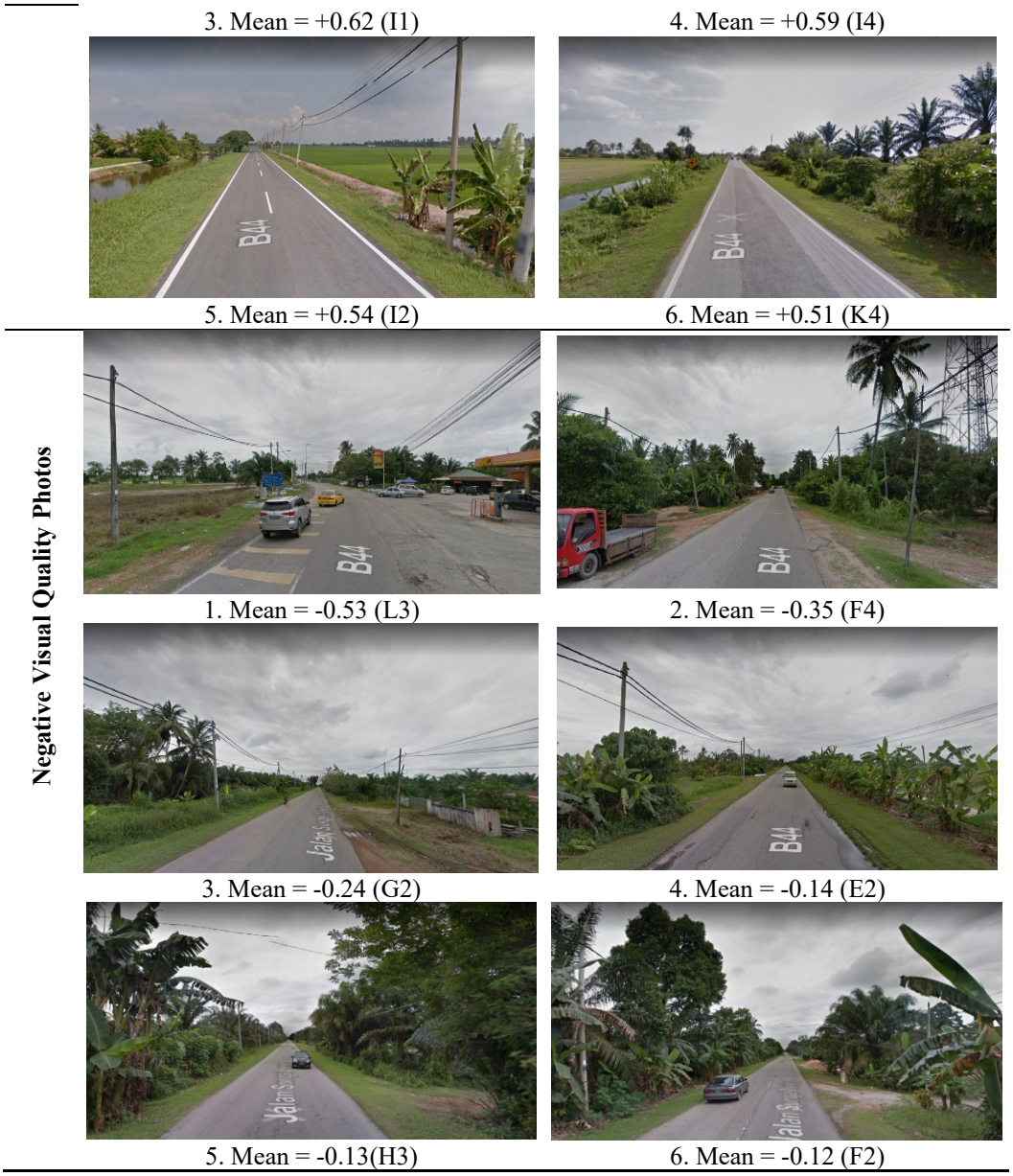

- Comparison of Landscap Character Groups

Average values of visual quality across different groups are presented in Table 6. A surprising finding is that groups having paddy fields as a main LC were classified in the positive visual group. In contrast, groups characterized by mixed vegetation as the dominant LC were classified as the negative visual group. In the positive LC groups, the top three (I M = +0.6625, K M = +0.3925, B M= +0.3) featured "paddy fields and irrigation canals," with the only differentiating factor being the phases of paddy plantation observed in the fields. The higher the maturity from semi-barren to green, the higher the respondent's preference. Next, in fourth place was group D (M = +0.3), which provided a complete view of the paddy field landscape. The last two groups (A M = +0.11, J M = +0.085) featured "paddy fields and vegetation." The value of visual quality for group D is lower than the first three groups, mainly due to the absence of a water landscape, which confirms that the existence of a water character in the landscape improves its visual appeal. However, group D has a higher visual quality rating than the other two (A and J) mainly because of its broader field of view. Group A and J, with a limited line of sight due to vegetation obstruction, exhibit a lower rating.

Subsequently, in the negative visual group, nearly all groups, except for group L (M = -0.19), which had the lowest preference for "roadside settlements and commercial structures," showed a landscape mostly covered in vegetation. Essentially, the top three views (C M = -0.0275, H M = -0.0575, E M = -0.0775) were simple plant-based views, with the oil palm (group C and group H) slightly

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more popular than the banana tree (E). The following three views showed a slightly more varied LC, such as group G (M = -0.0925) with "a mix of vegetation with settlements," group F (M = -0.175) with "dense roadside vegetation," and group L (M = -0.19) with "roadside settlements and commercial structures," causing those surveyed to feel confused, disordered, and complex. Notably, Groups G and F with vegetation were better than Group L, where artificial landscapes dominate. Hence, the preference for vegetation landscapes is generally better than artificial ones in the negative visual group. In comparing vegetation landscape groups only in this group, visual quality in vegetation landscapes can be changed by specific characters or elements.

Table 6. shows the ranking of group photo mean values.

	Group	Landscape Character	Code	Individual Mean Value	Average Value
Positive Visual Quality	I	Green paddy fields with irrigation canals	I1	+0.62	+0.6225
			I2	+0.54	
			I3	+0.74	
			I4	+0.59	
	K	Partially grown paddy fields and roadside vegetation with irrigation canals	K1	+0.05	+0.3925
			K2	+0.64	
			K3	+0.37	
			K4	+0.51	
	B	Semi-barren paddy fields with irrigation canals	B1	+0.33	+0.3
			B2	+0.24	
			B3	+0.28	
			B4	+0.35	
	D	Semi-barren paddy fields with open horizon view	D1	+0.01	+0.1125
			D2	-0.01	
			D3	+0.31	
			D4	+0.14	
	A	Barren paddy fields with roadside vegetation	A1	+0.14	+0.085
			A2	-0.01	
			A3	-0.05	
			A4	+0.26	
	J	Partially grown paddy fields with roadside vegetation	J1	+0.08	+0.045
			J2	+0.06	
			J3	+0.16	
			J4	-0.12	
Moderate Visual Quality (M = 0)					
Negative Visual Quality	C	Roadside oil palm vegetation	C1	-0.01	-0.0275
			C2	-0.02	
			C3	-0.04	
			C4	-0.04	
	H	Partial oil palm roadside vegetation	H1	-0.12	-0.0575
			H2	+0.07	
			H3	-0.13	
			H4	-0.05	
	E	Roadside banana tree vegetation	E1	-0.1	-0.0775
			E2	-0.14	
			E3	-0.06	
			E4	-0.01	
	G	Mix vegetation with settlements	G1	-0.02	-0.0925
			G2	-0.24	
			G3	-0.10	
			G4	-0.01	
	F	A dense mix of roadside vegetation	F1	-0.11	-0.175
			F2	-0.12	
			F3	-0.12	
			F4	-0.35	

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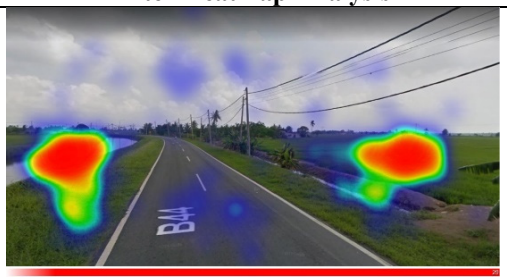
L	Roadside settlements and commercial structures	L1 L2 L3 L4	-0.12 -0.07 -0.53 -0.04	-0.19

3.3. Heatmap and Landscape Characters Effect on Visual Quality Assessment

This study used heatmap analysis to specific landscape elements that affect the overall visual quality of the rural areas. Heat map analysis relied on respondents' click density,' with areas shaded in red indicating the most clicks, while those in blue representing the fewest clicks (Table 7). The focal concentration of red areas suggested a greater preference among the respondents towards specific or dominant elements, while scattered and lighter red areas indicated a vice versa. Thus, photos and heatmap analysis provided a more accurate indication of the landscape elements that the respondents preferred. Table 7 provides examples of heatmap analysis based on positive and negative visual groups presented in Table 6. In the positive group, the red zones are more concentrated mainly towards paddy fields or irrigation canals, indicating a strong preference for these two specific characters among respondents. Despite some clusters of red regions on the vegetation, the red intensity was notably lesser than in the paddy fields and irrigation canals. This suggests that the visual appeal of paddy fields accompanied by irrigation canals is superior to the combination of paddy fields with roadside vegetation. Furthermore, the photographs belonging to the positive group depicted a scene with an open or semi-open view. The arrangement and integration of the landscape elements in the scene also appear coherent and harmonious, which may be attributed to the paddy field dominating a more significant portion of the scene, creating a sense of unity and order.

However, in the negative group, the absence of paddy fields and irrigation canals as dominating elements resulted in more scattered clusters of red areas. Notably, in the negative group, the preference for the view with enclosed horizons was higher than that with partially open horizons. The initial two scenes within the negative group exhibited a relatively uniform arrangement of the oil palm, albeit with a narrower field of enclosed view. The LCs maintained relatively high coherence in the scenes, with the oil palm dominating. However, these two groups caused negative visual quality probably because the vegetation created a more enclosed visual space. Next, although Group E was also a relatively homogeneous vegetation landscape (banana tree), the unity and integrity of the scene were less than that of the previous two groups. The subsequent scenes depicted diverse landscape elements; the overall scenery lacked more coherence and was abundant in human-made characters, causing the respondents to dislike it more. Hence, the scene's complexity and coherence could impact the respondent's visual preference. To some extent, it could be contended that the tidiness and coherence of the scenery hold greater significance than the openness of the scenery in terms of rural negative visual quality.

Table 7. shows a heatmap analysis to identify the key characters and elements for visual quality.

	Before Heatmap Analysis	After Heatmap Analysis
Positive Visual Quality.		
1.	Group (Mean)	I (I3, M = +0.74)
Landscape Character		Green paddy fields with irrigation canals

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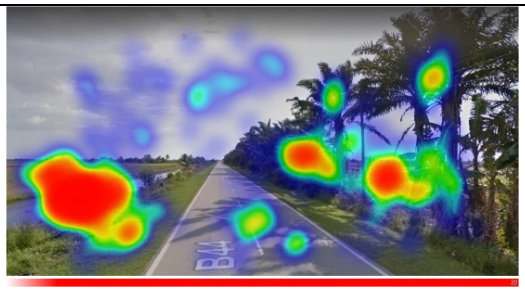
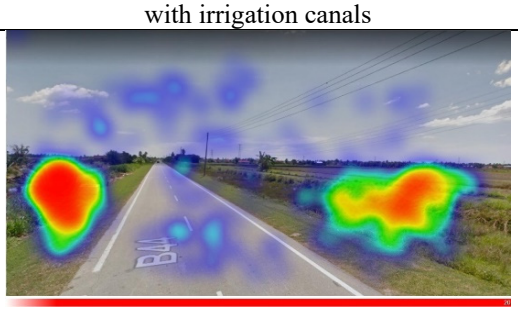
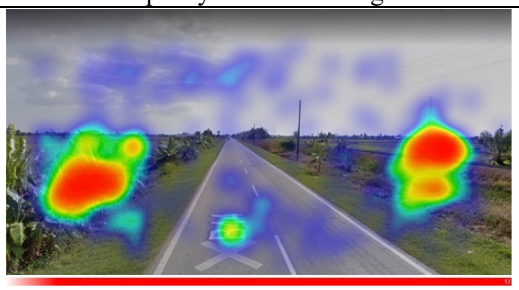
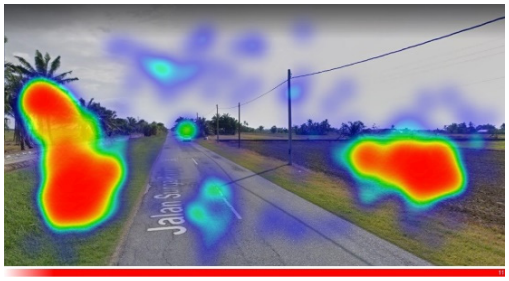
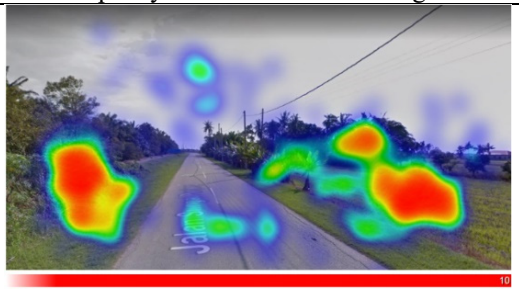
		
2.	**Group (Mean)**	K (K2, M = +0.64
Landscape Character		Partially grown paddy fields and roadside vegetation with irrigation canals
		
3.	**Group (Mean)**	B (B4, M = +0.35)
Landscape Character		Semi-barren paddy fields with irrigation canals
		
4.	**Group (Mean)**	D (D3, M = +0.31)
Landscape Character		Semi-barren paddy fields with open horizon view
		
5.	**Group (Mean)**	A (A4, M = +0.26)
Landscape Character		Barren paddy fields with roadside vegetation
		
6.	**Group (Mean)**	J (J2, M = +0.16)
Landscape Character		Partially grown paddy fields with roadside vegetation
Moderate Visual Quality (M = 0)		

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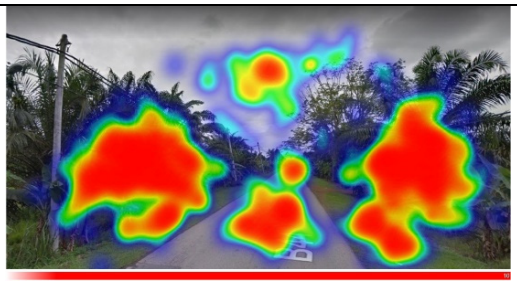
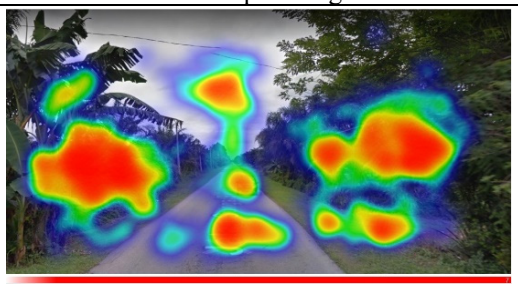
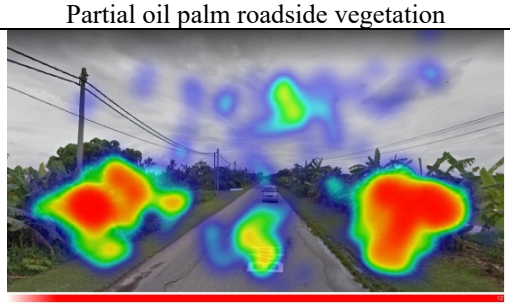
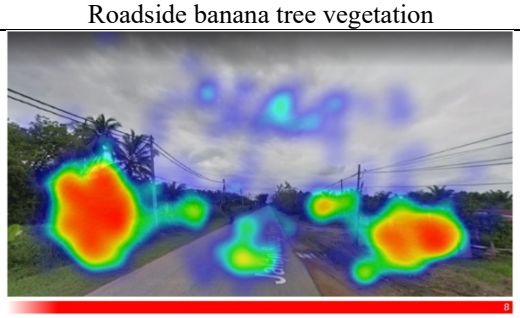
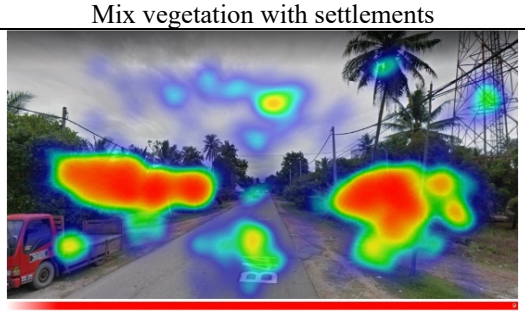
Negative Visual Quality

	**1. Group (Mean) Landscape Character**	 C (C3, M = -0.04) Roadside oil palm vegetation
	**2. Group (Mean) Landscape Character**	 H (H3, M = -0.13) Partial oil palm roadside vegetation
	**3. Group (Mean) Landscape Character**	 E (E2, M = -0.14) Roadside banana tree vegetation
	**4. Group (Mean) Landscape Character**	 G (G2, M = -0.24) Mix vegetation with settlements
	**5. Group (Mean) Landscape Character**	 F (F4, M = -0.35) A dense mix of roadside vegetation

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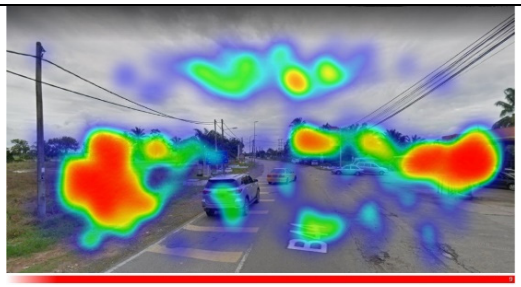
6.	Group (Mean) Landscape Character		 L (L3, M = -0.53) Roadside settlements and commercial structures

3.4. Factors Affecting Visual Quality on Rural Road Landscape

This section has focused on the influence of different respondents' demographic factors on the visual quality of rural road LCs. Following the previous grouping of means, the reliability of the two groups of positive and negative visual quality was examined separately. The reliability test indicated that the result is greater than 0.7 (PVQ Cronbach's Alpha = .969, NVQ Cronbach's Alpha = .961, total Cronbach's Alpha = .976), which is within the acceptable range, as shown in Table 8. Besides, the normality of the survey sample was also tested to determine the appropriate analysis. Based on the results indicated in Table 9, the Kolmogorov-Smirnov and Shapiro-Wilk Sig. values for the positive and negative groups were greater than 0.05 ($p > 0.05$), meaning the null hypothesis should be accepted. The results satisfied a normal distribution.

Table 8. shows the results of the reliability.

Visual Quality	Valid (N)	N of Items	Reliability Cronbach's Alpha
Positive visual quality (PVQ)	250	24	.969
Negative visual quality (NVQ)	250	24	.961
Total reliability (Cronbach's Alpha) for 48 photos			.976

Table 9. shows the results of the normality.

Visual Quality	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Positive	0.44	250	.200*	.992	250	.158
Negative	0.55	250	.069	.991	250	.128

*. This is a lower bound of the true significance. a. Lilliefors Significance Correction

Parametric analytical tests such as T-tests and One-way ANOVA were used in the following analysis with results that only presented significant differences ($p < 0.05$) listed. The independent t-test, as shown in Table 10, shows two factors influencing the positive visual quality: the respondents' citizenship and previous experience visiting Sungai Besar. However, these effects were limited to some specific LCs.

The factor "Local or Foreigner" influenced Group D, "Semi-barren paddy fields with open horizon view," Group A, "Barren paddy fields with roadside vegetation," and Group J, "Partially grown paddy fields with roadside vegetation," indicating there was a significant difference in the perception of these landscapes between locals and foreigners, with higher mean scores for these LCs in locals than foreigners. This difference may be attributed to Malaysians' familiarity with similar landscapes in real life, leading to a more pronounced perception of local landscapes. In contrast, non-Malaysians may have viewed the landscapes as unremarkable paddy fields without personal interaction, causing lower mean scores. Similarly, the factor "With or without experience" affecting

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the LC groups was almost the same as the previous one. Respondents who were familiar with and had visited the study area provided higher mean scores than those who had not been there. It is implied that respondents who have visited the study area may have been more associations with the local landscape, which influenced their visual judgments. Conversely, respondents who had not been there could only rate by visual impression in photos, resulting in lower average scores. These findings indicated that familiarity with specific local landscapes and the associated local landscape could influence respondents' visual judgments in rural road landscapes.

In the negative group, the factor "Local or Foreigner" influencing only LC, group L, showed a significant difference. Group L, "Roadside settlements and commercial structures," was the last one among the negative groups. The Malaysians rated this group better than the foreigners, indicating that they might have had prior exposure to this landscape and had been more common. On the other hand, non-Malaysians were less familiar with this type of landscape, leading to a more intuitive judgment with a lower mean score. Therefore, the degree of familiarity with some particular landscape could significantly affect people's visual experience, as evidenced by the results of these factors.

Table 10. shows the results of the T-test in the positive group.

Visual quality	Variable	Group	N		Mean	F	Sig.	T	Sig.(2-tailed)
Positive Visual Quality	Local or Foreigner	D	Yes	142	3.2535	1.037	.309	2.819	.005
			No	108	2.9190				
		A	Yes	142	3.2183	.884	.348	2.697	.007
			No	108	2.9097				
		J	Yes	142	3.1373	3.529	.061	2.031	.043
			No	108	2.9168				
	With or without experience	B	Yes	47	3.6277	1.217	.271	2.626	.009
			No	203	3.226				
		D	Yes	47	3.3670	.753	.386	2.097	.037
			No	203	3.0493				
		A	Yes	47	3.3404	.023	.879	2.157	.032
			No	203	3.0259				
Negative Visual Quality	Local or Foreigner	L	Yes	142	2.9595	3.848	.051	3.256	.001
			No	108	2.6134				

Significant at $p<0.05$.

Next, the One-way ANOVA analysis data were presented. The age groups of 46-55 and over 55 were merged into the 36-45 age range due to limited respondents. This new age range was then adjusted to above 36. After analyzing the socio-demographic data for all options equal to or greater than 3, it was discovered that only the age factor displayed a statistically significant difference ($p < 0.05$) in some positive groups (B, "Semi-barren paddy fields with irrigation canals" D, "Semi-barren paddy fields with open horizon view" A, "Barren paddy fields with roadside vegetation" J, "Partially grown paddy fields with roadside vegetation"), as demonstrated in Tables 11 and 12. The data presented in Table 11 only shows significant differences, with Sig values below 0.05, indicating a significant difference among at least one pair of the three age options. Next, Table 12 presents comparative data for these positive groups. Notably, the average scores for the photos provided to the 18-25 age group were higher than those for the 26-35 age group across all four groups. This suggests that younger respondents were more drawn to these LCs. However, there were no significant differences between those aged 18-25 or 26-35 to those aged 36 and above. This may be due to the small sample size of those aged 36 and above compared to the larger sample sizes of the 18-25 and 26-35 age groups.

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Table 11. shows the results of the Anova in the positive group.

Positive Group	(18-25, 26-35, Above 36) Group	F	Sig.
B	Between Groups Within Groups Total	3.259	.040
D	Between Groups Within Groups Total	3.902	.021
A	Between Groups Within Groups Total	3.612	.028
J	Between Groups Within Groups Total	3.621	.028

Significant at $p<0.05$.

Table 12. shows the results of the comparisons in the positive group.

Positive Group	(I) Age	(J) Age	Mean Difference (I-J)	Sig.
B	18-25	26-35	.32669*	.040
D	18-25	26-35	.33528*	.030
A	18-25	26-35	.31253*	.038
J	18-25	26-35	.30382*	.031

*. The mean difference is significant at the 0.05 level.

4. Discussion

4.1. The impact of landscape elements on visual quality

This study shows that the rural road landscape elements play a significant role in terms of influencing public preferences toward determining visual quality. The overall results show a distinct shift in the landscape's visual quality, transitioning from a predominantly paddy field with a positive visual quality to predominantly mixed vegetation or human-made structures with a negative visual quality. Within the positive visual group, the landscape elements paddy field is a critical determinant of visual quality. The paddy field not only provides economic value but also plays a crucial role in preserving local traditions and culture, protecting the environment, and offering educational and recreational opportunities [55]. When investigating rural tourism routes in a similar area, Sungai Besar, it is discovered that tourists are also intensely interested in the paddy fields that typify the scenery along those rural routes [43]. The preference for paddy fields is consistent with findings from studies on highway landscapes in Malaysia [56]. Paddy fields have the highest preferences compared to other landscape elements. Hence, it can be seen that paddy fields are an irreplaceable part of a scenic drive in Malaysia.

Besides, other landscape elements alongside the paddy field can affect the visual quality of the paddy field, such as water-related elements or vegetation. Landscapes containing water-related elements are the most preferred by the public in rural areas, contributing to a positive emotion and higher perceived recuperation [57,58]. The presence of water-related elements in the scene positively impacts human preference. As the proportion of water in the scene increases, so does the degree of human preference [57]. However, the excessive addition of elements are added to the paddy field landscape could result in a decline in its visual quality [59]. For example, abundant vegetation elements in paddy fields could result in a lower overall visual quality than in paddy fields with water-related elements. Hence, the visual quality of the groups with “paddy fields with irrigation canals ” is better than groups with “paddy fields with vegetation.”

Within the negative visual group, vegetation or human-made structure landscape elements become the main character. These landscape elements, especially scenes dominated by the human-made landscape, have unpopular in the Malaysian road landscape, offering the most unpleasant visual experience [60]. Similarly, Akbar et al. [61] found that most respondents regarded roadside vegetation as unpleasant and monotonous in their study. Besides, when visibly distinct and incongruous with the surrounding environment, human-made structures and elements such as electricity poles and settlements result in a lower public preference. Without proper management and maintenance, these elements could be perceived as visual pollutants [62]. Hence, the public's perception of these visual qualities is negative. Among the negative visual group, the visual quality of the group focusing on vegetation alone is better than the others, likely because, to some extent, road users consider roadside vegetation to be the primary aspect of scenic beauty on the road [63]. However, vegetation leading to the negative visual quality in this study may be the excessive density of vegetation, which creates a more confined environment. On the other hand, the groups where human-made landscape elements are distinctive and dominant are often perceived as a type of visual pollution, causing more visual discomfort and emotional disgust, further lowering public preference for such landscapes. Hence, these landscape elements are in the last group within the negative visual group, representing the poorest visual experience.

4.2. The Impact of Visual Character on Visual Quality

Visual characters are also a key factor affecting visual quality [64]. Each concept comes with its description and attributes; scholars only choose the corresponding concept to access based on the current context [65]. Given the landscape scenes presented in this study, we have further identified four key characteristics - visual scale, coherence, complexity, and disturbance - to provide a more detailed visual quality analysis.

For the positive visual group, the combination of unified and orderly landscape elements, paddy fields with water-related or vegetation elements, and the presence of more open views contribute to the public an excellent visual experience. The unified and orderly environmental components could be attributed to the coherence [66]. In other words, coherence, the degree to which scenes are put together using organized materials, textures, structures, repetition, and continuity, could be seen as unity [67]. The concept of unity in aesthetics results in a harmonious and balanced composition, allowing the various elements of the scene to be integrated cohesively [68]. The unity, in turn, creates an orderly arrangement of spaces and plants. Hence, there is connectivity with coherence, which pertains to the extent of association between perceivable features or elements within the environment and their potential significance in the broader context [69]. Landscapes with a more organized visual appearance are preferred over those that appear disorderly [70]. Additionally, there is a direct correlation between the extent of openness in a landscape and individuals' preferences [71]. This implies that landscape scenes characterized by a high degree of openness and a high sense of order are preferred by more respondents [72]. Hence, the landscape elements of the predominantly paddy fields, combined with other complementary landscape elements, present a more harmonious and comfortable composition, providing visual enjoyment for the public.

Conversely, within the negative visual group, a mixture of diverse, intricate, and disorderly landscape elements, vegetation and human-made elements, and a relatively closed view gives the public a negative visual experience. The entire negative visual group has a slightly worse field of view than the positive visual group. Since this degree of openness is generally low, the public's preference for such landscapes is also diminished. Furthermore, the concepts of diversity, intricacy, and disorder can be summarised as complexity in the visual LC [64,73]. Kaplan et al. [67] have subsequently mentioned that complexity could serve as a representation of both order and disorder. An orderly complexity contributes to the visual richness of a setting, whereas a disorganized complexity may be regarded as a chaotic element [74]. Therefore, the visual quality of a single vegetation-dominated landscape is better than others in n this negative visual group. The disturbance in the landscape's visual character is also a factor causing negative visual quality. The disturbance is generally the absence of contextual suitability and coherence in the scene of the landscape [65]. In

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some negative visual groups, the main distracting elements are the human-made landscape elements that do not harmonize with the surroundings and indirectly become visual pollution. Hence, the presence of such elements can distract and lead to an unpleasant visual experience for the public.

4.3. Respondent Background and its Influence on Preference

This study reveals that only a limited number of specific landscape characteristics are impacted by demographics, such as citizenship, experience in Sungai Besar, and age. These factors are primarily related to specific positive visual groups. Citizenship or experience in Sungai Besar could be seen as a familiarity. Previous studies have demonstrated the significance of familiarity in the visual assessment of landscapes, where familiarity mainly refers to the place of presence and current residence [75]. The relationship between people and place appears to be an essential element influencing visual landscape preferences [6]. Familiarity with landscape type is an important factor in preference for visual landscapes [76]. However, the impact of familiarity on preference is not always clear-cut [77], which may explain why citizenship or experience in Sungai Besar have little effect on the rest of the LCs. Other familiarity-related factors, such as hometown, are also found to have no relationship with LCs in this study. Besides, regarding age, some research has discovered that landscape preferences change with age [78,79]. The main differences in preference are typically observed between children and adults or young and elderly individuals (Howley, 2011). However, in this study, the observed difference in preference is primarily between two closely related age groups, namely 18-25 and 26-35, which is very different from the results of previous studies. Hence, there is a lack of relevant evidence to explain the difference between these two age groups.

5. Limitations and Future Studies

This study provides valuable information about people's preferences and the visual quality of rural roads. However, it is crucial to acknowledge its limitation. Firstly, most respondents were ethnic Chinese, while other ethnicities were under-represented. This imbalance in the proportions may have potentially influenced the results. Future research should strive to establish a more equal representation of different ethnicities in order to provide more inclusive and representative outcomes.

The second limitation is related to the difficulty in ensuring the seriousness of some respondents while answering the questionnaires. As most questionnaires were distributed through online links or QR codes, controlling the respondents' level of attentiveness and engagement was challenging. Hence, to improve this limitation, it is recommended to consider incorporating measures to assess and ensure the seriousness and attentiveness of respondents, such as conducting in-person interviews or implementing validation techniques.

Next, the study relied mainly on Google Street View images as the source of the landscape scenes. However, these images may not wholly reflect the actual visual experience due to the limitations of uploading and updating images. Hence, to guarantee that the sceneries are as accurate and realistic as possible, it is recommended to validate the visual data by visiting the actual locations and confirming the accuracy of the photographs. This is crucial for research or decision-making processes when visual data is used. Doing so can avoid biases and inaccuracies from relying solely on images from platforms such as Google Street View.

Lastly, it is proposed to include both qualitative interviews and quantitative questionnaires in future studies. This mixed-methods approach can provide a more comprehensive understanding of the visual quality of the rural road landscape and other related information. By integrating qualitative and quantitative data, researchers can discover more about the respondent's perceptions and preferences and capture subtle characteristics that quantitative measures alone may miss.

6. Conclusion

This study examined the visual quality of rural road LCs in Sabak Bernam, Malaysia, through a combination of heat map analysis and public preference surveys. The findings emphasized the

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significance of preserving the original appearance and scenery of the rural landscape in the face of rapid rural development. The study indicated that paddy fields hold a very high status in the Malaysian rural landscape and contribute significantly to enhancing the overall visual quality of the area. Although the public did not prefer the vegetation-based LC regarding visual quality, it was still essential in the rural road landscape. On the other hand, human-made elements in the rural road LC have significantly negatively impacted the landscape's visual experience and original appearance. It is essential to integrate human-made elements thoughtfully into the rural landscape to complement and enhance the rural environment rather than detract from it. This research contributes to valuable knowledge about the visual quality of rural road landscapes and offers the groundwork for future landscape planning and conservation initiatives in Sabak Bernam and surrounding areas. Besides, by taking the public's preferences into account, stakeholders may make well-informed decisions to maintain and enhance the visual quality of rural road landscapes. The study also emphasizes the necessity of sustainable development strategies that preserve the rural regions' unique natural beauty, cultural diversity, and customs. Overall, the results of this study can provide valuable insights for decision-makers, landscape architects, and planners, enabling them to make informed decisions regarding future landscape conservation and planning, particularly in rural tourism and preservation.

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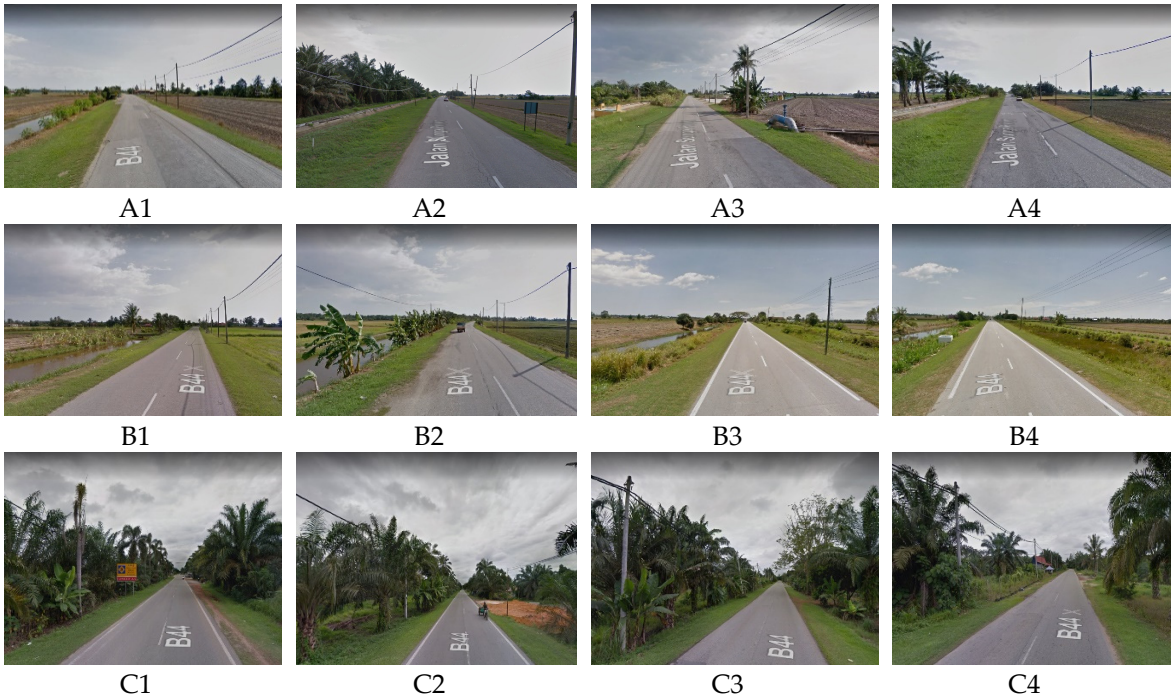
Appendix A



A1 A2 A3 A4

B1 B2 B3 B4

C1 C2 C3 C4

 doi:10.20944/preprints202306.2158.v1


D1


D2


D3


D4


E1


E2


E3


E4


F1


F2


F3


F4


G1


G2


G3


G4


H1


H2


H3


H4


I1


I2


I3


I4


J1


J2


J3


J4


K1


K2


K3


K4

Figure A1. Shows the group of landscape characters.

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