The value of highway corridor scenes

A case study for the Dutch city of Zwolle

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Preface

As a kid, I have always been fascinated by highways. While, my brother spend most of his time, sleeping in the backseat, I was always looking at the landscape. My mother once told me that when I was a few months old, I started yelling when my mother passed the highway exit, leading to my grandparents' house, trying to tell her that she missed the right exit. When I was a little older, we went on camping holidays all across Europe every summer. The funny thing was however that when my parents asked me which day I liked the most I always answered: ''The car trip''. It is therefore not very surprising that I am writing my master thesis about highway landscapes. I find it fascinating to see how highway landscapes differ between countries and cities and why they differ. Furthermore, I was interested to see whether other people have the same preferences regarding highway landscapes or corridor scenes as I have or that people just see it as nothing special.

I would like to thank a few people. First I want to thank Anne Marel Hilbers, my supervisor, who has been a great help in the last few of months. I really appreciate it that you have invested a lot of time in helping me out and giving feedback. Furthermore, I would like to thank the moderators of the Facebook group ''Weggeefhoek 038'' who gave the opportunity to post my questionnaire on their Facebook page. This has helped me to recruit enough respondents. Finally I would like to thank my parents who have been a great support during hard times last year.

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Abstract

In the last few decades, the amount of road traffic has increased strongly in the Netherlands and it is expected to continue to grow in the upcoming years. Consequently, people spend more of their time on the road, meaning more interaction with the environmental surrounding of the highway. At first sight, highway corridor scenes only seem to function as a safety barrier between the highway and the world next to the road. However, highway corridors can have a big effect on both the drivers' stress levels and health conditions. Consequently you might expect that policy makers take these effects into account when designing new highway projects, but the current use of cost-benefit analysis in the Netherlands often neglects the inclusion of highway corridor scenes. This master thesis aimed to value different highway corridor scenes to provide as input for future cost-benefit analysis. A questionnaire was used to find the preferences of Dutch car drivers regarding different highway corridor scenes in both a situation where location was known versus an unknown location. The results of this master thesis showed that tree screen and barren edge (grass land) landscapes received the highest scores on locations which were not known to the respondent. On locations which were known by the respondent, the tree screen and the ornamental frame were the most popular highway corridor scenes. The role of the respondent (citizen or driver) did not seem to affect their preference for a particular corridor scene. A few conclusions are drawn in this master thesis. First, location seems to play an important role in valuing a particular highway corridor scene. When a highway crosses a densely populated area, people tend to prefer closed natural landscapes (tree screens), since there seems to be the perception that tree screens are equally effective to absorb noise disturbances caused by road traffic compared to the more costly sound barriers. A second explanation is that tree screens can reduce driving stress. However, when the highway has a unique potential view, people tend to choose more often for a more open highway corridor scene. On locations that already feature an open landscape and which have a low density of houses in the proximity of the road, the barren edge and ornamental frame (both open landscapes) remain popular. Therefore, it is not possible to find one value for a particular landscape type. It both depends on the uniqueness or landscape potential and the density of people living in the surrounding area.

1. Highway corridors, more than just a safety barrier

On Monday the third of October 1994, it was a rainy autumn day like many others in the Netherlands. However, it was not a good day to drive home in rush hours. There was a total amount of 45 traffic jams occupying the Dutch highway system with a total length of 300 kilometers. That day was the most crowded evening rush hour in history (NRC, 2018). It had never been seen before. Until the 25th of November 2005. A snowstorm hit the Netherlands. It was a complete chaos on the roads and the total length of traffic jams was estimated to be 800 kilometers (KNMI, 2005). This was an extraordinary situation. Although, the evening rush hours of the 30th of October 2018 proved something differently. Again, it was a rainy autumn day, just like the third of October in 1994. However, the total length of traffic jams had now grown to a total amount of 1135 kilometers (NRC, 2018). Apart from traffic jams, the total distance travelled by road traffic has increased significantly in the last decades. In 1994, the total distance travelled was 102.798 million kilometers. In 2017, this distance had increased to 134.392 million kilometers, an increase of 32 million kilometers (CBS, 2018). It is expected that the Netherlands has to deal with a growing pressure on the highway system in the next few years. According to the Dutch knowledge institution of mobility policy (KiM, 2019), the total amount of traffic will increase will increase with 1,2% per year between this year and 2022 and only a part of the increase can be tackled by the planned expansion of the highway system. As a consequence, the KiM (2019) expects an increase of travel time loss of 28% in 2022 compared to 2016.

The increase in travel time can have a large impact, especially on the health of the driver. An increasing problem in the last decades is the issue of driving stress. This phenomenon was discovered by Rutley and Mace (1972). The blood pressure rises and heart rate variability increases as a result of driving compared to people who do not drive. Especially demanding driving conditions as on-ramps and roundabouts increase the amount of stress for car drivers (Rutley and Mace, 1972). Driving stress can have serious consequences as Novaco et al. (1990) have pointed out. They argue that commuting can

result in higher chances of illness, lowered job satisfaction and lower performances on cognitive tasks. Therefore, the health effects of car drivers have to be taken seriously as a result of the increases in traffic.

There are measures available to soften the perceived amount of driving stress, especially by using highway corridor scenes. Highway corridor scenes can be described as: ''*strips of public land that provide a buffer between high speed driving and adjacent land uses*'' (Wolf, 2003). Several empirical studies confirm that passive nature in these corridors can have restorative effects (Kaplan, 1995; Parsons et al., 1998). According to Kaplan (1995); *"experience in natural environments can not only help mitigate stress; it can also prevent it through aiding in the recovery of this essential resource"* Parsons et al. (1998) tested the response of drivers to different highway corridor scenes. They discovered that, "artifact-dominated" roadside corridors slowed down the process of recovery from feelings of stress and high blood pressure. However, participants who had to face natural corridors as tree lines and golf courses, recovered faster from feelings of stress and were better in coping with stressful tasks after driving.

It would be expected that when landscapes influence the amount of stress of drivers and even health effects, that much attention would be paid to this subject. Different highway corridors bring different health and stress effects. Therefore, each corridor type would represent a certain value. However, the value of these different highway corridor scenes is still unclear. Wolf (2003) has investigated which landscape drivers find aesthetically attractive, but this was only done for hypothetical landscapes and not for routes which these drivers use on a daily basis and thus have an effect on stress levels and the health of the driver. Furthermore, there is no clarity what the value of different highway corridors can be, while this could fill an important missing element within cost benefit analysis (CBA) in assessing future infrastructure projects. According to Bristow et al. (2000), indicators as noise and pollution are increasingly incorporated within CBA's. However, effects on landscapes are frequently left out of CBA's as a result of a lack of information about the value of landscapes and difficulties to measure this value.

The resulting main research question is: ***What is the value Dutch car drivers assign to different highway corridor scenes?***

In order to find these values, a few sub questions have to be answered:

- First, it is interesting to test if the results of Wolf (2003), regarding the scoring of drivers of different highway corridors, follow the same pattern for Dutch drivers as for US car drivers. Furthermore, it is necessary to find out which corridor scenes are preferred without considering any costs, location or role of the respondent in relation to the highway. The first sub-question is therefore: ***Which highway corridor scene do Dutch car drivers find aesthetically the most attractive?***
- Second, in order to find the value Dutch car drivers assign to different highway corridors, it is required to test which type of landscape drivers prefer on a commuting route which they use on a daily basis and when they are informed about landscaping costs? Thereafter, it is possible to see whether there is a difference between the valuation of the different corridor scene types when landscaping project costs and location are known to the respondent compared to the previous question where the location was unknown. The second sub-question is: ***What is the preference of Dutch car drivers regarding different highway corridor scene projects, when location and costs are known?***

- Third, as Mouter et al. (2017) point out, in order to obtain a value for different landscape types, it is important to consider the different roles respondents can fulfill. People who are not users tend to make different choices in valuing objects than citizens. In this instance: people who are frequent users of the highway could have a different preference regarding a particular landscape corridor type compared to people who are living close to the highway. Therefore, it is important to make a distinction between these groups in the valuation of different highway corridor scenes. The third sub-question is therefore: ***Is there is difference between citizens living nearby the highway and frequent highway users regarding the preference of different highway corridor scenes?***

1.1 Policy implications and thesis structure

The aesthetic scores and preferences regarding different highway corridor scenes derived in this thesis could function as input for policy makers within infrastructure planning to incorporate landscapes into future CBA's. This can help to partly solve issues regarding the consistent misjudgments of costs and benefits within CBA's (Flyvbjerg et al. 2002) by for instance adding landscapes as a non-monetary impact/benefit to the analysis.

This thesis has the following chapters. First, some background theory will be provided about the use of cost benefit analysis in the Netherlands, and the main findings in previous studies in the field of highway corridor aesthetics. Second, the methodological framework of this paper will be discussed. Third, the main findings will be presented, followed by a discussion and conclusion chapter.

2. Theoretical background

2.1.1 Cost-benefit analysis in Dutch infrastructure planning practice

Decision-making in infrastructure planning can be complicated. Whether it is to choose between different highway project alternatives, prioritizing projects within a program or whether a project represents a good social value for money (Bristow et al 2000). To assist in these kind of decision making processes, there are several assessment or appraisal methods available. According to Bristow et al. (2000) in the EU, appraisal methods are generally considered as an important tool to assist in decision-making processes. Hence it provides relevant information, but it does not actually make the decisions. Across Europe, a variety of assessment methods are used in infrastructure planning. The most widely used method is the cost benefit analysis (CBA) (Bristow et al. 2000). The idea is simple: costs and benefits related to an infrastructure project are monetized. As a result, the impact of a project can be expressed as a cost-benefit ratio (Vickerman, 2007). In a cost benefit analysis, some effects of an infrastructure project can be predicted systematically. These effects are so-called ''direct impacts''. Examples of direct impacts are time travel savings and construction costs (Bristow et al 2000). These impacts are fairly easy to calculate in terms of money. As a consequence, the direct effects of project alternatives in infrastructure planning can easily be compared (CPB, 2000) and project can be ranked based on their cost benefit ratio (Vickerman, 2007). Furthermore, the CBA method provides insight in the uncertainties related to each project alternative (in monetary terms) (CPB, 2000). However, costs like ecological losses are not easy to calculate. Therefore, in four countries across Europe, they have chosen for the multi-criteria analysis (MCA) as the main assessment method in infrastructure planning. This assessment method works with so-called ''weighted variables'' in which each criterion has been given a pre-specified weight (Annema et al. 2007). The advantage of this method is that criteria like

the ecological losses as a result of a project can be made comparable to economic benefits. However, the basis for the chosen weights is often unclear (Eijgenraam et al., 2000). As a result, policy makers do have to choose weights themselves that increases the risk of manipulation of assessment outcomes. Furthermore there is a big risk of double counting when using MCA (Eijgenraam et al., 2000). For instance, when both additional pollution and loss of green space are taken into consideration. To prevent these problems, the countries that use MCA have chosen to incorporate a CBA within the analysis.

In the Netherlands, the discussion about which assessment method to choose started at the end of the twentieth century. Until then, it was generally accepted that parties were free to choose a method for the assessment of infrastructure projects. However, this raised a few issues. First, as a result of the use of diverse methods, the economic effects of infrastructure projects varied widely (Eijgenraam et al., 2000). Second, the Dutch government concluded that the decision-making in choosing an infrastructure alternative was often based on hopes and beliefs instead of research findings (Annema et al. 2007). Therefore, the Dutch government decided to investigate the economic effects of Dutch infrastructure projects in 1998. This research program was called in Dutch: '' het OEI-programma''. The goal of the OEI program was to investigate both the economic effects of historic infrastructure projects and the methods available to assess future infrastructure projects in a more consistent way (CPB, 2000). Both the cost benefit analysis (CBA) and the multi-criteria analysis (MCA) proved to be the preferred methods. However, because of the difficulties mentioned before with the risk of abuse of political power in choosing weights in the MCA, the OEI-program decided to choose for the cost benefit analysis as the preferred method for infrastructure project assessments. Furthermore, to guide the assessment process in the future, a CBA-guide (OEI-guideline) was formulated in the year 2000 (Eijgenraam et al. 2000). This guideline functions as a handhold for infrastructure project CBA's. Besides, the Environmental Impact Assessment (EIA) was introduced, which investigates which project alternative is the most favorable for the environment (Mouter et al. 2013). This assessment helps to incorporate environmental effects, which cannot be expressed in terms of money in the CBA, in the decision making process. Variables that are taken into account in EIA's are for instance noise, emissions and smell. In the EIA, environmental effects of each project alternative are compared to the so-called ''null-alternative'' which reflects the current environmental situation. As a result, it is easier to compare which infrastructure projects have the least effect on the environment.

Since the introduction of the CBA in the Netherlands in 2000, much has changed in infrastructure planning practice. According to Annema et al. (2007) a few things have been improved. One improvement is that impacts of a project are estimated using similar scenarios. This results in smaller differences in effects between different projects. Furthermore, policy makers can now make decisions on the basis of a more complete set of information about the effects of each project alternative. Most of these effects are now summed up in terms of money and are therefore easy to interpret and compare (Annema et al, 2007). Finally, as Annema et al (2007) point out, in some cases, the quality of decision-making has improved. In these cases, project alternatives were altered during the decision making process, as a result of insights obtained by the CBA.

2.1.2 Problems with the cost benefit analysis

However, there is also critique among scholars on the use of CBA. One point of critique is equity issues. First, groups who suffer from the effects of a project are not really represented in the analysis (Annema et al. 2007). This is because the aim of the assessment is to serve the common good instead of

individuals (Annema et al. 2007). Secondly, there is a problem with the assumptions set in CBA's. One assumption that is commonly used is perfect market competition. This assumes that external effects stay the same (Vickerman, 2007). However, as a consequence, errors arise. For instance, the idea that the amount of traffic will be equal at the completion time of the project to nowadays traffic proved to have a problematic effect on the actual results in costs and benefits. Furthermore, the perfect market competition assumes that the costs of transport stay the same. Consequently, when the costs of transport change over time (e.g. as a result of higher oil prices) the outcomes of the cost-benefit analysis are not reliable anymore (Vickerman, 2007). Flyvbjerg et al. (2002) underline the problems with the accuracy of costs estimation. They investigated the accuracy of the costs in CBA's after infrastructure projects were completed. They discovered that on average the costs of these projects can be estimated 28% higher than calculated beforehand. Especially in infrastructure planning they note that: 'Underestimation of costs at the time of decision to build is the rule rather than the exception' (Flyvbjerg et al. 2002) The third problem within CBA's is that effects on nature or environment are still underrepresented, while infrastructure projects mostly have a large impact on these variables (Daniels & Hensher, 1999). Since there is no natural price of nature or health, artificial prices have to be created to make these variables quantifiable (Ackerman et al. 2002). A popular way to derive at this artificial price is using a willingness to pay survey. However, as Sunstein (2005) points out, this method is sometimes an inappropriate basis for policy, since people are not merely consumers but also citizens. Their monetary judgements can therefore be a mix of their valuation as a citizen and a consumer. According Mouter and Chorus (2016) the key distinction between the preferences of citizens and consumers is that ''they involve individual preferences inferred from choices within different budget constraints.'' The consumer prefers to express preferences bounded by their own personal budget, while citizens' preferences can be captured by budget constraints in additional tax (governmental expenses). According to Ackerman et al. (2002) there is a big risk that the derived value in willingness to pay assessments does not reflect the value of a citizen but only for a user, since it is not using governmental expenses. To illustrate this, they give an example of an experiment. A group of students were divided in two and had to fulfill the role of either citizen or consumer. Next they had to provide their willingness to pay for the preservation of a forest located on a hillside which was planned to be chopped down to make room for a skiing resort. As a result, the group of potential skiing consumers valued the forest lots lower than the group of citizen students (Ackerman et al. 2002). Mouter et al. (2017) confirm that there is a difference in the judgement between citizens and consumers. They discovered that people value safety higher compared to travel timesavings in their role as citizen than in their role as consumer. Therefore, it is important to take the role of the respondent into account when assessing environmental effects like noise using a willingness to pay survey.

Currently, in Dutch infrastructure CBA's, the mostly used non-monetary indicators are noise and pollution (Annema et al. 2007). Also in other EU-countries, noise and pollution have a main role in assessments of infrastructure project (Bristow et al. 2000). However, the impact of changes in the landscape as a result of infrastructure projects is often neglected. According to Bristow et al (2000) there is very little known about the effects of changes in the landscape and how to measure it. As a consequence, these effects are hardly incorporated in cost-benefit analysis across Europe (Bristow et al. 2000). Moreover, according to Wolf (2003), the inclusion of the value of the landscape from a driver's perspective is still underexposed in infrastructure valuation studies. She argues that most infrastructure valuation studies still choose to focus on corridors from the perspective of residents

living near the road instead of from the perspective of the car driver. As a consequence, there is no real body of research on this topic. Hamersma et al. (2014) for instance focus in their research on the satisfaction of people living next to highways. Interestingly they found that these residents have a higher residential satisfaction level when they can see the highway from their home compared to residents who only see a sound barrier. The highway landscape therefore seems to play a role in determining residential satisfaction. Furthermore, they discovered that people, who tend to use the highway more often, react differently to changes as a result of highway projects than residents living near the highway (Hamersma et al. 2014). It might therefore be interesting to add knowledge to future CBA's about the effects on the driver, as a result of changes in the environment of the highway, instead of only focusing on the effects on citizens (Hamersma et al. 2014).

2.2 Closing a gap in CBA: the inclusion of highway corridor scenes

One way to fill the gap in the valuation of landscape changes in CBA's mentioned by Bristow et al (2002) can be the inclusion of the value of highway corridor scenes from a drivers perspective. According to Wolf (2003), highway corridor scenes can be described as: ''strips of public land that provide a buffer between high speed driving and adjacent land uses.'' Although on first sight, these strips of land only seem to function as a safety barrier, it appears that it also affects the car drivers' behavior and health.

Antonson et al. (2009) argue that both driving behavior and safety is affected by the highway landscape. They found that the openness of the landscape influences both the driving speed and the stress levels of the driver. They argue that a more open landscape, e.g. a landscape with meadows, triggers the car driver to drive faster and has a negative effect on the safety. On the other hand, they found that a more varied road landscape, filled with for instance a couple of buildings and tree lines, reduces the haste of the driver. As a consequence, the more varied landscape proved to enhance road safety. The difference in speed levels can be explained by varying stress levels caused by the different highway corridors scenes (Antonson et al., 2009). An open landscape seems to be more predictable and therefore reduces the amount of driving stress, while an varied landscape is less predictable and raises stress levels and therefore forces drivers to drive slower. Other empirical studies underline the existence of a relationship between driving stress and roadside characteristics. Especially, natural scenes like tree lines and golf courses seem to have a positive effect. Parsons et al. (1998) argue that commuting over roads that do have natural corridors reduces the magnitude of stress in later tasks compared to roads that do not have a natural scene. It can therefore be concluded that highway corridor landscapes have an important role in the way drivers experience their commuting time.

However as mentioned before, still many questions remain regarding the value of highway corridor scenes (Wolf, 2003). Evans and Wood (1980) were one of the first who acknowledged the importance of the experience of drivers with the landscape around roads. They investigated the types of highway corridor scenes, drivers preferred, using photo simulations. They found that corridors with vegetation were valued higher than corridors filled with buildings. On top of that, they discovered that the more the landscape was affected by human interaction, the lower respondents graded the landscapes. Later, Wolf (2003) expanded the investigation of Evans and Wood by letting respondents value different road corridor landscapes, using pictures in a survey. She distinguished five types of landscape in her survey. The first landscape was the ''barren edge'', in which there is no large vegetation except from low grass, moss or shrubs. The second category used was ''prominent buildings'', in which buildings dominate the view. The third distinguished landscape by Wolf (2003) was called ''ornamental frame'' in which shrub and tree combinations, that soften visual obtrusiveness of built elements, were shown. The

fourth category was the ‘’tree buffer’’, which offers a visual balance between tree lines and buildings next to the highway. The Fifth and final category is the ‘’Tree screen’’ category, wherein all build environment is shielded by a visual wall of trees. Wolf (2003) discovered that both a combination of trees and a build environment, and a closed tree line were valued with the highest scores. The Barren edge and the prominent building category received the lowest scores. Furthermore she concluded that having lots of plants along the road could be perceived as boring. The driver likes to have a diverse visual balance between different seasonal plants and buildings. However, a disadvantage of her study was that respondents only could score highway corridor scenes in hypothetical situations and not on daily routes of the respondent. Therefore there is still room for improvement to test it in real life situations.

In short, the findings of Wolf (2003) and Evans and Wood (1980) can be seen as the fundament of highway corridor aesthetics research, but there is still room to expand their findings. Especially, by adding the value drivers assign to highway corridor scenes on locations which they are familiar with. In the next chapter, a measure to value different highway corridor scenes will be introduced.

3. Methodology

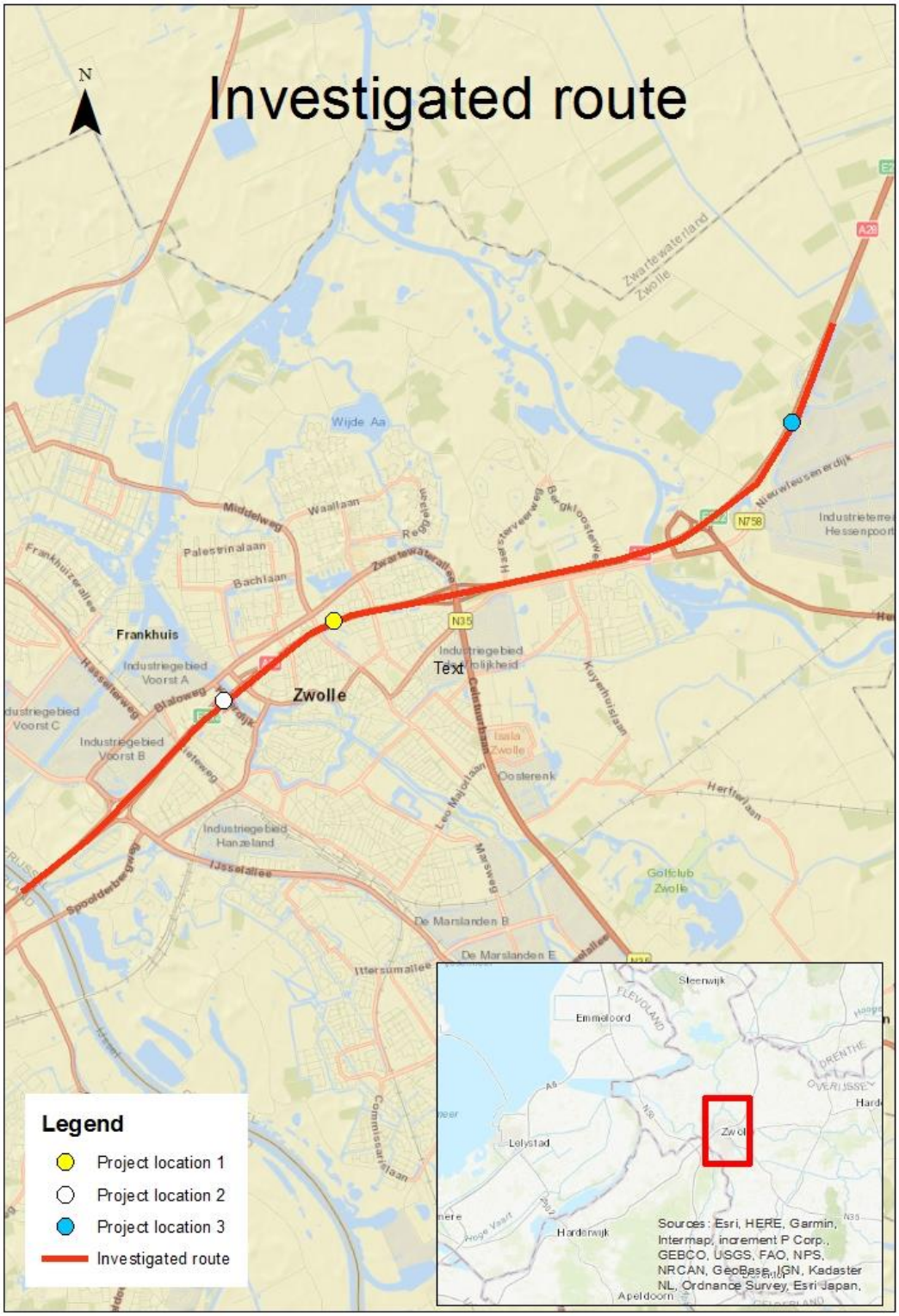
In this chapter, the methodology used in this thesis will be discussed. In the first part of this chapter, the location of the case study route will be discussed. Second, the method used to obtain the aesthetic scores Dutch car drivers assign to different highway corridor scenes, are described. The third part contains the procedures used to find how Dutch car drivers value different highway corridor scenes on several locations along the A28 highway. The fourth and final part contains the methodology to check for differences between the assessments of citizens versus frequent highway users (consumers).

3.1 Location of the case study route

3.1.1 Investigated route

The case used in this master thesis is the A28 highway, which crosses the city of Zwolle right through the city center (see figure 1). Zwolle is located in the north-east of the Netherlands. This route is particularly interesting because of the strong relationship (regarding noise and sight) between the city and the highway. At this moment noise barriers and trees, which prevent possible noise disturbances for citizens living in the surrounding area, block most of the sights seen from the perspective of the highway. However, as a result of the presence of these barriers, there is a potential loss in the driving experience of the driver. These possible-contradicting interests between drivers and citizens in Zwolle makes the A28 an interesting case to investigate whether drivers favor other corridor scenes compared to citizens.

Figure 1: Investigated route



3.2 Questionnaire

A questionnaire is used to obtain data about the valuations of different highway corridor scenes. According to Clifford et al. (2016) surveys are an appropriate measure to acquire information about the characteristics, behaviors and attitudes of a population. The use of questionnaire surveys has three advantages compared to methods as secondary data collection and observational methods. The first advantage is that surveys are very useful to get insight in people's opinions about political, social and environmental issues (Clifford et al, 2016). The second advantage is that it is a functional tool to investigate complex behavior and social interaction among population groups (Clifford et al, 2016). Third, questionnaires make it possible to gather data about people's lives, which are not freely available from other sources (Clifford et al, 2016). In this case, we want to investigate people's attitudes towards different highway corridor scenes, and whether there is a difference between citizens and consumers (drivers). Since, there is limited information available about this topic within secondary sources, a questionnaire can be seen as the most useful data gathering method to use. The questionnaire used in this research is a fully anonymous online questionnaire, which is developed using a website called maptionnaire.com. This website enables to connect geographical data to questions asked in the questionnaire, which proved to be useful for this study.

Respondents are recruited using Facebook groups for citizens of Zwolle and by using advertising notes delivered to random addresses across the city. Both messages contained a description of this research and a link to the online questionnaire (See appendix 3 for messages).

3.3 Identifying citizens and consumers

As Mouter et al. (2017) pointed out, it is important to distinguish citizens and consumers, since consumers, in this case drivers, have different preferences compared to citizens. In order to identify each group in the questionnaire, respondents were asked about their whereabouts, the frequency of using the A28, and the possession of a driving license. The following assumptions regarding the definition of citizens have been formalized (see table 1):

- First, it was required that citizens have to live within the municipal border of the city of Zwolle.
- Second, it was required that citizens live within a 1-kilometer range from the A28 highway. This range is based on the research of Hamersma et al. (2014) in which a range of 1 kilometer is used to identify households who are affected by noise disturbance.
- Third, it was required that citizens do not use (parts of) the route more than two days a week. Otherwise, they can be designated as consumers.
- Fourth, if the respondent is not in the possession of a driving license, he or she is automatically assumed as citizen, since it is impossible to be a driver without having a driving license.

- Table 1: Assumptions citizens and consumers

	Citizen	Consumer (driver)
Address within municipal border	Yes	No
Distance address to highway	≤1000 meters	>1000 meters
Frequency of using route	<3 days per week	≥3 days per week
Possession of driving license	Yes/No	Yes

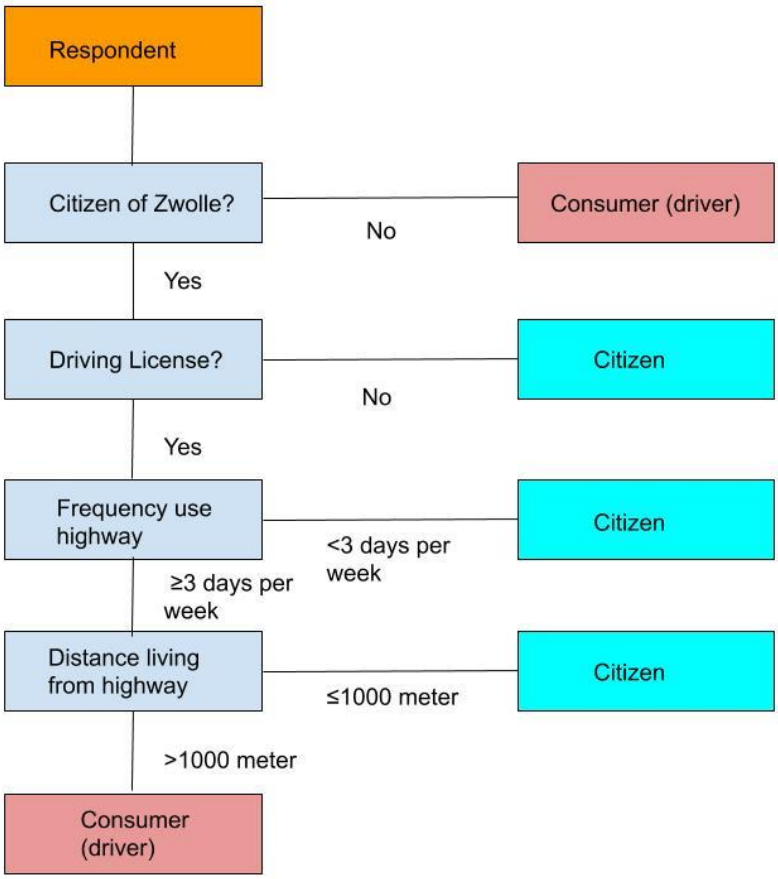


Figure 2: Definition of citizens and consumers

Figure 2 shows how the distinction between citizens and consumers is determined in this thesis. First, to be designated as citizen it is a necessity to live within the municipal borders of Zwolle. Otherwise, the respondent is less sensitive to highway landscaping changes, like the removal of sound barriers. Furthermore there is a possibility that the respondent is not familiar with the landscape, which makes it more likely that he will make similar choices as drivers. Next, the possession of a driving license is necessary to be defined as citizen, since driving without a driving license is not very likely. Finally, it is assumed that a driver uses the A28 more than twice a week and lives more than 1 kilometer from the highway.

3.4 Scoring different highway corridor scenes

In this paper, the same valuation method as performed by Wolf (2003) and Evans and Wood (1980) was used in order to find the aesthetic score Dutch car drivers assign to different corridor scenes. To do this, respondents had to give a score to a range of random pictures of different highway landscapes that, represented the different highway corridor scenes of Wolf (2003). Wolf (2003) distinguished five types of highway corridor scenes in her research: The barren edge, the prominent buildings, the tree screen, the tree barrier and the ornamental view (for the characteristics of each landscape, see previous chapter). Since the tree barrier and the ornamental are similar, the tree barrier has been removed from the analysis. Two new highway corridor scenes have been added to the analysis to include the possible preference of citizens to have a corridor scene, which reduces noise disturbances. The first one is a noise barrier, which completely blocks the view of the surrounding landscape. The second one is a transparent noise barrier, which both makes it possible for the driver to experience the landscape and which prevent additional noise disturbance for the citizen.

To prevent errors in the scoring of the pictures, as a result of for instance bad weather conditions, three pictures are used to represent each corridor scene type (Wolf, 2003). The corridor scenes are displayed in a random order and are selected from random highway locations across the Netherlands. The pictures were derived from google maps street view (Google maps, 2018). The pictures used in the questionnaire are displayed in table 1.1 below.

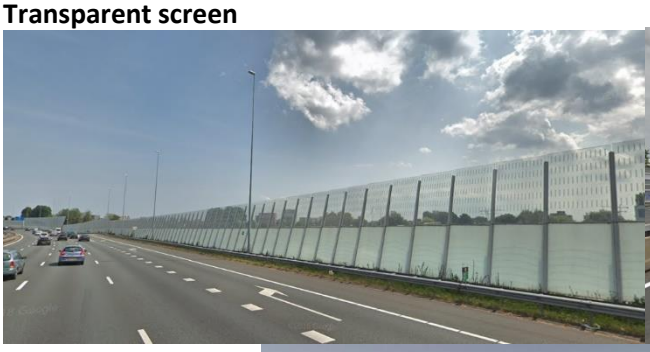
Table 1.1

Barren edge

Tree screen

There are only two pictures of the tree screen added to the questionnaire, since all tree screens looked very similar.

Transparent screen



Prominent buildings

Solid sound barrier

Ornamental frame

The respondents had to assign a score using a five point Likert scale (QuestionPro, 2019), ranging from 1 to 5 to each corridor scene displayed on the pictures (Wolf, 2003). A score of 1 represented the lowest negative score, a score of 3 represented a neutral score and a score of 5 represented the highest positive score.

3.4.1 Data analysis

The data analysis of the valuations of different highway corridor scenes generally consisted of comparing the average score per corridor scene type. The average scores per corridor scene were determined by the sum of the total scores divided by the total number of respondents. Next, the derived scores were compared with the scores found by Wolf (2003) and tested on significance by executing a two-sample t-test (Moore & McCabe, 2006).

3.5 Valuing different highway corridors using project alternatives

In order to grasp the value Dutch car drivers assign to different highway corridor scenes on routes which they are familiar with, they get the opportunity to choose between 5 project alternatives on 3 different locations along the A28 through Zwolle. The method is based on the participation budget experiment (in Dutch: participatiebegroting) designed by Mouter (2018). In the experiment by Mouter, the respondents have the opportunity to allocate a limited budget on different infrastructure projects across the region of Amsterdam. Each project is characterized by costs, travel timesavings, safety

effects and noise disturbance effects (Mouter, 2018). Consequently, this tool gives insight in how respondents prioritize different kind of projects.

In the current research, effects on noise, safety and travel timesavings are not included in the analysis, since it is the aim to measure the value assigned to different highway corridor scenes. The project alternatives in our method are based on the landscapes described by Wolf (2003) and the noise barrier landscapes described in the previous section. Each project alternative is visualized in the questionnaire by adjusted street view images. The adjustments have been made using Adobe Photoshop. The images shown to the respondents of these altered highway landscapes are shown in the next section (3.5.1).

Chorus and Mouter (2016) argue that consumers can only express their individual preferences by using their own budget constraint, while citizens can only express individual preferences via additional taxes. Therefore, the total additional tax to be paid as a result of choosing for this project alternative is used to represent the costs of each project. These costs are displayed below each project photo. For the calculation steps of the tax, see appendix 2.

To sum up, the respondent chooses one of the five project alternatives per location. Each of the five project alternatives is represented by a photo impression, the costs of developing the project alternative and the additional tax to be paid as a result for choosing that project alternative.

3.5.1 Project locations

Three project locations have been chosen along the A28 through Zwolle (for the exact location see figure 1). On each location the landscape has been (visually) altered into both highway corridor scenes as defined by Wolf (2003) and highway corridor scenes containing the previously described sound barriers. These locations have been chosen on the basis of their variety in current landscape, potential landscape and location.

Project location 1

Figure 3: Project location 1; A28 Holtenbroek

The first location is displayed in Figure 3. On this location the current highway corridor accommodates a noise barrier, which blocks the view on the surroundings. On both sides, the highway is surrounded by neighborhoods (Holtenbroek and Diezerpoort), which can be sensible to additional noise effects.

The images below (see figure 3.1) show the adjustments made for project location 1. The respondent had to choose one project out of these five, based on aesthetics, costs and location.

Barren edge

Tree screen

Transparent screen

Solid sound barrier

Figure 3.1: Projects at location 1

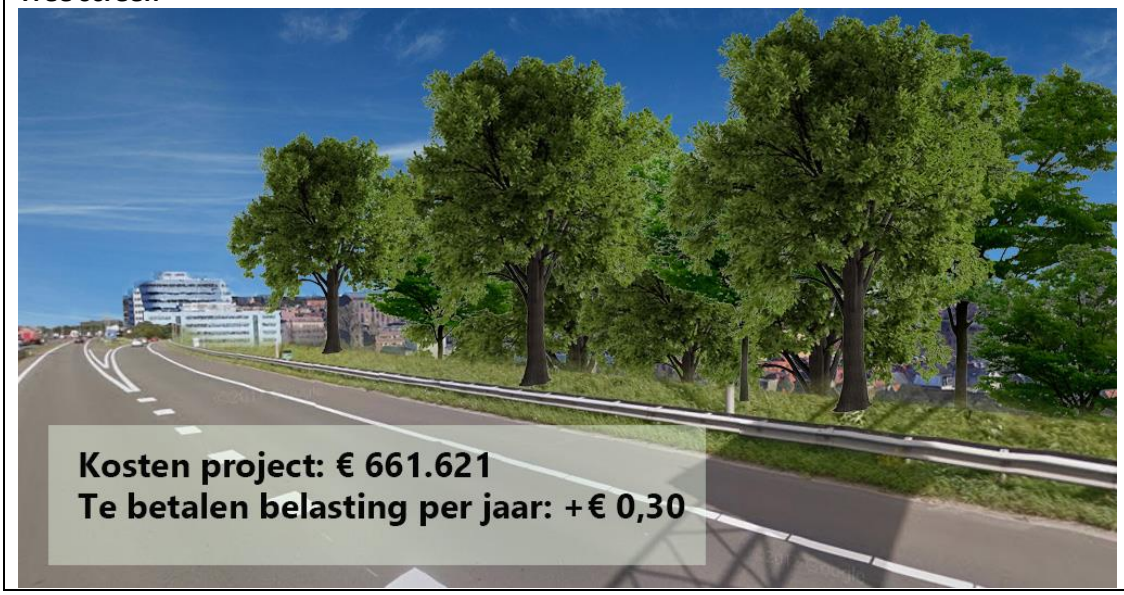
Project location 2

Figure 4: Project location 2; A28 Zwolle city centre

The second location (See figure 4) is located near the city centre of Zwolle. This location might have the best potential view on the city from the perspective of the driver. In the current state, the corridor accommodates a green wall of grass and a tree line. Behind the wall, there is an office building and a neighborhood called Kamperpoort. Furthermore, the old city centre is located on this side of the road, including the iconic Peperbus church tower. The pictures (4.1) below show the project alternatives on this location.

Barren edge

Tree screen



Transparent screen

Solid sound barrier

Figure 4.1: Projects at location 2

Project location 3

Figure 5: Project location 3; A28 outskirts of Zwolle

The third project location is located on the outskirts of the city of Zwolle. An industrial site called Hessenpoort and agricultural land characterize the surrounding area. The highway corridor accommodates a strip of grass, which makes it possible for the driver to experience the landscape. This location was chosen to see whether citizens/consumers make different choices, when the location of the project is outside the city. Figure 5.1 displays the project alternatives on this particular location.

Barren edge

(This alternative is cost free, since nothing changes in this situation)

Tree screen

Transparent screen

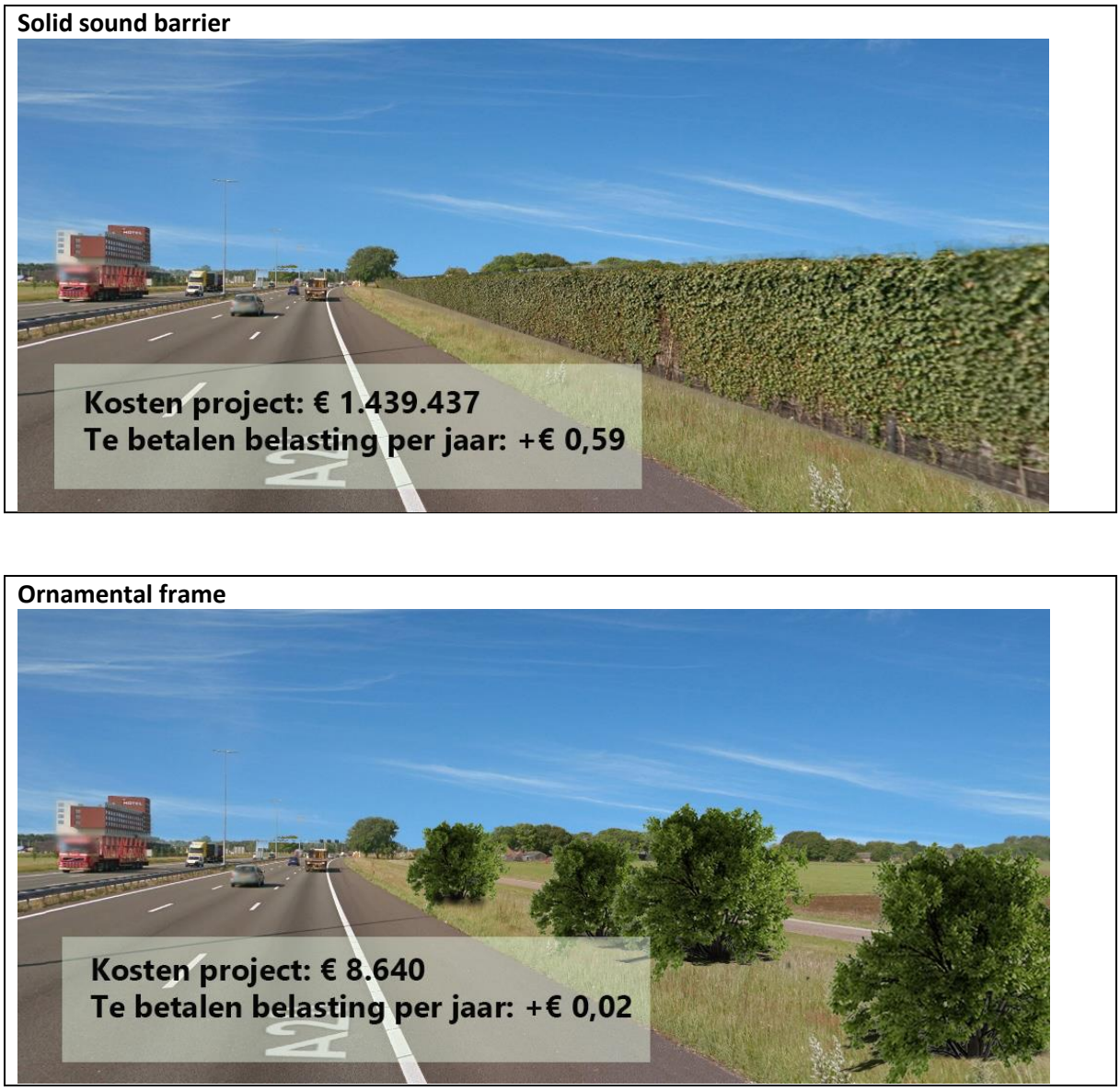


Figure 5.1: Projects at location 3

3.5.2 Data analysis

The gathered data consisted of the total number of respondents, which preferred a particular project on each location. Each project represented a specific corridor scene, which made it possible to compare whether the average scores derived in the previous research question (the aesthetic scores to random highway corridor scenes) did correspond with the amount of respondents choosing a particular project when location and costs are known. Furthermore, to check whether costs have a negative effect on the popularity of a project, the total number of votes for each project has been compared to the costs.

3.6 Measuring the difference between citizens and consumers

The dataset was divided between citizens and consumers, in order to find whether the role of the respondent influenced the preference for a particular highway corridor scene. First, we compared whether the preference for a specific project (and corridor type) differs between both groups. This was measured by using a chi-square test (Moore & McCabe, 2006) for all project locations together and for each project location individually. Second, a comparison was made whether consumers and citizens

make different choices regarding which highway corridor scene they find the most appealing when location and costs are known compared to when these characteristics are unknown. In order to check for this difference, the average scores assigned to each highway corridor scene type is compared to the total number of selections for each landscape project alternative, using descriptive statistics. Descriptive statistics were used, since there was no statistical test available to compare the average scores to a number of selections for a preferred landscape type.

3.7 Robustness checks

To check whether differences between the driver and citizen were consistent, several robustness checks have been performed.

- First, the requirement of using the pre-specified route more than twice a week to be designated as a user has been increased to more than 4 times a week. This can help to see whether drivers who commute more often have other preferences than drivers who commute only three or four times a week.
- Second, the assumption of citizens living within a 1000-meter range from the highway has been adjusted to 500 meters and to 1500 meters. This gave the opportunity to check whether people who are living closer to the highway had other preferences than citizens living farther away, and whether they were more sensitive to highway corridor scene alternatives that may cause more noise disturbances.
- Third, because of differences in the attendance of the total number of men and women, the data has been split, to check whether differences in gender did have an effect.

3.8 Framework of data collection

To conclude, the following steps have been taken in order to answer all research questions. First, after examining the work of Wolf (2003), five highway corridor scenes were defined. Next, Google streets view images were collected based on these five highway corridor scenes plus two additional sound barrier landscapes. All pictures served as input for the online questionnaire. In the questionnaire the respondent had the opportunity to assign scores reaching from 1 to 5 to each highway corridor displayed on the pictures. These scores helped to get insight in the preferences regarding different highway corridor scenes, when the respondent does not know the exact location.

In the next section, location and costs were added to analysis. Again the paper of Wolf (2003) was used as input to define the different highway corridor scene types. Next, Google street view images of the A28 highway were collected and edited into 5 project visualisations on 3 locations using Photoshop. The project costs were based on reports of Cite (2015) and the municipality of Velsen (2014). All visualiations represented a specific landscaping project and were added to the online questionnaire. In this questionnaire respondents had the option to choose between the 5 project alternatives, which finally provided the preference for a specific highway corridor scene.

The last section of the data collection process aimed at finding the difference between citizens and consumers regarding their preferences for a specific highway corridor scene. The definition of a citizen was defined by the whereabouts, the commuting frequency over the pre-specified route and the possession of a driving licence. Questions regarding these subjects were added to the questionnaire, resulting in the possibility to divide the data into a citizen and consumer group. First, the mean scores per highway corridor scene were compared in order to check whether both groups have different

preferences when location is not known. Second, the frequencies of chosing for a particular landscaping project were compared between both group. As a result, it was possible to check whether both groups had different preferences when location is known, compared to a situation where the location of highway landscapes is not known.

4. Results

This chapter contains the results from the study. First, the descriptive statistics will be presented. In the second section, the aesthetic scores Dutch car drivers assign to different highway corridor scenes will be discussed. The third section presents the results of sub-question 2: in which we look at the preferred highway corridor scenes when location and costs are known to the respondent. In the fourth section, the results for the difference between car drivers (consumers) and citizens (e.g. people living in the proximity of the highway) regarding their preference for a particular highway corridor scene when location and costs are known, will be presented. Finally, the results after performing robustness checks are discussed.

4.1 Descriptive statistics

The total number of respondents who participated in this research was 185. 44 Respondents were removed from the analysis as a result of missing data or a missing address location, leaving 141 as useful total. More women than men participated in the research (44 men vs. 97 women).

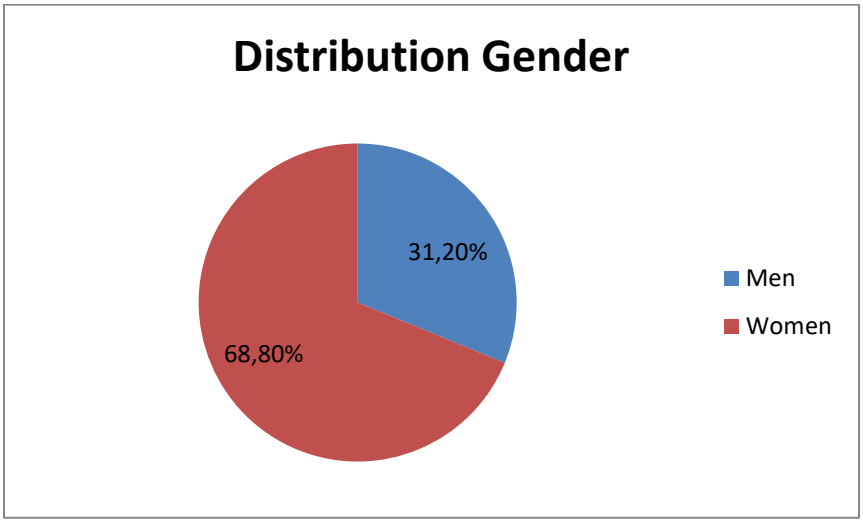
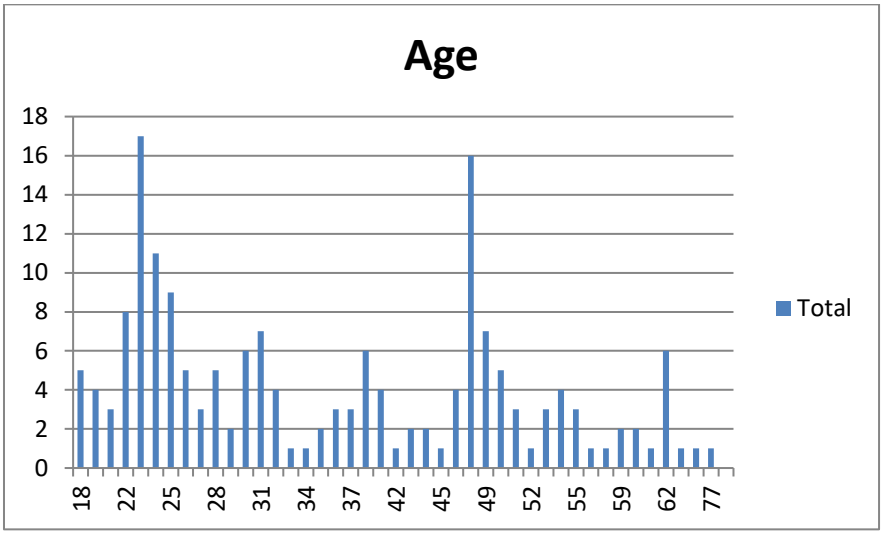


Figure 6: Distribution gender of respondents

Age

Table 2: Descriptive statistics age



The average age among the respondents was 37. The minimum age was 18 years old, which is the age when Dutch people are allowed to drive a car. The oldest respondent was 77 years old.

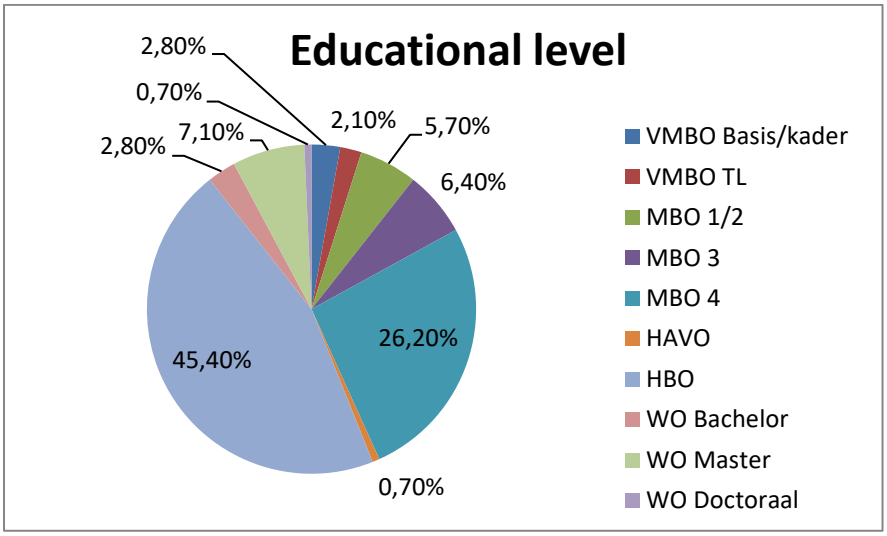


Figure 7: Descriptive statistics educational level

Looking at the level of education (See figure 7), it is clear that the majority of the respondents have attended HBO and MBO level 4, which corresponds with the average education level in the Netherlands. Therefore, in terms of educational level, this sample provides a good representation of the population of the Netherlands.

Frequency

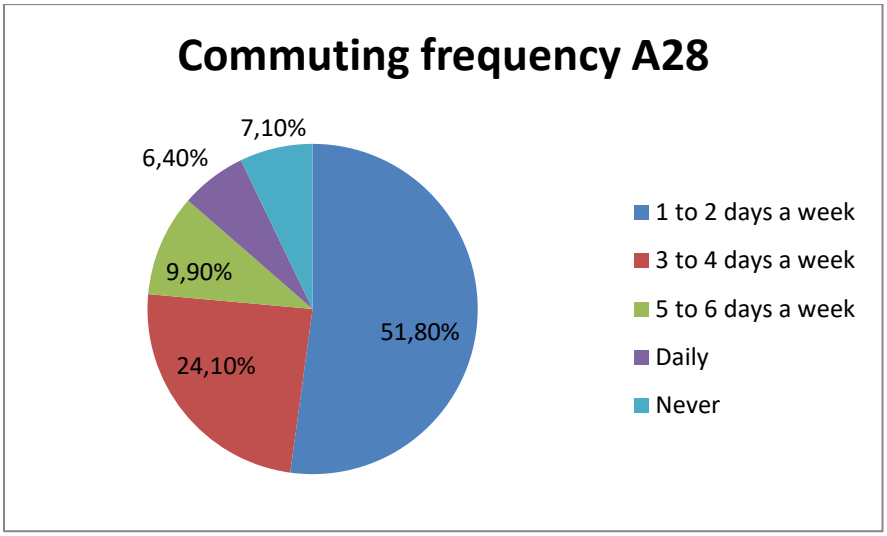


Figure 8: descriptive statistics commuting frequency

The amount of respondents using the A28 is presented in figure 8. Almost half of the respondents used the A28 between 1 and 2 days a week (51,8%). 10 respondents stated to never use the investigated route.

4.2 Valuing highway corridor scenes

Table 3 below presents the average scores per highway corridor scene, assigned by Dutch car drivers. Each landscape is represented by one out of three pictures used in the questionnaire. The barren edge has the highest score with a mean score of 3,57 followed by the tree screen with a score of 3,40. Interesting is the difference between the transparent sound barrier which enables the driver to view the landscape, and the solid sound barrier. The transparent noise barrier is the least popular with a score of 1,90, while the solid sound barrier received a score of 2,33, which is significantly different from 1,90 (See table 4). However, still both barriers are negatively appreciated.

Table 3: Mean scores highway corridor scenes

Barren edge

Tree screen

Ornamental frame

Mean score = 2,89 **Std. Deviation = 0,74361**

Prominent buildings

Mean score = 2,46 **Std. Deviation = 1,03618**

Solid sound barrier

Transparent screen

One-sample test Transparent barrier vs Solid sound barrier

Table 4: One-sample t-test transparent barrier vs solid sound barrier

	t	df	Sig. (2-tailed)	Mean difference
Transparent barrier	-6,533	138	0,000	-0,42682

4.2.1 Differences with the USA

Highway corridor scene	Mean score USA	Mean score NL
Barren edge	1,56	3,57
Prominent buildings	1,66	2,46
Ornamental frame	2,71	2,89
Tree screen	3,87	3,40
Solid sound barrier	Not investigated	
Transparent screen	Not investigated	

Looking at the previously found scores by Wolf (2003), big differences can be observed between the Netherlands and the US. All average scores differed significantly from the scores found by Wolf (2003) (see table 5). Wolf (2003) found that the average score in the US assigned to the barren edge was 1,56. Dutch car drivers gave a score of 3,57, which is with 99% certainty different from the score in the US. Furthermore, prominent buildings received a score of 1,66 in the US, while in the Netherlands this corridor scene received a score of 2,46, which is significantly higher than the score in the US. The score for the ornamental frame was 2,71 in the US, while in the Netherlands, drivers assigned an average of 2,89. Finally, in the US, respondents gave the tree screen landscape a score of 3,87 on average. In the Netherlands, this score was lower (3,4).

One sample T-test (USA vs Netherlands)

Table 5: One-sample T-test USA scores vs NL

	t	df	Sig. (2-tailed)	Mean difference
Barren edge	26,366	140	0,000	2,012
Prominent buildings	9,157	139	0,000	0,802
Ornamental frame	2,849	138	0,005	0,180
Tree screen	-6,985	140	0,000	-0,469

4.3 Valuing highway corridor scenes based on projects

In the second section the respondent had the opportunity to choose between five project alternatives along the A28 (The landscaping projects can be found in 3.5.1). The results are presented in the tables below. Figure 9 shows the results for location 1. At project **location 1**, most of the participants preferred the tree screen project. 19,1% of the respondents chose for the ornamental frame alternative. Looking at the scores derived in the previous section, it is remarkable that the barren edge project alternative is less popular, however it can be assumed that due to the large presence of buildings on location 1, the barren edge project in this case looks more like a prominent building project, which received a lower score in the previous section.

Project location 1

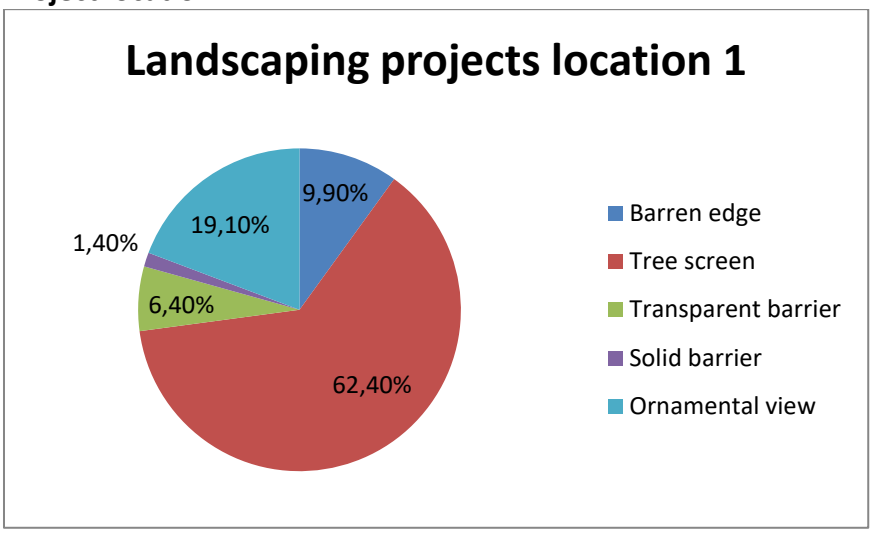


Figure 9: Frequency of choosing for a specific landscaping project on location 1

The **second project** was located near the city centre of Zwolle and therefore had a potential view on the old part of the city. On this location (see figure 10), both the tree screen (39,7%) and the ornamental frame project (37,6%) received the largest amount of votes. The tree screen alternative was in this case less popular then on the previous location, meaning that respondents had a preference for more view possibilities on the city than on the previous location.

Project location 2

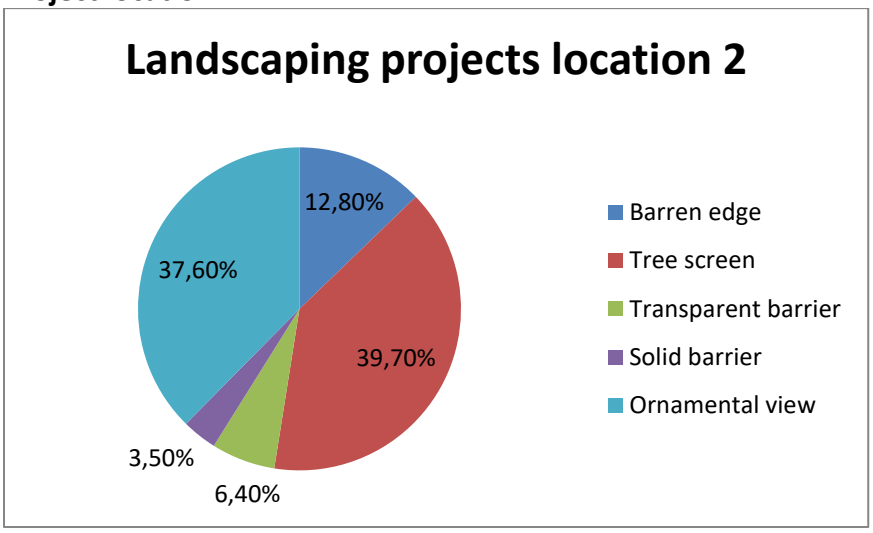


Figure 10: Frequency of choosing for a specific landscaping project on location 2

On the **third project location**, which was located on the outskirts of the city, the barren edge is the most popular project (see figure 11). This project was a 'doing nothing' scenario, since it could already be assumed as a barren edge location. On this location, there were no prominent buildings, which could explain why the barren edge is more popular in this case than for the previous locations.

Project location 3

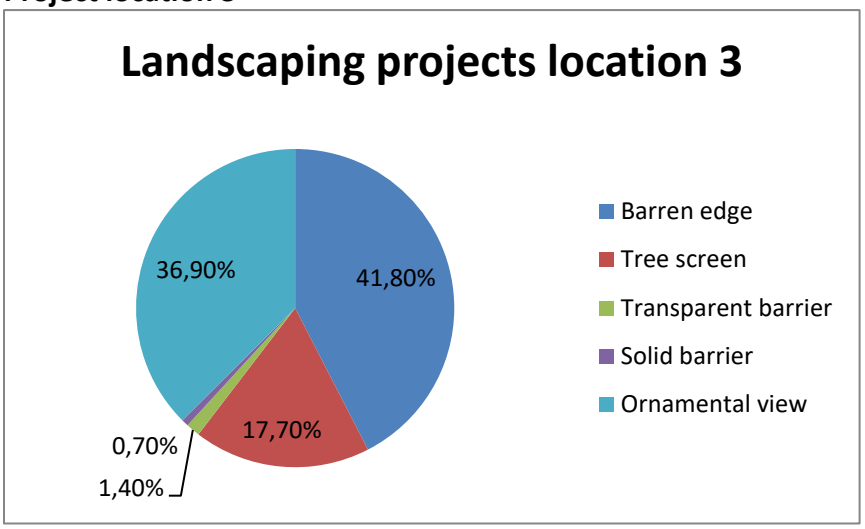


Figure 11: Frequency of choosing for a specific landscaping project on location 3

4.3.1 Costs

Project 1

Both project costs and tax were added to the visualisations in the online questionnaire to check whether cost differences would influence the popularity of a particular landscaping project. The total construction costs and the additional annual tax versus the number of respondents choosing for a particular project is displayed in figure 12 and figure 13 respectively. It appears that the more costly projects are less popular then the cheaper options. However, there is no clear linear relationship.

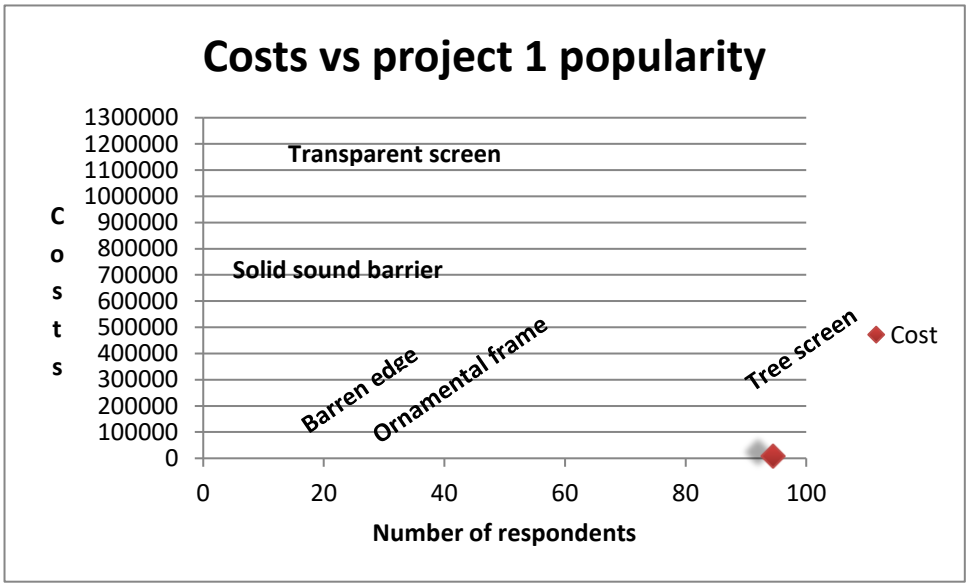


Figure 12: Building costs vs project popularity, location 1

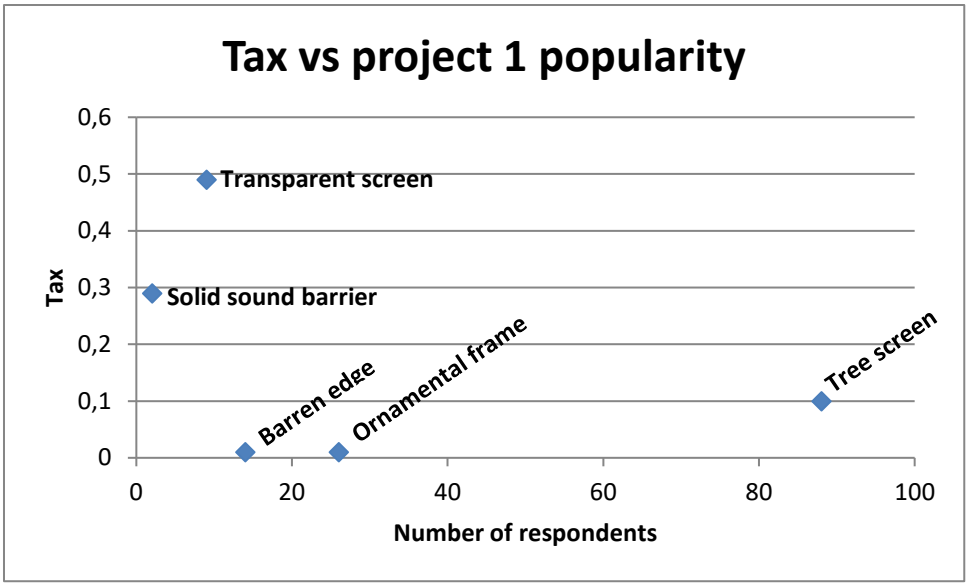


Figure 13: Additional annual tax vs project popularity, location 1

Project 2

On the second project location (figure 14 and 15), the relationship between the costs and the number of respondents choosing for a particular project is not explicit. The cheaper projects in terms of both building costs and additional tax seem to be a little more popular, however the shape of the figures follows the same pattern as for location 1.

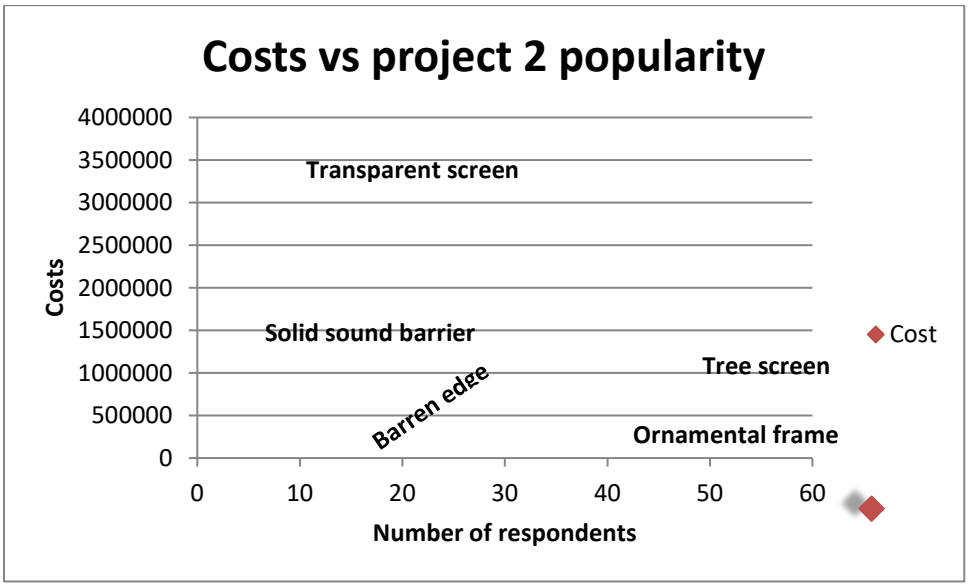


Figure 14: Building costs vs project popularity, location 2

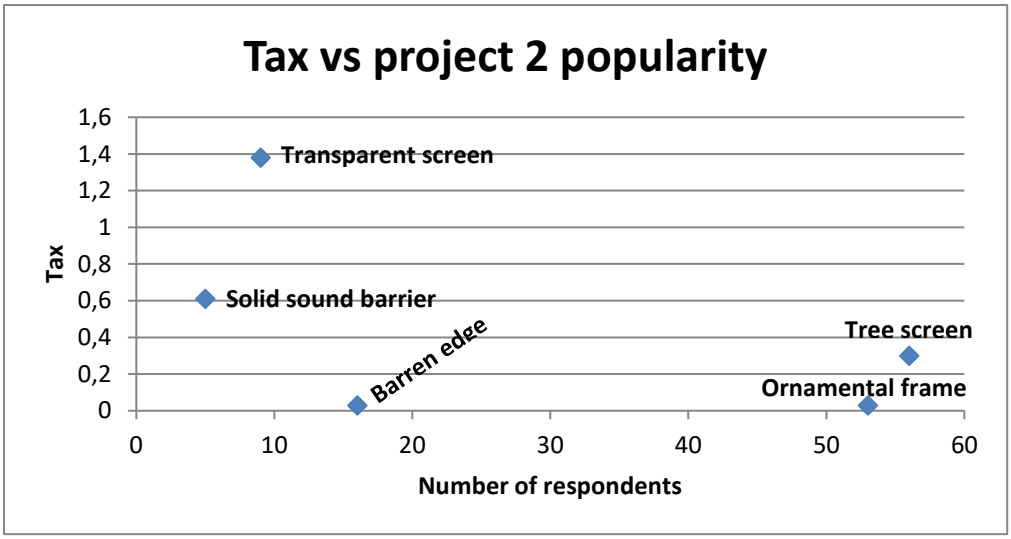


Figure 15: Additional annual tax vs project popularity, location 2

Project 3

The relationships between the total building costs and additional tax compared to the popularity of each project are displayed below in figure 16 and figure 17. On this location, there appears to be a more linear relationship between costs and frequency of choosing for a specific project than on the previous locations. The costly projects (sound barrier projects) are close to zero respondents. On the other hand, the barren edge project, which is costless, is by far the most popular project.

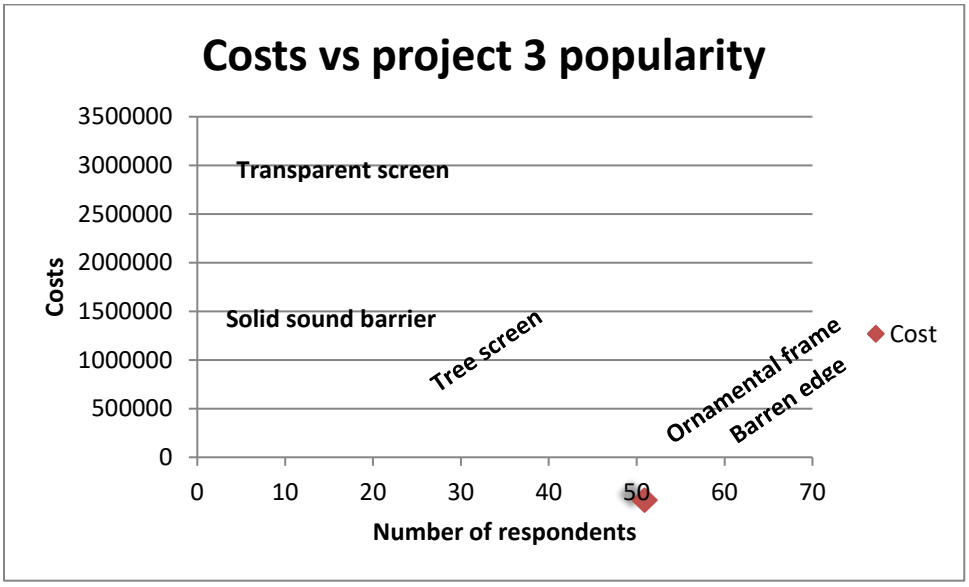


Figure 16: Building costs vs project popularity, location 3

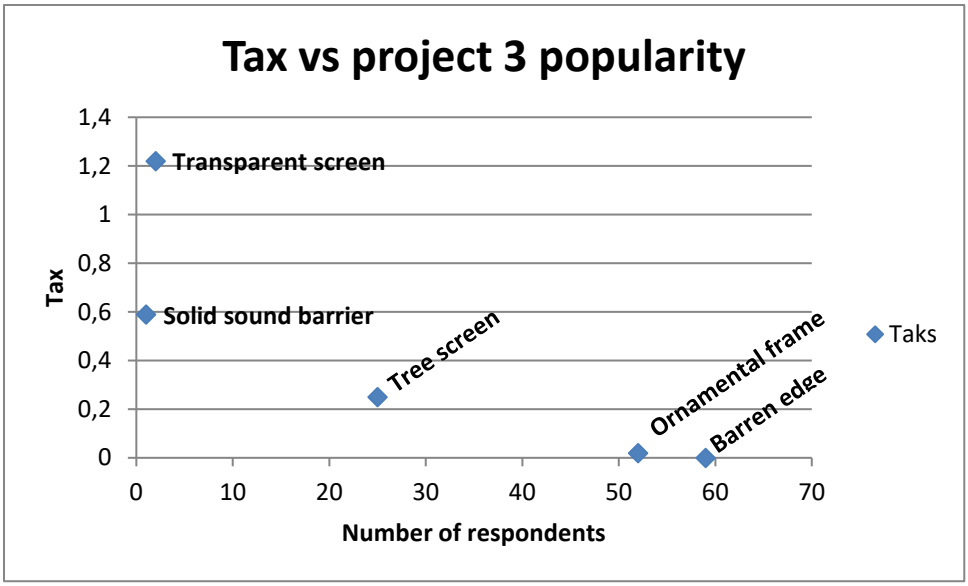


Figure 17: Additional annual tax vs project popularity, location 3

4.4 Differences between citizens and consumers

4.4.1 Valuing random highway corridor scene locations

Table 6 shows the average scores for each highway corridor scene for both the citizens and consumers. A few things are worth noting. First, it appears that there are no large differences between both groups in terms of scoring all landscapes. Second, citizens appear to assign lower scores to noise barriers, than drivers, while it was expected that citizens would be more sensible to noise disturbances and would therefore prefer noise barrier locations. However, it must be noted that location of the highway corridor scene is still unknown to the respondents in this case.

Table 6: Mean scores of random highway corridor scenes, citizens vs consumers

Landscape type	Role	N	Mean	Std. Deviation
Barren edge	Citizen	71	3,45	0,09295
	Driver	69	3,70	0,12178
Solid barrier	Citizen	70	2,25	0,06424
	Driver	68	2,41	0,08634
Prominent buildings	Citizen	70	2,35	0,11628
	Driver	69	2,58	0,13173
Transparent barrier	Citizen	70	1,82	0,08103
	Driver	68	1,97	0,10353
Ornamental frame	Citizen	70	2,90	0,08030
	Driver	68	2,86	0,09810
Tree screen	Citizen	71	3,53	0,09295
	Driver	69	3,26	0,09607

Differences between both groups were checked using an independent samples test (see table 7). There is only a significant difference (95% certainty) between the average scores of the tree screen scenes. Citizens of Zwolle assign a higher value to tree screen locations than drivers. The other observed differences did not show significant results.

Table 7: T-test Difference mean scores between citizens and consumers

Landscape type	Levene's test		t-test for equality of means			
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference
Barren edge	1,587	0,210	1,606	138	0,111	-0,24508
Solid barrier	6,367	0,013	1,486	136	0,140	-0,15924
Prominent buildings	2,316	0,130	1,322	137	0,188	-0,23216
Transparent barrier	3,908	0,050	1,120	136	0,265	-0,14678
Ornamental frame	2,508	0,116	0,371	136	0,711	0,04692
Tree screen	0,722	0,397	2,00	138	0,047	0,26730

4.4.2 Highway corridor scene projects

Figure 18 and 19 show the distribution of the preference for a particular project alternative for both citizens and consumers at **location 1** (see 3.5.1 for the projects). Both groups prefer the tree screen corridor scene, which blocks the view on the surrounding area. The popularity of the ornamental frame is also similar for both groups. Despite the assumption that citizens would choose more often for sound barrier projects, the results are different. Likewise, the higher average scores assigned to sound barriers by drivers in the previous section, drivers chose more often for sound barrier projects than citizens.

14,5% of the drivers preferred the barren edge project. Among citizens, 5,6% chose for the barren edge project. However, differences between both groups are not significant.

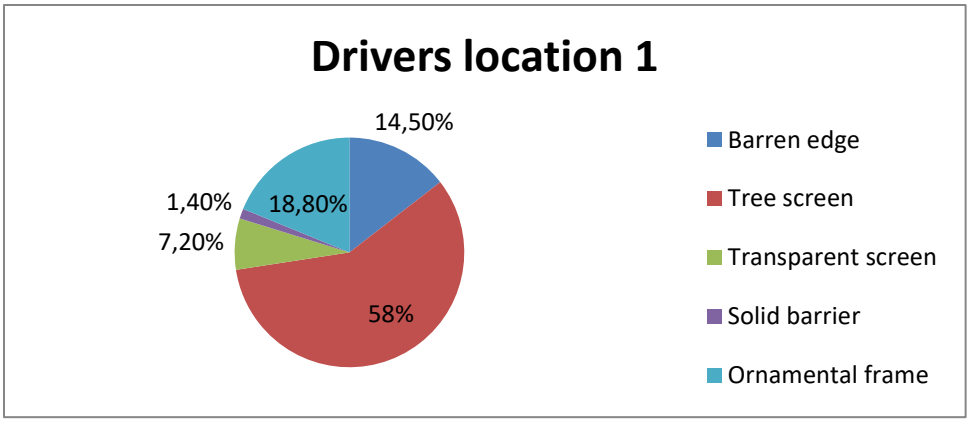


Figure 18: Frequency of drivers choosing for a particular project on location 1

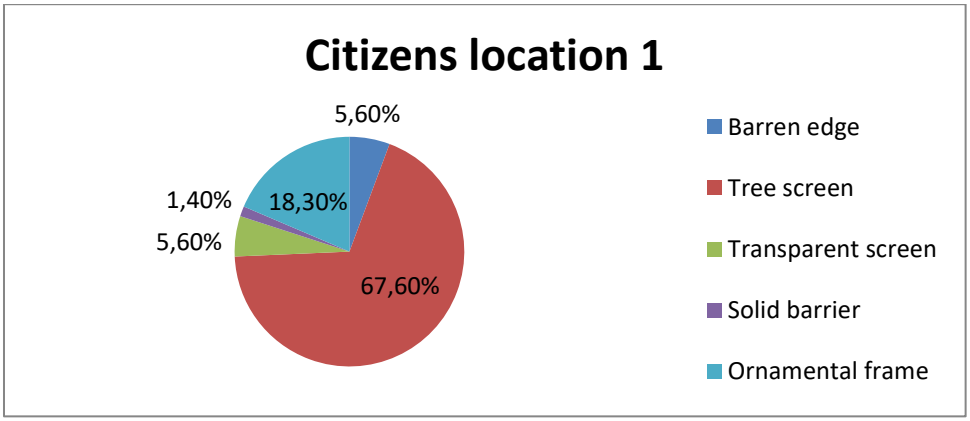


Figure 19: Frequency of citizens choosing for a particular project on location 1

Differences between groups were checked using a chi-square test (see table 8). However, there are no significant differences found. Therefore, it can be assumed that both citizens and drivers have the same preferences in choosing a particular project alternative on project location 1.

Chi-Square Test

Table 8: Chi-square test; differences between consumers and citizens at location 1

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-Square	4,382	5	0,496
Likelihood Ratio	4,854	5	0,434

a. 6 cells (50,0%) have expected count less than 5. The minimum expected count is ,49.

Project location 2

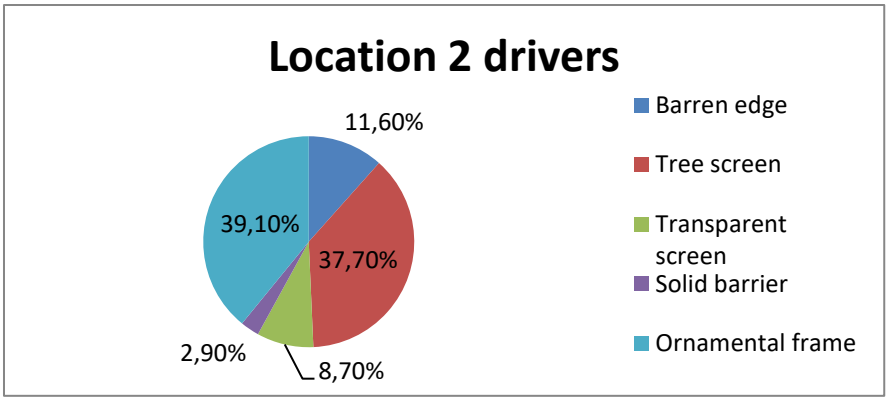


Figure 20: Frequency of drivers choosing for a particular project on location 2

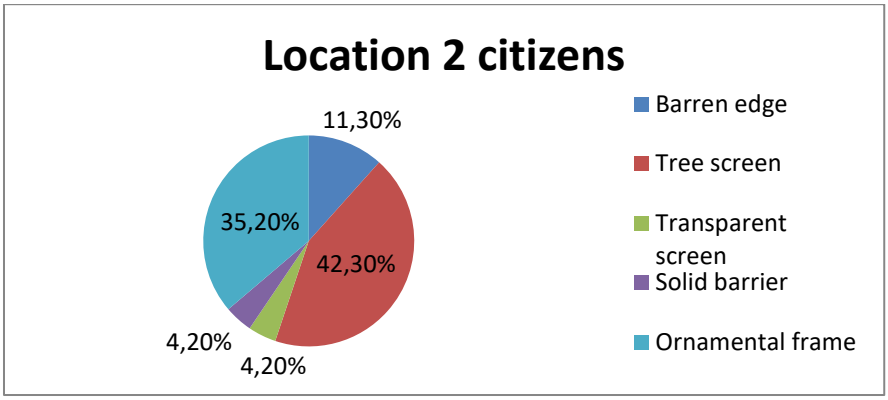


Figure 21: Frequency of citizens choosing for a particular project on location 2

Figure 20 and 21 present the frequencies of choosing for a particular project on **location 2**. It is again remarkable that, despite the previously set assumption that citizens would prefer sound barrier measures, drivers choose more often for a sound barrier compared to citizens. Furthermore, looking at table 9, there are no significant differences between both groups. Both groups have similar preferences regarding their choice for a particular landscaping project.

Chi-Square Test

Table 9: Chi-square test; differences between consumers and citizens at location 2

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-Square	3,535	5	0,618
Likelihood Ratio	4,328	5	0,503

a. 6 cells (50,0%) have expected count less than 5. The minimum expected count is ,99.

Project location 3

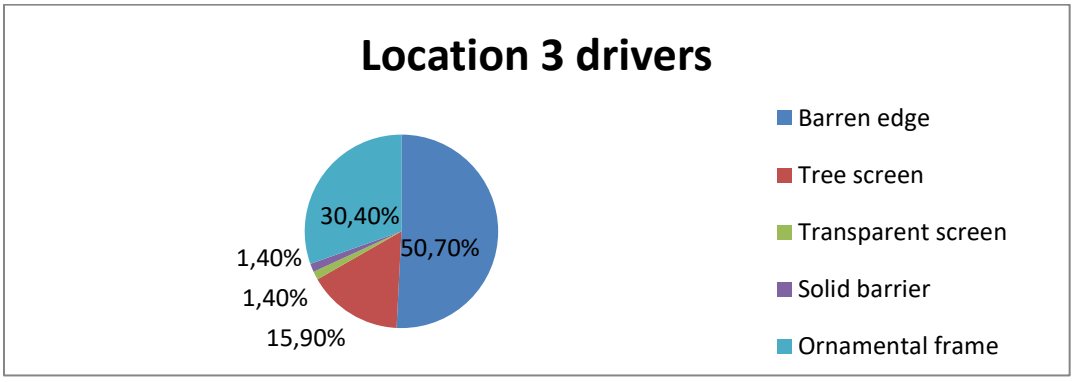


Figure 22: Frequency of drivers choosing for a particular project on location 3

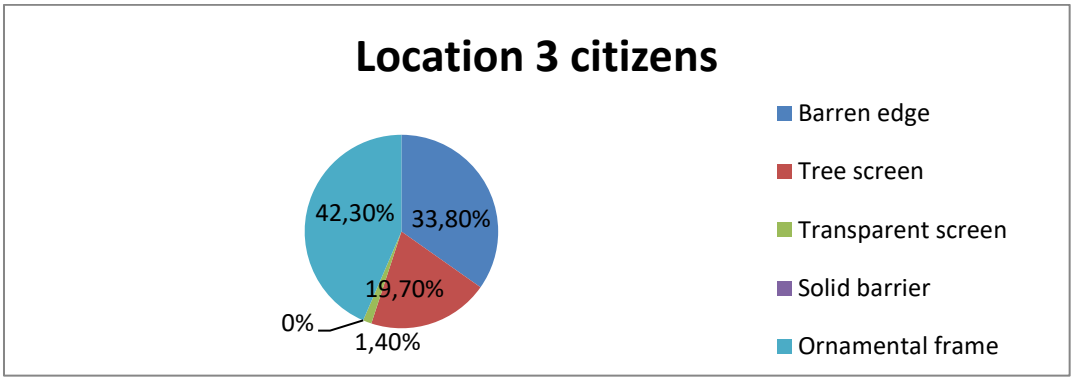


Figure 23: Frequency of citizens choosing for a particular project on location 3

On project **location 3**, there seems to be a bigger difference between driver and citizen (figure 22 and 23) The barren edge (doing nothing scenario) is the most popular alternative among drivers, while citizens have a clear preference for the ornamental frame project. However, the chi-square test (see table 10) rejected the existence of a difference between both groups. Therefore, likewise at the previous project locations, there is no difference between citizens and drivers regarding their preference for a particular project alternative.

Chi-Square Test

Table 10: Chi-square test; differences between consumers and citizens at location 3

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-Square	6,972	5	0,223
Likelihood Ratio	8,151	5	0,148

a. 6 cells (50,0%) have expected count less than 5. The minimum expected count is ,49.

4.5 Robustness checks

A few robustness checks have been performed in order to see whether the outcomes presented above still hold when changing the underlying assumptions. First, differences between men and women were checked. Next, the distance from the highway assumption to be designated as citizen was adjusted to 500 meter and 1500 meter respectively. Finally, assumption regarding the commuting frequency to be categorized as a driver was adjusted from 3 times per week, to 4 times or more per week.

4.5.1 Gender differences

When comparing the scores assigned to different highway corridor scenes at random location by men and women, there is a clear difference in the scoring of the prominent building pictures (see table 20). Men assigned a mean score of 2,90 to this corridor type, while women assigned a mean score of 2,26 to prominent buildings. However, no significant differences were found. When comparing the frequencies of choosing landscaping projects, there was one significant result (95%). At location 3, men had a clear preference for the cheapest option, the barren edge, while women preferred the ornamental view landscape.

4.5.2 Adjusting range

The distance between the whereabouts of citizens and the highway assumption was adjusted to both 500 meter and 1500 meter. However, no different results were found.

4.5.3 Adjusting commuting frequencies

Similarly to the previous adjustments, no different results were found when increasing the commuting frequencies to be designated as a driver.

5. Conclusion and discussion

The aim of this thesis was to find the value of highway corridor scenes in the Netherlands. The following paragraphs will contain a recap of this thesis and will discuss the findings of this thesis for each research question.

Recap

In the last few decades, the amount of road traffic has increased strongly in the Netherlands and it is expected to continue to grow in the upcoming years. Consequently, people spend more of their time on the road, meaning more interaction with the environmental surrounding of the highway. At first sight, highway corridor scenes only seem to function as a safety barrier between the highway and the world next to the road. However, highway corridors can have a big effect on both the drivers' stress levels and health conditions. Several studies have found that highway corridors scenes containing artifacts have a negative effect on people's blood pressure and stress levels. However, natural highway corridor scenes can have a restorative effect. These highway corridors therefore seems to play a larger role as expected. As a consequence, you might expect that adding the inclusion of highway corridor scenes to infrastructure project assessments is important. However, this is not the case. Most countries in Europa use the so-called "cost benefit analysis" (CBA) as their main appraisal tool The monetization of costs and benefits in CBA's proves to be problematic, especially for the assessment of the value of nature around infrastructure projects.

Looking at previous literature in the field of highway landscape valuation, it was discovered that previous studies mainly focused on the aesthetic scoring of different highway corridor scenes on

random locations, rather than adding highway corridor scenes locations which are known to the respondents. Furthermore, the costs of constructing and maintaining different highway corridor scenes were missing in previous studies. In order to fill the gap (with regard to the inclusion of nature) in current CBA"s, this thesis aimed to find the value, Dutch car drivers assign to different highway corridor scenes. First, it was necessary to look at the score Dutch car drivers assigned to highway corridor scenes at random locations (just like in previous research, e.g. Wolf, 2003). Second, location and costs were added, in order to see whether the preference for a particular highway corridor scene would differ. Finally, a distinction was made between citizens (e.g. people living close to the highway) and consumers (users), in order to check whether there is a difference in preference for a particular highway corridor scene between both groups.

5.1 Aesthetic scoring of different highway corridor scenes

To find the aesthetic scores, respondents had to assign scores to random highway corridor scenes. Looking at the results, there seems to be a clear preference for the natural landscapes among Dutch car drivers (the barren edge and tree screen landscapes) Especially, the barren edge score differed significantly from the mean scores assigned by drivers in the US. Therefore, the preferences regarding different highway corridor scenes seem to differ per country. However, a possible explanation for the difference between scores of the barren edge is a different use of pictures compared to the research of Wolf (2003). Wolf (2003) used pictures of more urban settings, while in this research, all barren edge pictures were taken in rural areas. Perhaps, the prominent building landscape pictures used in this thesis are more comparable to the barren edge pictures used by Wolf (2003) than the barren edge pictures. Furthermore, It was expected that drivers would prefer the possibility to view the landscape behind the sound barriers compared to a solid sound barrier, which blocks the view. However the transparent sound barrier received the lowest mean score. A possible explanation is that driving stress is enhanced by corridors, that contain buildings. The solid sound barrier prevents the driver to be distracted by a chaotic landscape and could therefore relieve stress.

5.2 Highway corridor scene projects

Looking at the results, it appears that location is a very important factor when considering a landscaping project. The first location of project 1 was situated close to a neighborhood. On this location, most respondents chose for the tree screen alternative, while in the previous section, the barren edge received the highest score. It appears that respondents take into account the possible noise disturbances as a result of the openness of the barren edge landscape. However, it seems that they perceive the tree screen as a good alternative to a noise barrier due to its density, while in fact this is not true. Another explanation for choosing the tree screen on this particular location is that tree screens reduce the risk of driving stress, while an urban environment (or varied landscape) enhances driving stress. The tree screen alternative makes the highway corridor less varied.

On location 2, the situation is different. Both the barren edge and the ornamental frame were more popular than on the previous location. A possible explanation is that both corridor scenes enable the driver to see the old city center of Zwolle, including the iconic Peperbus church tower. So, if the build environment offers a unique setting, drivers are more willing to choose for an open highway corridor scene, than on a location that is less unique. A second explanation might be the fact that

neighborhoods are located farther away from the highway, which might reduce the sense of urgency to reduce noise disturbances by choosing for a tree screen or noise barrier.

On the third location, costs seem to play an important role. The third location was situated on the outskirts of the city of Zwolle. The current highway corridor scene can be described as barren edge. As a result, the barren edge project alternative was assumed to be costless. Consequently, most of the respondents (41,8%) chose for the barren edge alternative. Furthermore, this location was the most similar to the barren edge pictures shown in the first section (which received the highest scores). It appears that respondents are satisfied with the current situation and are not willing to invest money in order to alter the landscape. Finally, the housing density is very low on this location, which lowers the sense of urgency that sound absorbing measures should be necessary.

All in all, the potential landscape seems to play an important role when people have to choose highway corridor scene landscaping projects. In a densely build environment, people tend to choose for the tree screen alternative, since this both reduces driving stress and perceived noise disturbance. On a location, which features a unique build environment, people tend to choose more often for an open landscape, but the tree screen remains very popular. On locations that already offer a relaxing and open environment, costs start to play an important role. People are only willing to pay additional tax on locations that offer a potential improvement in terms of uniqueness or tranquility.

5.3 The difference between consumers (drivers) and citizens

First, looking at the differences between the average scores assigned to highway corridor scenes on random location, no big differences can be found. Both groups have similar preferences.

Second, when comparing the preference for a particular landscaping project on location 1, there are no big differences between both groups. The tree screen remains the most popular alternative on this location for both groups. Interestingly enough, drivers chose more often for sound barrier landscapes compared to citizens. However, in the previous section it became clear that people tend to choose for the tree screen as a result of the perception that a dense wall of trees might absorb more noise than an open landscape. When the landscapes are rearranged in two groups: open landscapes (containing barren edge, transparent sound barrier and ornamental frame) and closed landscapes (solid sound barriers and tree screens), it becomes clear that citizens choose more often for closed landscapes (69%) than drivers (59,4%). Assuming that citizens are more sensitive to noise disturbance, there indeed seems to be a perception that closed highway corridor barriers, including vegetation, absorb more noise than barriers that enables drivers to see the landscape behind the barrier.

On the second location, citizens again had a greater preference for closed barriers, however differences are very small on this location (40,6% drivers compared to 46,5% citizens). Therefore it seems that both groups make equal decisions regarding their preferences for a particular landscaping project on this location. The proximity of the city center and the potential view on the old city center plays an important role. Furthermore, the density of houses close to the highway is lower on this location, which might affect the popularity of the more open highway corridor types.

On the third location, there are no big differences between both groups. More than half of the drivers chose for the barren edge option, while among the ornamental frame option was the most popular among citizens. However, in the robustness checks we have seen that there was a big difference

between men and women regarding their favorite project on this location. Since, women are overrepresented in the database, it is not possible to draw conclusions on this particular location.

5.4 What value do Dutch car drivers assign to different highway corridor scenes?

Dutch car drivers assign the highest aesthetic value to tree screens and barren edges, especially on locations, which they are not familiar with. However, when location is known both the landscape potential and the housing density play a role. When a highway is located in an area, which features high density of housing and a low landscape potential (in terms of uniqueness of the buildings), people tend to value tree screens more than open highway corridor scenes. When a landscape features high landscape potential and has a lower housing density, more open landscapes, like the ornamental frame become more valuable to respondents. On locations with low density, which already features an open landscape, people tend to choose for open landscapes. Furthermore, costs starts playing a role when people are already satisfied with the current landscape.

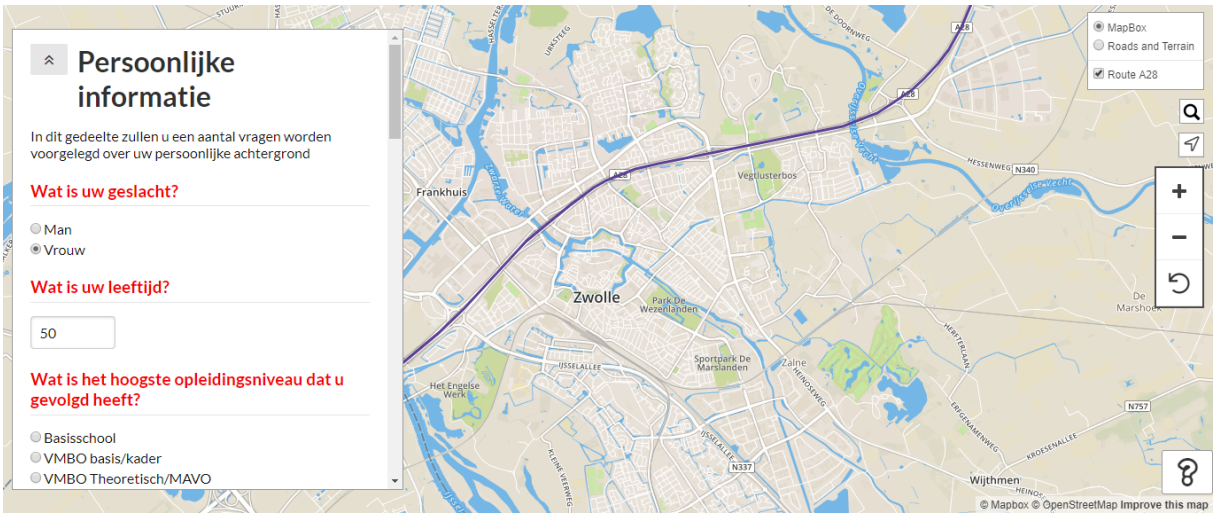
5.5 Recommendations

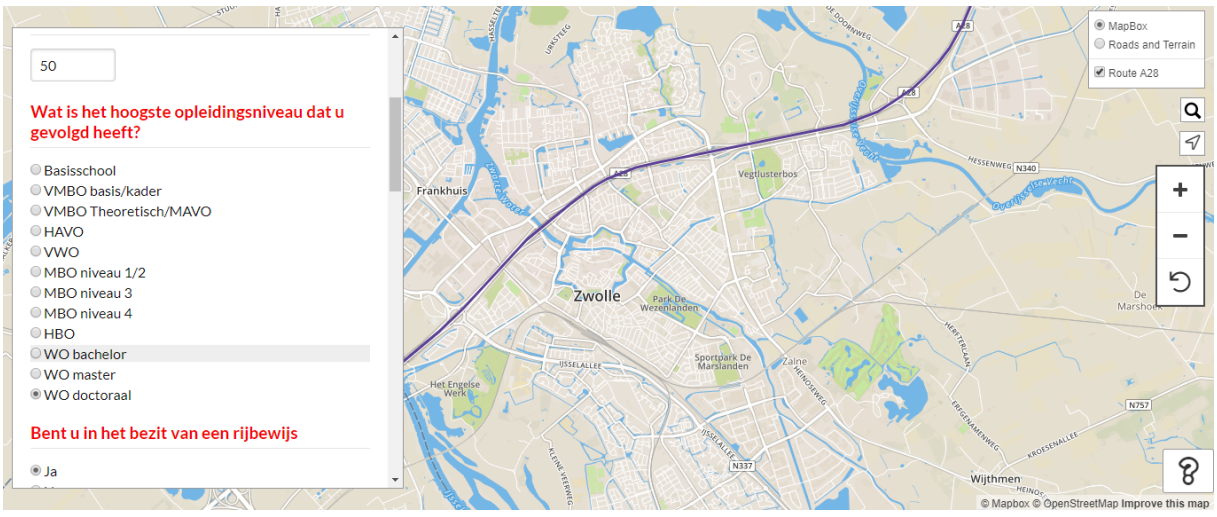
A few recommendations can be done for further research:

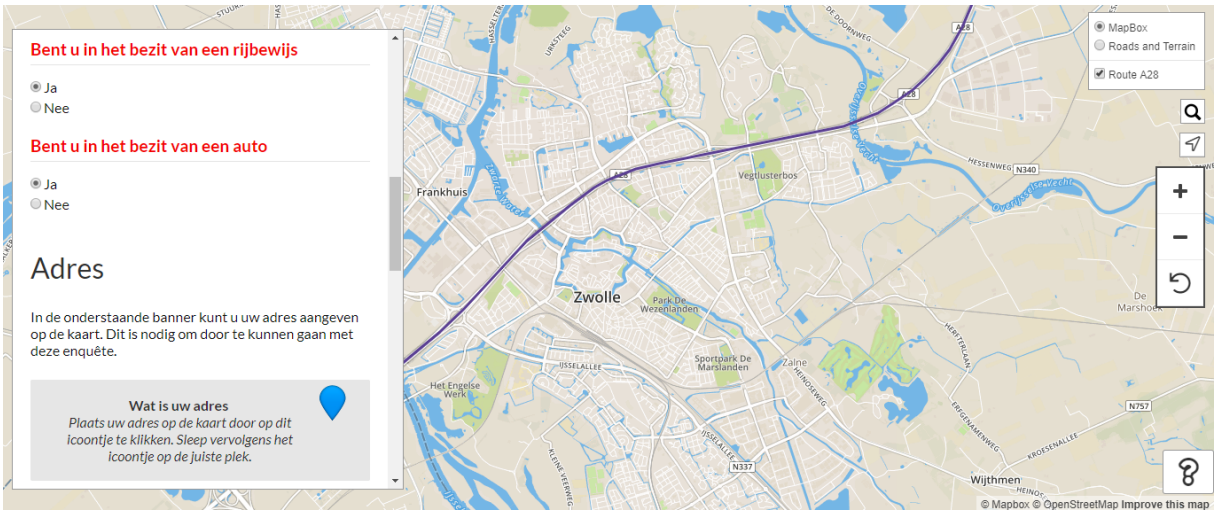
- It could be interesting to check whether differences in preferences for a particular highway corridor scene are similar on other locations. Especially whether the uniqueness or the potential of the highway corridor scene does indeed influence the preference of the respondent to choose for a more open landscape.
- Furthermore, one drawback of this research was that the effects of noise disturbance were not directly included in the analysis. Respondents did not have any information regarding the noise disturbance effects of each landscaping project. This could be added in future research to check whether citizens would make different choices compared to drivers.
- Another interesting option could be to add population density to the analysis to check whether people are indeed more willing to choose for ‘’closed’’ highway corridors on locations were the population density around the highway is higher.
- Next, A problem in this research was that in the questionnaire, people had tell how many times they use the A28 highway per week. They had the option to choose between: never, once or twice per week etc. However, as the results were collected, it became clear that a lot of respondents chose the ‘’never’’ option, while in reality they used the highway a few times per month. This did not influence the results, but it is recommended to add the option ‘’a few times per month’’ to future questionnaires.
- Another recommendation is to use more respondents. For this thesis, 141 respondents were recruited, however to generate more significant results, it is recommended to have more than 200 respondents.
- The distinction between citizens and consumers can be improved. In this research, a range of 1000 meter from the highway to the homes of citizens were used as an requirement to be categorized as citizen. However, for future analysis it could be interesting to make a distinction between citizens living directly next to the highway and citizens living on a larger distance.
- Finally, one can think of the introduction of virtual reality to this method. VR could for instance be used to enhance the experience of the different highway landscape alternatives.

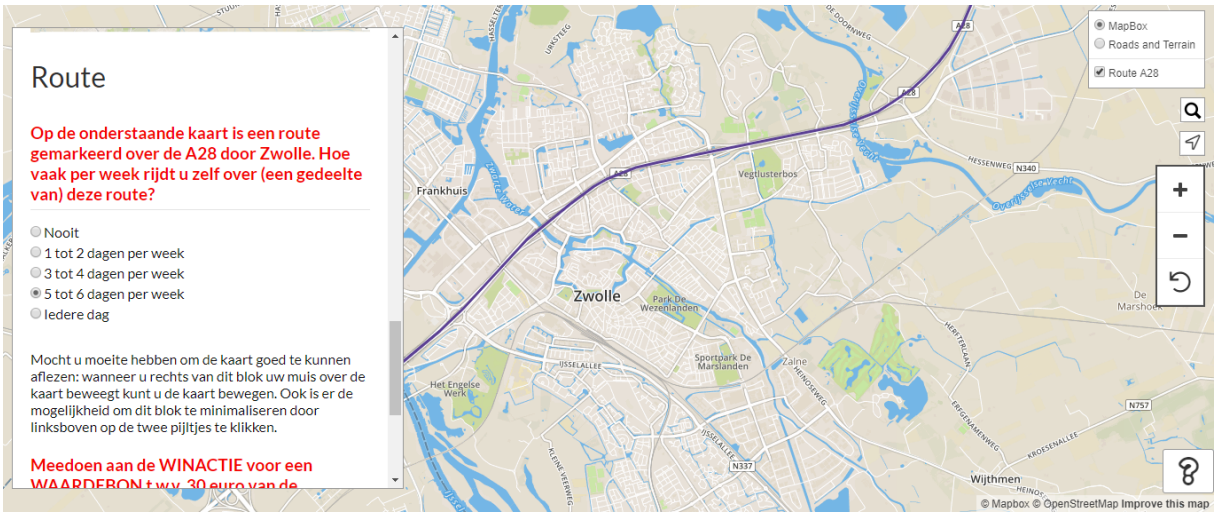
Appendix 1

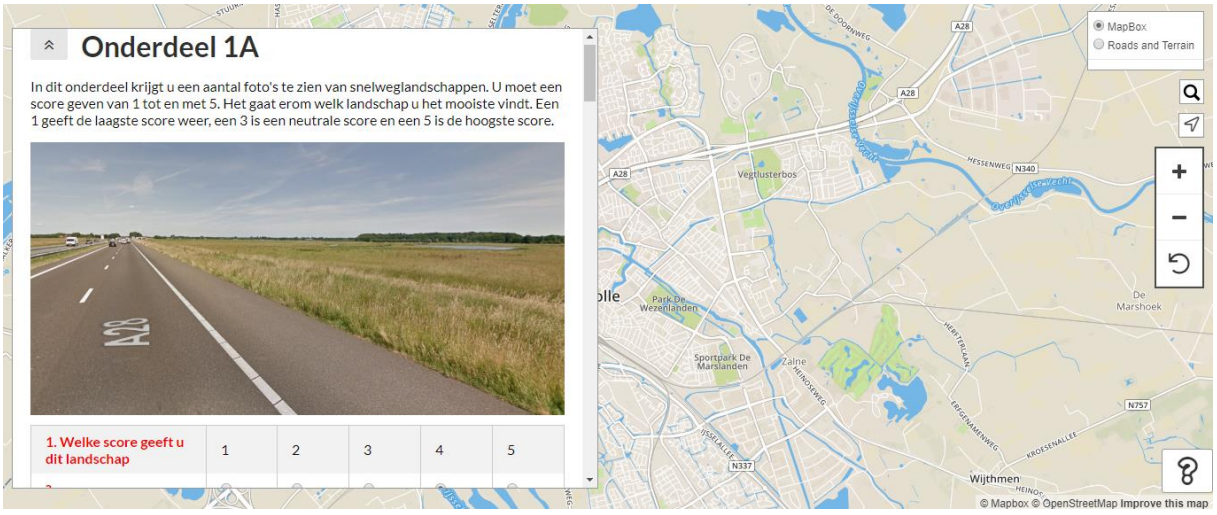
Questionnaire

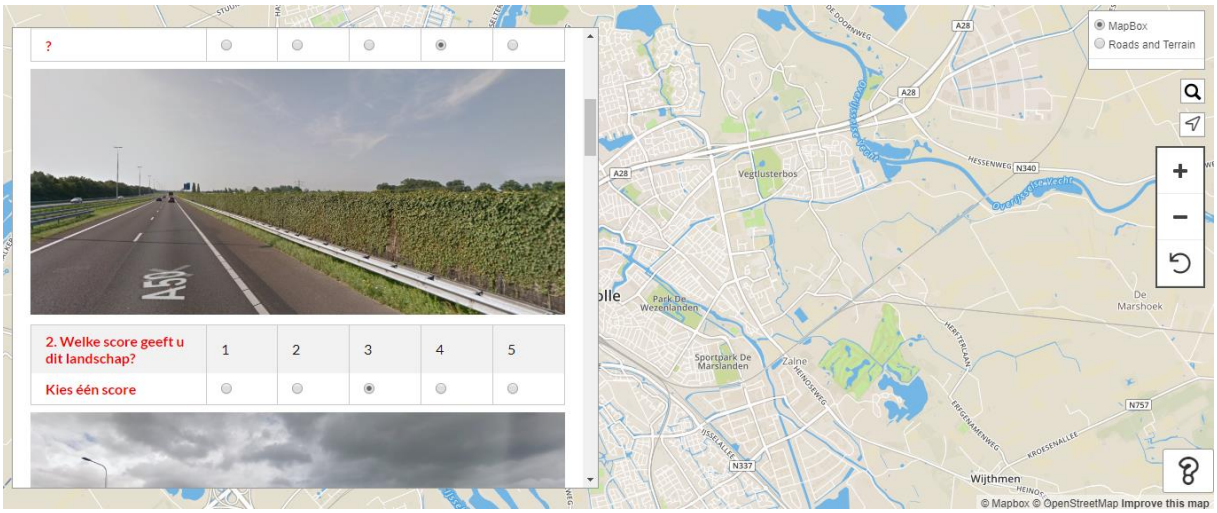


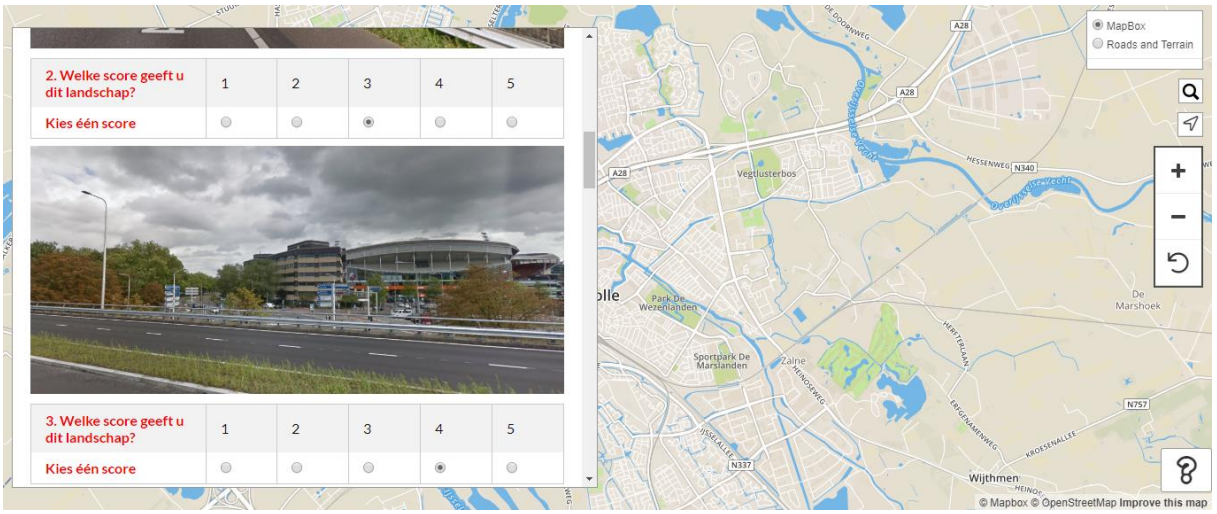


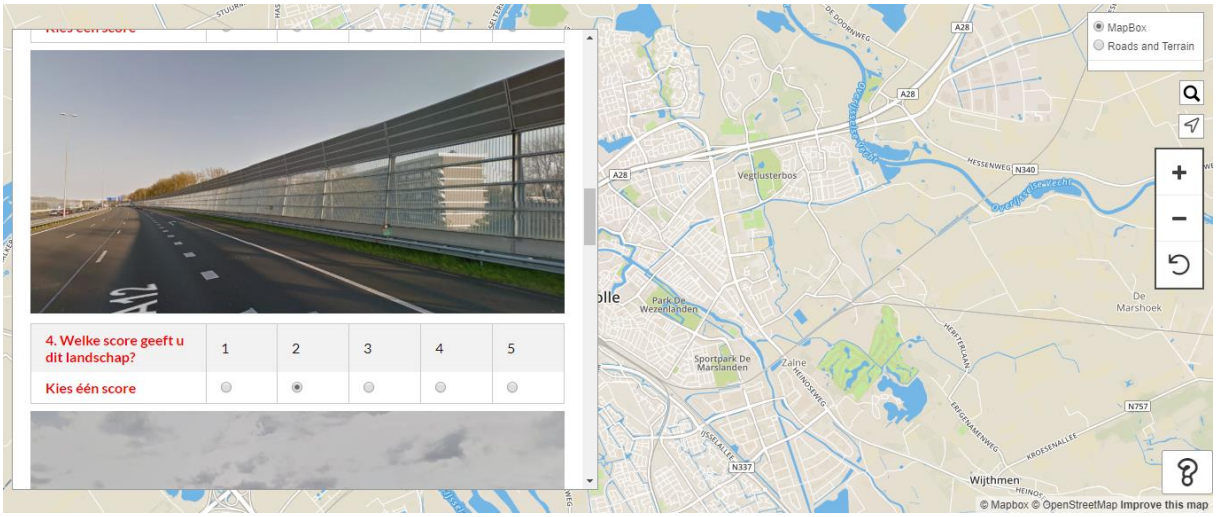

Bent u in het bezit van een rijbewijs
Ja
Nee
Bent u in het bezit van een auto
Ja
Nee
Adres
In de onderstaande banner kunt u uw adres aangeven op de kaart. Dit is nodig om door te kunnen gaan met deze enquête.
Wat is uw adres
Plaats uw adres op de kaart door op dit icoontje te klikken. Sleep vervolgens het icoontje op de juiste plek.
MapBox
Roads and Terrain
Route A28
Zwolle
Frankhuis
Wijthmen
© Mapbox © OpenStreetMap Improve this map


Route
Op de onderstaande kaart is een route gemarkeerd over de A28 door Zwolle. Hoe vaak per week rijdt u zelf over (een gedeelte van) deze route?
Nooit
1 tot 2 dagen per week
3 tot 4 dagen per week
5 tot 6 dagen per week
Iedere dag
Mocht u moeite hebben om de kaart goed te kunnen aflezen: wanneer u rechts van dit blok uw muis over de kaart beweegt kunt u de kaart bewegen. Ook is er de mogelijkheid om dit blok te minimaliseren door linksboven op de twee pijltjes te klikken.
Meedoen aan de WINACTIE voor een
MapBox
Roads and Terrain
Route A28
Zwolle
Frankhuis
Wijthmen
© Mapbox © OpenStreetMap Improve this map


Onderdeel 1A
In dit onderdeel krijgt u een aantal foto's te zien van snelweglandschappen. U moet een score geven van 1 tot en met 5. Het gaat erom welk landschap u het mooiste vindt. Een 1 geeft de laagste score weer, een 3 is een neutrale score en een 5 is de hoogste score.
A28
1. Welke score geeft u dit landschap
1
2
3
4
5
MapBox
Roads and Terrain
Wijthmen
© Mapbox © OpenStreetMap Improve this map


?
2. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
© Mapbox © OpenStreetMap Improve this map


2. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
3. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
© Mapbox © OpenStreetMap Improve this map


4. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
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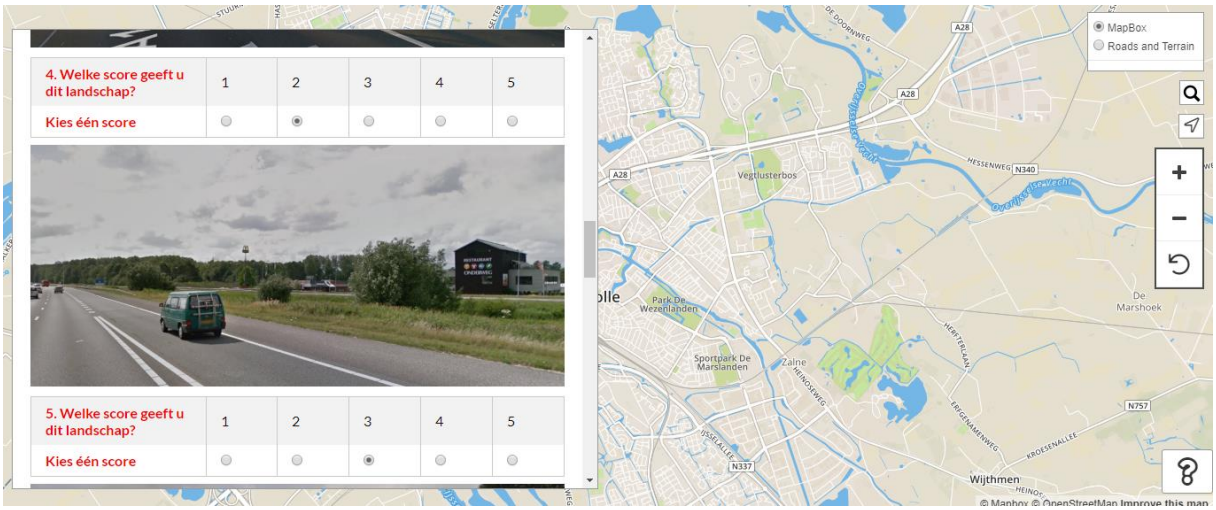
4. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
5. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
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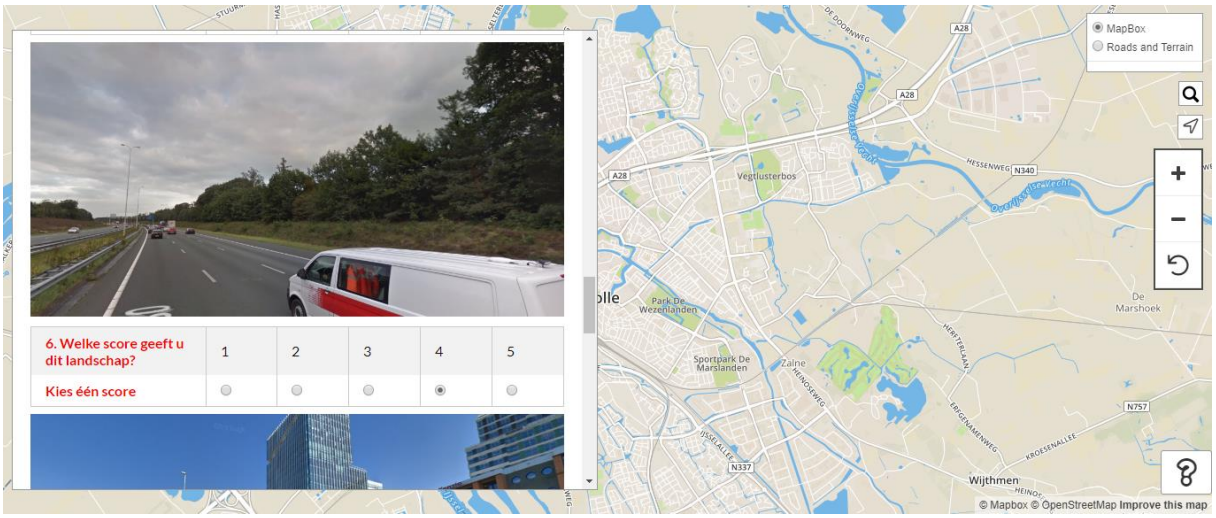
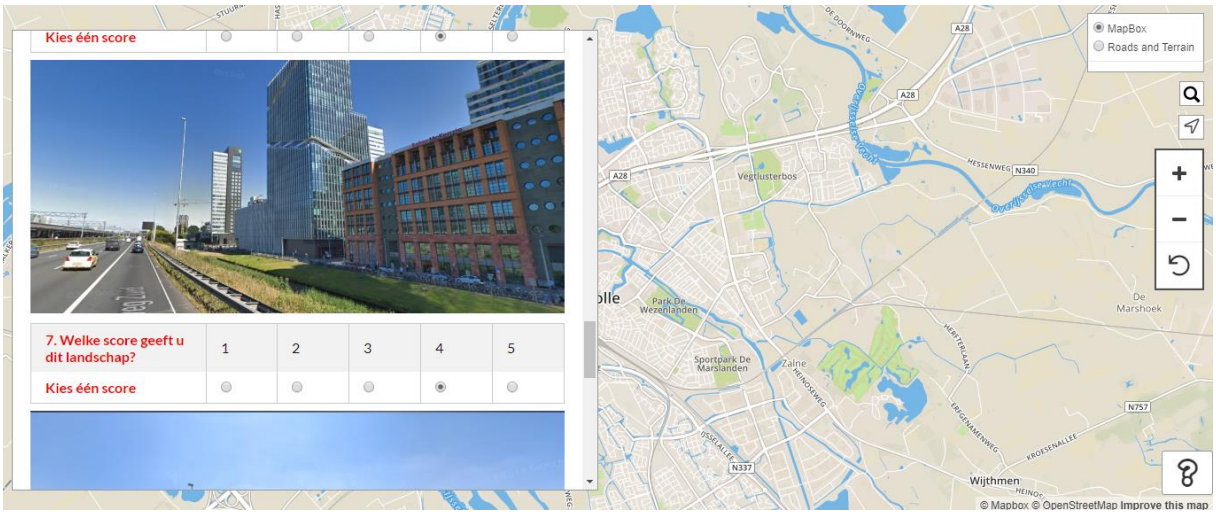
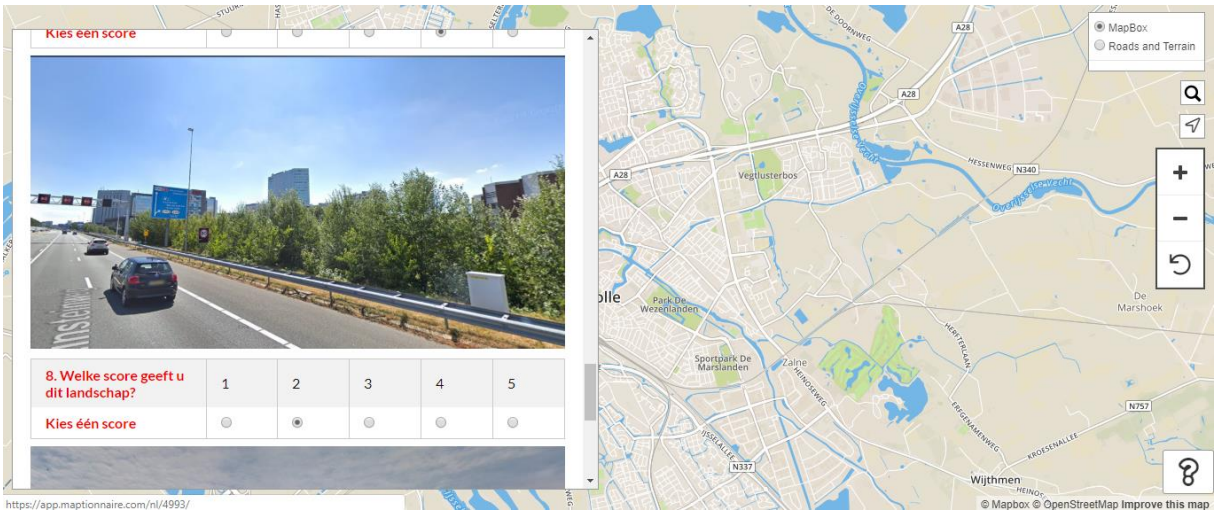

6. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
© Mapbox © OpenStreetMap Improve this map


Kies één score
7. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
© Mapbox © OpenStreetMap Improve this map


Kies één score
8. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
https://app.maptionnaire.com/nl/4993/
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
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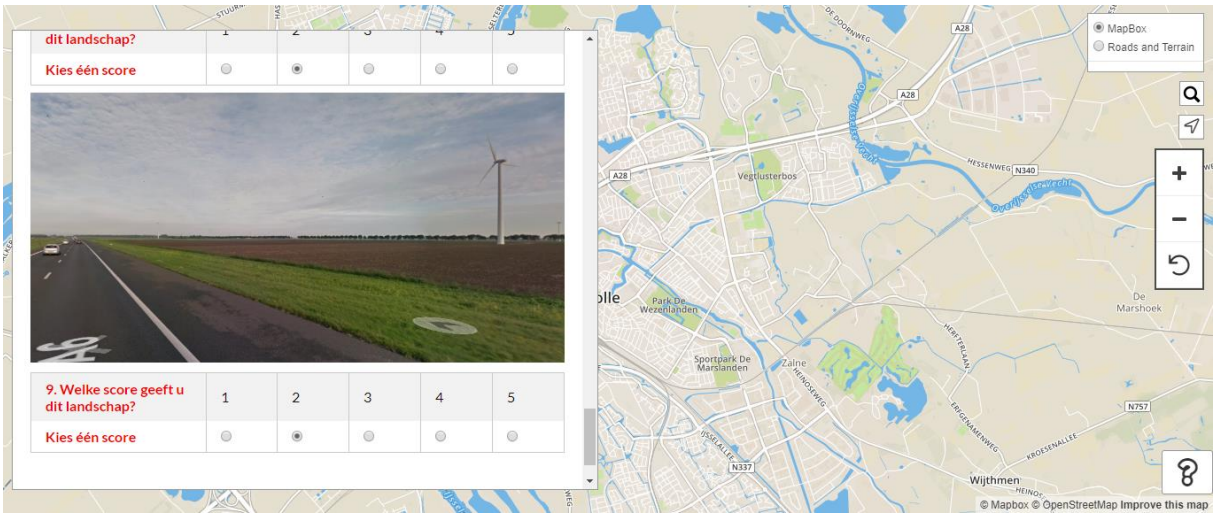
dit landschap?
Kies één score
9. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
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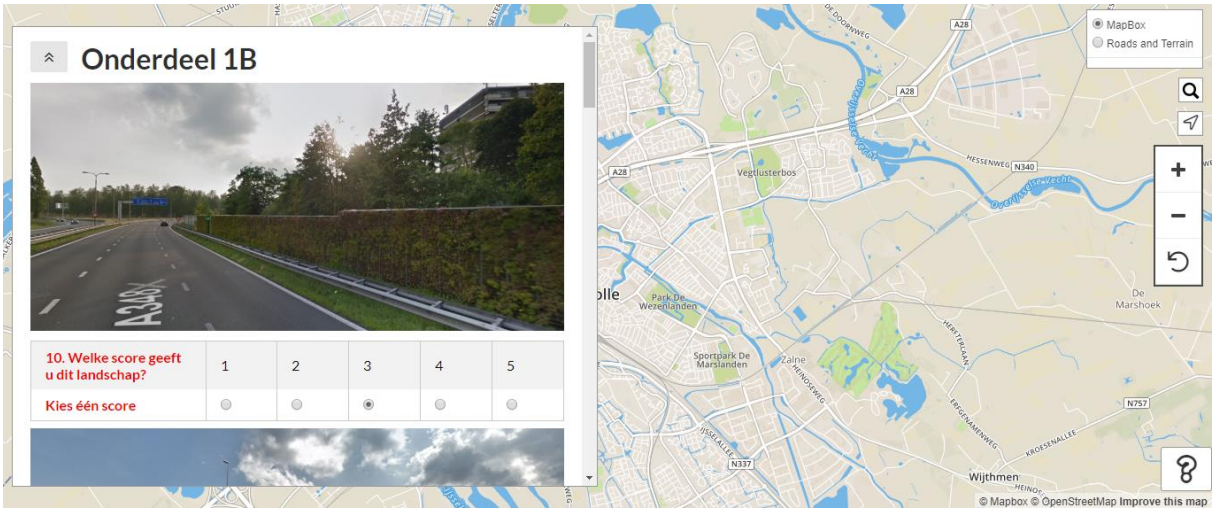
Onderdeel 1B
10. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
MapBox
Roads and Terrain
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
De Marshoek
Wijthmen
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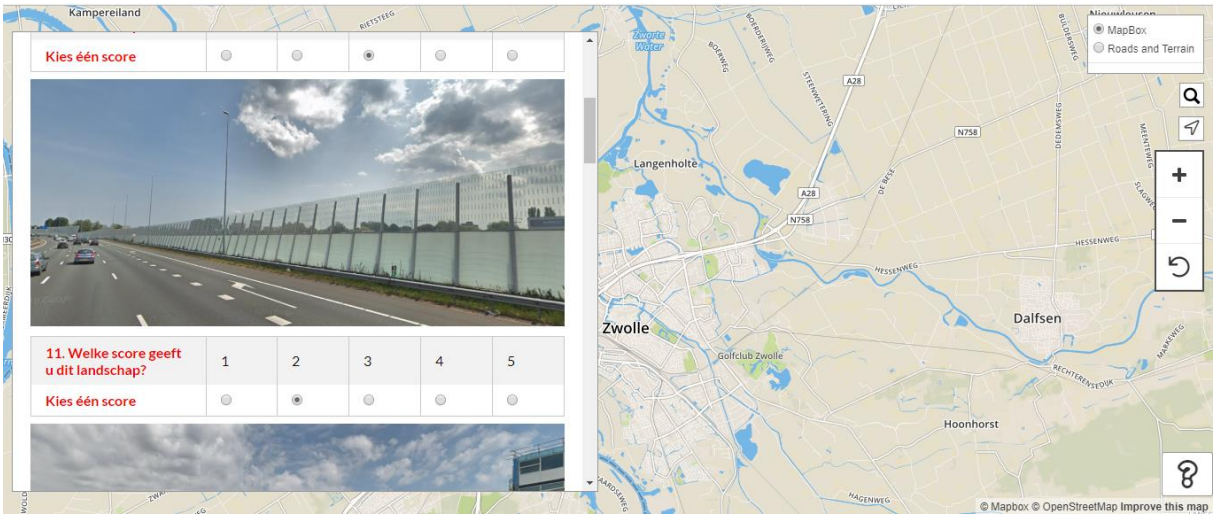
Kies één score
11. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
Kampereiland
Langenholte
Zwolle
Dalfsen
Hoonhorst
Golfclub Zwolle
MapBox
Roads and Terrain
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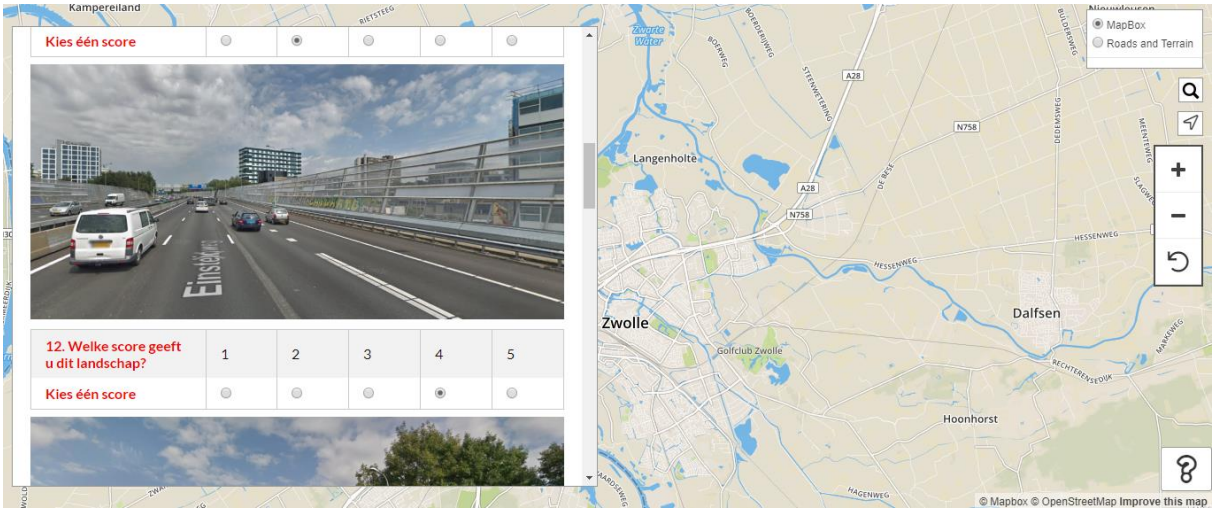
Kies één score
12. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
Kampereiland
Langenholte
Zwolle
Dalfsen
Hoonhorst
Golfclub Zwolle
MapBox
Roads and Terrain
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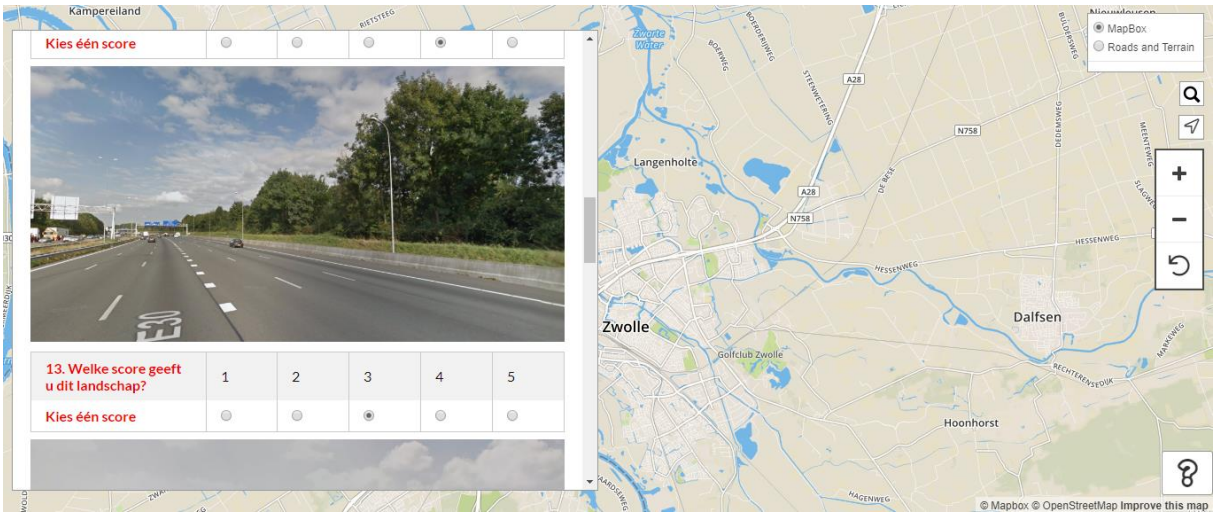
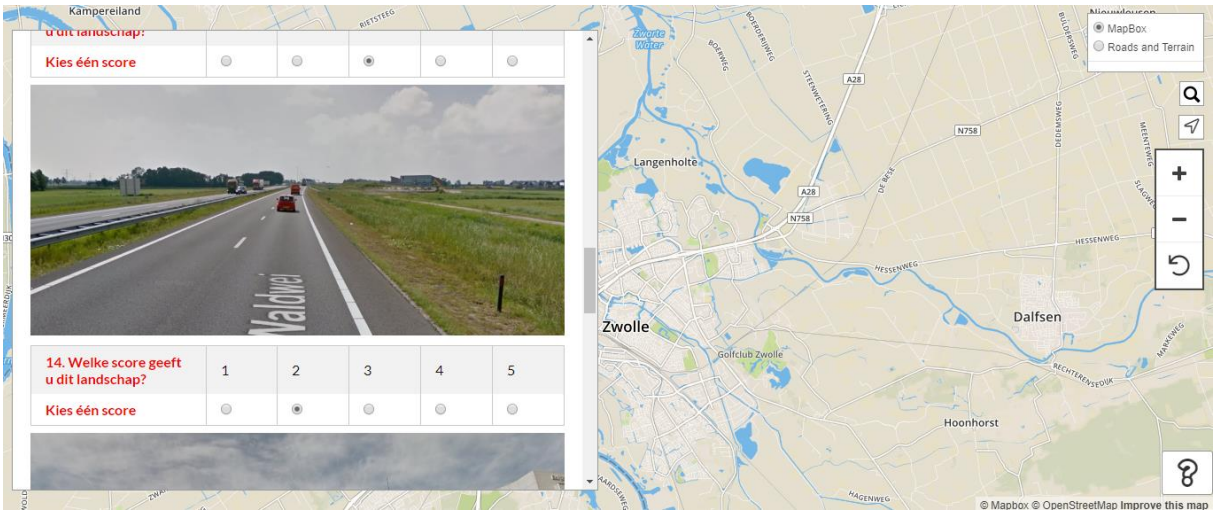
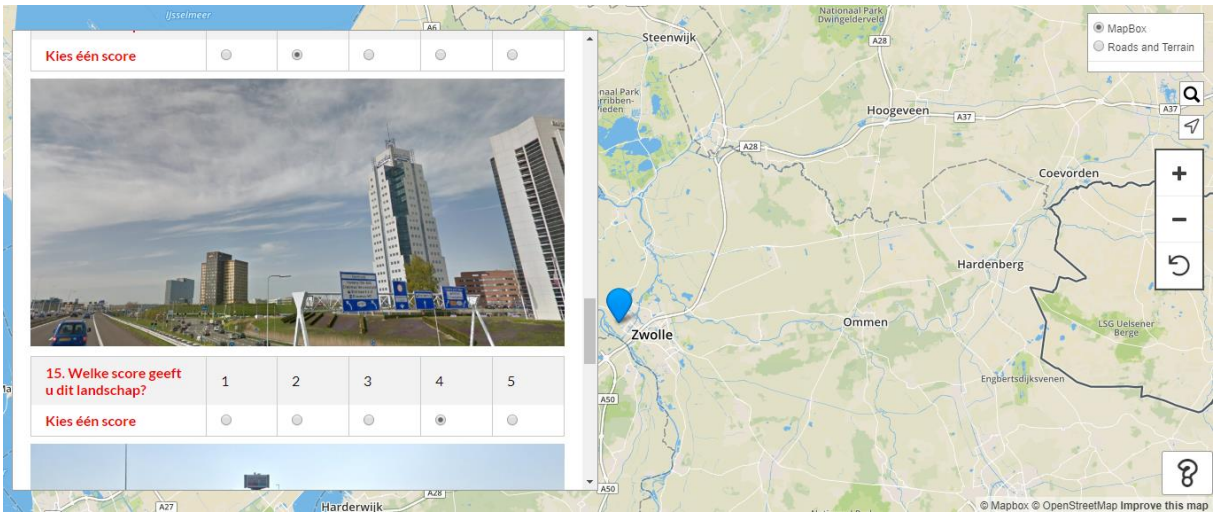
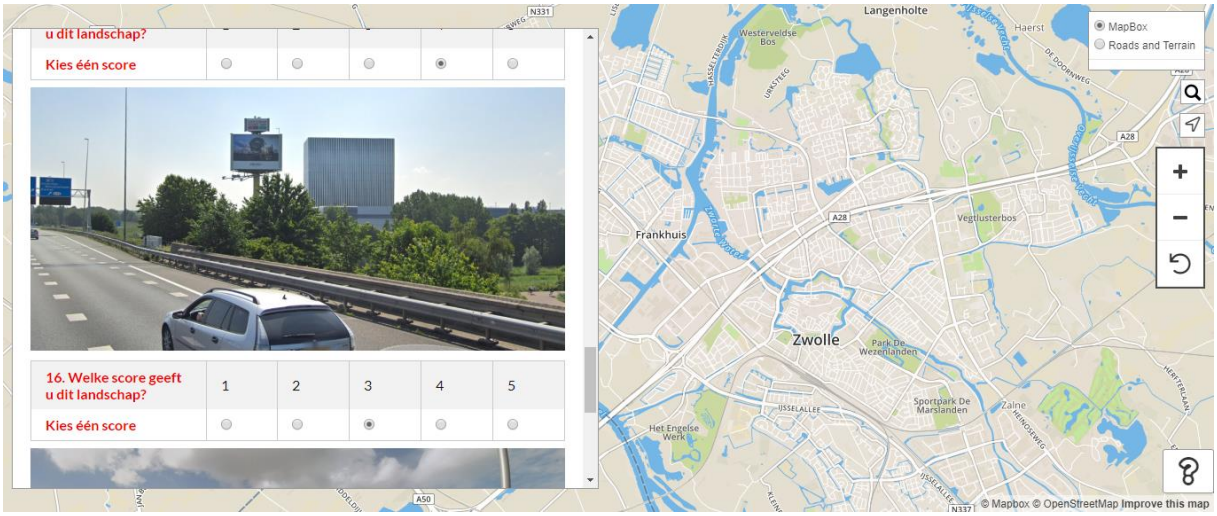
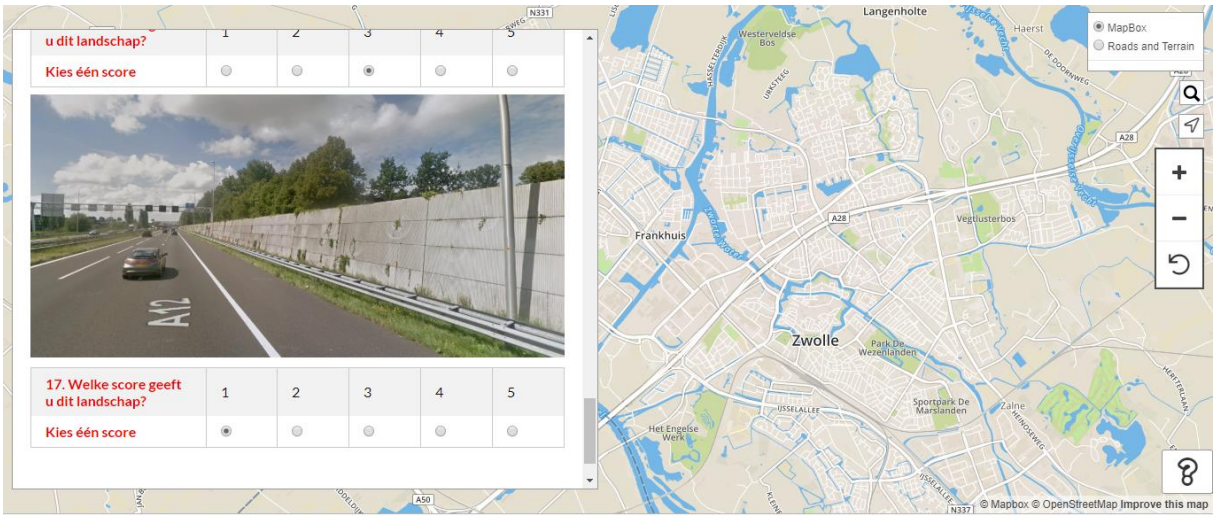

Kies één score
13. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
Kampereiland
Langenholte
Zwolle
Dalfsen
Hoonhorst
Golfclub Zwolle
MapBox
Roads and Terrain
© Mapbox © OpenStreetMap Improve this map

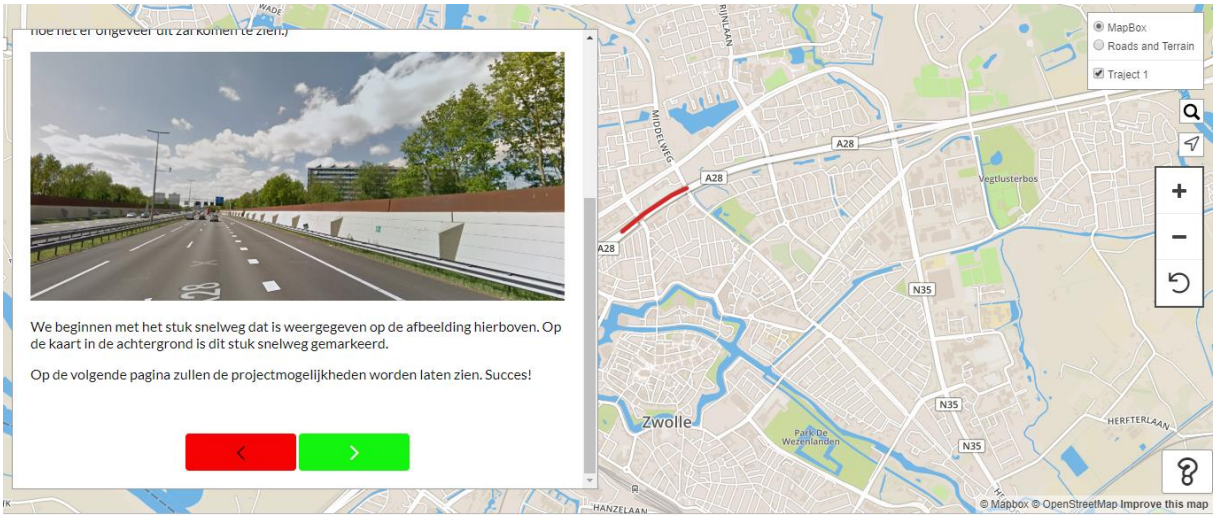

Kies één score
14. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
Zwolle
Dalfsen
Hoonhorst
Langenholte
MapBox
Roads and Terrain
© Mapbox © OpenStreetMap Improve this map

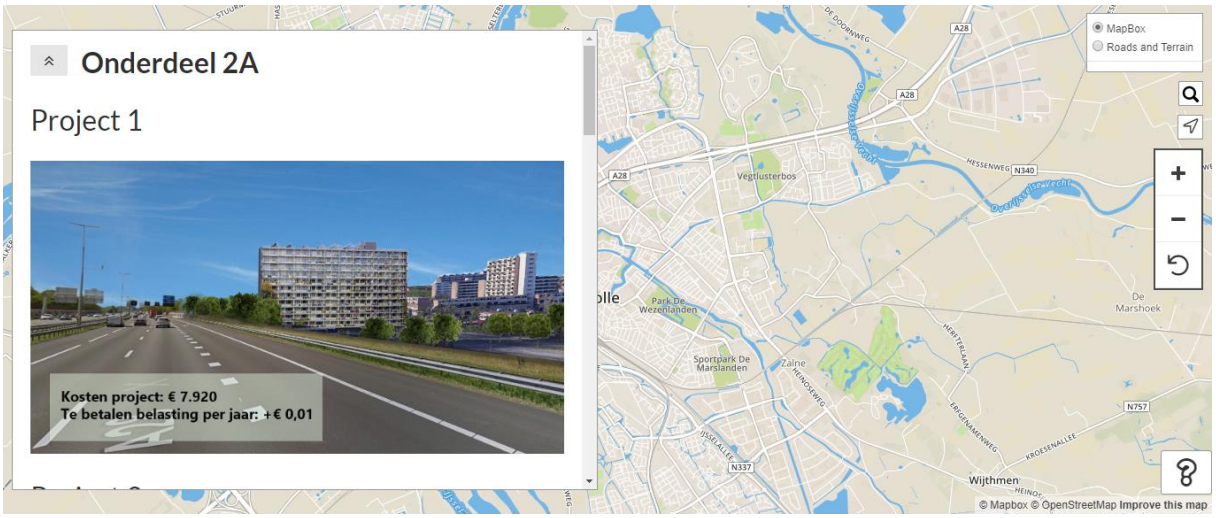

Kies één score
15. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
Steenwijk
Hoogeveen
Coevorden
Hardenberg
Zwolle
Ommen
Harderwijk
MapBox
Roads and Terrain
© Mapbox © OpenStreetMap Improve this map

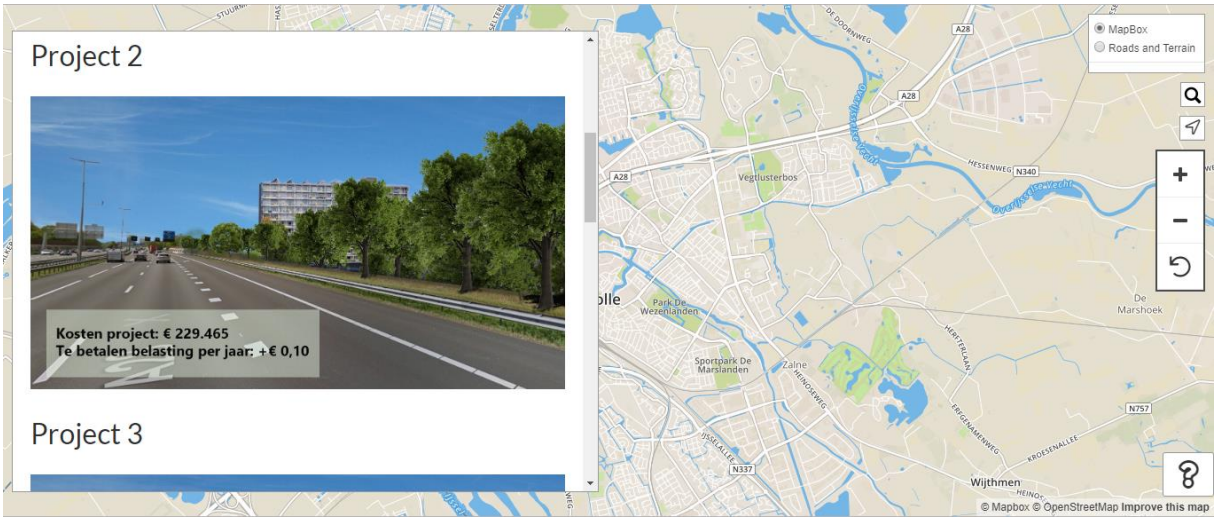

Kies één score
16. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
Langenholte
Frankhuis
Zwolle
MapBox
Roads and Terrain
© Mapbox © OpenStreetMap Improve this map

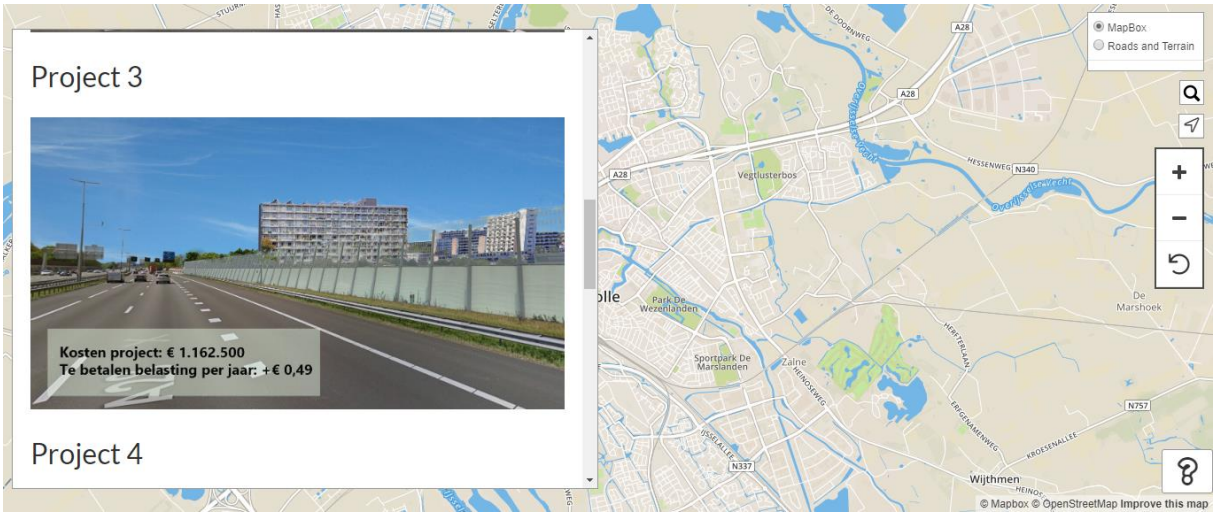

u dit landschap?
1
2
3
4
5
Kies één score
A12
17. Welke score geeft u dit landschap?
1
2
3
4
5
Kies één score
Langenholte
Haerst
Westerveldse Bos
Frankhuis
Zwolle
Vegtlusterbos
Park De Wezenlanden
Sportpark De Marslanden
Zalne
Het Engelse Werk
MapBox
Roads and Terrain
© Mapbox © OpenStreetMap Improve this map

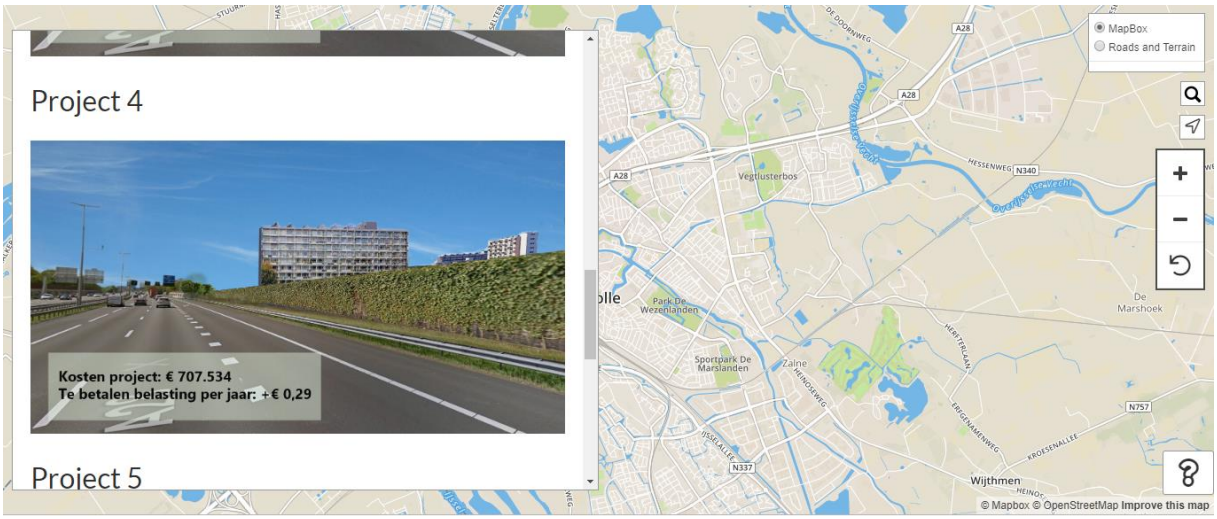

Onderdeel 2
Projecten A28
In dit onderdeel krijgt u de kans om in de huid te kruipen van de gemeente Zwolle. U krijgt drie stukken snelweg te zien. Het is uw taak om een keuze te maken welk landschap u het prettigst vindt als automobilist. Verder is het belangrijk om te letten op de kosten van ieder project. Voor ieder project is aangegeven hoeveel extra belasting u moet betalen wanneer u voor dit project kiest.
(De foto's van de projectalternatieven zijn impressies en dienen alleen ter illustratie hoe het er ongeveer uit zal komen te zien.)
MapBox
Roads and Terrain
Traject 1
A28
N35
Zwolle
Vegtlusterbos
Park De Wezenlanden
MIDDELWEG
RIJNLAAN
HERFTERLAAN
© Mapbox © OpenStreetMap Improve this map

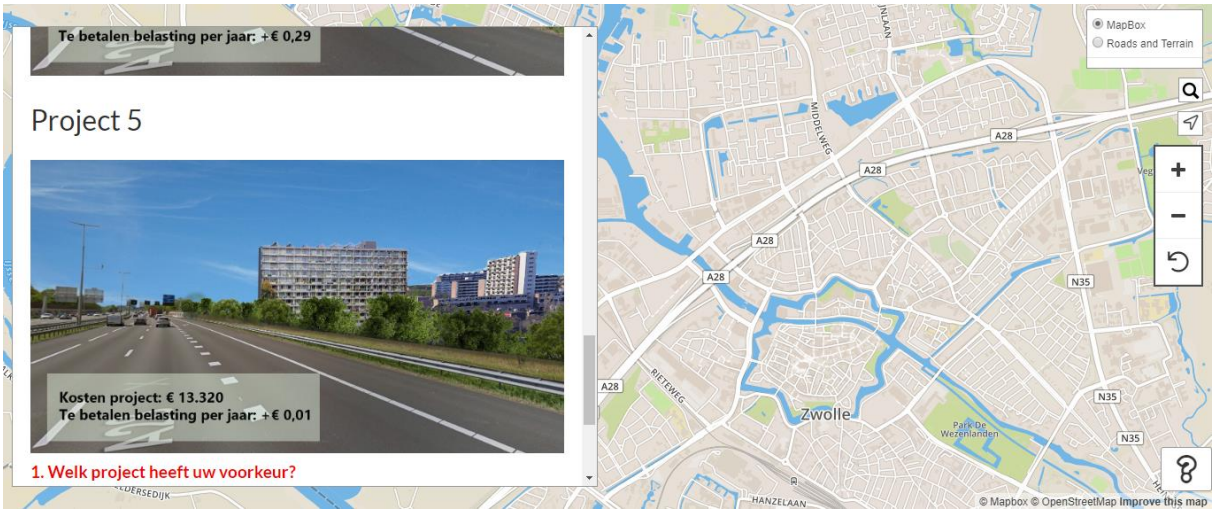

We beginnen met het stuk snelweg dat is weergegeven op de afbeelding hierboven. Op de kaart in de achtergrond is dit stuk snelweg gemarkeerd.
Op de volgende pagina zullen de projectmogelijkheden worden laten zien. Succes!
MapBox
Roads and Terrain
Traject 1
A28
N35
Zwolle
Vegtlusterbos
Park De Wezenlanden
MIDDELWEG
RIJNLAAN
HERFTERLAAN
© Mapbox © OpenStreetMap Improve this map

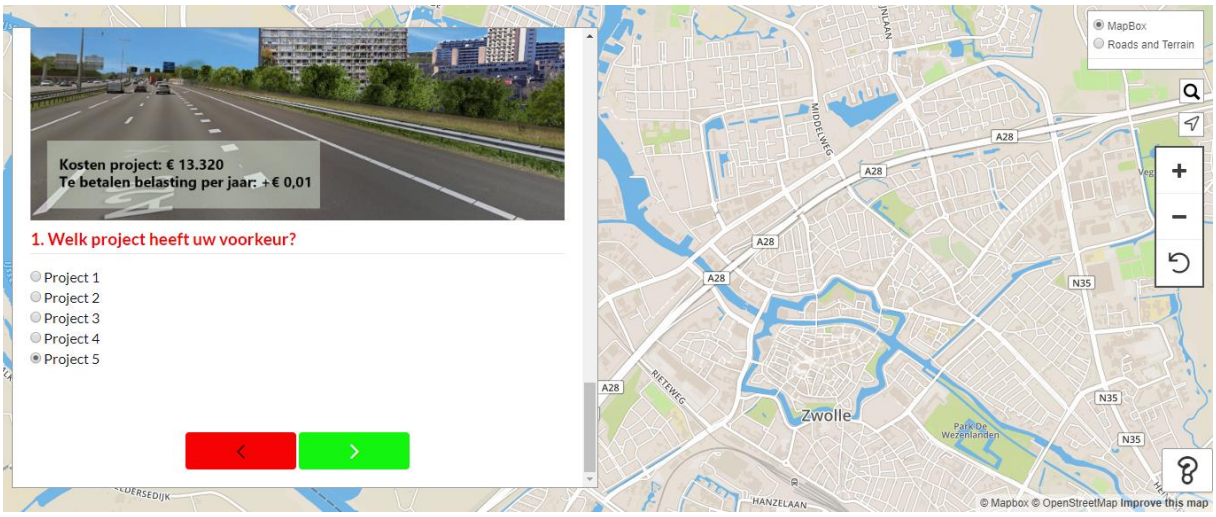

Onderdeel 2A
Project 1
Kosten project: € 7.920
Te betalen belasting per jaar: +€ 0,01
MapBox
Roads and Terrain
Wijthmen
© Mapbox © OpenStreetMap Improve this map

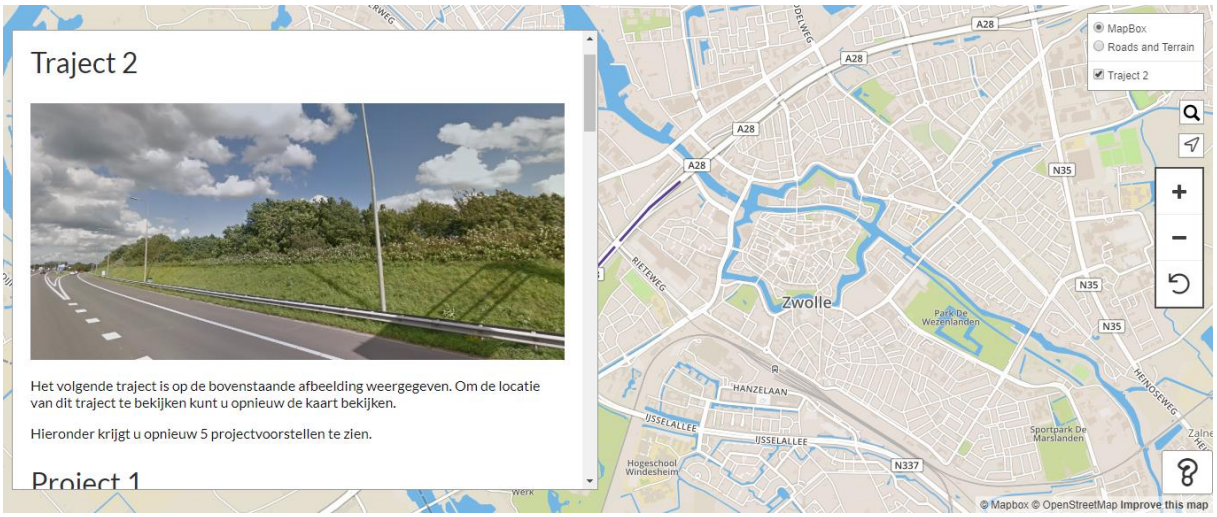

Project 2
Kosten project: € 229.465
Te betalen belasting per jaar: +€ 0,10
Project 3
MapBox
Roads and Terrain
Wijthmen
© Mapbox © OpenStreetMap Improve this map

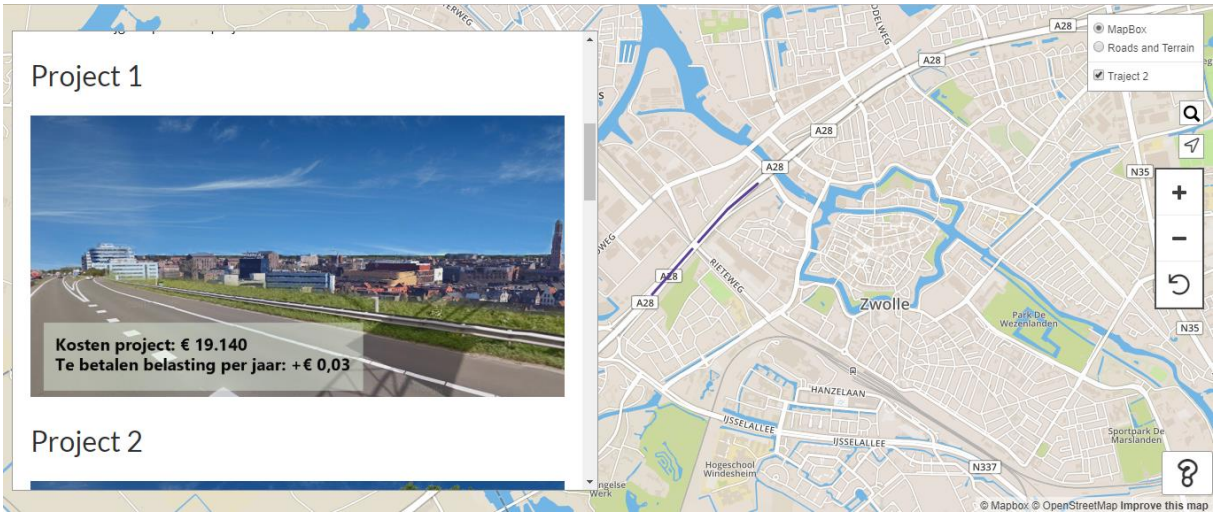

Project 3
Kosten project: € 1.162.500
Te betalen belasting per jaar: +€ 0,49
Project 4
MapBox
Roads and Terrain
Wijthmen
© Mapbox © OpenStreetMap Improve this map

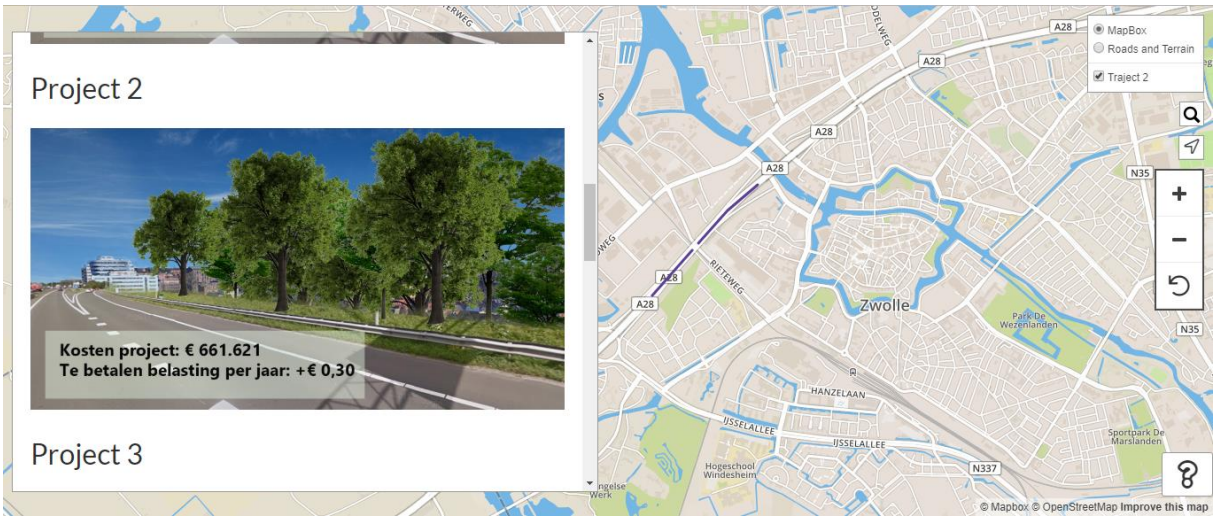

Project 4
Kosten project: € 707.534
Te betalen belasting per jaar: +€ 0,29
Project 5
MapBox
Roads and Terrain
Wijthmen
© Mapbox © OpenStreetMap Improve this map

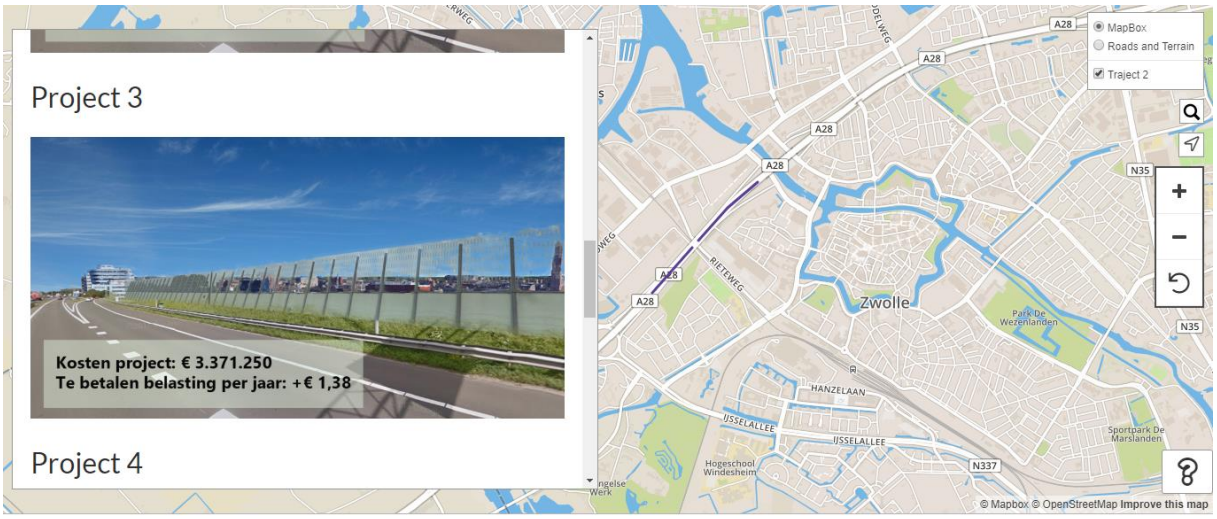

Te betalen belasting per jaar: +€ 0,29
Project 5
Kosten project: € 13.320
Te betalen belasting per jaar: +€ 0,01
1. Welk project heeft uw voorkeur?
MapBox
Roads and Terrain
Zwolle
© Mapbox © OpenStreetMap Improve this map

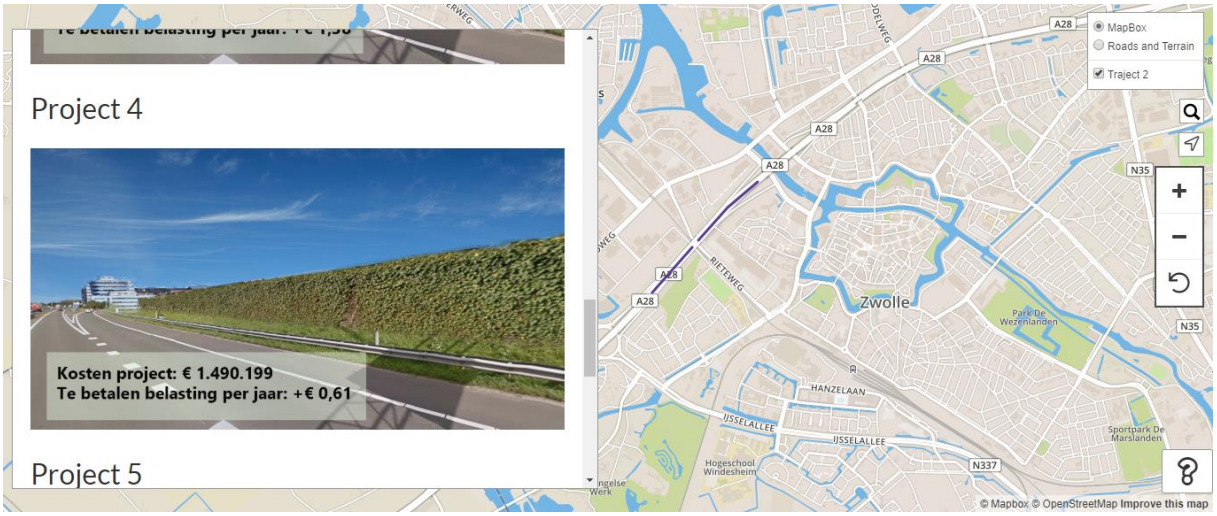

Kosten project: € 13.320
Te betalen belasting per jaar: +€ 0,01
1. Welk project heeft uw voorkeur?
Project 1
Project 2
Project 3
Project 4
Project 5
MapBox
Roads and Terrain
Zwolle
© Mapbox © OpenStreetMap Improve this map

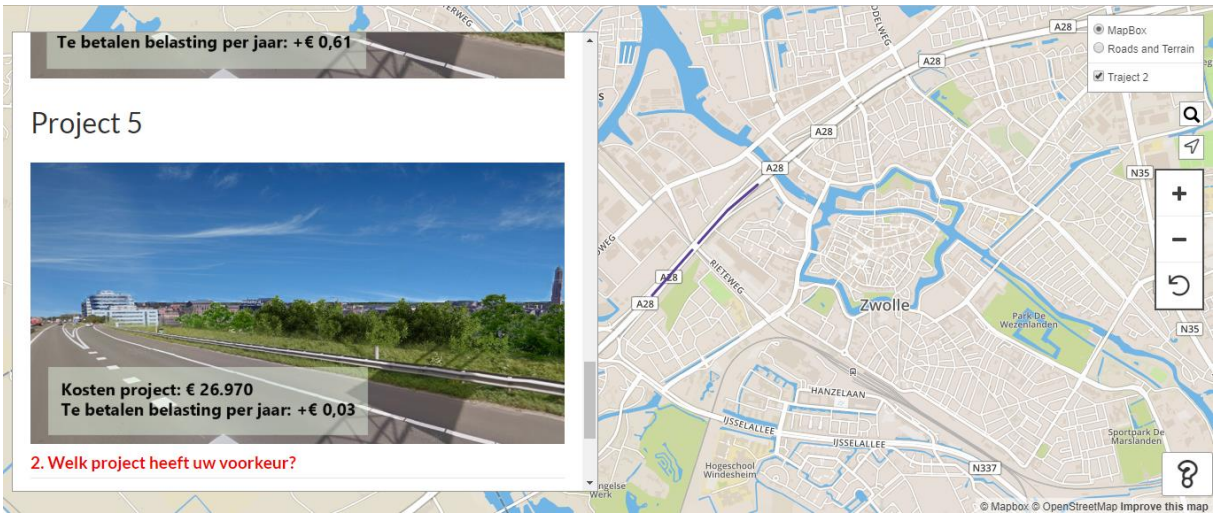

Traject 2
Het volgende traject is op de bovenstaande afbeelding weergegeven. Om de locatie van dit traject te bekijken kunt u opnieuw de kaart bekijken.
Hieronder krijgt u opnieuw 5 projectvoorstellen te zien.
Project 1
MapBox
Roads and Terrain
Traject 2
Zwolle
A28
N35
N337
HANZELAAN
IJSSELALLEE
RIETEWEG
Park De Wezenlanden
Sportpark De Marslanden
Hogeschool Windesheim
© Mapbox © OpenStreetMap Improve this map

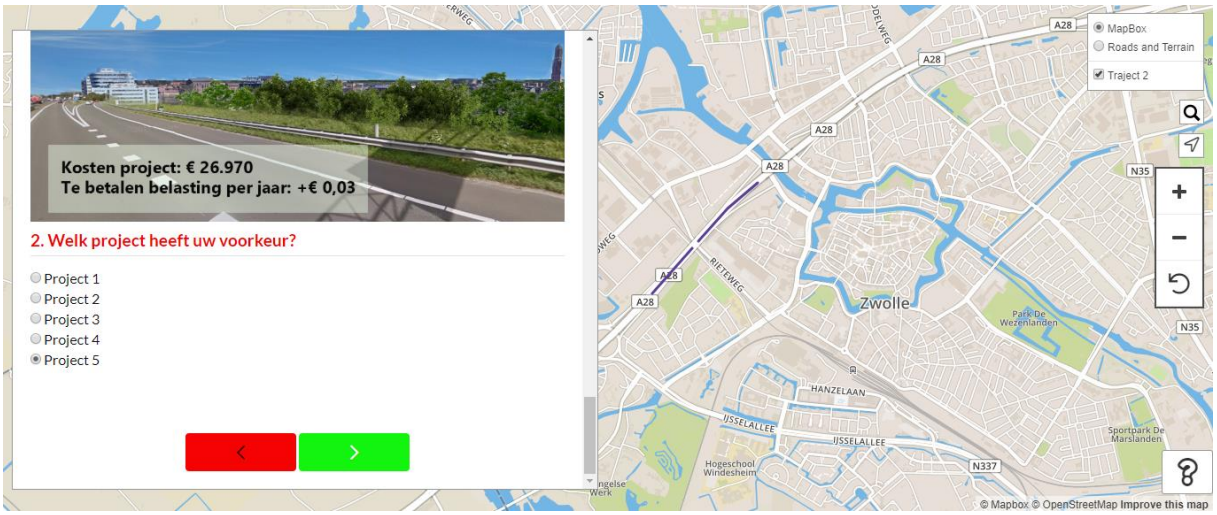

Project 1
Kosten project: € 19.140
Te betalen belasting per jaar: +€ 0,03
Project 2
MapBox
Roads and Terrain
Traject 2
Zwolle
A28
N35
N337
HANZELAAN
IJSSELALLEE
RIETEWEG
Park De Wezenlanden
Sportpark De Marslanden
Hogeschool Windesheim
© Mapbox © OpenStreetMap Improve this map

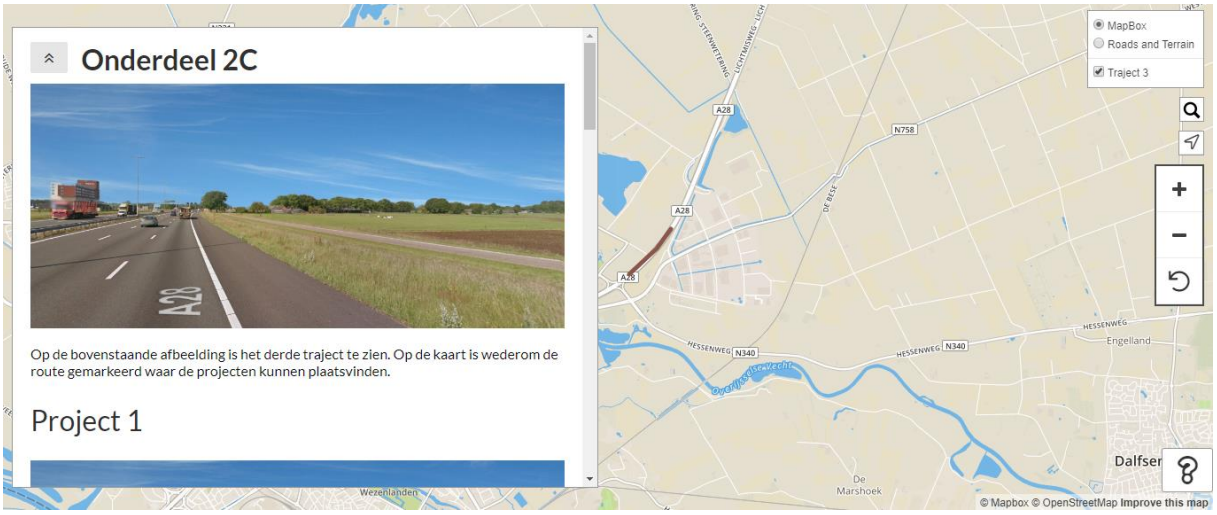

Project 2
Kosten project: € 661.621
Te betalen belasting per jaar: +€ 0,30
Project 3
MapBox
Roads and Terrain
Traject 2
Zwolle
A28
N35
N337
HANZELAAN
IJSSELALLEE
RIETEWEG
Park De Wezenlanden
Sportpark De Marslanden
Hogeschool Windesheim
© Mapbox © OpenStreetMap Improve this map

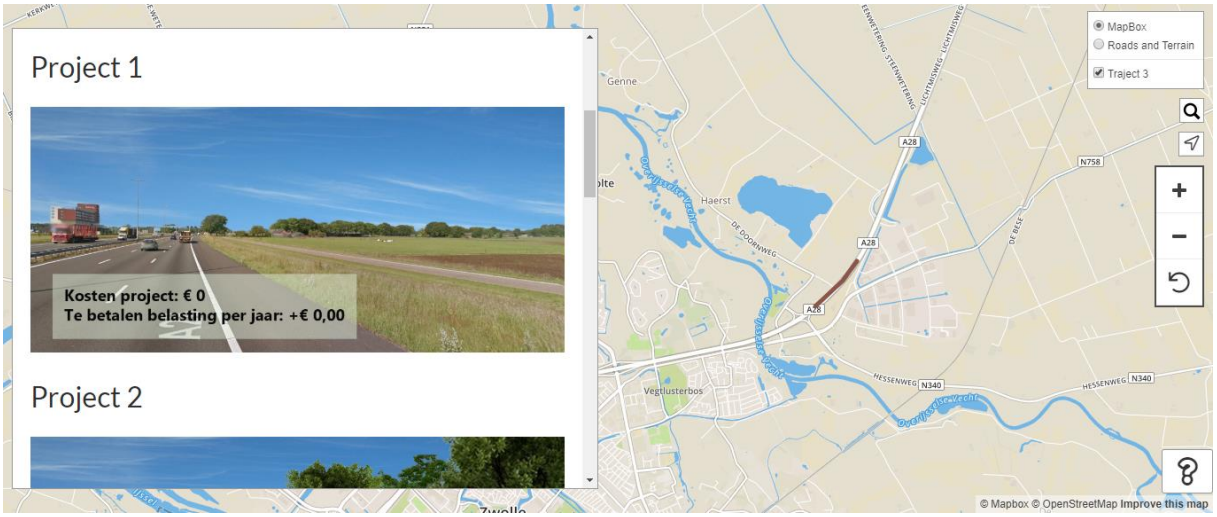

Project 3
Kosten project: € 3.371.250
Te betalen belasting per jaar: +€ 1,38
Project 4
MapBox
Roads and Terrain
Traject 2
Zwolle
A28
N35
N337
HANZELAAN
IJSSELALLEE
RIETEWEG
Hogeschool Windesheim
Sportpark De Marslanden
Park De Wezenlanden
© Mapbox © OpenStreetMap Improve this map

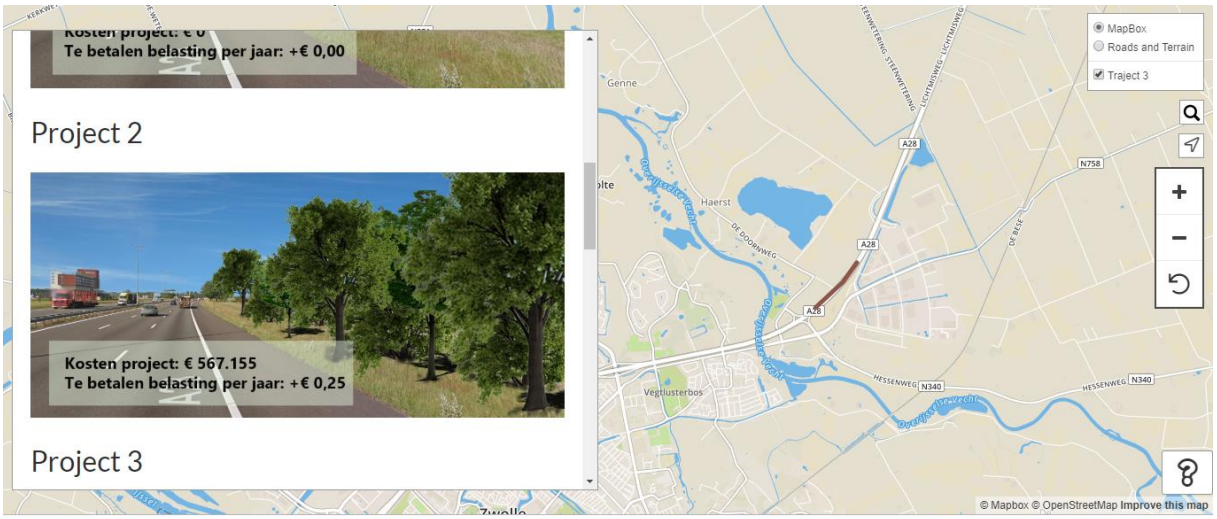

Project 4
Kosten project: € 1.490.199
Te betalen belasting per jaar: +€ 0,61
Project 5
MapBox
Roads and Terrain
Traject 2
Zwolle
A28
N35
N337
HANZELAAN
IJSSELALLEE
RIETEWEG
Hogeschool Windesheim
Sportpark De Marslanden
Park De Wezenlanden
© Mapbox © OpenStreetMap Improve this map

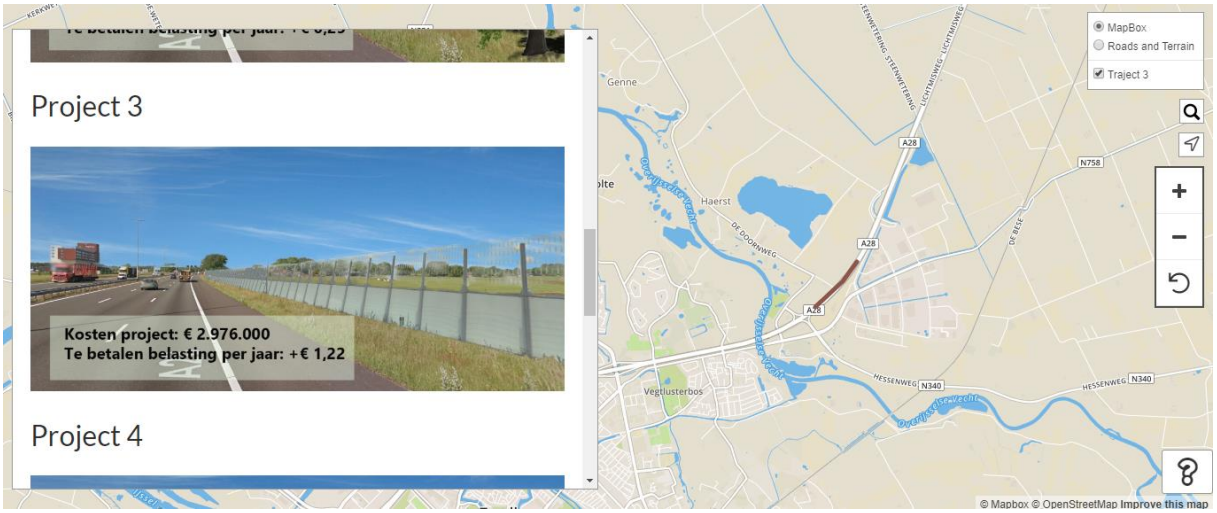

Te betalen belasting per jaar: +€ 0,61
Project 5
Kosten project: € 26.970
Te betalen belasting per jaar: +€ 0,03
2. Welk project heeft uw voorkeur?
MapBox
Roads and Terrain
Traject 2
Zwolle
A28
N35
N337
HANZELAAN
IJSSELALLEE
RIETEWEG
Hogeschool Windesheim
Sportpark De Marslanden
Park De Wezenlanden
© Mapbox © OpenStreetMap Improve this map

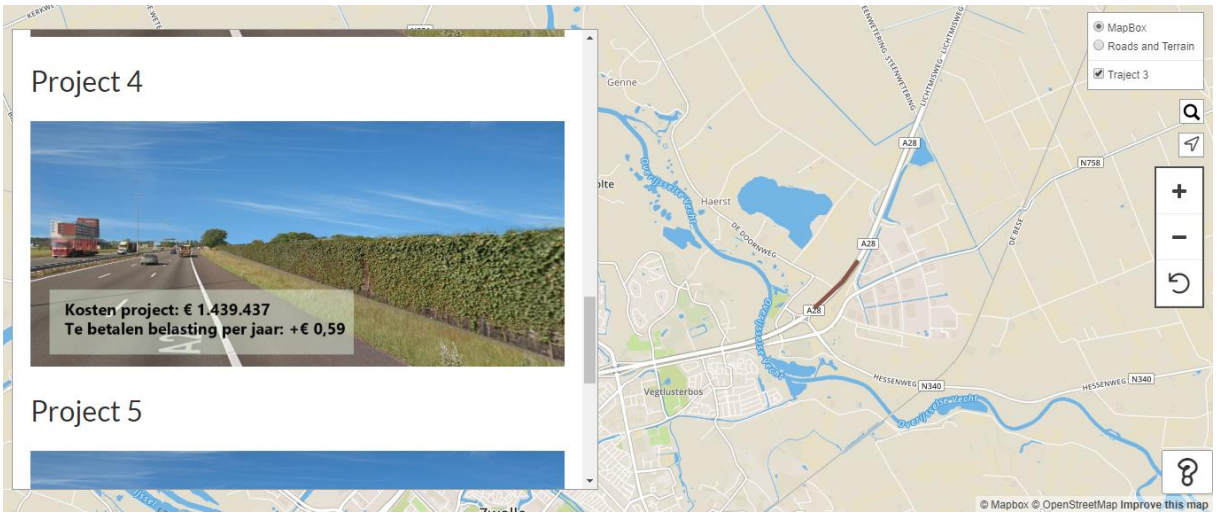

Kosten project: € 26.970
Te betalen belasting per jaar: +€ 0,03
2. Welk project heeft uw voorkeur?
Project 1
Project 2
Project 3
Project 4
Project 5
MapBox
Roads and Terrain
Traject 2
Zwolle
© Mapbox © OpenStreetMap Improve this map

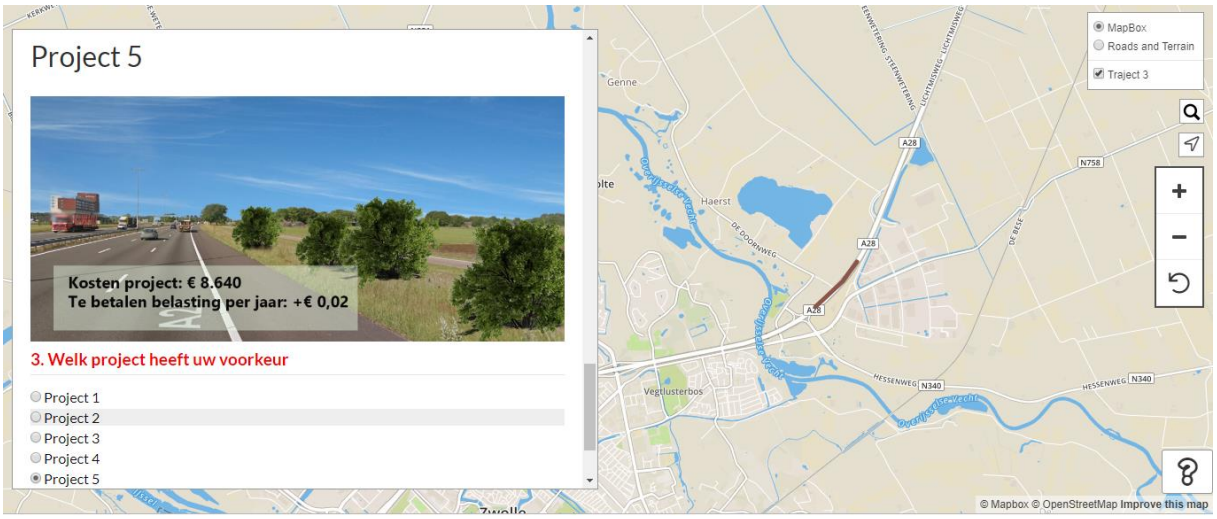

Onderdeel 2C
Op de bovenstaande afbeelding is het derde traject te zien. Op de kaart is wederom de route gemarkeerd waar de projecten kunnen plaatsvinden.
Project 1
MapBox
Roads and Terrain
Traject 3
© Mapbox © OpenStreetMap Improve this map


Project 1
Kosten project: € 0
Te betalen belasting per jaar: +€ 0,00
Project 2
MapBox
Roads and Terrain
Traject 3
© Mapbox © OpenStreetMap Improve this map


Te betalen belasting per jaar: +€ 0,00
Project 2
Kosten project: € 567.155
Te betalen belasting per jaar: +€ 0,25
Project 3
MapBox
Roads and Terrain
Traject 3
© Mapbox © OpenStreetMap Improve this map


Project 3
Kosten project: € 2.976.000
Te betalen belasting per jaar: +€ 1,22
Project 4
MapBox
Roads and Terrain
Traject 3
© Mapbox © OpenStreetMap Improve this map


Project 4
Kosten project: € 1.439.437
Te betalen belasting per jaar: +€ 0,59
Project 5
MapBox
Roads and Terrain
Traject 3
© Mapbox © OpenStreetMap Improve this map



Appendix 2

Calculation of costs and taxes

Two types of costs are involved in the calculation of the additional tax: the construction costs of the new highway barrier and the maintenance costs. The costs of each project alternative are calculated using two data sources. First, the costs of green barriers have been acquired using maintenance reports of greenery of the municipality of Haarlemmerliede (Cite, 2015). In this report, the costs of both constructing different types of green and maintaining different types of green, are summarized. Second, the costs of sound barriers have been acquired using an alternative study report for different types of sound barriers of the municipality of Velsen (2014). Likewise, the report for greenery, this study contains both the cost of constructing and maintaining different types of sound barriers.

Calculating the construction costs

To calculate the construction costs of each project alternative, the costs of construction per meter and the construction costs per square meter have been used. The costs of constructing sound barriers are calculated per meter. The total costs of sound barrier projects are determined by the length of the project location, multiplied by the costs per meter. The total costs of constructing greenery are determined by the costs per square meter. The total length of the chosen project location along the highway times an estimation of the width needed to construct the project alternative determines the total amount of square meters. Lengths and widths are calculated using ArcGis. (ArcGIS is a geographical information system software, which enables to perform spatial analysis.)

Calculating tax

Based on the maintenance report of the municipality of Haarlemmermeer (Cite, 2015), the depreciation time has been determined to be 30 years. All construction costs calculated in the previous section are depreciated over 30 years. After that, annual maintenance costs are added. The maintenance costs are based on the maintenance reports and are calculated per meter for sound barriers and per square meter for greenery. The sum of both the depreciated construction costs and the annual maintenance costs are divided by the total labor force of the city of Zwolle. Data of the labor force in the city of Zwolle is obtained via ‘de buurtmonitor Zwolle’ (Buurtmonitor, 2018).

Note

It is important to note that costs of demolishing are not included in the calculation of costs.

Appendix 3

university of groningen

Beste bewoner van Zwolle,

Voor mijn masterscriptie ben ik op zoek naar respondenten die mijn enquête willen invullen. U krijgt in deze online enquête de unieke kans om uw mening te geven over de A28 door Zwolle en het landschap daadwerkelijk te veranderen. Het is een erg interactieve enquête met veel afbeeldingen, waardoor mensen het invullen vaak leuk vinden. Ook kunt u zich aanmelden om kans te maken op een ***waardebon t.w.v. 30 euro*** bij mediamarkt.

De enquête is via de volgende link te vinden: app.maptionnaire.com/nl/4993/

Voor vragen kunt u mij mailen via s.van.beek.3@student.rug.nl

Bedankt voor uw tijd!
Sven van Beek
MSc Environmental and infrastructure planning, Rijksuniversiteit Groningen

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