Resounding Overbetuwe.

An acoustic gradient in a sustainable transport corridor

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Abstract

Overbetuwe, a region in the Netherlands, functions as a transport corridor. The presence of large-scale infrastructure causes noise nuisance and make the landscape in Overbetuwe unpleasant be in. New functions with noise sensitive facades are planned, while the presence of traffic noise will increase due the A15 expansion of 2x3 ways. Meanwhile the Overbetuwe municipality strives to reach climate neutrality by the year of 2030. The widening of the A15 and the ambition to become climate neutral will affect the landscape experience in Overbetuwe. Both undoubtly mean an increase in the number of sound sources and noise pollution. The challenge here is the implementation of renewable energy technologies in the surroundings of the motorway, but also aims acoustic landscape quality.

Keywords: Landscape architecture, landscape experience, Overbetuwe, traffic noise, soundscape

1. Introduction

In a densely populated country, as the Netherlands, sound is ubiquitous in the landscape. The Dutch soundscape exists out of airports, wind turbines and natural areas. Nevertheless, no sound is as present as the sound of cars passing by with an average speed of 130 kilometres per hour. We produce this sound every day when we travel between home and work. Depending on the direction of the wind, the noise of the motorway is audible in many places. The sound is all around us and is penetrated into our daily lives. Although sound can be perceived both as pleasant and unpleasant, the impact of noise pollution is immense. With the increase of infrastructure, as motor for economic growth, the soundscape of the Netherlands changed drastically. Not only, has it become hard to find silence in our noisy country, but also natural environmental sounds, such as bird songs, are overwhelmed by traffic noise.

1.1. Case study: Overbetuwe

Traffic noise is also dominating the soundscape of Overbetuwe. The region is intersected by three freeways, several highways and two train lines. The most important linear structures are the A15 and the Betuweroute, which transect the region from East to West (figure 1). The A15 connects Rotterdam and Enschede with each other. Parallel to this motorway the Betuweroute is constructed (a freight railway). Both infrastructural networks form an important connection for the distribution of goods and services to Germany.

The large-scale infrastructure thus connects spaces. It creates connectivity and economic development on the national level as well for the region. Nevertheless, the construction of large scale infrastructure also includes negative side effects, such as large-scale developments near the motorway, noise nuisances, pollution and intersections of the landscape without significance for the traditional structures in this landscape.

These negative consequences will increase in the near future, since it is modelled that traffic congestion will occur when the A15 will not be adjusted to the increase of road users (Projectbureau ViA15, 2011). This not only affects transport within the region of Arnhem-Nijmegen, but also the distribution of goods between Randstad[1] and Germany. In order to avoid congestion a new plans are introduced for the A15 trace. The plan connects the A15 with the

1. Randstad includes the Rotterdam harbour. Nevertheless, the distribution of goods will hardly affect the traffic congestion at the A15, since this will be transported by water and rail traffic. This means an increase of traffic noise produced by trucks on motorways, but an increase of noise produced by railways (Betuweroute) (Havenbedrijf Rotterdam, n.d.).

A12 and current connection between Valburg and Ressen will be widened to 2x3 lanes (Projectbureau ViA15, n.d.).

Figure 1. Construction plan A15 (author; Projectbureau ViA15, n.d.b): Current connection between Valburg and Ressen will be widened to 2x3 lanes and the A15 will be connected to A12.

Recently, the municipality of Overbetuwe introduced a new land use by setting the ambition to become climate neutral by 2030 (Berns, Willems, & Berg, 2009; Libercé-Kruit & Uitbeijerse, 2010; Tempelman, Ahoud, Berns, Jaarsma, & Westerdiep, 2010). In other words, the municipality wants to reduce the emission of greenhouse gasses (CO2, etc.) to zero with regard to electricity and gas consumption by households, business and organizations(Berns et al., 2009). Within the research conducted for the author's bachelor thesis both the implementation of renewable energy technologies in the surroundings of the motorway and acoustic landscape quality are taken into account. Nevertheless in the context of this publication this paper focuses on the implementation of an acoustic gradient in the sustainable transport corridor of Overbetuwe.

1.2. Problem statement

The widening of the A15 and the ambition to become climate neutral in 2030 will affect the landscape experience in Overbetuwe. Both undoubtly mean an increase in the number of sound sources and noise pollution. Moreover, is the appearance and spatial organisation of renewable energy technologies in the physical environment hardly taken into considering by landscape architects (Dobbelsteen & Stremke, 2013; Sijmons et al., 2008). It is therefore necessary to study the impact large scale infrastructure, energy transition and the use of different (renewable) energy sources, on landscapes around us.

Dobbelsteen and Stremke (2013) are doing this by postulating that landscape architects should develop sustainable energy landscapes, rather than renewable energy landscapes. Although a lot has already been written on sustainable energy landscapes, and designers are anticipating on the topic, there is a need for a better integration of aesthetics and environmental psychology into the shaping of sustainable energy landscapes (Dobbelsteen & Stremke, 2013). In other words, there should be a focus on the experience of sustainable energy landscapes.

Traditionally, the focus of landscape experience, within the discipline of landscape architecture, was always on scenic quality (Blesser & Salter, 2007; Hedfors, 2003). Especially acoustic landscape experience has been hardly studied so far (Benfield, Belll, Troup, & Soderstrom, 2010; Hedfors, 2003). In case the acoustic environment was taken into account, it mostly was integrated in motorway design for noise reduction. Brown and Muhar (2004), therefore, encourage a more positive approach to sound. Accordance to them landscape design should focus on environments that produce sound that people prefer or consider as desirable. This thesis elaborates on both the knowledge gap and the statement of Brown and Muhar (2004) by studying present and (expected) future sound changes in Overbetuwe.

1.3. Research objective

The research in this paper aims to explore the possibilities of landscape architecture to contribute the development of a sustainable transport corridor, with large scale-infrastructure and renewable energy technologies, which fosters visual and acoustic experience in Overbetuwe. The study focus is on the concept of soundscapes, which exist out of any acoustic landscape experience. Augoyard, Karlsson & Winkler (1999) define soundscapes in more detail as the “totality of sound phenomena that lead to perceptual, aesthetics and representational comprehension of the sonic world” (Hedfors, 2003, p. 25).

Although the receiving of sound is highly personal,Schafer (1997) indicated the existence of a favourable andunfavourable sound, namely *hi-fi* and *lo-fi soundsystem*. Between these systems a contrast between noise and silencecan be indicated.The hi-fi system is processing favourable signals:discrete sounds with a low ambient noise level that can beheard clearly (Schafer, 1997). Soundscapes where hi-fi sounddominates allows listeners to hear noises on distance. In a hi-fisoundscape hearing cannot be closed off at will, neverthelessa receiver is able to hear what he or she is willing to hear. Inother words, people have are able to filter out undesirablesound, while concentrating on what is desirable (Schafer,1997).This is not the case in lo-fi soundscapes, whereunfavourable sounds are produced. Here the amount ofsignals are overcrowded and exist out of loud sounds. Underthese conditions noise so much

acoustic signals are presentthat people get lost in orientation. It causes a soundscape thatis unpleasant to be in. The lo-fi system is therefore closelyrelated to the term *noise pollution*.

Most of the time such loud sounds are unfavourableand perceived as unwanted. Brown and Muhar (2004) madea distinction between wanted and unwanted sound signals.They state that wanted sounds are mainly produced in thenatural and human soundscape, such as church bells, soundsof nature, sounds of city vitality, food steps, sounds of runningwater music etc. (Brown & Muhar, 2004). Unwanted soundsare mostly present in the mechanical soundscape, such asroad traffic, human sounds, amplified music, machinerynoises, etc. (Brown & Muhar, 2004).

Within the study the term *noise pollution* will be used to make a distinction between natural acoustic environment and the disruption of this acoustic environment by mechanical sound (noise pollution). Furthermore, audio audio□visual interactions are taken into account; there is a contradiction between the dominating sounds and the visual appearance of the landscape itself.

2. Acoustic landscape experience in Overbetuwe

Traffic noise is a one of the most dominating sounds in the landscape of Overbetuwe, since the region is intersected by three freeways, several highways and two train lines. The most important linear structures are the A15, A50 and the Betuwe route, which transect the region from East to West (figure 2). Although it is acknowledged that traffic noise has a disruptive effect and can damage the auditory organ (Keulen, 1970; Maschke & Widmann, 2013), it has been not proven that it is perceived as noise pollution or overwhelms natural and human sounds in Overbetuwe yet. In order to do so this chapter identifies the characteristics and acoustic environment of the Overbetuwe landscape in the surroundings of the A15, A50 and the Betuwe route. In addition the chapter identifies the potentials for renewable energy technologies in Overbetuwe in relation to its soundscape.

Figure 2. Topographical map (author): The landscape gradients still dictates current land uses and settlements.

2.1. River landscape

Overbetuwe is part of the river delta of the Rhine. Entering Overbetuwe this river splits up in rivers Nederrijn and Waal (figure 2). Both stream from East to West and formed the landscape of Overbetuwe, which is known for its soils, fruit nurseries and particular landscapes. The appearance of this landscape nowadays finds its origin in the Pleistocene. In that time the region was surrounded by sand hills, push moraines (Dutch: *stuwallen*), that were formed by glaciers in the penultimate glacial period, the Saalien (figure 3) (Jongmans, van den Berg, Sonneveld, Peek, & van den Berg van Saparoera, 2013). In the lower areas, inbetween the push moraines raging rivers, Waal and Nederrijn, flowed freely by constant shifting their beds.

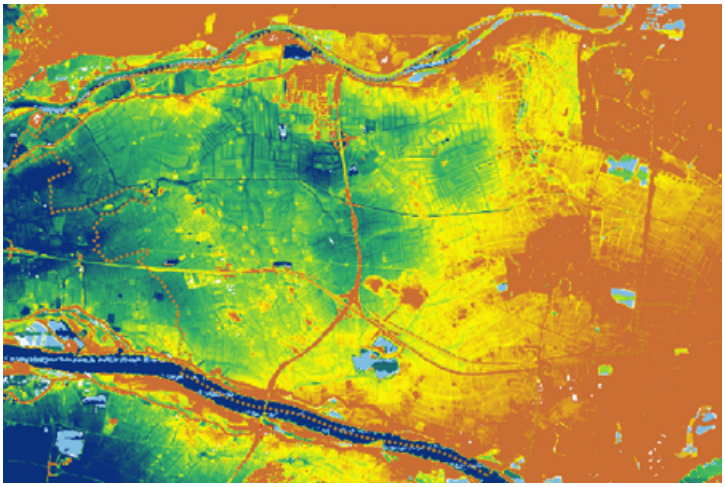

Figure 3. Elevation map (Geodan, 2012): Situation of push moraines (red), natural levees (red-yellow) and river basins (green-blue) in the landscape of Overbetuwe.

2.2. Natural landscape

Such a moving curved riverbed is called a meandering river system. Since the Netherlands is a flat country rivers have the tendency to meander all the time. On the one hand rivers erode in the outer curve due fast flow velocity. On the other hand sedimentation of sand and clay takes place in inner outer curves due slow low flow (Jongmans et al., 2013).

The same principle takes place at high tide when the river overflows its banks. When a river floods, sand and clay particles are transported out of the riverbed and deposited on the river banks as soon through loss of flow velocity (Jongmans et al., 2013). Due the deposition of sand close near the river natural levees (Dutch: *oeverwallen*) are formed. These are sandy depositions that form elongated elevations along (former) beds in the river landscape. Natural levees are covered with hardwood alluvial forest (Dutch: hardhout ooibos), such as Fraxines excelsior, Quercus robur, Quercus palustris, Alnus Glutinosa, Salex Alba (Jongmans et al., 2013). At the lower parts of natural levees alluvial forest is not able to grow due high water levels. Therefore another vegetation type is present there, namely the swamp forest (Dutch: moerasbos).

Behind natural levees, flood basins (Dutch: *kommen*) are formed. Since sand (coarse sediment) is heavier than clay it is deposited very close to the river bank. Clay (fin sediment), in contrast, is light and can be transported over a longer distance before deposition (Jongmans et al., 2013). Flood basins are situated low lying parts or flat areas inbetween natural levees. Flood basins are characterised by high groundwater levels and open landscapes. Within this open landscape some elevation can occur. This are river dunes (Dutch: *rivierduinen* or *donken*), which are formed by wind depositions during the last ice age (Weichselien). In Overbetuwe Valburg and Elmeren are built on these elevations.

As show in figure 3 and figure 4, the landscape of Overbetuwe is characterised by small flood basins. This is the result of the meandering river system whereby a great amount of large flat levees formed by fossil rivers.

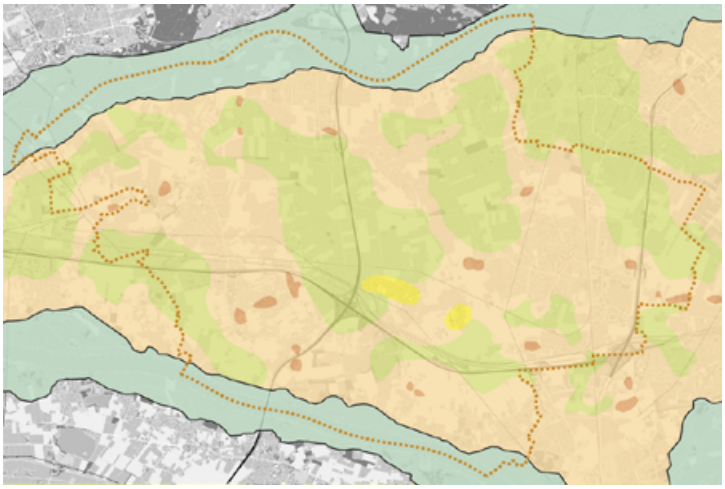

Figure 4.Landscape type map (author): flood plains (blue), natural levees (orange), river basins (green), river dunes (yellow) and historical occupation sites (brown).

2.3. Cultural landscape

The appearance of natural levees and flood basins has dictated the land uses and settlements in Overbetuwe, since people determined their place of establishment on flood hazards. First human settlements (circa 700 before Christ) were located on higher grounds: natural levees and river dunes (Gemeente Overbetuwe, 2010; Haartsen, 2009; Jongmans et al., 2013). Nevertheless, since these the natural levees were not as big as nowadays, the first occupation sites were heighten with organic waste (Dutch: *woerd*) (Jongmans et al., 2013) (figure 4).

From the eighth century, almost all villages, farms, roads and estates in Overbetuwe concentrated on natural levees. Hence, figure 2 in combination with figure 3 and figure 4 show that in Overbetuwe different dominant lines of human settlements can be identified on the natural levees of fossil rivers (Dutch: *stroomrug*). People settle, thus on high areas, since they are dry. Other places, such as Heteren, Driel and Randwijk, are developed in the Roman time at places where roads met (Gemeente Overbetuwe, 2010). Roman settlements were situated on location that were not only high and dry, but also close the river (transport) and suitable soils for agriculture as result of fertile river deposits. Therefore, most of these settlements remained during the Middle Ages.

Since the low-lying lands, flood basins, were not suitable for human settlement they were used as uncultivated land (Dutch: *woeste gronden*). That is, land that only was used in summer for grazing and hay production. In order to reclaim and protect low-lying lands for being flooded dykes (Dutch: *dijken*) were constructed during in the 12th and 13th century (Gemeente Overbetuwe, 2010; Haartsen, 2009; Jongmans et al., 2013). Wild rivers were tamed by long stretched ground bodies along the rivers. Originally the cultivation of land

started form the natural levees, but due the diking of the rivers it was also possible to cultivate the flood basins. Gradually, the land use in Overbetuwe changed with the introduction of fruit orchards (17th century). In the 19th centuries agricultural land, which are close to human settlements, are replaced by tree nurseries (Gemeente Overbetuwe, 2010).

Although the dyke system leads to more security it also changed the drainage system in Overbetuwe. Traditionally water, originated from natural levees, is distributed by ditches (Dutch: *zegen*) to the flood basin. Meanwhile, soil in the river basins were saturated with seepage (Dutch: kwelwater) from the push moraines. The increase of excess rainfall could not be infiltrated in the ground anymore. Therefore, river basins are dewatered by a system ditches (Dutch: *sloten* or *zegen*), which transport water from the natural levees to the Linge; a drainage canal (Dutch: *wetering*). In contrast with the natural part of the canal, the Linge in Overbetuwe is dug around 1250.

The introduction of the dykes did not only change the landscape in the river basins, but also the landscape wedged inbetween the dykes. Different processes have transformed this area into an undulating landscape, which exist out old river beds (Dutch: *geulen* or *strangen*) and deep water bodies that are remained after dyke breaks in the past (Dutch: *kolken*). At the same time the brick industry (figure 5) had a great influence on the appearance of flood plains (Gemeente Overbetuwe, 2010), since they excavate the clay soil for brick production. Since the river still floods every winter, still sediments are deposed on in the flood plains, which cause a micro relief for different grass habitats close near the river. In summer the flood plains are these grasslands are used as meadow land.

Figure 5. Impressions of the natural gradient (author): (a) brick industry in the flood plains by the Nederrijn, (b) estate on a high natural levee by Hemmen, (c) orchards on low natural levee by Slijk-Ewijk and (d) open field in river basins between Andelst and Herveld.

2.4. Current landscape

The natural gradients of flood plains, natural levees and flood basins, still dictate current land uses and settlements. In the Northern part of Overbetuwe this landscape, despite recent changes, still very readable since most occupation still is situated on natural levees. Nevertheless due urban growth of Arnhem, Elst and Nijmegen the rural area in the East of Overbetuwe decreases, while more and more farmers are not economically viable anymore. In the next 10 years, 100 farmers are, therefore, forced to stop their activities within the area of Overbetuwe or switch to crop production in glass houses (Gemeente Overbetuwe, 2010). Another option for farmers is to increase the amount of owned land. Nevertheless, this is not always possible since land in Overbetuwe is not always available or farmers are not able to pay for the land prices.

Both developments, the urban growth and changes in the agricultural sector, have led to settlements and densification in the open water basins. Furthermore, it increases the levelling of natural gradients in the landscape (Haartsen, 2009). Besides these developments, urban growth will also increase the need for outdoor recreational space.

Down south, over the years large scale infrastructure has been introduced, which also affects the clarity of the visual transition from one landscape type to another. First infrastructural line that has been introduced is the rail connection between Arnhem and Nijmegen (1879) (Gemeente Overbetuwe, 2010). Later on the rail line between Arnhem, Tiel and Nijmegen was realised in 1882 (Gemeente Overbetuwe, 2010). More recently constructed are the motorways: A15, A50 and A325 (figure 2).

The A50 is elevated in the landscape and forms therefore a physical and visual barrier. The A15, in contrast, is situated at surface level. It therefore does not forms such a strong visual barrier, but this changed with the introduced of the Betuweroute parallel to the A15 in 2007 (Haartsen, 2009). Both infrastructural transect the region of Overbetuwe form East to West and split up the region of Overbetuwe in a North and a South (Gemeente Overbetuwe, 2010) since by the construction of both infrastructural lines the traditional landscape structures are not taken into account. Most unrecognizable is the traditional water system, which transports water to the Linge. That is since the water system is intersected by the A50. Other factors that suppose that the traditional landscape is not taken into account are the placing of trees and scrubs at traffic junctions and the placing of sound barriers (screens) along both sides of the Betuweroute.

Besides its appearance, the introduction of large scale infrastructure also included other negative side effects, such as large-scale developments near the motorway, limited access and pollution. Off all these negative side effects the introduction of large-scale develop-

ments by exits. By the motorway exits of Andelst, Heteren and Elst, for example are business areas introduced, which just as the large-scale infrastructure not is adjusted to the natural landscape. The business area of Heteren, for instance, is situated in a river basin that used to provide an open view.

2.5. Soundscape

Not mentioned yet is the noise nuisance that is caused by large scale infrastructure in Overbetuwe. In the south of Overbetuwe noise nuisance is most ubiquitous in the landscape, since large scale infrastructure is concentrated here (figure 2). The nuisance concerns the existence of road and rail traffic noise that is produced by motorized vehicles at the A15,A50 and Betuweroute (chapter 1). Figure 6 and figure 7 show the striking character of both sound sources. Road traffic noise seems to have less impact then rail traffic noise, but appearances are deceptive. Though it is true that the sound level (dB) of railroad traffic noise exceeds the volume of road traffic noise the endurance of both sound sources is not indicated in the figures. Since rail traffic noise is not always present in the landscape its impact is big large but short-lived. In contrast, road traffic is ever present. Although its presence fluctuates over time this omnipresence disrupts the perception of natural and human sounds in the landscape. Where a train passing by makes the acoustic environment for a moment unclear while motorways produces a continuous lo-fi sound system. Figures 6 and figure 7 also show that this system is not limited to the surroundings of the motorway or train rail. Instead traffic noise can still be heard at a distance of 2000 meters away from its sound source. The presence of this mechanical sound has accordance theorya major impact on the acoustic landscape experience.

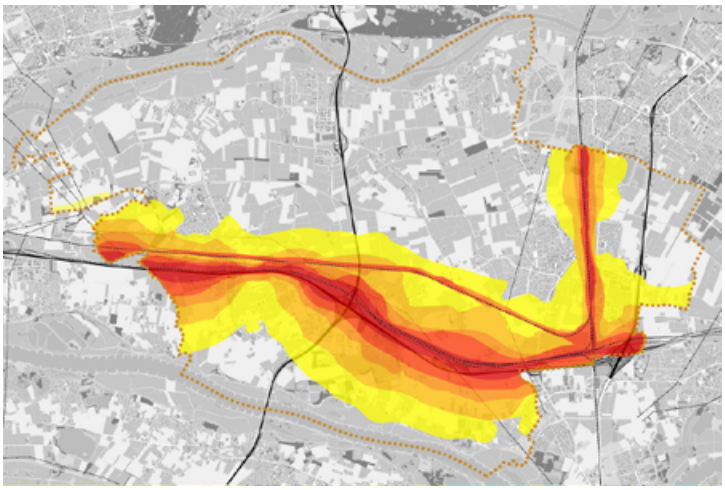

Figure 6. Isobel contour map: railroad traffic (author; Gemeente Overbetuwe, 2007, fig. 17): 45-50 dB (yellow), 50-55 dB (yellow-orange), 55-60 dB (orange), 60-65 dB (orange-red) and >65 dB (red).

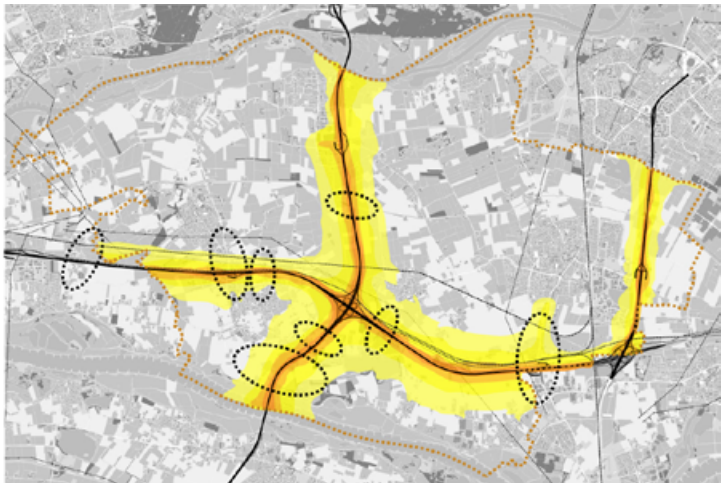

Figure 7. Isobel contour map: road traffic (author; Gemeente Overbetuwe, 2007, fig. 17): 45-50 dB (yellow), 50-55 dB (yellow-orange), 55-60 dB (orange), 60-65 dB (orange-red) and >65 dB (red).

To indicate to what extends the presence of traffic noise in overwhelms the natural and human sounds the soundscape of the south of Overbetuwe has been quantified and measured by an acoustic landscape analysis. This analysis focuses on human and natural sounds that occur in the surroundings of the motorway and the dominance of road traffic noise produced by the A15 and A50 to these sounds. In other words, the acoustic analysis indicates what sound sources are present in the soundscape of Overbetuwe and how their appearance is perceived. Railroad traffic is in the analysis not considered as a sound source, since its presence is accidentally and therefore difficult to measure in time.

Along the A15 and A50 in total 8 strips of 4 measurements have been taken; 2 at both sides of the motorway (figure 7). Since the appearance of sound is influenced by wind direction and the distance from each measurement to the motorway should be approximately equal the selection of measurement points is based on its accessibility. In other words, the measurements are taken at transitions that are transverse to the motorway at about 25-50 and 200-250 meter distance from the motorway. In addition, the measurements are taken between 10:00 am and 16:00 pm, to avoid intensity fluctuations during rush hours. At the moment of measurement there the wind was coming from the southwest with a wind speed of 4 Bft.

At each measurement the intensity of the ambient sound is measured by a Sound Level Meter and notations written down by the author in the field. This data analyses for the sounds is based on the book The soundscape: our sonic environment and the tuning of the world by Schafer (1997)gives an good guide for noting sounds within the field. To ground the impression of the soundscape and minimize the effect of subjectivity sound records and panorama photos are taken. Since it is hard to formulate and represent an exact expression

of a soundscape the measurements are analysed and visualised in (1) Isobel contour maps (2) sound event maps , (3) visual impressions and (4) sound description diagrams.

The Isobel contour and sound event maps show the locations of the four measurement points in one strip, in what direction the visual impressions are taken and where the sound sources are appear. The visual impressions exist out of panorama photos show the (sometimes) present contradiction between the dominating sounds and the visual appearance of the landscape itself. The sound diagram analyses the sound record by the following parameters: (1) duration (time), (2) frequency (acoustic frequency patterns) and (3) intensity (volume).

Duration gives a time indication of the presence of sound, in this case minutes. Thus, it indicates temporal patterns in the soundscape, such as seasonal (winter-spring,-summer-fall) and day-night (dawn-noon-dusk) rhythms (Pijaonwski, Farina, Dumyahn, & Krause, 2011). In addition, frequency indicates the frequency patterns of a sound. So it indicates if a sound is inconsistent or continuous if it is present. Continuous sound is continuously present, while frequent inconsistent sound is contain repetitive patterns of silence and high/low notes. In the sound description diagram a distinction has been made between inconsistent sounds and frequent inconsistent sounds. Inconsistent sounds exist of long repetitive sound patterns, while frequent inconsistent sounds are characterized by a rapid succession of repetitive sound patterns. The intensity indicates the dominance of sounds in the soundscape by using the notation from very loud (ff) to very soft (pp) (Schafer, 1997). In contrast with the Sound Level Meter measurement a notation of sound conducted by the author which indicates the acoustic dominance of a certain sound source.

By comparing the sound diagrams can be made clear that road noise from the motorway always present, as it runs from east to west and from north to south though the region. In addition the amount of sound sources in the area is a limited number. Except from sounds produced by motorized vehicles, only the sound of wind, birds and talking people are identified. These natural and human sounds, apart from wind, are hardly heard because of their low intensity and the inconsistent character. Against the very loud intensity and continuous sound of traffic noise and wind, the sound of birds and talking people is muffled away. Traffic noise and wind are therefore dominating the soundscape The sound measurements contribute to the statement found in literature that mechanical sound dominates acoustic landscape. Nevertheless, the acoustic analyses gained also new insight in the fact that there is hardly any differentiation in sounds in the landscape. The visual impressions of each measurement, state this this birds songs only occur in vegetation zones and wind is always most dominant in open space. At all other places sounds are mostly submerged by traffic noise. The appearance of sounds in the landscape is thus as monotonous as the visual landscape, which mostly exist of agricultural land.

3. Acoustic landscape design challenges and strategy for Overbetuwe

In order to design such sustainable transport corridor it has been argued that landscape architects should participate on the acoustic landscape quality. This quality is determined by sound waves that are produced by natural, human or mechanical sound sources, which all produce their own soundscapes. The appreciation these soundscapes is highly depending on audio-visual interactions and personal preferences. They can be perceived as keynote sound, sound signal and soundmark. Of all these soundscapes the mechanical soundscape is the most polluting one since it produces lo-fi sounds which overwhelm the natural and human soundscape.

The mechanical soundscape is most of the time produced by motorized vehicles. In Overbetuwe the mechanical soundscape is dominated by road traffic noise and rail traffic noise. In order to reduce this noise legislation has been formulated in terms of spatial interventions and risk zones. Most effective spatial interventions against traffic noise are the creation of distance, noise barriers and the use of slopes or sunken infrastructure. The presence of vegetation is less effective as spatial intervention for noise reduction, but also reduces air pollution and has positive impact on the landscape experience of both motorist and residents.

The implementation of renewable energy technologies in the landscape asks for an acoustic strategy. Soundscapes are not accidental by products of today's society; they are produced on purpose by carrying out a particular activity in a given environment. Landscape architectural design plays an important role in allocating actives to places, since a spatial design invites activities and therefore sound (Hedfors, 2003). This can result in places that are associated with life but can also turn in lo-fi environments, such as roadsides of a motorway. Due a vast increase and intensity of lo-fi sound produced by machines in current society the connection with the natural soundscape is disappearing in Overbetuwe. Schafer (1997) states that our soundscape nowadays not only tends to obscure natural sounds, but also creates an inhuman environment.

3.1. Design challenge

Schafer refers with inhuman environments to environments that produce unpleasant sounds; soundscapes where people feel uncomfortable in because they are not able to filter out un-

desirable sound. In other words people prefer clear landscapes, where they can recognize sounds and identify themselves with the landscapes.

In order make a soundscape attractive again design was focused on noise reduction for a long time. Nevertheless landscape architects where designing for the deaf by playing with distance, walls, heights and the texture of pavements. They aimed to make landscape more attractive by noise reduction (Blesser & Salter, 2007; Brown & Muhar, 2004; Schafer, 1997) rather than designing landscapes that are both visually and auditory attractive.

Accordance to Brown and Muhar (2004) a more positive focus on acoustic design is needed in order to create soundscapes that people prefer or consider as desirable environments. The challenge thereby is to deal with the dominant noises in an environment in an existing environment. In other words, a landscape is always inhabited with sound and landscape architect has to design with the many sounds are already present that landscape.

3.2. Soundscapes design

Since sound production is closely related to human activities, the best way of designing is soundscapes is by zoning them (Brown & Muhar, 2004) in terms of land use of the location of facilities (Kersten & Noordhuizen, 2011). Designing in this context means the carefully placing or allowing certain keynotes, sound signals or soundmarks in a certain zone to create clear landscapes. Zoning thus creates diversity within a landscape and gives each zone a unique soundscape. It helps the designer to create a "sub substantial portion of the prominent sounds' progression possessed (...) which could easily be identified" (Hedfors, 2003, p. 37).

In order to make a zone recognizable for people a distinction has to be made between foreground and background sounds. A clear distinction between the two creates a pleasurable soundscape. In order to create a clear acoustic zone the acoustic space of foreground sound must not overlap. Background sounds may overlap, but must not tend to turn the turn into a lo-fi landscape. Another way to produce clear landscapes is to take into account the temporary or lasting nature, rhythm and tempo of foreground and background sounds.

In order to classify the types of sounds and to turn them into sound should be defined as a resource (Hedfors, 2003) of which behaviour can be can be influenced in a certain environment. For influencing of three strategies by spatial design can be identified in literature: (1) sound reduction, (2) sound masking and (3) sound experience.

First, sound reduction includes the prevention of environments form acoustic pollution by the isolation of sound vibrations. This can be done by the placing noise barriers in the form of screens or earthworks or vegetation. Nevertheless, the creation of distance reduces the sound level.

Second, sound masking refers to camouflaging an undesirable sound by a pleasurable sound. In other words, when a undesirable sound is not to loud it can be turned into a background noise by overwhelming it with a pleasurable sound (Brown & Muhar, 2004; Schafer, 1997). Traffic noise, noise for example, can be overwhelmed by the noise of a flowing water stream when this one is loud enough overrule the traffic noise. While reducing the impact of the unfavourable sound, the sounds that give sense of a place are preserved. Accordance to Schafer (1997) the preservation of a soundmark is one of the most important sounds to fight for in a design, since they reflect the character of a place.

Third, sound experience allows unpleasurable sound or other sound signals at certain places to create an attractive and stimulating environment(Brown & Muhar, 2004). In order to do this human and mechanical sound must always grow out to a sublime acoustic experience at a certain location. This can, for instance, be done by creating a platform. Where the first two strategies can cover a whole zone, the third strategy can carefully be placed within a zone to create an unexpected experience.

3.3. Design location

For implementation of the design strategies in Overbetuwe in the surrounding of Overbetuwe is identified where the impact of road and railroad traffic has affects the landscape the most. This is where the sound intensity of the traffic noise is above 48 dB and where noise sensitive facades are located. A comparison of figure 8 indicates that the impact of traffic noise is highest in the south east of Overbetuwe. Although the intensity of sound here is comparable to other surroundings in the transport corridor, most noise sensitive facades are located here. In addition there are new developments are planned in this area along the motorway and plans for the widening the connection between Valburg and Ressen to 2x3 lanes will increase the intensity of traffic noise in this area and will not take into account the gradients in the landscape.

Figure 8. Noise sensitive facade map (author; Kersteren & Snitselaar, 2009a, fig. 13; 2009b; fig. 1): residential area (red), recreation area (yellow), business area (orange). The coloured spots are existing sensitive facades, while the dashed line indicates planned noise sensitive facades.

Focussing on the South of Overbetuwe it becomes clear that the development of urban areas on the regional scale, such as urban growth and changes in the agricultural sector are threatening the readability of the gradient in the south of Overbetuwe. The urban growth on the natural levee by Oosterhout (on the border of Overbetuwe and Nijmegen) threats the quality and readability of the landscape. Current developments indicate already the appearance of glass houses and citizen inherits (Dutch: burgererven) within this area (Gemeente Overbetuwe, 2010). The urban growth will increase the need for recreational area which is planned by the expansion of Strandpark Slijk-Ewijk. That is a place where sand has mined for the development of the Betuweroute, but now is used as recreational pond. Meanwhile the expansion of the motorway creates attractive location for the enlargement and development of business areas.

In order to make the landscape gradient in Overbetuwe clear again the design should contain elements that counter further urbanisation from the Waalsprong. At the same time the natural gradient in the area strengths or even reintroduces.

Currently within the area three landscape types can be indicated: namely flood plains, natural levees and a transition area from the natural levee to the river basin. The landscape types form an gradual transition from a relative small scale landscape along the Waaldijk (natural levee) to an opener and low laying landscape along the A15 (transition from natural levee to river basin).

Recent years, the differences between these landscape types have become less readable, except from the flood plains. These are still very recognizable in the landscape, because of the present of the Waaldijk and the fact the flood plains remained unbuild (flood risk). In

contrast appearance of the natural levee has changed drastically; traditional orchards with high trunks have been replaced by orchards with low trunks, tree nurseries are introduced and reparcelling has taken place. This all resulted in the loss of small scale structures in the landscape such as hedges on the plot slopes (Dutch: houtwallen).

Since the once relatively dense coulisse landscape on the natural levee has become an open landscape, also the transition from natural levee to the river basin has become less clear. Hence, the intensification of agricultural land and the introduction of large scale infrastructure in river basins only strengthened this effect. The intensification of agricultural land introduces more building farms and plantings in the open landscape, while infrastructural lines, including the network of electricity transmission towers, intersect the landscaping structures.

Nevertheless, some relicts of the natural levees and the river basins are still present in the south of Overbetuwe, such as Landgoed Loenen, Huis Oosterhout and De Danenberg. Landgoed Loenen and Huis Oosterhout are real estates, which are located at the east and west site of the area. Both are recognizable due the presence of boscages and tree-lined avenues. Danenberg is a former country seat, which is located on a site that is elevated (Dutch: woerd). In addition there are old village centres, such as Slijk-Ewijk. From a top view the structure of these villages stretches along historical transit roads where (former) farms where located (Dutch: boerenlint or dorpslint) figure 9 and figure 10. Other important structures that are still present are the Waaldijk, Rietgraaf, Oosterhoutse straat, Griftdijk, Eimerensestraat, Reethsestraat and Esterveldsche Zeeg (figure 11).

Figure 9. Topographical map (author).

Figure 10. Landscape type map (author): flood plains (blue), natural levees (orange), river basins (green), river dunes (yellow) and historical occupation sites (brown).

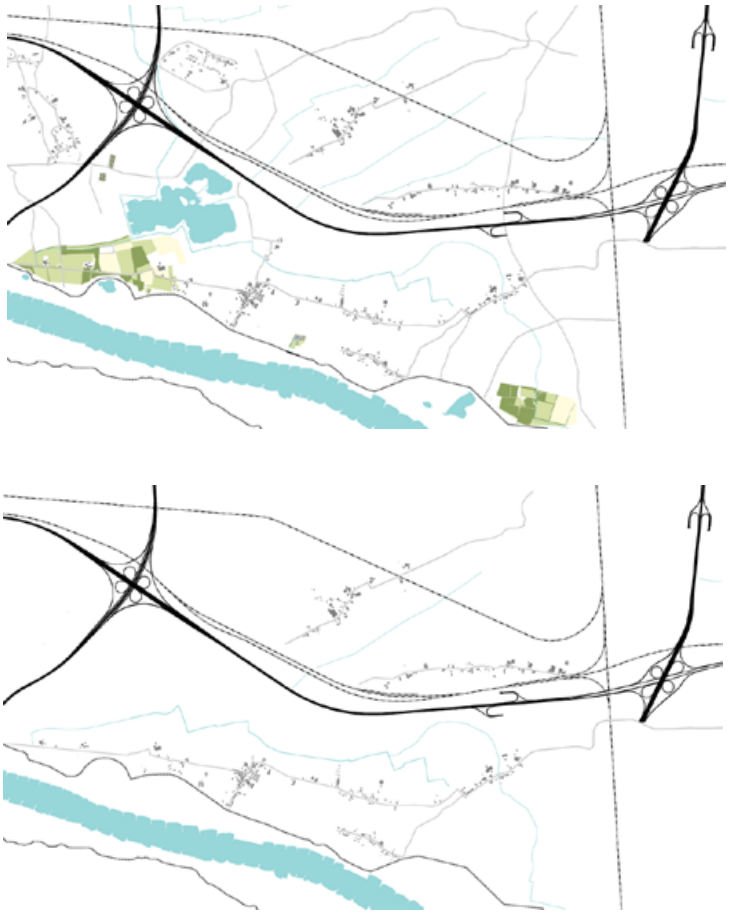

Figure 11. Historical linear structures and elements in Overbetuwe landscape (a) and Dominant linear structures in Overbetuwe landscape (b) (author).

Most important structures were the Waaldijk and Griftdijk. They formed important transit roads while protecting the people for flooding at the same time. In addition the Riet-

graaf is an old river bed, which has been damped and moved during the intensification of agricultural land in Overbetuwe (figure 11). The Estervelsche Zeeg, on the other hand forms a straight ditch that not has been changed of course. The Oosterhoustse straat, Eimerensestraat, Reethstraat and Esterveldsche straat are historic linear structured villages in the area. Of all the Oosterhouste straat was the most important one, since it connected Oosterhout and Slijk-Ewijk.

3.4. Design strategy

As figure 11 these historic structures are still dictate as long lines in the landscape. Two directions can be indicated. First there is the north south direction that follows the transition from the natural levee towards the river basin (figure 11) Second have a dominant east-west direction indicate the different gradients of the high and low natural levees parallel along the river Waal (figure 11). These horizontal lines can form a basis for acoustic zoning design, since each landscape gradient is characterized by different land uses and different sounds.

The first zone that can be identified is situated on the higher part of the natural levee inbetween the Waaldijk and the Oosterhoutse straat (figure 12). This zone is formed by the presence of Landgoed Loenen, De Danenberg and Huis Oosterhout. In this zone sound experience will play an important role.

Second zone is layer on the lower part of the natural levee, enclosed by Oosterhoutsestraat and the Rietgraaf. Most important strategy to include in this zone is sound masking to overwhelm the traffic noise. Nevertheless, further away from the motorway sound experience can play a more important role.

Third zone is formed by the agricultural land inbetween the Eimerensestraat and Reethstraat, which forms the transition area form the natural levee towards the river basin. Just as in the second zone sound masking will play an important role in here.

Although sound masking helps to reduce the impact of acoustic landscape experience, it will not be enough to protect the noise sensitive facades along the motorway. Therefore the strategy of sound reduction will be deployed in surroundings of the motorway.

As figure 12shows the concept of zoning not only provides the opportunity to strength the natural gradient with an acoustic layer but also can gives each zone an unique soundscape. This can be done by the identification of possible sound sources within the area. Since mechanical sound made other natural and human sounds tend to be obscure in the Overbetuwe landscape, the design tends to decrease the acoustic experience of mechanical sounds and increase the occurrence of human and natural sounds in the gradients of Overbetuwe.

Figure 12. Identification of different soundscape (zones) in the landscape of South Overbetuwe (author).

3.4.1. Human soundscape

The location of land use is closely related to human activities (Kersten & Noordhuizen, 2011) and can gives clues about the kind of human sounds occur where and when at a certain place. Places that are inhibited by are most of the places where facilities are present, such as shopping centre or leisure facilities. This are places where people gather together and produce human sounds. At places that are less inhibited human sound is only occasionally present. That is for example the case by agricultural land use. Although human sounds occur in many ways, it impossible to specify them in detail. The differentiations in human sounds are therefore too similar, since they are all related to human voice and body and only noticeable by being on site close to the source. Especially in the acoustic design of Overbetuwe it is not necessary to make a distinction between human sounds, such as speaking, call, singing, laughing or groaning, because it concerns just the presence of human sounds is scarce in general. Only a few spots that are more inhibited by human sounds could be indicated. These sound sources are visualised in figure 13. The recreational area by Strandpark Slijk-Ewijk, for example, forms an important cluster for the production of human sound sources, especially in summer when people gather there for swimming and other leisure activities. In addition human sounds are present in visitor centres and camping grounds and leisure parks. In addition human sounds can also occur in moving condition along recreational pedestrian and cycle routes.

Figure 13. Sound event map: human soundscape (author).

3.4.2. Natural soundscape

The identification of natural sounds in the area of Overbetuwe is less easy to identify. On the one hand it is ever present by climatic conditions such as wind and rainfall, while on the other hand animals' sounds are hard to indicate. They are not standing still, are constantly moving and influenced by the rhythms in nature. Nevertheless, just as humans the living area of animals can be pointed out. By analysing the habitat preference of animals and inventory where they live they can be identified as sound sources on a map. Figure 14 shows where animals' sounds sources are present. The event maps show hints for the allowance of certain natural sounds as keynotes, sound signals or soundmarks in each landscape gradient.

Potential keynote sounds can be formed by mammals that are the hedgehog (Dutch: egel), rabbit (Dutch: konijn), different mouse and marten species (Vries, 2007). Sounds produced by breed birds that are present in the area are characteristic for agricultural landscapes in the Netherlands. The means that the sounds produced by the following species can be indicated as sound signals: Boerenzwaluw, Huiszwaluw, Graspieper, Gele Kwikstaart, Kneu, Huismus, Spotvogel and Patrijs (Vries, 2007). Amphibians can also become sound signals since they are foreground sounds. They amphibians that are present within the area is formed by different frog species (Vries, 2007). Sound marks refer to a beacon sound that mark a certain place in the landscape, is highly recognizable and in contrast with other elements in the landscape. Such sounds can be formed by animals that are endangered or scarcely present in the south of Overbetuwe. These species are the bat (Dutch: vleermuis), Steenuil, Grote bonte specht and the Ransuit, since a bat colony is located in Oosterhout. The Steenuil, Grote bonte specht and Ransuit are endangered species (Vries, 2007), which live in orchards and small scale coulisse landscape at the natural levee in the south of Overbetuwe.

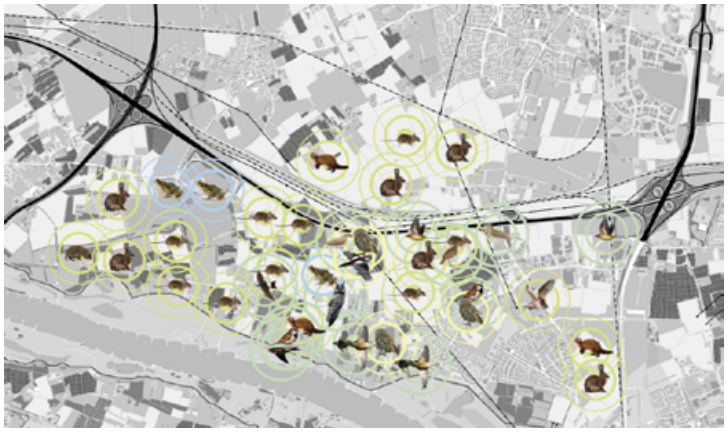

Figure 14. Sound event map: natural soundscape (author).

3.4.3. Mechanical soundscape

In order to let people experience acoustic sounds in Overbetuwe the mechanical sound has to bed reduced. The spatial interventions for doing this are (1) distance, (2) noise barrier, (3) raised or sunken infrastructure and (4) the use of vegetation. Most effective spatial interventions for applications in Overbetuwe are the use of (1) distance, (2) slopes and (3) vegetation. Distance and slopes can help to increase the openness of the transition from the natural levee to the river basin. In addition noise barriers are needed to protect noise sensitive facades along the motorway. Further away from the motorway vegetation can strength the coulisse landscape at the natural levee.

Renewable energy techniques can also be used to strength the acoustic landscape gradient. The presence of solar energy, wind and biomass energy have highest potential in Overbetuwe. In addition the introduction of solar panels has no acoustic impact on the acoustic environment. They can easily be implanted in at places where the landscape experience strategy will be applied. The production of biomass energy introduces vegetation in the landscape that can increase the amount of natural sound in Overbetuwe. Nevertheless it also introduces mechanical sound during harvesting and the generation of heat. Of all these techniques the conventional wind turbine is most unsuitable for implementation in the soundscape, since it produces an unpleasurable sound. Nevertheless, in comparison to rail road traffic noise is limited. Placement of wind turbines can therefore be desired for fuelling mechanical acoustic landscape experience at certain places.

Figure 15. Sound event map: mechanical soundscape (author).

4. Resounding Overbetuwe

The design strategy as suggested in previous chapter proposes a future for the development of a sustainable transport corridor in Overbetuwe. It concerns a research-based-design that challenges the implementation of energy technologies in Overbetuwe, but also aims the acoustic quality in the surroundings of the A15 and Betuweroute.

4.1. Concept

Based on the historical lines of the natural gradient that is present in Overbetuwe, it is argued that the natural gradient can be strengthening with an acoustic layer. In other words, this design aims the reintroduction of the natural gradient, whereby natural energy technologies (solar, wind and biomass energy) are used for the generation of a pleasurable acoustic experience.

The natural gradient will be strengthened by making the transiton form a coulisse landscape at the natural levee to the open field in the river basis clear again. Therefore three zones are identified.

Seen from the river Waal, the first estate zone is identified as natural gradient. In this one two estates and former country seat are present. By expansion of existing boscages and

the introduction of new levelled hedges (Dutch: houtwallen) the small scale returns to the natural level and produces organic waste (punning's).

As second, the orchard zone, which is characteristic for Overbetuwe, is reintroduced in the form of an energy orchard. The orchard provides a pleasurable acoustic experience since its covers a slope where PV panes are situated. In addition the orchard trees form living habitat for different breeding bird species, such as the Steenuil (owl).

Third zone, the open field, covers the transition from the natural level to the river basin. Here energy crops are harvested and can people experience the mechanical sound of a wind turbine.

4.2. Landscape plan

Figure 16and 17 show the implementation of the zoning strategy, as discussed in chapter 3, in the landscape of Overbetuwe. Most important structures in this design are Waaldijk, Oosterhoutse straat and Rietgraaf, since they form the borders between the estate zone, energy orchard zone and field zone.

The energy orchard is most important, since it provides the highest differentiation in acoustic experience and forms a buffer against the urbanization form the Waalsprong. The differentiation in the orchard zone is highest since it is living habitat for different animal species and is surrounded by other zones that produce mechanical and human sounds, such as the recreation pond.

Energy provision is delivered by each zone. Together they produce a total energy amount of 516.9 TJ. Since Overbetuwe has the ambition to be energy neutral, and thus self-sufficient by 2030 the landscape plan provides a design based on closing energy cycles. In other words, energy and water flows are combined in order to match supply and demand as much as possible within the region. As residual kitchen waste (e.g. fruit and vegetables), organic waste and black water streams will be pumped towards the anaerobic digestion installation (Zeeman et al, 2008). At the anaerobic digestion installation, biogas will be produced. The CHP (Combined Heat and Power) will burn the biogas to produce electricity and heat. Heat will be used for the heat distribution network and for direct application at the digestion installation. The still polluted water coming from the digester will be treated with magnesium to recover phosphorus in the form of struvite (Zeeman et al, 2008). Struvite can be used as fertilizer for agricultural practice (Green et al, 1988). The anaerobic digester, ATEZ and CHP, are located in the east of Overbetuwe.

Figure 16. Design strategy (author): Dominant long structured lines form the basis for the implementation of an acoustic gradient in the South of Overbetuwe.

Figure 17. Landscape plan (author).

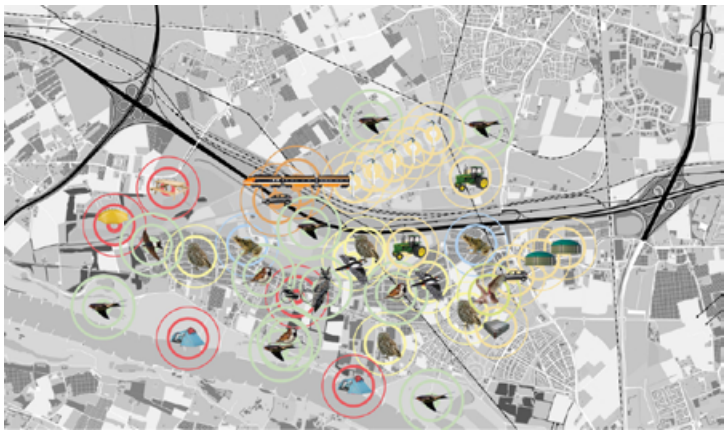

Figure 18. Sound event map: landscape plan (author).

4.3. Site design

The site design and design detail indicate more precisely the strengthening of the landscape gradient in Overbetuwe. Near Danenburg a new coulisse landscape has been introduced (figure 19). Agricultural land has been replaced by a stronger structure of energy orchards and an open field has been realized (figure 21). To deal with noise nuisance of the large scale infrastructure sound barriers and a slope with elephant grass are introduced there were noise sensitive facades or activities are located (figure 20). In conclusion are all the zones connected by a foot/cycle path which stretches from the river plains to Elst. Along this path different sound sources can be experienced.

Figure 19. Current situation and artist impression of the estate zone (author). Keynote sound: Gewone dwergvleermuis.

Figure 20. Current situation and artist impression of the field zone (author). Keynote sound: Boerenzwaluw; keynote sound: wind turbine; sound signal: agricultural motorized vehicles.

Figure 21. Current situation and artist impression of the energy orchard zone (author). Soundmark: Steenuil; sound signal: frog.

5. Discussion

This paper focused on acoustic landscape experience in sustainable energy landscapes and how these could be improved by landscape architectural design. Although most literature is focused on noise pollution by traffic, this thesis tried to encourage a more positive approach to sound. In other words, it aimed to explore how a landscape architectural approach can contribute to pleasurable acoustic experience while taken into account the impact of renewable energy technologies on the acoustic environment. This topic turned out to be relevant for landscape architecture since the traditional focus within the discipline of landscape architecture was on scenic quality and there is need for a better integration of aesthetics and en environmental psychology into the shaping of sustainable energy landscapes. Although the initial idea of this thesis was to show how a landscape architectural design can contribute to pleasurable acoustic experience, it turned out that is impossible since acoustic landscape experience is highly subjective. It depends on personal preference and people's associations with a certain landscape or sound in particular. In addition the time and place also play an important role in acoustic landscape experience.

In order to ground the design interventions of the proposed design in this thesis an acoustic landscape analysis has been conducted. The purpose of this acoustic analysis was not only conduct an impression of the current soundscape, but also to minimize the effect of subjectivity within this paper. By the comparison of sound description diagrams for example could be stated why certain sound sources produce a lo-fi or hi-fi system and why they are more or less preferred by the human ear. Nevertheless, since the observations are still taking by one person and not repeated of time they can still be qualified as subjective.

In an addition the research lacks in a multisensory analysis to capture the whole landscape experience. Although the visual landscape experience is partly taken into account the presents other features, such as smell is necessary to determine the whole landscape experience. Due limitation in time, this paper furthermore does not contain a field analyses of differentiation in soundscapes in gradients. The same applies for the effectiveness of spatial interventions to noise reduction and impact of different renewable energy techniques. All are covered by secondary literature research, but field acoustic analyses should contribute to valuable conclusions about the changes in sounds in place and time. Such numbers would have strengthened the statement and proposed design of this thesis.

Since the design interventions are only based on theory, it is hard to forecast if the proposed design actually contributes to a more pleasurable experience is. More research and acoustic landscape analysis to the performance of executed acoustic designs are needed to determine its effectiveness. Such research should not only exist of intensity measurements, but also value judgement should be taken into account. This can be done by asking the users of the acoustic design to comment on sounds they are. By visualizing these into sound event maps can be indicated which sounds take place where and are less or more preferred by others. Such maps only show hints for acoustic design improvement. By doing so it can be guaranteed that an acoustic design can provide a pleasurable acoustic experience over time.

Despite of the limitations of this research the knowledge gathered in this paper can be valuable for our discipline since the topic of soundscapes has hardly been studied in landscape architecture so far. Let alone that acoustic experience has been associated with the acoustic impact of sustainable energy technology. This paper (and the author's bachelor thesis) can be therefore be interpreted as a first attempt to bring knowledge about acoustic landscape experience in relations to the topics of traffic noise en renewable energy technologies together.

6. Conclusion

This paper started a fascination for soundscapes and aimed to explore the possibilities of landscape architecture to contribute the development of a sustainable transport corridor, with large scale-infrastructure and renewable energy technologies, which fosters visual and acoustic experience in Overbetuwe.

The impact of renewable energy technologies has been taken in account. Since the Netherlands limits hydropower resources and does not lie in a region of great potential for deep geothermal, biomass is one of the leading renewable energy sources. Other leading energy sources are solar, wind and heat–cold storage and a heat exchanger. Of all these techniques the conventional wind turbine is most unsuitable for implementation in the soundscape, since it produces an unpleasurable sound. Most silent are the solar panel and thermal heat exchanger: they are noiseless and can be in the river landscape of Overbetuwe without changing the soundscape. Originally the landscape of Overbetuwe was dynamic landscape with clear landscape gradients of floodplains, natural levees and water basins. Nevertheless, due organic growth and the introduction of large scale infrastructure the landscape in the south of Overbetuwe has become less readable. The presence of large scale infrastructure and business area makes this part over Overbetuwe unattractive as recreation area. In addition the introduction of large scale infrastructure causes noise nuisance in Overbetuwe that overwhelms natural and human sound if they are present. This notation contributes to the statement found in literature that mechanical sound dominates acoustic landscape. Nevertheless, acoustic analyses gained also new insight that there is hardly any differentiation in sounds in the landscape. In addition, its present is closely related to the type of land use and the presence of vegetation in Overbetuwe. This visual and acoustic appearance of the landscape can be more or less attractive with the introduction of renewable energy technologies. Highest local potentials for renewable energy in Overbetuwe are solar, wind and biomass energy and are implemented in the acoustic design of Overbetuwe. The design as proposed in this paper not about quoting landscapes or banning out mechanical sound. Instead it focuses at special places where the opportunity exist to reduce, mask or experience (design strategies) certain sounds in order to increase human enjoyment. Zoning plays an important role by the implementations of these strategies in order to strength the qualities that are already present in a soundscape. For Overbetuwe a zoning has been introduced by following the natural gradient and long historical lines that are present in this landscape. Zoning provides here not only provides the opportunity to strength the natural gradient with

an acoustic layer, but also gives each zone a unique soundscape. Since mechanical sound made other natural and human sounds tend to be obscure in the Overbetuwe landscape, the design tends to decrease the acoustic experience of mechanical sounds and increase the occurrence of human and natural sounds in the gradients of Overbetuwe. The focus hereby is on natural sounds; since it's the appearance of different type animal sounds can easily be created within the different landscape zones. In Overbetuwe the bad and three endangered breeding bird species have the potential to become soundmarks. In addition to mechanical noise can best be reduced by the creation of distance, the use of slopes and vegetation. Mechanical sounds produced by an solar, wind and bioenergy technologies can give an extra dimension to the landscape experience in Overbetuwe since it provide both silence and mechanical experience.

The zoning strategy, as applied in this report has resulted in a landscape architectural design that contributes to the development of a sustainable energy transport corridor by the implementation of renewable energy technologies in the design, which together can largely foresee in the energy provision of 500 TJ. In addition the design is in theory able foster to pleasurable acoustic landscape experience. Nevertheless its effectiveness is highly depending on personal preference and people's associations with a certain landscape or sound in particular. Since a total reduction of traffic noise is impossible it will always be present in the landscape. Nevertheless, the design proposed in this paper has proven that zoning strategies can create differentiation in soundscapes and therefore for a more pleasurable acoustic experience.

In addition to this remark it has to be mentioned that the design proposed as proposed in this paper is based on landscape characteristics and local circumstances of the Overbetuwe landscape. Since this is the case and soundscape differs in time and space, it is impossible to give a one set approach for designing soundscapes in general. Nonetheless, the given framework for the development of an acoustic design can be used as a guide for further research, which is important since (traffic) noise pollution and energy provision are important topics. That we, as landscape architectural designers, should not lose out of sight.

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