Water based

A landscape approach to the Basque flood problem

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MSc Thesis Landscape Architecture
2013

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This publication is written as a final master thesis report landscape architecture by order of the chair-group of landscape architecture at Wageningen University.

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This research was made possible through the funding of Stichting NH Bos

Preface

The coming years, climate change is expected to continue, with shifted weather patterns, and more extreme precipitation events as two of its consequences. We started this thesis out of our fascination for the problems extreme precipitation events can lead to in the rough, mountainous landscape of the Basque Cantabrian Basin. With its precarious weather pattern, rugged character and thin soils on the one hand, and the human impacts on the landscape on the other, we took on a challenging topic. We were curious on what our role as landscape architects could be on such a seemingly technical problem.

For months we have been studying maps, literature, followed lectures and spoke to experts. We have immersed ourselves into the Basque landscape and way of living, observing, analysing and sketching. At times it was a struggle to understand the mountainous system, which is so different from our Dutch flat landscape. With the expertise acquired during out study and the support of experts we gained understanding of the landscape and the overarching problems.

After almost a year of hard work, the end result of our thesis lies in front of you. The purpose of this thesis has never been to come with a blueprint design, but rather to inspire. We believe we have come to interesting insights with respect to the problem and possible solutions. We hope to raise discussion and debate and that this thesis may provide some food for thought.

We were very happy to get the help of the Basque Centre for Climate Change, in the person of Ibon Galarraga, Anil Markandya and Rocío Fernandez, who kindly provided us with relevant literature and contacts within the Úr Agencia, at the start of our thesis. Within the Úr Agencia Christian Stocker has been of great help, providing us with maps and data and listening to our findings. We hope that our thesis can be of value for them in inspiring local people that water is not only a problem but offers many changes and possibilities as well and that something needs to be done.

We could not have written this thesis without the supervision, critics, support and inspiration of Ingrid Duchhart.

The following people have contributed to this thesis by listening to us and providing us with their expertise: Paul Roncken, Bas Pedroli, Roel Dijksma, Pieter Germeraad, Niek Hazendonk and Jeroen Schoorl.

Finally, we would like to thank our fellow students, friends, and family, who were always there to help us.

Wageningen,
October 7, 2013

Hessel Rasch and Teun Schuwer

Summary

The Basque Country is a region in the north of Spain that is known for its strong cultural identity and its shifty weather. The people that inhabited this land have historically been coping with the whims of nature, and adapting their lifestyle to the land. As society changed and pressure on the land increased, problems started to occur in the form of floods. These floods now cause damages each year to the Basque people and the Basque economy. Where natural resources first served development; they later became neglected. The natural water system of the Basque Country has eventually been altered to such an extent that the water itself became a nuisance instead of a valuable force. This divergence of the anthropogenic system from the natural subsystems is the main cause of the problems experienced in the Basque Country.

Research has been done on how a highly responsive landscape such as occur in the Basque Cantabrian Basin can become resilient to extreme precipitation events. This is done on the basis of the landscape approach, and from a landscape architectural point of view. The main focus is on the Urola watershed, which is a representative watershed for the surrounding watersheds in the Basque Cantabrian Basin. It is characterized by its mountainous character, narrow canyons and broad, build up floodplains.
Considering that resilience is not only in creating an adaptive and sustainable water system, but also in 'cultural sustainability', a broader view on the term resilience and the problem can be developed. Linking the water system with the everyday life and landscape of people will give meaning to the system in peoples their lifes, which is referred to as cultural sustainability. To create an adaptive water system, an approach on the level of the watershed is necessary, as is the use of nature its generative and adaptive processes as foundation.

A strategy with management on the watershed level and interventions on the local level is proposed. The local interventions are linked to everyday activities and local land use functions, which ensures that a water system is created that is embedded in the landscape and the everyday life of people. Linking the water system with functions in the everyday life can help people realizing that the extreme precipitation is not only a nuisance, but is a valuable resource as well.

The local interventions together form a strategy on the watershed level, based upon the idea that water that precipitates at one place should be retained in that place, so that the upper reaches of the watershed do not confront the lower parts of the watershed with a large surplus in river water. A change is proposed from a decentralized water management focussed on getting rid of the water as fast as possible, to water management on the watershed level, with the focus on improved infiltration and retention capacity and reduced run-off.

An insight in a broad (landscape) approach towards flood problems and the positive side effects that can be attained are provided. Following from this, it can be debated whether solely adapting our system is enough to create resilience. An explicit role for cultural sustainability in issues on climate change is advocated, furthermore it is pledged that a resilient landscape can be reached by creating an adaptive system that has an important role in people their everyday lifes and landscape.

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Part 1 Fascination

Rain. You cannot visit the Basque Country without noticing the precarious weather. The Basque people are used to it. This part forms the introduction a thesis about flood problems caused by extreme precipitation events in the Basque Country. The problem and aim are stated and the research area is introduced.

01 Introduction

Floods and the need for a sustainable future

The Basque country is a region in the north of Spain that is known for its strong cultural identity and its shifty weather. The people that inhabited this land have historically been coping with the whims of nature, and adapting their lifestyle to the land. The large amounts of rainfall have provided for a lush green landscape, but are also a source of problems. As society changed and pressure on the land increased, these problems started to occur in the form of floods. These floods now cause major damages each year to the Basque people and the Basque economy.

The Basque Cantabrian Basin has an average annual rainfall of around 1700mm, with most of this precipitation appearing in late summer and early fall. (García Codrón, J.C., Rasilla Ál Varez, D., Garmendia Pedraja, 2009). Originally, gentle showers and thick mists characterized the precipitation pattern in the area, but since a few decades more and more extreme precipitation events started to occur. This is something that cannot yet officially be confirmed by the Úr Agencia, since the available historical data about precipitation is not suitable for this. Most of the experts and local people however agree that the precipitation pattern has changed and that more extreme precipitation events occur (Stocker, 2013).

These observations are consistent with results from climate studies. According to the climate models of the Intergovernmental Panel on Climate Change (IPCC) there are changes in precipitation pattern all over the world. This leads to longer dry periods and more extreme precipitation events. (Christensen, J.H., B. Hewitson et al., 2007) Future scenarios predict an increase in the intensity and propensity of rain in the Basque Country. (Eraso, N. O., Gallastegui, M. C., Agirre, 2009; Galarraga, Osés, Markandya, Chiabai, & Khatun, 2011) According to Eraso et al. the probability of an extreme event happening in the Basque Cantabria Basin will double. Although there are a lot of uncertainties and differences in the predicted increase per study, the general consensus is that the occurrence of extreme precipitation events will increase in the Basque Cantabrian Basin.

Problem statement

The Basque country is very sensitive to changing weather patterns. Changes in the occurrence and intensity of precipitation events can be immediately noticed. This is due to the characteristics of the landscape, which features steep hills, thin soils and narrow valleys, but also to the way the inhabitants have occupied the land. As technical capabilities have progressed and an industrialized society developed, human dependence of nature and natural processes has declined and the demand for land has increased.

Where natural resources first served development; they later became neglected, which is a general trend in many parts of the developed world (Thayer Jr., 2003). The natural water system of the Basque Country has eventually been altered to such an extent that the water itself became a nuisance instead of a valuable force. Because ownership and political boundaries determine how the land is managed, and not its natural subsystems (Thayer Jr., 2003), water-related problems are addressed individually, which often results in a shift of the water issue to other locations. This ultimately results in high discharge peaks to the floodplains along the Basque rivers, where the majority of human activities take place.

This divergence of the anthropogenic system from the natural subsystems is the main cause of the problems experienced in the Basque Country.

Aim

The aim of this research is to make a sensitive landscape like the Basque Country more resilient to climate change by providing interventions and principles that address the underlying causes of the observed problems.

Knowledge gap

A lot of research has been done on preventing floods and sustainable flood management. Most of these researches focus on the mitigation of spatial problems, rather than considering the interaction between humans and the landscape and environment to be crucial factor. In this research the combination is sought between adapting the water system and management to climate change and strengthening the interaction between humans and the landscape and water system. The landscape approach can play an important role in strengthening the interaction between humans and their environment, which is an important part of a resilient landscape.

02 The Basque Country

A land of contrasts

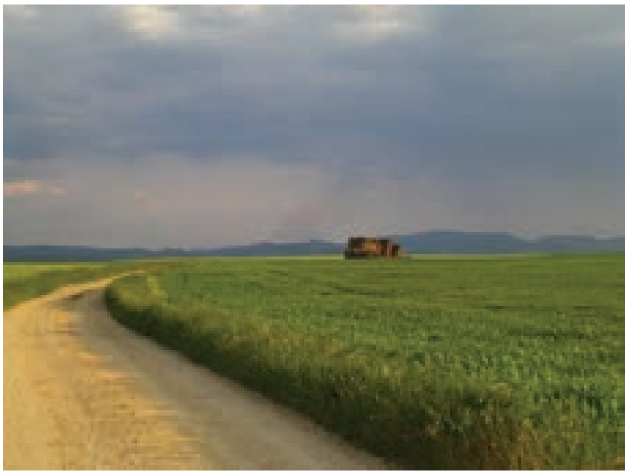
[2.1] **The Basque Country in Spain**

Apart from our inquisitiveness towards the precipitation events and water system, we find our fascination in the geomorphology of the Basque Cantabrian Basin and the stark contrasts that can be found in this mountainous landscape. On the one hand the overpowering and greatness of the bare mountain peaks and coastal cliffs, which in its turn has a very refined structure of layers. On the other hand there is a small scale and subtle landscape with rippling streams, fords and small plots of meadow, cropland and orchards.This landscape of overwhelming and subtle scenes pre-eminently asks for a very refined approach when it comes to intervening and designing. It is this landscape that forms the fascination and basis for this thesis.

The formation of the a-biotic and biotic Basque landscape

The Basque Country consists of a varied and interesting landscape. Geology has had a strong influence on the geomorphology of the current landscape of the Basque country. Geological processes have created a remarkable distinction between the southern part of the area, part Ebro Basin, and the northern part, the Basque Cantabrian Basin (Pujalte, n.d.), which is the focus area of this thesis. When driving the highway north to south one can hardly miss this distinction in geomorphology of the landscape, it is even strengthened by the occurrence of the tunnel one drives through. [2.2 & 2.3]

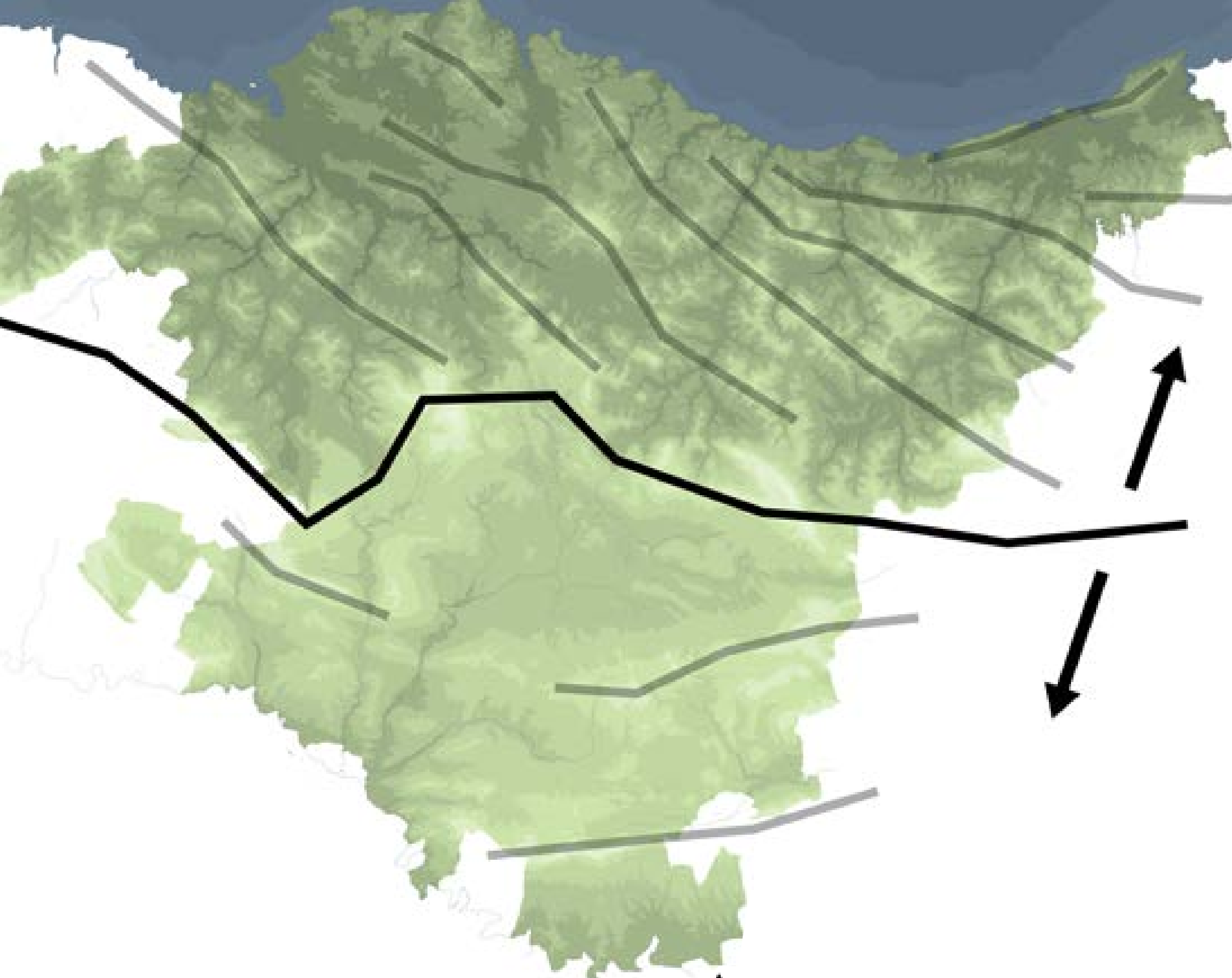
The landscape in the Basque Cantabrian Basin is characterized by lots of river valleys (also called Atlantic Valleys (Iriarte, 2003)) with steep and rolling hills. It is a landscape with a variety of green colors and stone and earth colors. Narrow canyons and broader floodplains alternate. On the south side of the tunnel, which leads through a high mountain ridge, the landscape is far more flat.



[2.2] The Ebro Basin's flat character

[2.3] The accidented character of the Basque Cantabrian Basin

[2.4] The layered subsoil is exposed in the coastal cliffs; only covered with a thin layer of soil



[2.5] **The ridge divides the two basins**

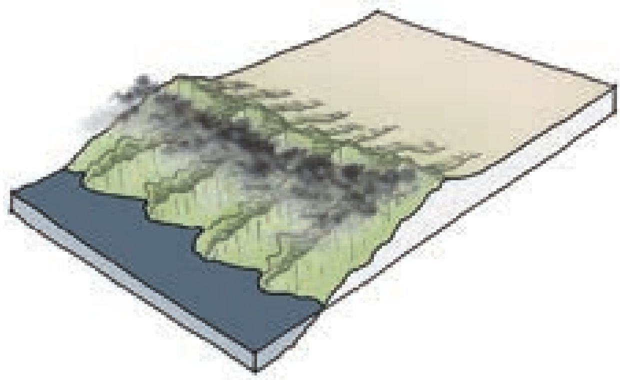
The high mountain ridge is the key in this strong distinction of geomorphology. During the Paleocene era, from 66 until 56 million years ago, the tectonic processes of the Pyrenean orogeny caused the landscape to invert (Gómez, 2002). With the inverting of the landscape several horizontal layers of the subsoil were pushed up and down, which resulted in the occurrence of vertical and diagonal layers of different types of subsoil in the Basque Cantabrian Basin (Gómez, 2002). The occurrence of these diagonal directed layers can be seen along the coast, on the mountain tops and on bare parts of the hill sides [2.4].

Eventually, this mountain ridge has divided the flow of water [2.5]. On the north of the ridge, the water flows north into the Atlantic Ocean, while south of the ridge the water flows south from the ridge and continues in the river Ebro that flows, more or less, parallel to the ridge. The ridge also creates a strong division in the climate and the amount of rainfall: the Basque Cantabrian basin is an area with a large amount of precipitation, whereas the area south of the ridge is a lot dryer. This has everything to do with the east-west orientation of the mountain ridge. Because of its east west direction, this mountain ridge acts as a barrier, tempering the influence of the Cantabrian Sea on the climate south of the ridge and increasing the amount of rainfall north of it (Gipuzkoako Batzar Nagusiak, 2006; Iriarte, 2003) [2.6]. As a result of the diagonal directed layers and the relief of the landscape, the soils on the steep hillsides are really thin.

The landscape its response to changing precipitation patterns

The natural system and the landscape reacts to changing precipitation patterns in a certain way. As has been explained above, the area consists mainly of very young and thin soils, and in some parts the soil is even absent. These thin soils have a very low infiltration capacity, which means that they saturate very fast. The parts without a soil that consist of bare rock are often impermeable and the infiltration here is close to zero (Boonstra, 1994). In cases of extreme precipitation the soil will be saturated after a short period of time and as a consequence most of the precipitation does not infiltrate, but runs off over land. This run off over land can lead to erosion gullies on parts of the hills where water accumulates. [2.7].

During an annual extreme precipitation event up to 60 mm of rain can fall in just one day, whereas for events occurring every 10 years about 150mm can fall in a day. Because of the low infiltration capacity and the large amount of run off over land, a lot of the precipitation reaches the main river very fast. In a natural situation the main river overflows its regular channel, flooding parts of its floodplains when it is fed with a certain amount of precipitation.



[2.6] The mountain ridge prevents rain clouds from going further inland

[2.7] Small erosion gullies

[2.8] **Paintings found in a cave**

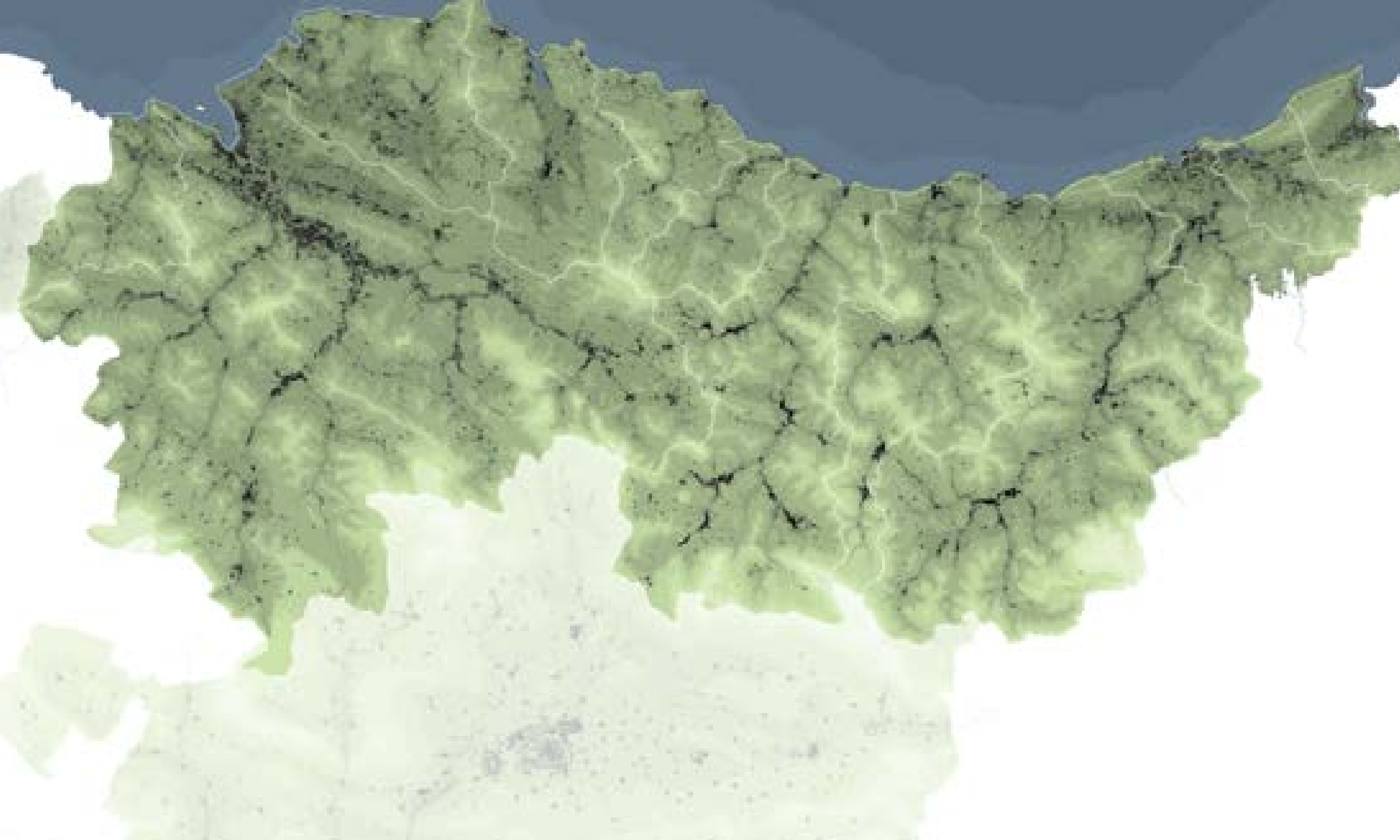
The human occupation of the landscape

The flooding of the floodplains by the river is restrained by the presence of buildings. Practically all the space on the floodplains has been built up with dwellings (mainly apartment buildings) and industry [2.11].

The occurrence of humans in the landscape has been strongly restricted by the physical conditions of the landscape for a long time. These physical conditions necessitated people to live in caves for a long time and restricted the formation of proper villages. (Gipuzkoako Batzar Nagusiak, 2006) [2.8] Only since the Mesolithic, from 9000 to 4000 B.C., people abandoned their caves to settle in the river valleys and floodplains. (Gipuzkoako Batzar Nagusiak, 2006) These were the most logic places to build a village around that time, since its geomorphology offers the most flat building sites. Furthermore, the river offered a solid base for (trade-) routes, although the rivers itself are often not navigable, but the river banks offer flat tracks that one can easily walk along. In the decades and centuries that followed, the villages and cities expanded. During the middle ages, most villages and cities would be under the influence of the Feudal Kingdom of Castillia and as a consequence of that they would become walled towns. (AindoaingoUdala, 2013; Azkoitikoudala.info, n.d.; AzpeitikoUdala, 2013; ElgoibarkoUdala, 2013; TolosakoUdala, 2013) During the sixteenth century industry would become an important economic incentive and it caused the further expansion of cities and settlements. The main industry would be the iron industry, run by small factories (watermills) along the river, the so called Ferrerias. The watersheds of the Basin would be full with watermills that were used for this industry ((Arkeolan, n.d.)). The raw materials for the iron and steel industry would be shipped in via the ocean harbours, such as Deba. After elaboration in the Ferrerias it would be transported inland towards Castillia. This century is referred to as the golden age for the area. (Azkoitikoudala.info, n.d.; AzpeitikoUdala, 2013; ElgoibarkoUdala, 2013; Solsten, E., Meditz, 1988; TolosakoUdala, 2013)
In the 18th century, with the coming of the industrial revolution, the cities would expand further with a thriving textile industry, whereas the traditional ferrerias became inoperable, causing the entrance of more heavy industrial iron factories. Another industry that made its entrance was the textile industry. (AindoaingoUdala, 2013; Azkoitikoudala.info, n.d.; AzpeitikoUdala, 2013; ElgoibarkoUdala, 2013; Gipuzkoako Batzar Nagusiak, 2006; Solsten, E., Meditz, 1988; TolosakoUdala, 2013) The introduction of these industries would cause the villages to expand, but smaller settlements that were thriving on their watermill tend to remain stable in size.

With the coming of the 20th century the industry would expand even further, especially in the sector of the industrial steel and ship industry. [2.9] (AindoaingoUdala, 2013; Azkoitikoudala.info, n.d.; AzpeitikoUdala, 2013; ElgoibarkoUdala, 2013; Solsten, E., Meditz, 1988; TolosakoUdala, 2013) With the rapid technological progress humans became

[2.9] **Industry on the river's floodplain**



[2.10] **Highway through the mountains**

[2.11] **Most build up areas are located along the rivers**

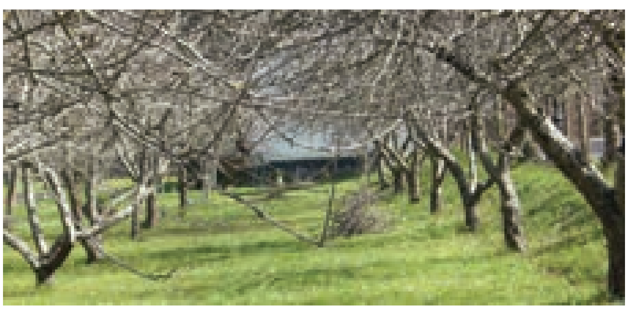
less and less restricted in the construction of roads and building by the a-biotic characteristics of the landscape. This development caused the human occupation pattern to become more dominant towards the natural system and patterns. [2.10, 2.12]

Outside of the cities, most of the land is covered in forest, and nowadays mostly used for agroforestry. Only the more gentle slopes and flat plains along the rivers are cultivated by humans. The agricultural system of the area has always been very traditional and small scale, with lots of mixed functions (Gipuzkoako Batzar Nagusiak, 2006) .

[2.12] **The mountain makes way for flat building grounds**

[2.13] **Basseri**

[2.14] **Cropland with farmhouse in the back**



[2.15] **Orchard**

[2.16] **Farmer with his sheep**

The typical Basseri (farm) consists of the farmhouse with integrated stable surrounded by a small orchard and some small croplands and pasture land [2.13 - 2.17]. Even nowadays, most of the farmers do not have agriculture as a main source of income. Due to the poor soil conditions and accidented landscape, farmers have limited possibilities to intensify their activities. The farms are small, between 5 and 30 ha maximum, and the plots are also of small scale, causing a typical mosaic of parcels. ((Ruiz, R., Mandaluniz, N., Albizu, I., Oregui, 1998)) There is a very small scale system of food production, but also of food networks, with farmers selling their products to local people on the markets in the villages. Many people living in the villages have their own allotment garden in or around the village. The people in the Basque Cantabrian Basin are in that sense closely related to the landscape they live in.

[2.17] **Farmer harvesting fruit from the trees** >

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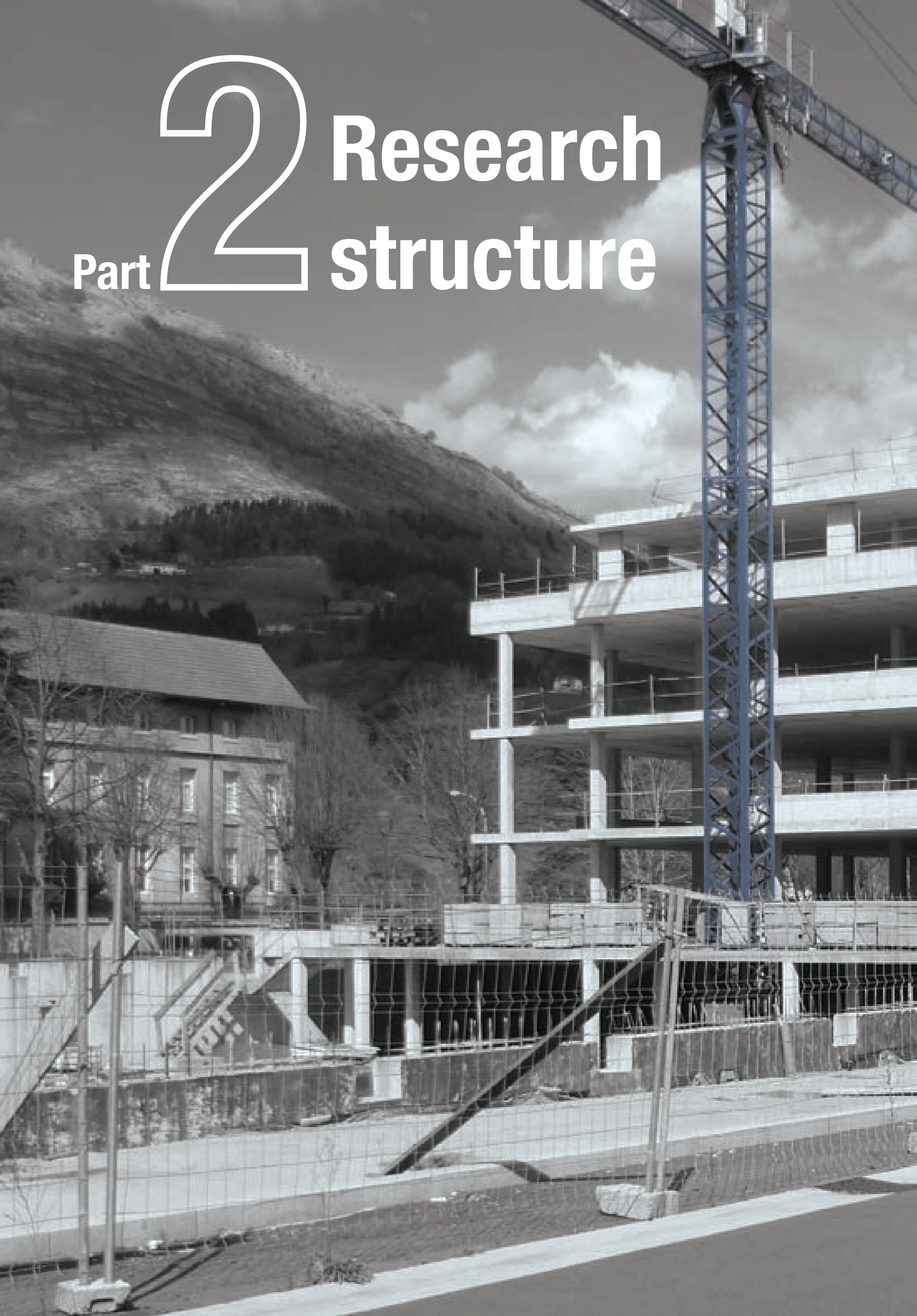
Illustrations

2.2 Photo by Cembraniyo; http://www.panoramio.com/photo/72673800 [Accessed: 15-07-2013]
2.8 http://www.gipuzkoakomuseoak.net/museos/actividades/actividad.php?id=eu&Nactivid=1263542240&Nmuseo=1259065407 [Accessed: 15-07-2013]
2.10 http://static.panoramio.com/photos/original/12524358.jpg [Accessed: 6-10-2013]

Part 2 Research structure



This part elaborates the structure of this research. It shows how this research is built up, which methods that are used and it outlines the scope and main questions. In the last chapter theories are explored to frame the research.

03 Scope of this thesis

The scope and lens of the research

As two students in landscape architecture at Wageningen University, it is fairly logic that this thesis is written from a landscape architectural point of view. Though, the definition of this landscape architectural lens is yet quite broad and how we see this lens is of influence on the design and process of this thesis.

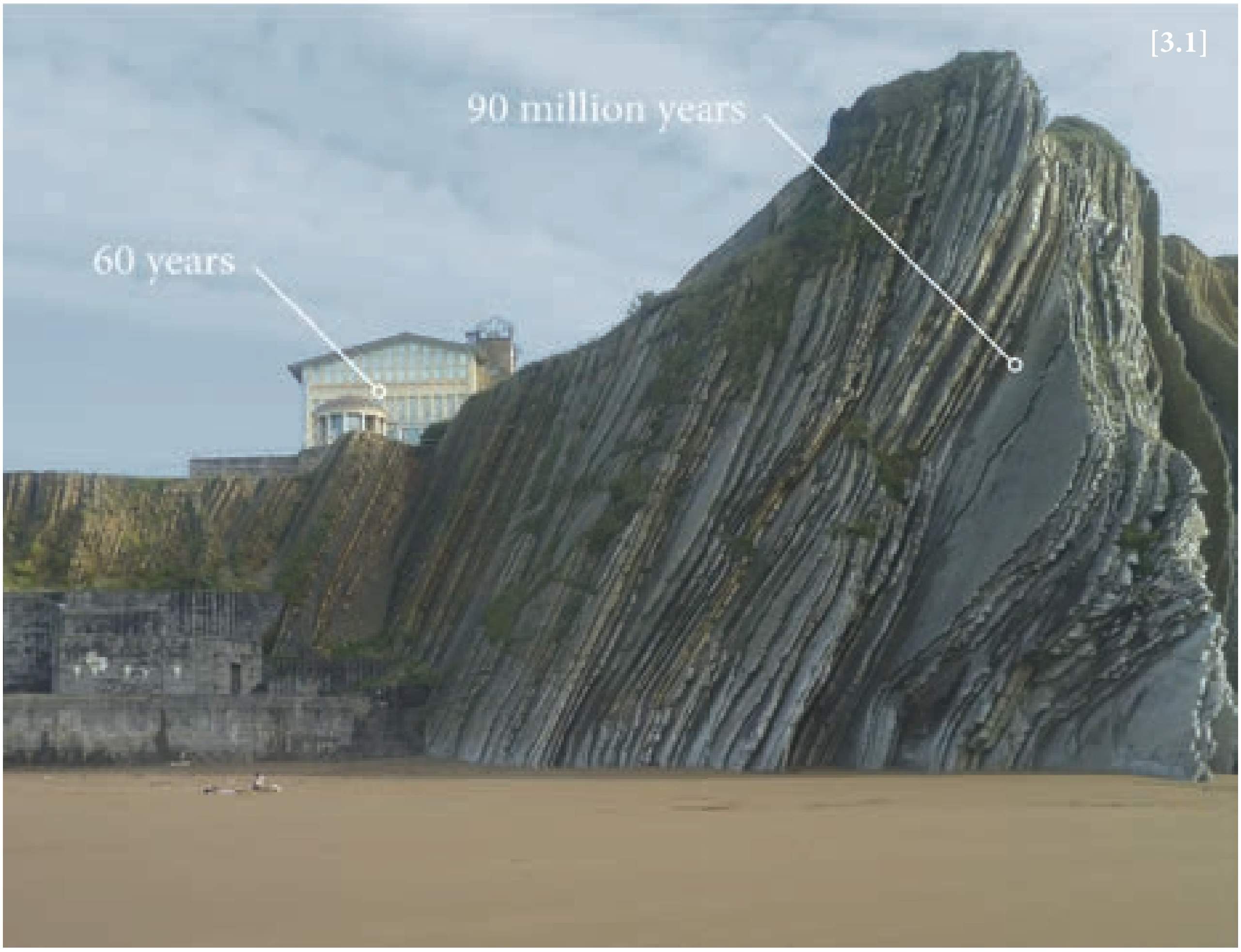
First we will further define the term landscape. Marc Antrop describes landscape as “a dynamic phenomenon that almost continuously changes.” (Antrop, 1998) It is a dynamic phenomenon that is the interaction between human occupation and natural processes; landscape is the visible result of this interaction (Antrop, 1998; Duchhart, 2007; Kerkstra, K., Vrijlandt, 1988) Our interest lies with this interaction between human and nature.

A landscape architect works with the landscape as a physical space, and the activities of the landscape architect primarely have a spatial character. (Duchhart, 2007; Vroom, 1986) We see landscape architecture according to the landscape approach, which is, amongst others, described by Jusuck Koh (Koh, 2013):

“A landscape approach balances creativity with conservation, shaping with managing, and transcends both a compositional approach to design and a typological approach to design analysis. Instead of a formal type, a landscape approach models after process and type using nature’s generative and adaptive strategies.”

A landscape approach takes into consideration time, scale and process. It is not only process oriented but also focusses on the experience of these processes by people. It works from the idea that experience will create awareness. It is about the response of human beings to their physical environment. (Duchhart, 2007; Koh, 2013)

It is from this landscape approach as our lens, that we will formultate the scope of this thesis:



It is not simply the problem that needs to be fixed, but it is the landscape that needs to be adapted and healed. Instead of continuing the current practice of resisting natural forces, it is better to move along with these forces and see the advantages these forces offer.

This statement is the scope of this thesis. We will not merely focus on 'solving the floods', moreover, a certain form of acceptance of and adaptation to the extreme precipitation events might be necessary. This thesis looks at the lack of interaction between the a-biotic system and the human occupation rather than emphasizing on the conflict between nature and human. In the theoretical framework this interaction will be further defined.

We believe that this interaction contains positive outcomes that are currently left unexplored. We want to show that a different approach might lead to an interaction that has many positive outcomes, for both nature and humans, while at the same time adapting the landscape to the extreme precipitation events and preventing flood damage.

04 Research framework

Structure of the research and research questions

As mentioned in the introduction, the aim of this research is to make a highly responsive landscape, such as appear in the Basque Cantabrian Basin, resilient to extreme precipitation events. Part of this aim is to increase the interaction between humans and the natural landscape/system.

The research questions follow from the aim and the problem statement.

The research framework gives an overview of how this research is carried out.

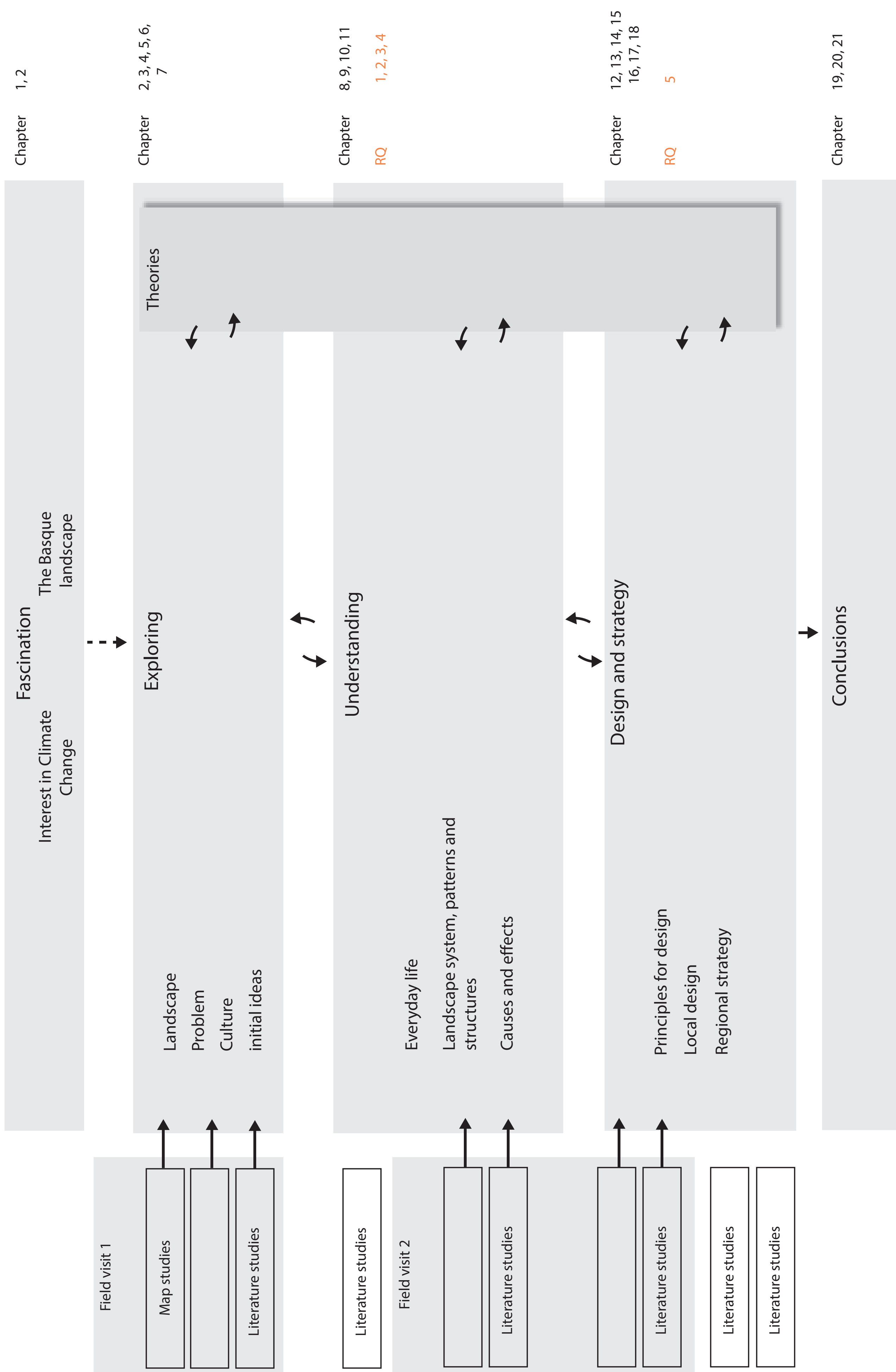
Research question

What interventions have to be made to the landscape to create a flood resilient landscape in the Urola watershed?

Subquestions

1. How does the landscape (system) work?
2. Where do conflicts emerge between the human occupation/organisation and the natural system?
3. What is the character of the landscape?
4. What is the character of the everyday life?

5. In what way can the interventions be designed to optimize the interaction between humans and the natural system?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Map studies
Literature studies
Literature studies
Field visit 2
Literature studies
Literature studies
Literature studies
Literature studies

05 Methods

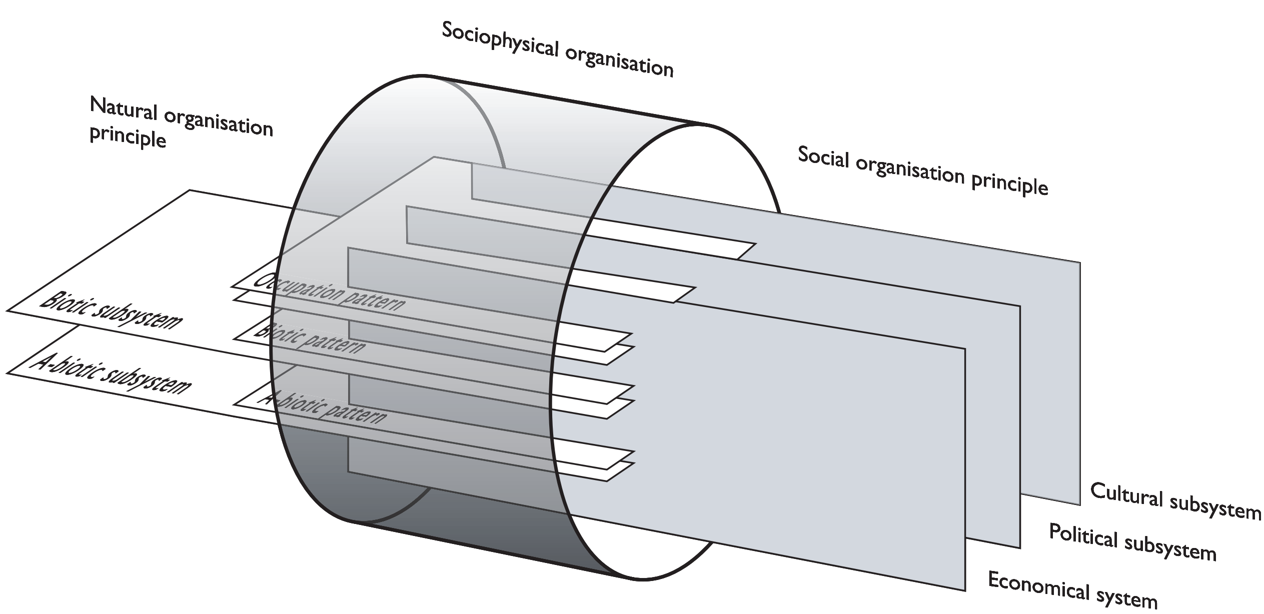
Which methods are used, and why?

This research is based upon the mixed methods approach as described by Cresswell (2009). During the research we use both quantitative and qualitative methods (Cresswell, 2009). Descriptive strategies are used, in the form of observation and secondary descriptive data. Next to that parts of engaged action research have been applied, with participatory methods, such as interviews and talks with locals (Deming & Swaffield, 2011).

The design-process and the design as outcome contain a major part of this research. The design process has been a research through design (Deming & Swaffield, 2011), in which design and research are interlinked and were used to support each other. The outcome of this research is a strategy for the case study area from which general principles can be generated that could be applied to areas alike.

It is important that the design process is not somewhere at the end of the whole research process but interweaved throughout the whole process. The design is then used as a research method as well. This can be seen for instance in the sketching process. Through sketching and designing the landscape system and the land use could be better determined, as can be seen in the coming parts of this thesis.

As stated in the scope, to us the landscape approach is an integrative way of dealing with complex problems to come to solutions that fit to the dynamic nature of the landscape and takes into account its systems and patterns, both human and natural. This complex relation of the physical landscape and the processes that shape it can best be analysed and described by the Duchhart model (Duchhart, 2007) [5.1]. This model is based on the triplex model (Kerkstra, Struik, & Vrijlandt, 1976), and the sociophysical organisation model (M. C. Hidding & Kleefmann, 1989; M. Hidding, 2006; Kleefmann & Vlist, 1989).



[5.1] **Duchhart model**

The Duchhart model forms the basis for our research, as it is a comprehensive way to understanding the landscape. The research does not treat all parts of the model literally, but it does cover all the aspects. The dual nature of the model is used to divide research methods into a physical part, focussed more on human and natural systems and patterns, and a cultural part, that focuses on the social forces that influence the natural processes, namely the human experience of and behaviour in the landscape.

Apart from the sociophysical organisation model as a method, several other methods have been used in order to meet our aim and answer our research questions.

Case study: a representative case is used to delimit the research area. The case study area for this research is the Urola watershed.

CN-ratio method: to get a grip on the size of the problem we used the CN-ratio method, amongst others described by Boonstra (1994). The CN-ratio is a ratio that represents the soil capacity to infiltrate. It is not a method that gives exact data and numbers but it can be used for rough calculations. In this case these rough calculations were enough to work with, since this thesis objective is not to come with a blueprint plan. It would require a hydrological study that would take a lot of time and asks for a lot of expertise that we are lacking.

Literature study: scientific articles, books, and raw data are used to analyse the landscape, and understand the behaviour of people. Additional grey literature such as news reports, websites and tourist brochures are used to comprehend the relevance and size of the problem and to explore cultural elements of the research area.

Map study (Martin & Hanington, 2012); by analysing the landscape and its systems on maps, a spatial image can be obtained, which is relevant for proposing physical interventions.

Expert interviews: to reinforce and adjust the research findings, interviews with experts such as Christian Stocker from the Ur Agentzia (Basque waterboard), Ibon Galarraga from the Basque Centre for Climate Change (Bc3), Jeroen Schoorl, a soil scientist associated to the WUR, Roel Dijksma who is an hydrologist associated to the WUR, landscape architect Pieter Germeraads and Bas Pedroli from Alterra have been essential to accomplish a well-founded research.

By immersing ourselves in the Basque culture by living in the area, and exploring the natural landscape and cultural elements, and observing the behaviour of people, nature, and the weather, we were able to get a feeling for what the Basque country is. We used photo studies, informal interviews with local people and observation to analyse the socio-physical organisation of the landscape (Martin & Hanington, 2012).

We used an adapted version of photo studies (as described by Martin & Hanington, 2012) to find out which parts of the research area people find attractive and like visiting. This adapted version is actually a reversed photo studies: normally as a researcher you ask people to take pictures from objects they like but in this case we subtracted this information from Google Earth on which people tag locations with photos. By counting the amount of photos that have been uploaded by different people we were able to get a grip on popular places in the Urola watershed.

Closely related to these photo studies was the use of behavioural mapping (Martin & Hanington, 2012) as a method. We focussed on the daily activities of people and tried to map relations between certain activities.Next to the above described methods some less important methods have been used, such as Brainstorm organizers (Martin & Hanington, 2012). Storyboards (Martin & Hanington, 2012) have been used to set forth parts of the proposed design. Finally triangulation (Deming & Swaffield, 2011; Martin & Hanington, 2012) of literature studies, map studies, interviews and observations have been used to increase the reliance of the research.

06 Theoretical framework

Exploration of theoretical concepts

The following chapter is an exploration of theoretical concepts in landscape architecture or closely related to landscape. These theoretical concepts have formed starting points for our research and fit in with the scope and landscape architectural lens of the researchers.

Resilient landscapes

The term resilience is part of the main question "What interventions have to be made to the landscape to create a flood resilient landscape in the Urola watershed?" The Oxford Dictionary defines resilience as 'the ability to withstand or recover quickly from difficult conditions' (Oxford Dictionaries, 2013).

When 'resilience' is attached to the term landscape, and approached from a landscape (architectural) point of view, it becomes clear that a resilient landscape is a landscape that is able to withstand the deteriorating forces of the natural system or recover quickly from it. (Duchhart, 2007) The other way around, the natural system is able to withstand the 'deteriorating forces' of the human organization. A resilient landscape requires a human organization that is in harmony with the natural system (Koh, 2013), it requires an interaction between both. It requires the landscape to be able to adapt to changes (Koh, 2013).

A resilient landscape emerges if on the one hand the human organization of the landscape is adapted to and based upon the natural system and its processes (Duchhart, 2007; Koh, 2013). The landscape is modeled after processes and in this modeling nature's generative and adaptive strategies are used as a basis (Koh, 2013). On the other hand the experience of this system and processes are important as well, which is based upon the idea that "to know is to care" (Koh, 2013). This idea is supported by theories outside of the landscape approach, such as conservation psychologists Clayton & Myers, who state that the landscape should be in the hearts of people and they should understand it in order to increase the care they take for it (Clayton & Myers, 2009). The natural system should be experienced in a positive way (Koh, 2013) and if so, people will take better care for it. Hence, a resilience landscape can be reached by adapting the landscape to natural processes and its generative and adaptive strategies and by making these processes visible to people in order to make them take care of the landscape.

Modeling landscape after natural processes and its generative and adaptive strategies

As has been stated above, in order for landscape to become resilient, it needs to be modeled after nature's processes and its generative and adaptive strategies. Part of this is that the design of a landscape becomes adaptive and open, since natural landscapes are adaptive and open too (Koh, 2013). The landscape to design must remain open for developments and changes by users over time and to adjustment after monitoring, especially in the case of dynamic, complex and uncertain situations (Koh, 2013).

An adaptive landscape design can adapt itself to new situations and other purposes. An adaptive system should contain multiple functions, apart from its main function, in order to make it adaptable to changing circumstances in the human organization. Furthermore, it should be able to go along with the dynamics of the natural system and should be able to cope with changes in the natural system (Koh, 2013). The landscape design should be dynamic and its management should be dynamic too. This thesis should comply with this, in order to come to a sustainable water system.

A flood management system that is based upon nature's generative and adaptive strategies is also promoted and advised by the European Union. In their 2007 Floods Directive it is stated that with the growth of our understanding of the interplay between rivers and the landscape, effective solutions that work with nature, rather than against it, have become more important. They add to this that this type of flood risk management can go hand in hand with the protection and restoration of nature and above that can create benefits for people. Traditional flood risk management methods are disclaimed to be effective on the long term and adaptive and dynamic flood risk management is encouraged. (EUROPEAN COMMISSION, DIRECTORATE-GENERAL, & ENVIRONMENT, 2011) This natural flood management as described by the European commission is closely related to what the landscape approach stands for.

More specifically focused on the level of a water system or watershed, general phenomena of human management are channelized run-off streams and static flood bypasses. These phenomena are part of a static water management, which is the opposite of adaptive, more dynamic watershed management and landscape design. These landscapes and its management are not resilient to changes in precipitation pattern and climate change in general, which forms a dynamic, complex and uncertain situation. Contrary to this static landscape, a more adaptive approach would be able to cope with changes in precipitation pattern. This adaptive system models after the natural water system and enhances its qualities and capacity to control floods and extreme amounts of water (EUROPEAN COMMISSION et al., 2011; Thayer Jr., 2003).

Part of being adapted to a natural water system or watershed is the management on the level of this system or watershed. It is very important to plan and cooperatively manage a whole watershed, from its headwaters to the outflow or confluence (Thayer Jr., 2003), since the upstream management has effect on the downstream flow of the river and as such downstream problems might be solvable in the upstream parts. Thus an integral management and landscape plan are very important and statements and ideas about this should be included in this thesis.

Cultural sustainability

As said before, in order for the landscape system to be resilient, its processes need to be experienceable by local people. Saito defines this part of resilience as the cultural sustainability of a landscape, adapting this term from Joan Nassauer (Saito, 2007). By this term Saito means that the landscape is embraced by humans, that they like it, see the value of it and take care of it (Saito, 2007). This statement is supported by Nassauer, as she says:

"Landscapes that attract the admiring attention of human beings may be more likely to survive than landscapes that do not attract care or admiration. Survival depends on human attention might be called cultural sustainability. Landscapes that are ecologically sound, and that also evoke enjoyment and approval, are more likely to be sustained by appropriate human care over the long term. People will be less likely to redevelop, pave, mine, or 'improve' landscapes that they recognize as attractive. In short, the health of the landscape requires that humans enjoy and take care of it." (Nassauer, 1997 cited in Saito, 2007)

One of the core aspects in this cultural sustainability are aesthetics and experience, simply because people will be persuaded to act easier by the experience of beauty in all of its forms than by intellectual arguments or abstract appeals of duty (Orr, 2002 cited in; Saito, 2007). A landscape will be culturally more sustainable if people value and experience it as aesthetically pleasing (Saito, 2007).

Apart from the aesthetics and experience, the creation of a significant role for the natural system/ landscape for the human organization is important for a landscape to be culturally sustainable. The adaptive system should not serve a single purpose or function, but it should be multifunctional and serve multiple purposes. By doing so, the system becomes embedded in the human organization and it has a role in the everyday life of people (Clayton & Myers, 2009).

Aesthetics and experience of landscape

'The aesthetic' is defined here as any reaction people form toward the sensuous and/or design qualities of any activity, object or phenomenon (Saito, 2007). According to Saito, aesthetic experiences can be split into two kinds. On the one hand there are the special experiences that are part of what Saito calls scenic aesthetics. These are (memorable) experiences that stand out from the flow of everyday experiences (Saito, 2007). If translated to landscapes, these experiences often emerge in landscapes that form nice scenes to make pictures. Experiences related to scenic aesthetics will be referred to as scenic experiences in this thesis. In general, people are tend to be more attracted to spectacular and unfamiliar landscapes, which can be made into a nice image (Saito, 2007). If people do find a landscape aesthetically pleasing, it can lead to better care for this landscape, the other way around, if people do not find a landscape a sight to behold, they tend to care less about what happens with it (Saito, 2007).

On the other hand there is the phenomenon of everyday aesthetics that often form an almost insignificant experience that is ordinary and might occur every day (Saito, 2007). For example, selecting garment or picking an apple out of a display with apples (Danto, 2003 cited in Saito, 2007). Experiences related to everyday aesthetics will be referred to as everyday experiences in this thesis. These everyday experiences are also recognized as an important part of the landscape within the landscape approach (Koh, 2013).

Unless it leads to a stand-out aesthetic experience, the power of the everyday aesthetics is for the most part unrecognized (Saito, 2007). However, Saito claims that everyday aesthetic tastes and judgments can exert a powerful influence on the state of the world and our quality of life'. According to her an effective way of ensuring a positive aesthetic experience of a particular environment is for people to participate in this landscape in a way that generates our affection and attachment (Saito, 2007). The landscape or system should be tied to the identity of people (Clayton & Myers, 2009). This identity is formed through experiences and by creating (everyday) experiences for people with a system or a landscape in a way that they might become attached to it and take better care for it (Clayton & Myers, 2009; Karmanov, 2009; Saito, 2007). Nature has to become part of our social world and social context, it should allow us to benefit from the contact with nature in our day-to-day activities (Saito, 2007). This will help reminding people to what they value in nature (Gross and Lane, 2007 cited in Saito, 2007), furthermore it will bring the natural system and its processes closer to people and people tend to care more about things that are close to them (Clayton & Myers, 2009). Hence for this research, the everyday life of the people should be linked to and interacting with the water system.

According to Saito, (landscape) architects and (landscape) designers have a key role in creating both everyday- and scenic experiences for people with natural processes and systems. These (everyday) aesthetics and judgments can exert a powerful and positive influence on the state of the world and our quality of life. At last, our (everyday) experience cannot but be affected by the quality of these experiences, as it consists of our interaction not only with other people or natural elements but also with numerous artifacts (Saito, 2007). This matches the scope of this thesis that believes in a landscape approach to a flood problem.

Others reckon the importance of experiences as well. According to James Corner, experience is at the heart of the relationship of humans and the landscape/ natural system. Experiential landscape qualities are strongly linked to the meaning of the landscape. To experience these qualities of the landscape, one does not need to be able to analyze the landscape by its patterns or subsystems, nor be able to recognize its symbolic content (Corner, 1992). On the contrary, many of the experiential qualities of a landscape are determined by its physical properties, and just perceiving these physical properties by seeing, hearing and feeling can be a very rich experience (Karmanov, 2009).

In conservation psychology there is the theory that humans have the tendency to prefer landscapes that are more able to support the things they need to live: food, water and shelter. (Clayton & Myers, 2009)This theory is supported by several researches done. The general outcome of these researches is that people prefer landscapes with water over landscapes without water, and that they react positively to a landscape with flowering trees, which suggests fertile vegetation (Clayton & Myers, 2009). Furthermore landscapes that offer the ability to navigate successfully across and offer shelter are preferred (Heerwagen & Orians, 1993 cited in Clayton & Myers, 2009). People prefer landscapes that they perceive as natural (Dearden, 1987; Herzog, 1989; Kaplan, 1983; Knopf, 1987; Smardon, 1988; Ulrich, 1986 cited in Nassauer, 1995).
The basic experience of the landscape can be distinguished in several elements that are linked to the sensory faculty. The experience is strongest and most memorable if they are multi-sensory and multi-dimensional, it can then become a unified experience that becomes the source of aesthetic appreciation (Saito, 2007).

Landscape architects utilize these potential sources of experience, for instance as strategies in form, balance, repetition, the use of color, the creation of surprise and the arousal of interest. (Karmanov, 2009) The use of material, the texture of the material and the color, the type of vegetation used and the style of the vegetation are all important factors that influence the scenic and everyday experience of the landscape. They form the essence of an objects identity (Saito, 2007).

Concluding remarks

The above stated theoretical framework offers important starting notions for this thesis. It has become clear from the theoretical explorations above that a more dynamic and natural water system and strategy are more resilient than static systems. The European Commission has already come with guidelines for a more natural water management. Seen from a landscape approach however, the resilience of a landscape or system is not only in making it adaptable and withstanding to natural forces. The cultural sustainability can be seen as evenly important in creating a resilient landscape, since people need to see the importance of and need to care for the landscape and water system. If people do not see the urge for a new approach or strategy, no public support will be gained, with the consequence that the strategy will not be resilient to the developing and ever growing influence of humans in the landscape. The cultural sustainability can be enhanced by the visibility and possibility to experience the water system. The water system should become part of the everyday life of people, interacting with the activities people do. Furthermore, creating scenic aesthetic experiences with the water system will enhance peoples' appreciation for the water system.

Synopsis

- A resilient landscape is a landscape that is able to withstand the deteriorating forces of the natural system (and human occupation) or recover quickly from it.
- Resilience, as seen from the landscape approach, is twofold: on the one hand the landscape should be based on nature's generative and adaptive processes and strategies. On the other hand the landscape should be 'culturally sustainable'.
- An adaptive landscape is a landscape based upon nature's generative and adaptive processes. It is open to changes in function and changing circumstances.
- Adaptive and sustainable watershed management is focused on restoring natural streams and retaining/buffering water on logic places in the landscape.
- Adaptive and sustainable watershed management considers the watershed as one area and asks for a centralized regional strategy.
- A culturally sustainable landscape is a landscape that people 'like' and find aesthetically pleasing. Furthermore, it has one or more functions in the everyday life of people.
- (Everyday and scenic) aesthetics and judgments can exert a powerful and positive influence on the state of the world and our quality of life (Saito, 2007).
- (Landscape) architects and (landscape) designers have a key role in creating both everyday- and scenic experiences for people with natural processes and systems (Saito, 2007).
- Landscape architects utilize these potential sources of experience, for instance as strategies in form, balance, repetition, the use of color, the creation of surprise and the arousal of interest (Karmanov, 2009).

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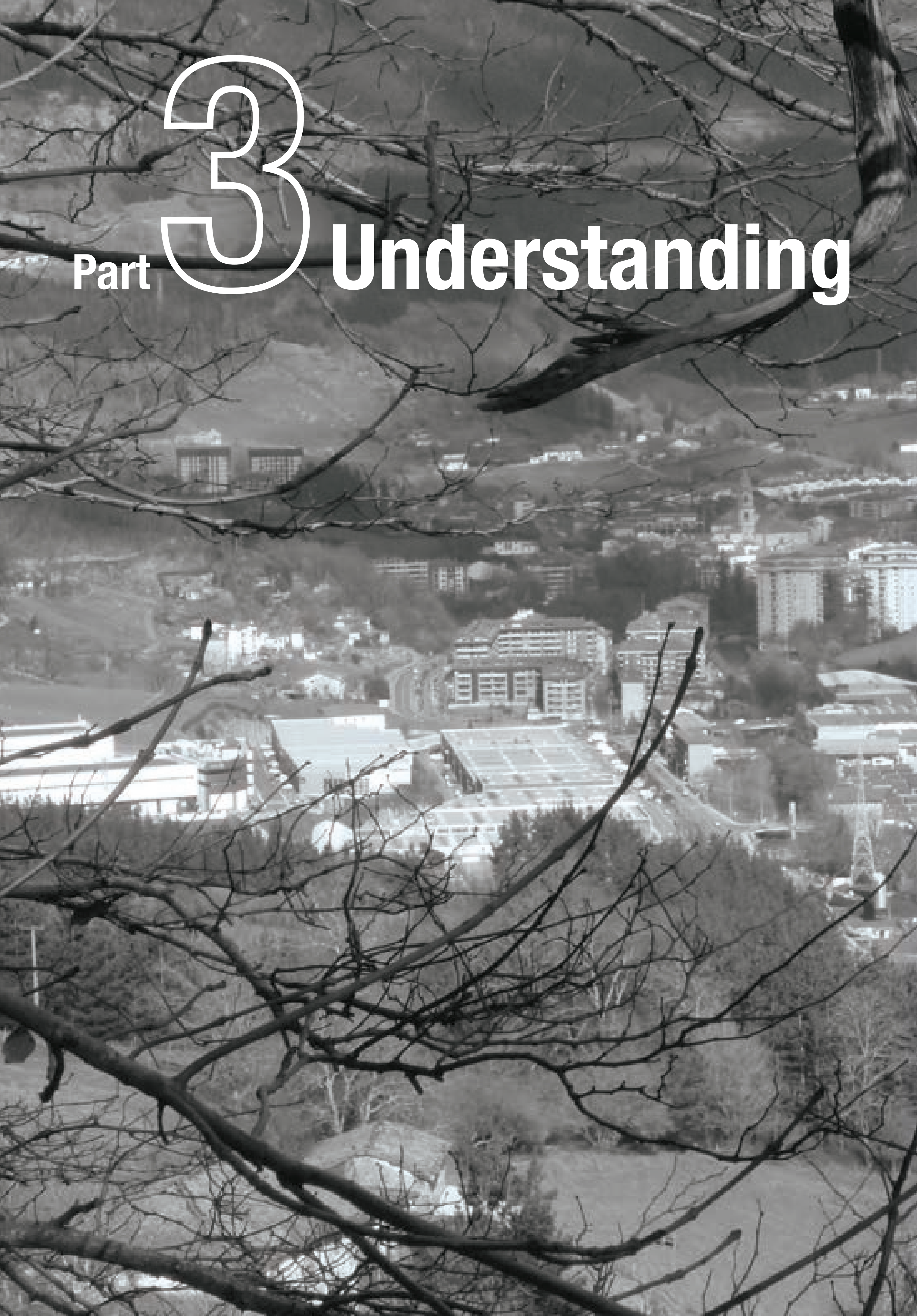
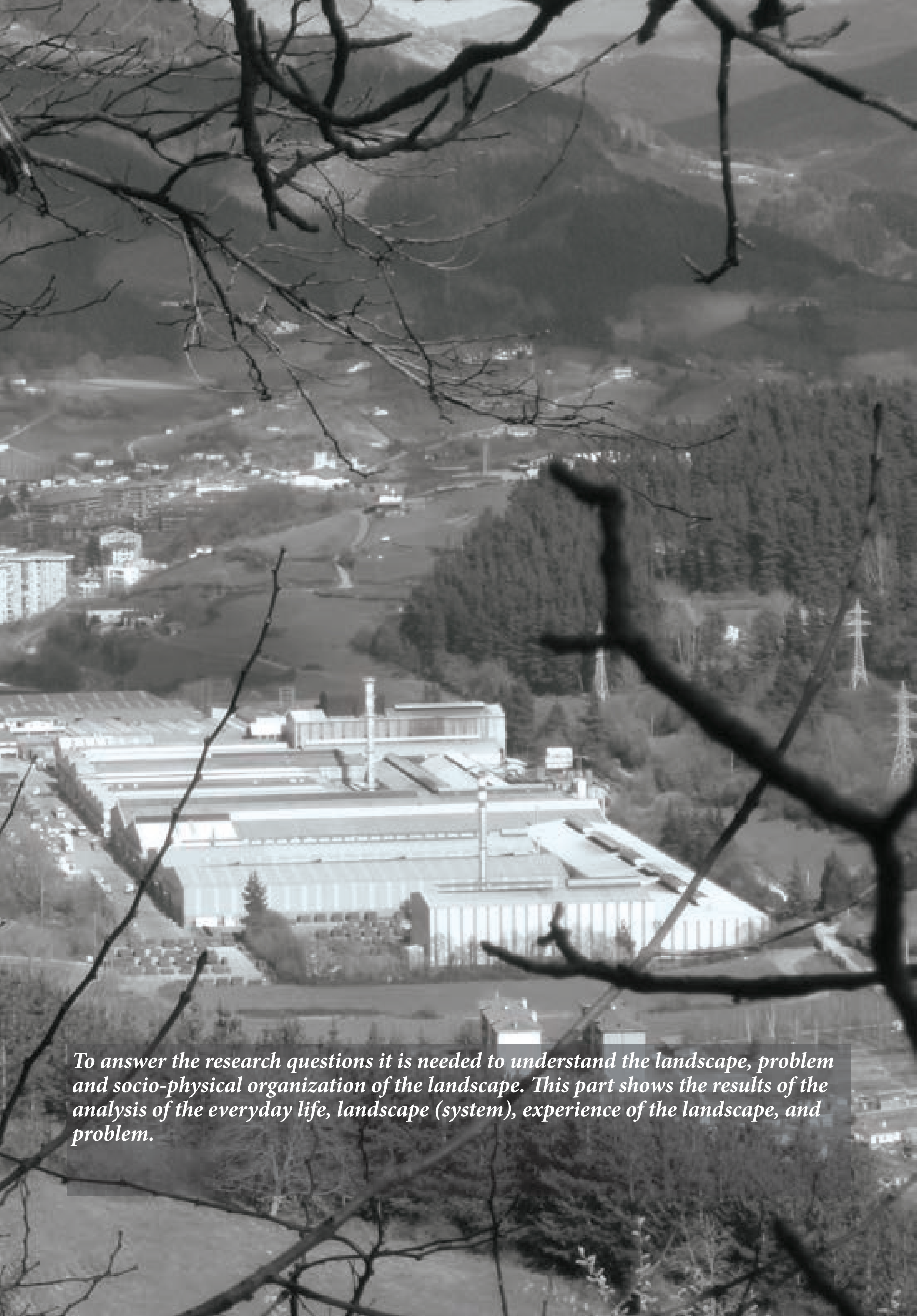
Illustrations

5.1 *Adapted from* Duchhart, I. (2007). Designing Sustainable Landscapes From Experience to Theory; A Process of Reflective Learning from Case-study Projects in Kenya (p. 224). Wageningen University, The Netherlands.; p.194

Part 3 Understanding





To answer the research questions it is needed to understand the landscape, problem and socio-physical organization of the landscape. This part shows the results of the analysis of the everyday life, landscape (system), experience of the landscape, and problem.

07 Everyday life

What is the character of the everyday life?

During our fieldwork trips to the research area, we stayed in an apartment in Zumaia, the coastal village at the estuary of the river. Apart from intensive excursions throughout the whole watershed Urola and neighbouring watersheds we took quite some time wandering around Zumaia and other places in the watershed. These moments of wandering were very important to grasp the way of living in the Basque Country and Urola watershed more specifically. In this chapter our findings and impressions of the everyday life of the people are explicated. Note that some of the images used are not our own, since our impressions often contained moments of social interaction between people, in which we did not always feel comfortable taking pictures. The images shown have been found on the internet, are made by Basque people during their everyday life activities and are retrospectively looked up by the authors.

The main focus of this chapter is on the Urola watershed, as it is our case study area, but we also observed everyday activities in other watersheds, as mentioned above. Furthermore, we did some in depth analysis on the central valley of the Urola, called the Iraurgi valley. This area has our special interest as it contains two of the largest villages of the watershed as well as agricultural areas and it is a representative area for most of the watershed. Later on in this Part it will become clearer why the Iraurgi valley is representative.

Social activities as part of the everyday routine

Early in the morning, when we would do our groceries, the parks and squares of the village are already crowded with people. Some people head to work, which is mainly in the industry and services sector (EUSTAT). In coffee bars and bakeries many people take their breakfast and morning coffee. After a certain time, kids are brought to school and people continue their daily activity. Though during the day, the coffee bars and bakeries remain filled with people that are meeting each other.

One remarkable thing about the daily rhythm in the village is the tranquillity of the afternoons, during the siesta. Every street, square and park is empty and most of the stores are closed. At the end of the afternoon, the siesta ends and the public spaces are even fuller than in the morning, children are playing, people are chatting, and more people join them when they arrive home from work. As long as it's dry and not to cold, people stay outside, until the early evening. Then it turns quieter again, as people are having their dinner. Most of them eat this at home, but at some nights, dinner is eaten in the bars (or outside the bars) that serve pintxos (the Basque version of tapas).

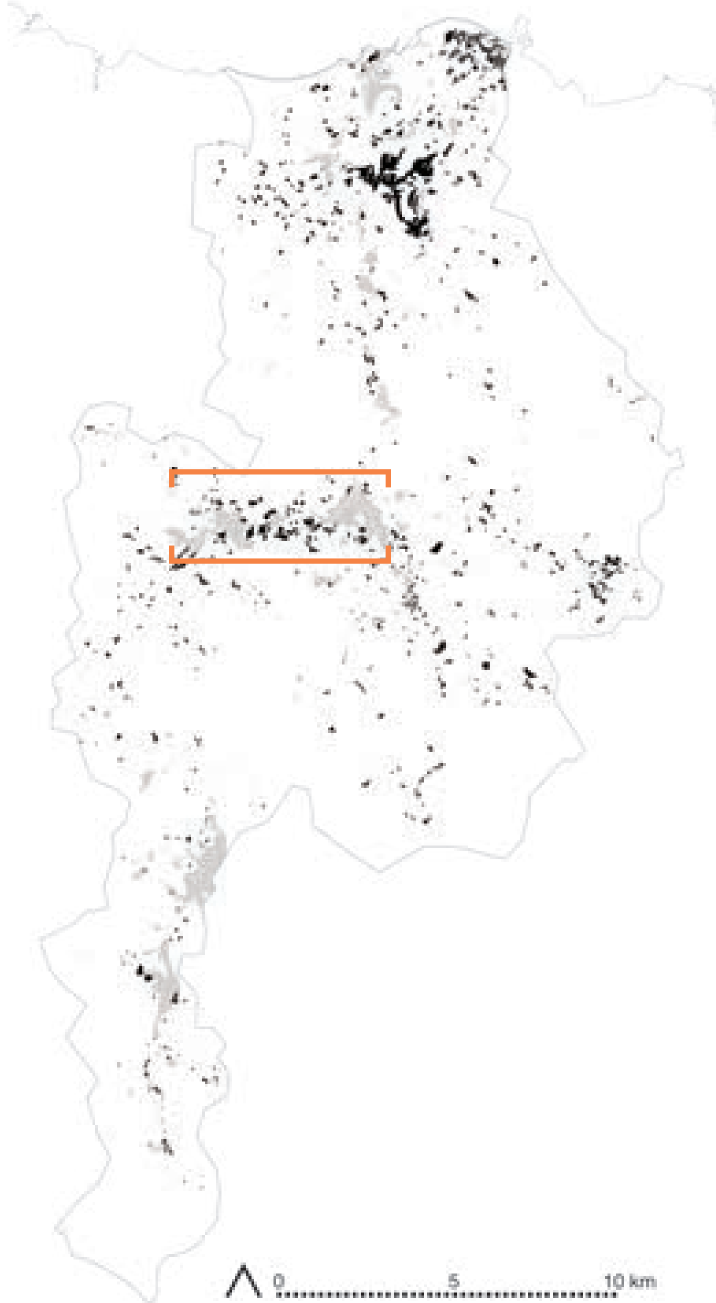
Every village seems to have many bars and after dinner many people head to these bars for a drink with friends and neighbours. The bars are usually quite crowded on every evening.

It is very noteworthy to see the role that public space and (outdoor) social activities and meetings play in the everyday routine of people. Of course, our experience is mainly generated from the outdoor life of people, but it is remarkable to see how much time people actually spend outside. Schoolyards, parks, streets and squares are all intensively used social public spaces.

[7.1-7.2] **Social life outdoors >**

[7.1]

[7.2]



[7.12] Huertas, orchards, and vineyards in the Urola watershed and the Iraurgi valley

< [7.3-7.11]

Local food

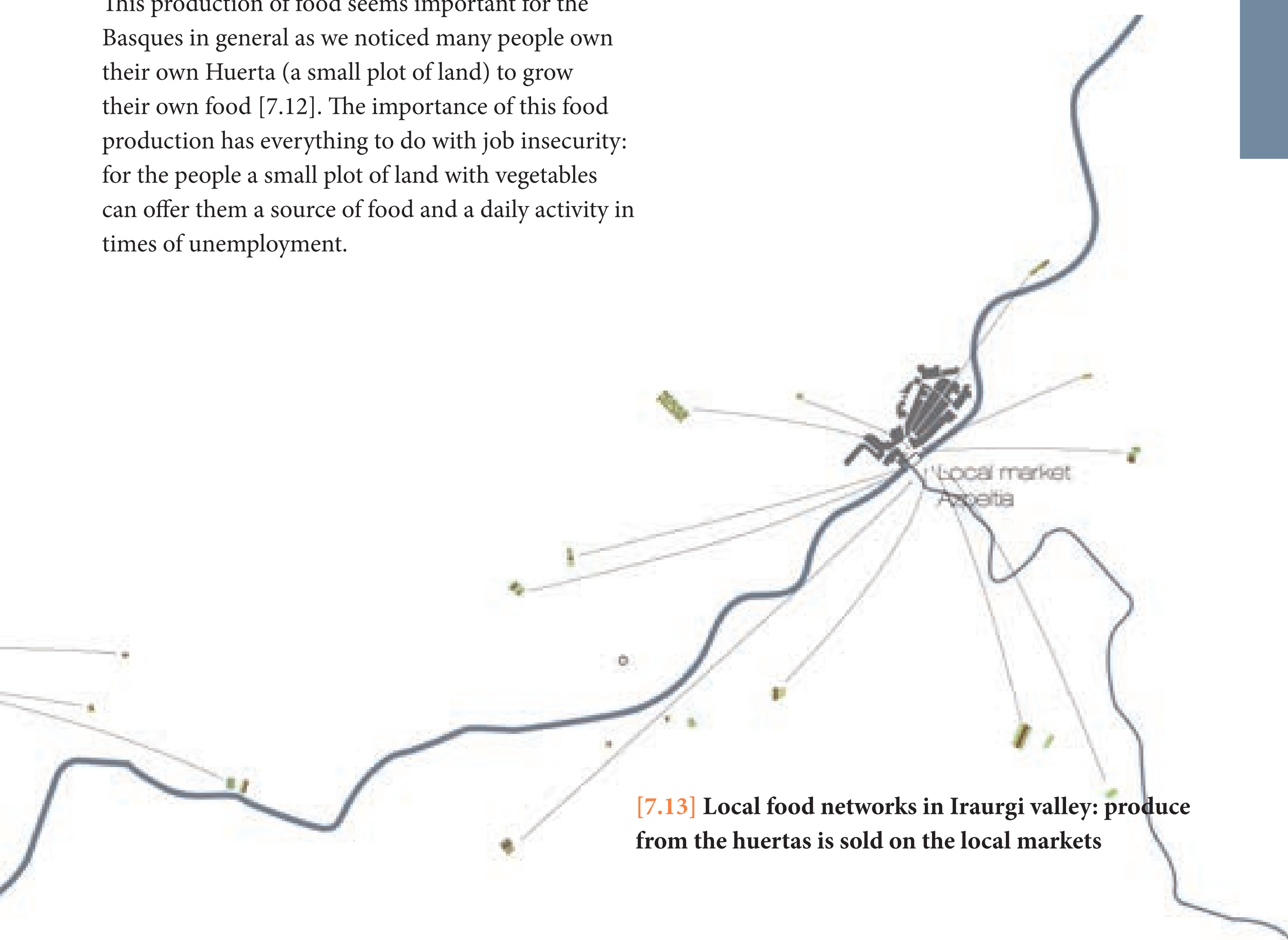
As can be concluded from the above, the Basques live outside during a large part of the day if the weather allows it. This can not only be observed in the cities and villages but also outside of these villages.

To start with, the farmers that live in the Basseri have a lot of activities to do outdoors. These are important to keep their agricultural business running, although most of the farmers do not have this business as their primary income (Ruiz, Mandaluniz, Albizu, & Oregui, 1998). Their way of farming is very traditional and there seems to be no monoculture or intensive production in the area. Most of the farmers both have cropland and cattle (mainly sheep), as well as orchards and vineyards. Nowadays many farmers have planted parts of their land with Pinus Radiata to gain money out of the agroforestry business. The production of food has remained the main task and agricultural activity of most farmers. [7.3 – 7.7]

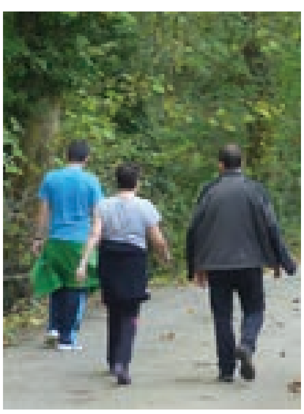
This production of food seems important for the Basques in general as we noticed many people own their own Huerta (a small plot of land) to grow their own food [7.12]. The importance of this food production has everything to do with job insecurity: for the people a small plot of land with vegetables can offer them a source of food and a daily activity in times of unemployment.

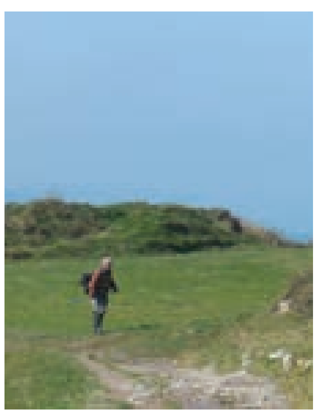
Closely related to this food production are the local markets [7.13] that are to be found in most of the villages. On these markets, farmers and other locals sell products that they grew on the huertas, such as vegetables and herbs [7.8 - 7.9]. It seems as if the Basques have a very traditional and local food network that consists of many people producing food in a very traditional way; the production is either used for their own consumption or to trade it on the local market.

Additionally, the consumption of food is also important, with the pintxo's [7.10] as evidence of this. The Basques take care of their food from the very seed up to the preparation and consumption [7.11]. Slow food culture appears to be an important aspect of the Basque way of living.



[7.13] **Local food networks in Iraurgi valley: produce from the huertas is sold on the local markets**





Outdoor activities

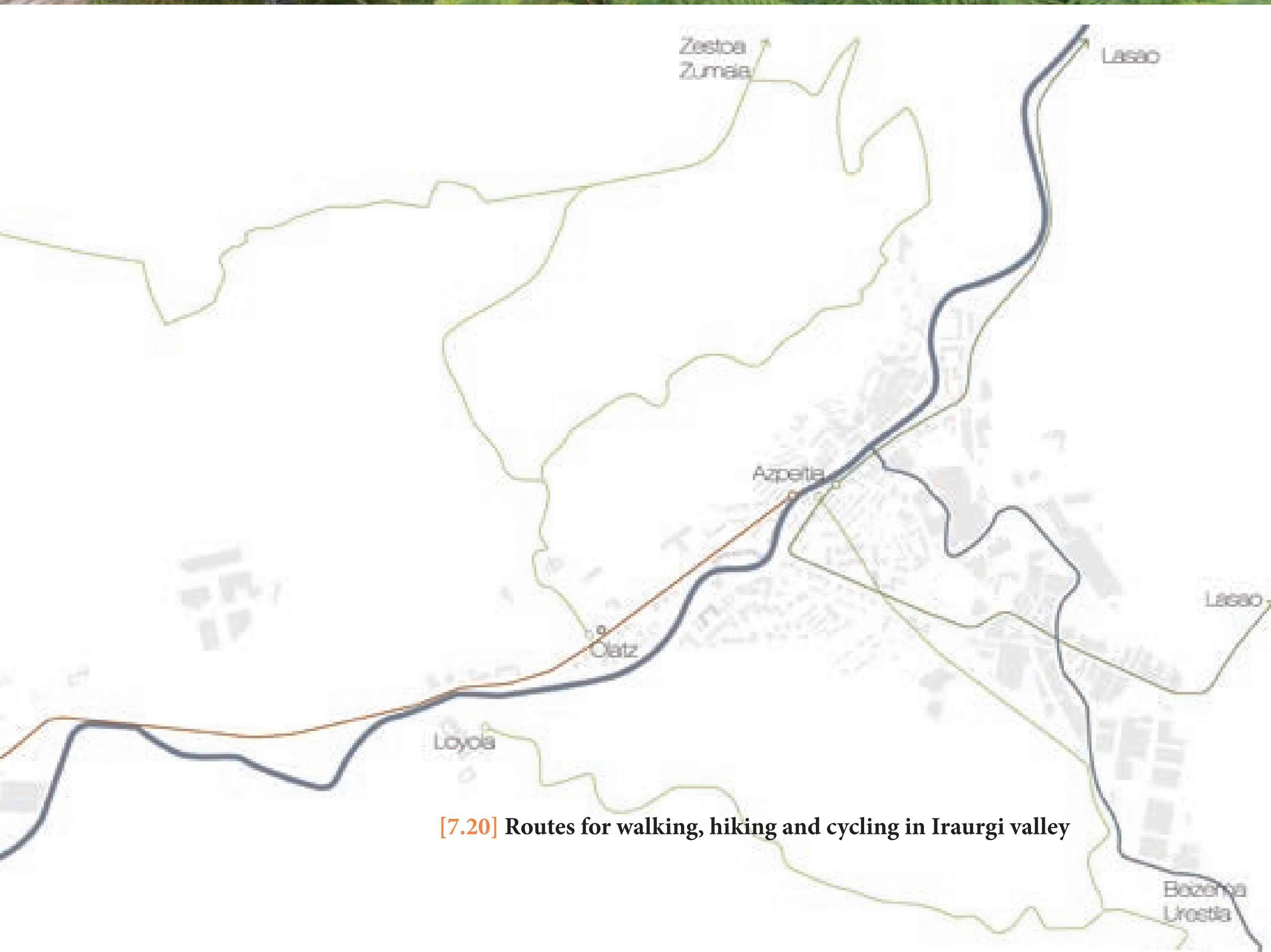
The outdoor way of living can also be distinguished from the habits of people to walk hike and bicycle through the mountains. It is remarkable how many people we've seen undertaking these activities. Basques seem fond of the landscape they live in and like to explore the rough mountain areas. Along the course of the river Urola and along other rivers former railroads have been transformed into trails that people enjoy walking, running and bicycling along [7.14-7.17, 7.19].

Closer to their homes in the villages, the Basques enjoy the game of pelota, that is often played on outdoor fields. Every village seems to have an outdoor field of pelota, most often with bright colours. [7.18]

Outdoor sports are in general important in the Basque culture, with every village having their own sports events.

< [7.14-7.18]

[7.19]



[7.20] Routes for walking, hiking and cycling in Iraurgi valley

[7.21] **Coastal tourism**

[7.22] **Basilic of St. Ignatius of Loyola**

[7.23] **Geological formations along the coast**

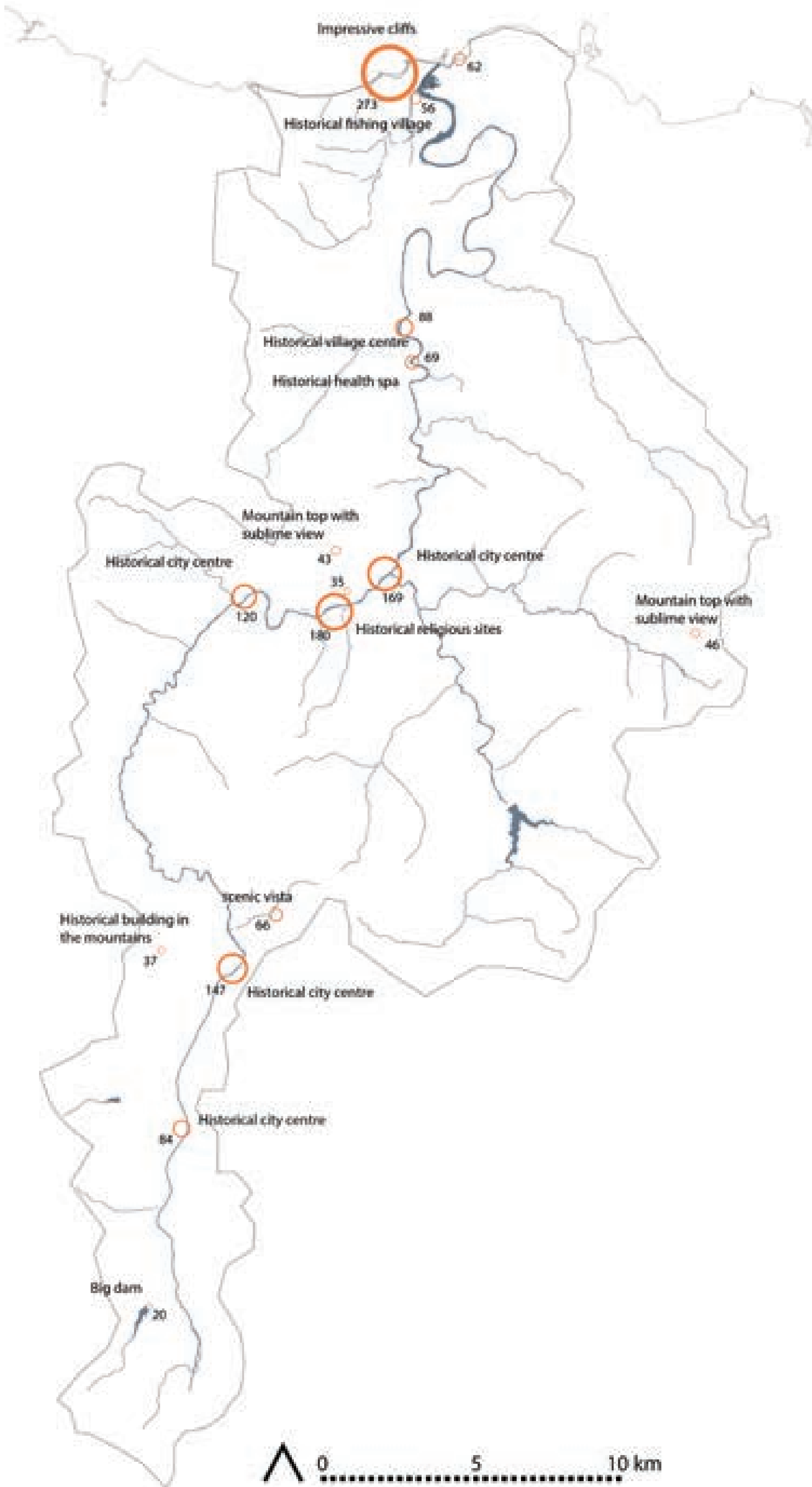
Tourism

A group of people that do not fit in the everyday life as described are the tourists. Most of the tourists are staying in the coastal villages, close to the sea and the beach. According to a farmer in the area, some tourists, mainly Spanish people from the cities, stay at a basseri in the inland to escape from their busy everyday life. There appears to be a lot of potential for this sort of agrotourism. Another group of 'tourists' passes either through the coastal area or through the inland as they head towards Santiago the Compostella on their pilgrimage, these tourists only pass through the area and or not staying for long.

Tourism magazines mostly highlight the culture, coasts, geological formations, green and rough inland and gastronomy (represented by the Pintxos) of the Basque Country. Most tourists come to Basque for its coast and sea [7.21], and that the inland is mainly seen as an area to take a trip to.

Basques recreate in their own landscapes a lot, and they can act as tourists in a sense. Illustration [7.25] shows the places that Basque people and tourists find attractive and interesting to photograph in the Urola watershed. This map is based upon the amount of photos that people tagged on Google earth. Some spots pop out clearly, such as the geological formations at the coast near Zumaia [7.23], the Basilic of St. Ignacius of Loyola between Azkoitia and Azpeitia [7.22], and mount Erlo above Azpeitia.

[7.24] **Tourist brochures**



[7.25] **Types of scenery and number of photos that people upload to Google Earth**

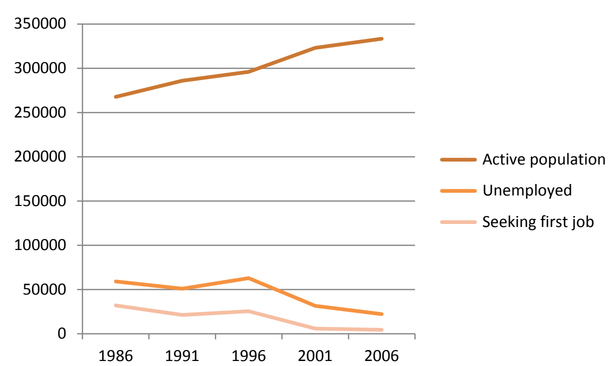
How the Basques make a living

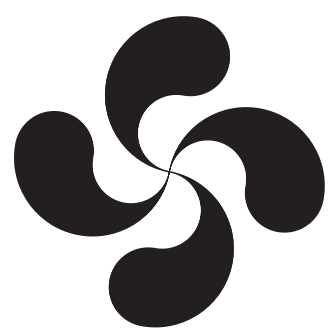
The agricultural sector in the Basque country is small, and most people work at one of the industrial companies located in the villages or in the public and commercial services sector (EUSTAT, n.d.). The crisis of 2007 has also struck the Basque Country and the Urola watershed and more people are unemployed now than before the economical crisis. Growing their own food on their Huertas helps many people to cope with the crisis and be self-sufficient.

We noticed many young people hanging outside of the bars every day, which we assumed to be unemployed, yet we do not know this for sure as we found it inappropriate to ask them about it. Unfortunately, the EUSTAT database does not offer statistical data about the rate of unemployment after 2006, which was the year before the crisis. The graph in [7.26] shows the development of the active population and employment from 1986 until 2006. What can be noticed was that during the crisis of the 1980s the unemployment rate was much higher than in 2006. Another remarkable thing is that a large part of the unemployed are people seeking their first job.

Euskal Herria

Euskal Herria is the term that refers to the Basque Country as a homeland. The Basques have a strong sense of identity and culture, with their own language, habits and traditions. This is reflected in the struggle for autonomy that the Basques have been in for centuries and which continuous to this day, as many flags and posters on the walls of houses illustrate [7.27]. The Lauburu [7.28] is an important symbol in the Basque Culture (Mujica, 1968). It is a very old symbol that was already used by the Basques during the time of the Romans and it can still be found in many places of the everyday lives of the Basques, as can be seen in [7.29]. The Lauburu stands for the four elements fire, water, earth and air and the harmony between humans and nature. (Mujica, 1968)





[7.26-7.27]

[7.28-7.29]

Relation between the people and their environment

The Basques are closely connected to the landscape and the natural environment they live in, especially regarding the traditional way food is produced, traded and prepared. This is remarkable compared to the observed lack of interaction in other parts of the research. As has been stated in the introduction, the human organization and way of living have been based upon the natural system for a long time, but due to the technical innovation and industrial developments the human organization of the landscape became independent of the natural system. The agricultural system remained traditional and of small scale until this day, though even the agricultural system has its downsides for the natural system, after all, the farmers have their part in the canalization of the natural streams and static, decentralized management of the run-off of water. Furthermore a shift in agricultural activities, with more emphasis on agroforestry also has its consequences, which will be explained in the next chapter.
It seems that people are not aware of this lack of interaction and neglect of the natural system, while their culture has always been closely related to the landscape and nature, as the importance of the Lauburu and the slow food tradition, but also more historical land use features attest.

Synopsis

- Large parts of the everyday lives of the people take place outdoors in public spaces such as streets, parks, schoolyards and squares.
- There is a tradition of food production with both farmers and other people, linked to the typical Basque gastronomy and local food networks.
- The people of the Basque Country and Urola watershed are proud of their culture and landscape.
- A lot of people like to undertake 'active outdoor' activities, such as hiking and cycling in the (natural) landscape.
- There are certain places that seem to be very popular to tourists and Basques, such as the Loyola Basilic and mount Erlo.
- Basque people mainly work in services and industry, although unemployment rates are quite high during the economical crisis, especially amongst young people
- The people are in certain ways very closely connected to their natural environment
- The relation of the people with the natural water system has degraded, while they used to be connected to it very closely in the past.

08 Landscape experience

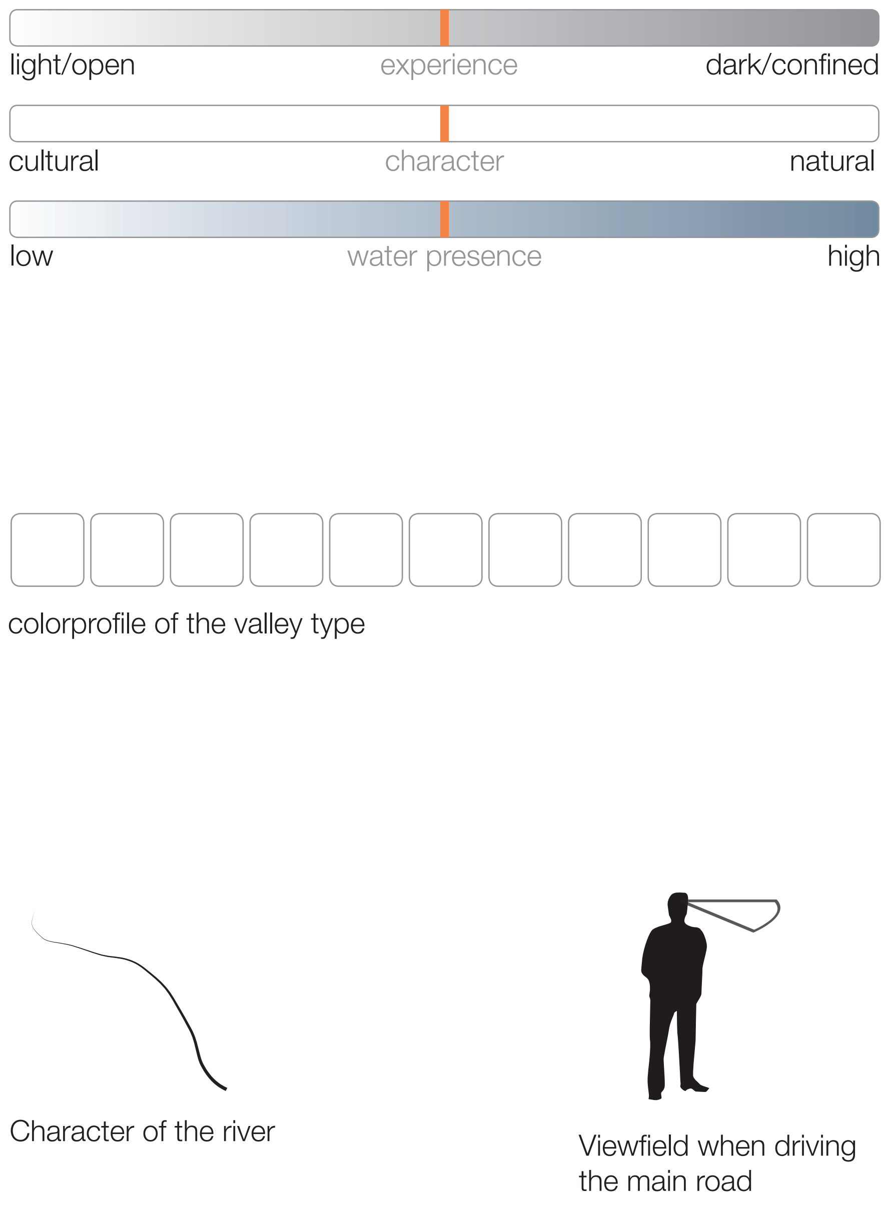
Thematic research analysis

This chapter is an exploration and understanding of the character of the landscape. Key in this character are certain aspects, that have been mentioned before in the theoretical framework, that influence the way people perceive the landscape.

These aspects are: scale, lightness, openess, color, material; and in this case also: the presence of the river in the landscape

This last aspect plays an important role in this thesis as its goal is to improve the interaction between the natural (water) system and the human organisation. In this interaction, the presence of the river plays an important role. As has been determined in the previous chapter, the landscape exists of several types of valleys that are built up out of different slope gradients. These types of valley all offer a different kind of experience when one drives through the watershed.

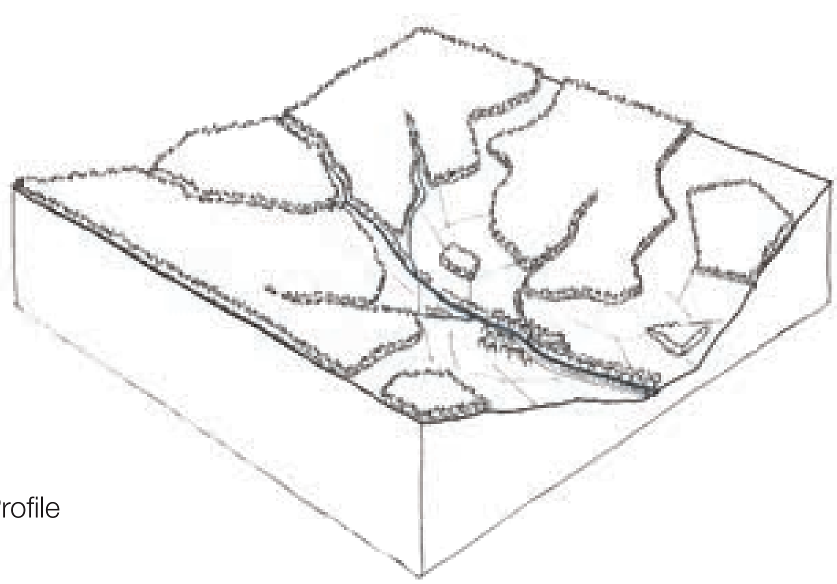
The basis of this chapter is formed by this drive through the watershed. For every watershed the presence of the river has been determined as well as the character of the river and the role the river plays in the landscape. Then the scale, lightness and openess have been determined per valley as well. Finally, a color analysis and material analysis have been done. The presented data are supported by photos of the valley type.



8.1 Example of the presentation of the data

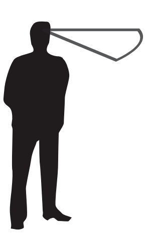
Upstream

The first streams that will form the Urola river spring from Cantabrian basin dividing range. Water comes down the high mountain ridges and congregates in the small V-shaped river valley. Forested slopes surround the grasslands of the valley. Small, picturesque villages such as Brinkola are located on the riverside, and remains of watermills can be found along the river.
The road and railway run along the river and into the industrial city of Legazpi, that is situated in a slightly wider part of the valley. In Legazpi, and also in Urretxu/Zumarraga a few kilometers down the river, the river is mostly underground or tucked away to the edge of the city, hidden behind generic apartment blocks.
From Urretxu on, the railway is no longer used, but its former route is now transformed into the Via Verde, a hiking/biking path that runs through the canyon to the north.

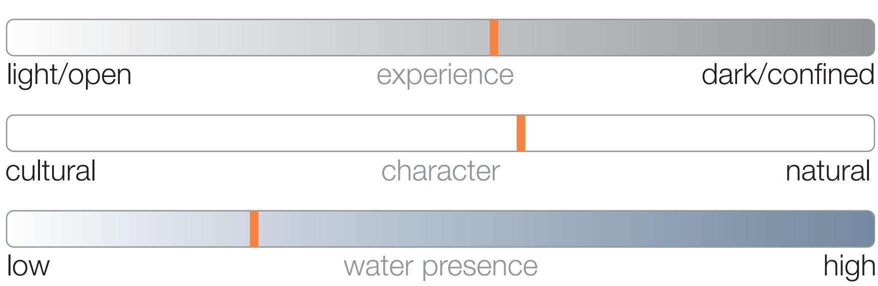


Profile

Small and rippling stream

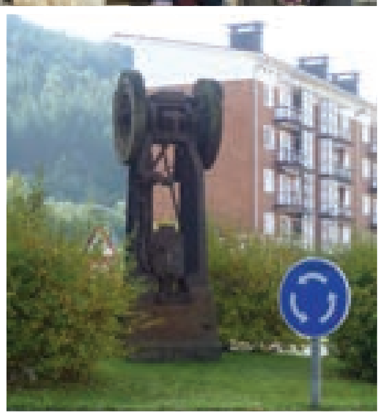


Limited views



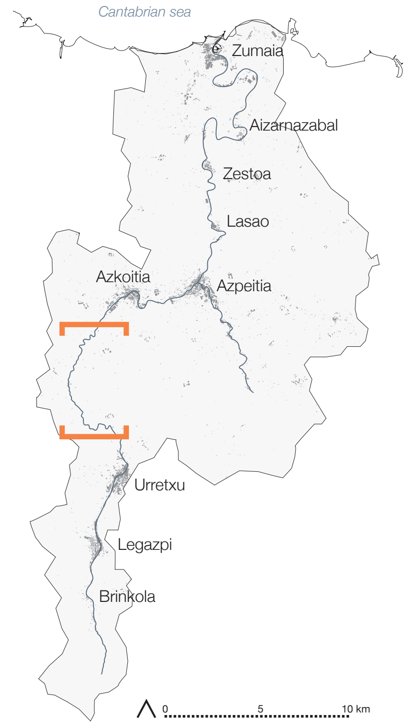


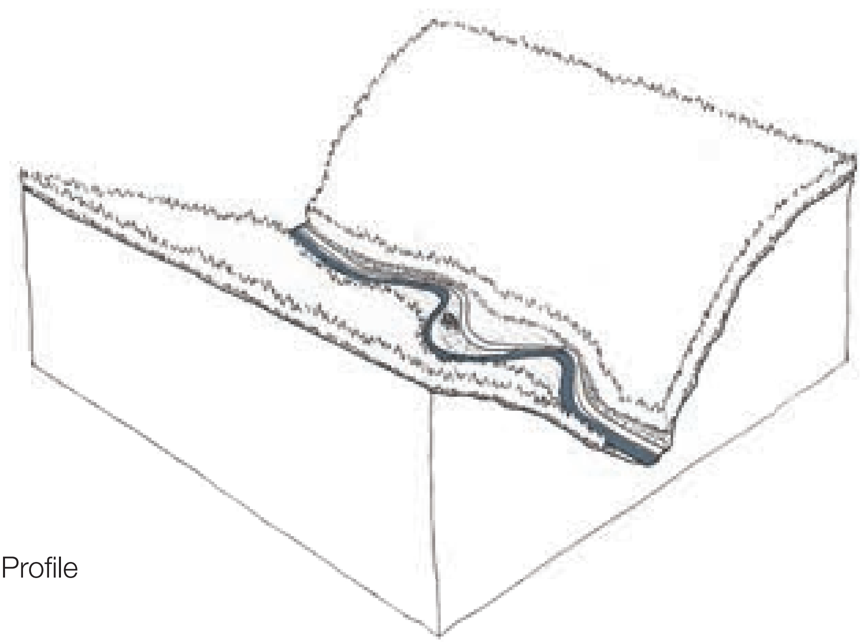




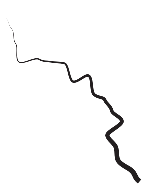
Canyon

The upstream valley is demarcated by the canyon, where the river has carved a deep V-profile in the volcanic bedrock. The narrow passage provides only enough room for the road and the river, which flows briskly over the shallow rocks. Plane and alder trees grow at the waters edge. The steep slopes are densely covered with (pine) trees. Views in the canyon are limited due to these steep slopes and the bends in the river.
In some places the slopes are gentler and used as grassland. Apart from a few incidental farms, there are no buildings in the canyon. The historical Via Verde, with its tunnels and bridges, and the remains of cutoff drains on the slopes are the only further signs of human activities.

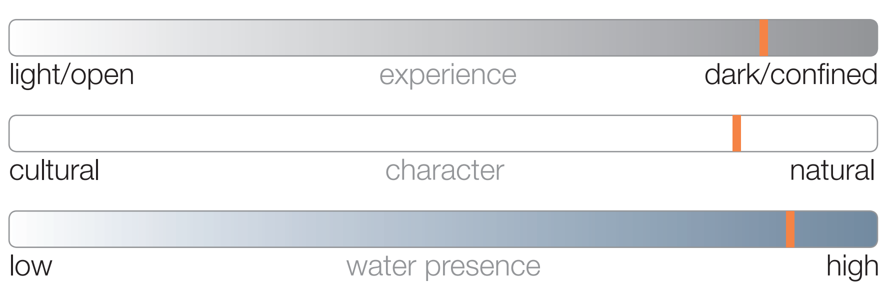


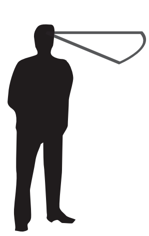


Profile

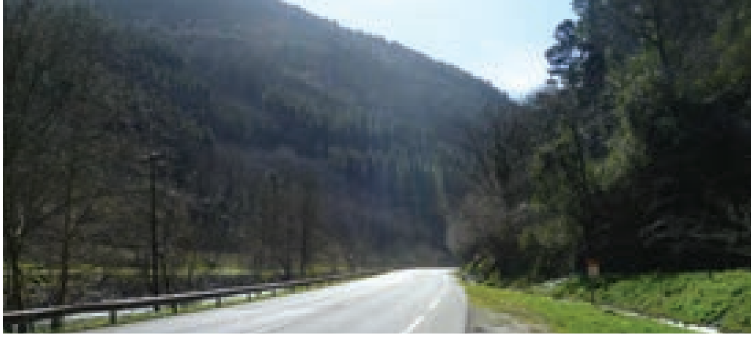


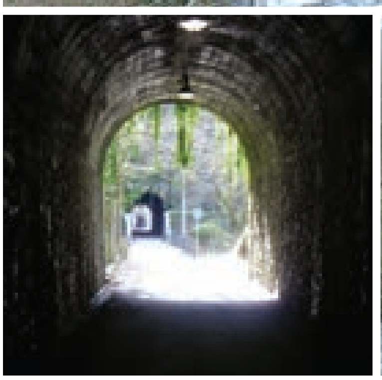
Rough and bending river

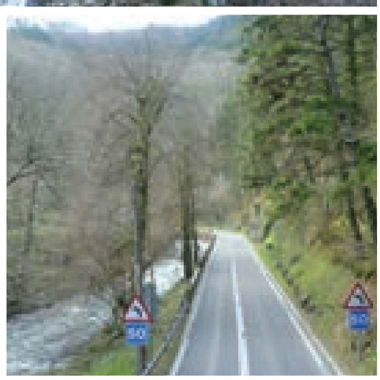




Narrowed view

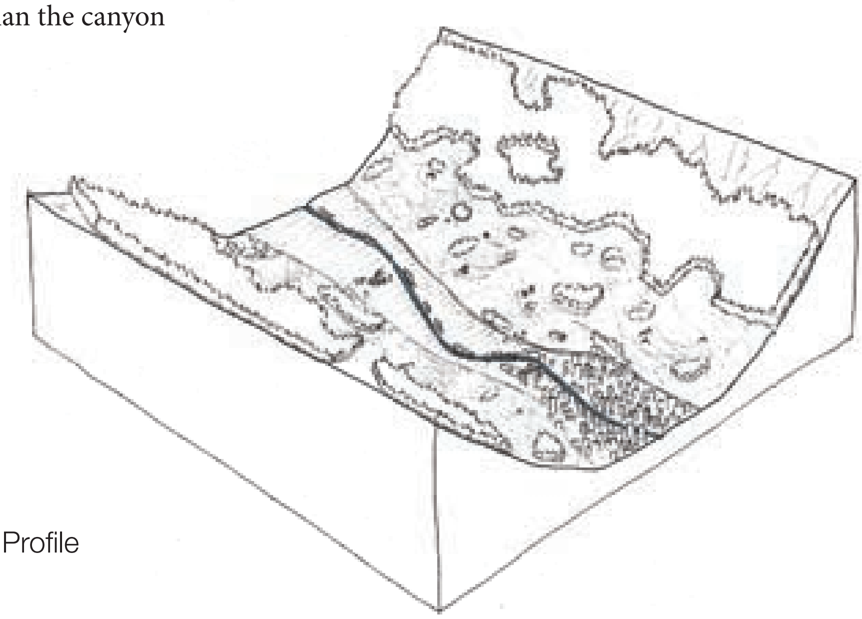






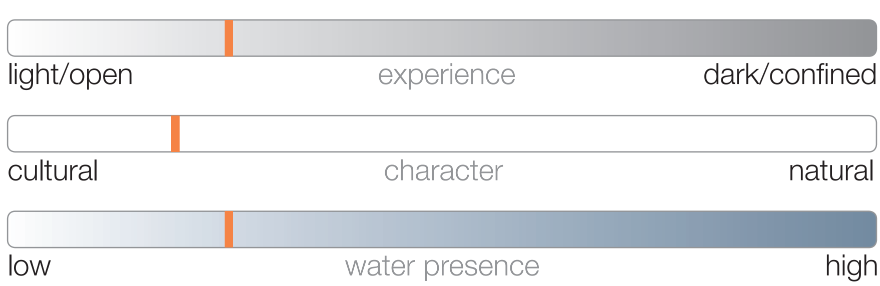
Valley

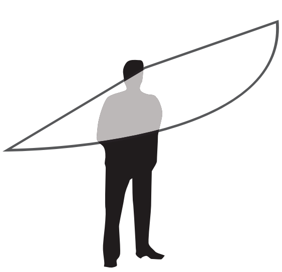
Eventually the canyon widens and the Iraurgi valley reveals itself, Mount Erlo looming in the distance. The slopes are gentler and the mountain ridges further away, though still present. The broad floodplain leaves room for crop fields and grasslands. The agricultural land is abruptly interrupted by the industrial outskirts of Azkoitia, the first of the two cities in the Iraurgi valley. Beyond the industrial area, the river enters the residential parts of the city where it has a narrow and urban profile. After leaving the city the riverbanks become more natural again, and it is lined with flat crop fields and grasslands. A few farms are on this floodplain.
In the center of the valley, next to the river, is the sanctuary of Loyola, the main cultural attraction in the area. Passing the garden of the sanctuary, the city of Azpeitia fills up the floodplain. At the historical center the Urola river is joined by its main tributary, the Ibaieder. These combined streams are then pushed into the canyon on the north edge of the city, which is shorter and more open than the canyon before the valley.



Profile

Slow and lightly bending river

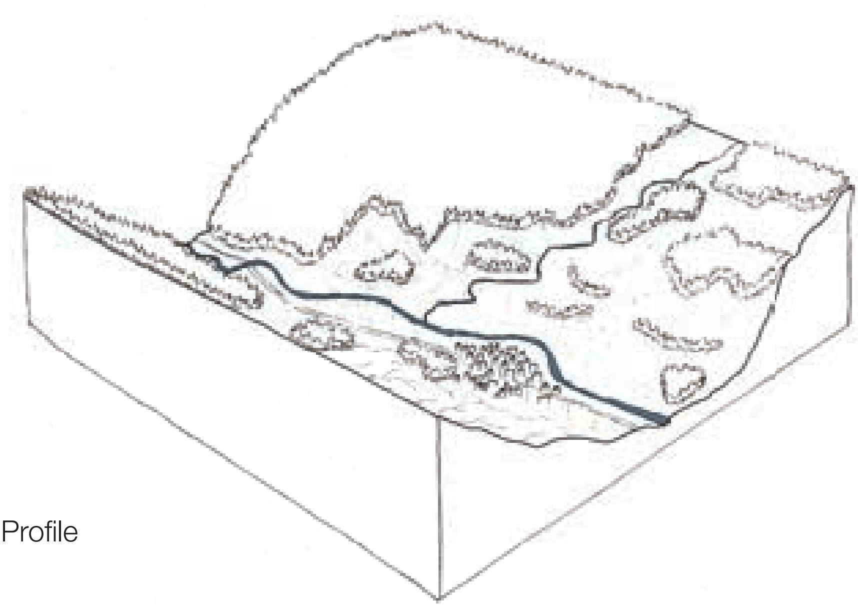


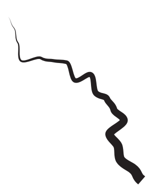


Open views

Transition

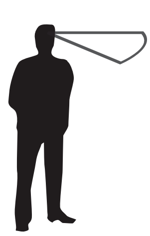
Alternating short canyons and more open valleys form the transition between the inland to the south and the coastal area to the north. After passing an few industrial sites and a quarry, the river passes the small village of Lasao, and then continues to Zestoa, a town on the foot of a mountain ridge close to the river. Zestoa is known for its thermal wells and historical health spa, and an early tourist destination in the area. Ekainberri, the earliest prehistoric settlement known in the Basque country, is situated in a side stream valley of the Urola. The mountain ridge north of Zestoa forces the river into a canyon again, which accommodates a big cement factory and quarry.





Rough and bending river, broad

Profile



Limited views

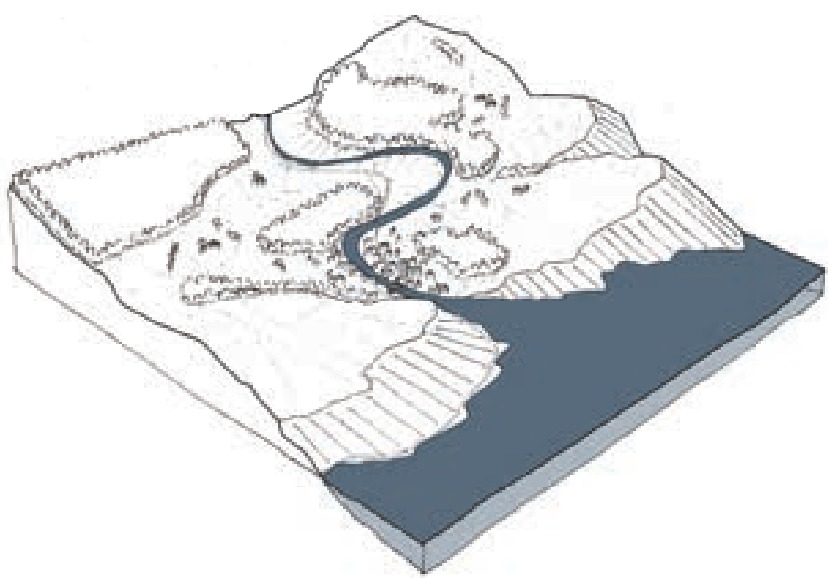




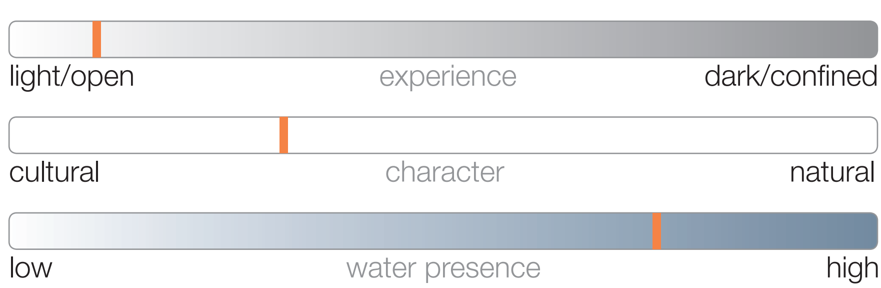


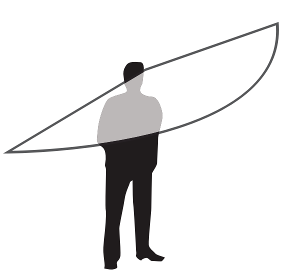

Meander/estuary

After the last canyon, the river starts meandering in big loops, leaving wide, gentle slopes on the insides of the bends. The hills become gradually less forested from south to north. After almost circling the high and dry village of Aizarnazabal, the Urola reaches its estuary next to the edge of a final mountain ridge. Protected from the sea by huge cliffs famous for their sedimentary layers, lies the fishing town Zumaia, bordering the river at the place where it enters the ocean. The seaside is an important tourist attraction of the Basque Country, and this lively town is packed with beach-goers during the summer months.

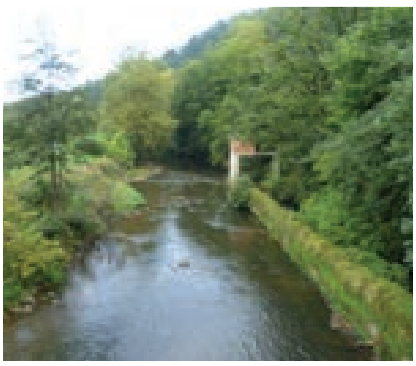


Calm meandering river, broad

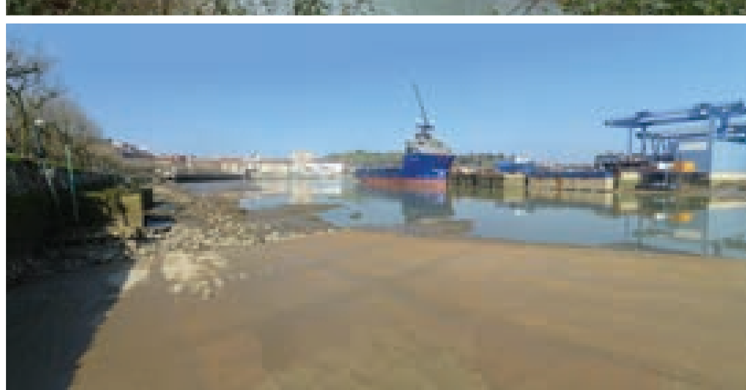




Open views



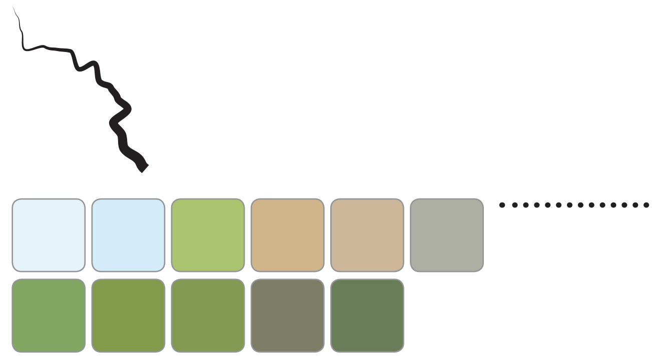



In this chapter the watershed has been explored and analyzed on the experience one has when driving through the different valleys. It can be concluded that every valley type has its very own character, although some valleys show similarities. Below and in the map on the next page an overview of the different characters is given. These characters can be used as a basis for design.

As can be seen in the map and the descriptions, the canyon and transition show some similarities. Both are characterized by a wild river and a narrow valley in which the river leads the way. Similarities can be seen between the valley and the meander/estuary as well. with a slow and broad river and large flat plains. Both have a cultural character with agriculture, but also urban and industrial areas. The upstream area contains some small floodplains as well.

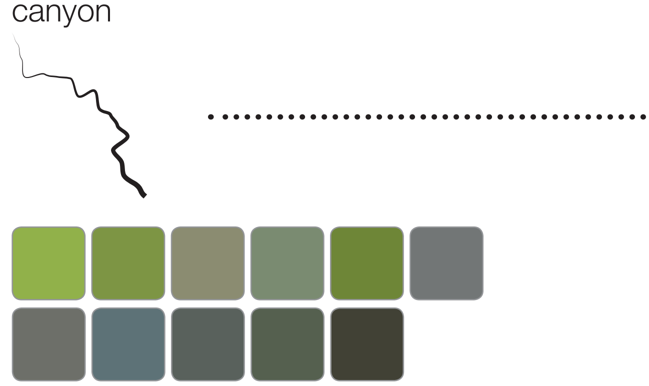
This characterization of the valleys of the main river can be seen as a general characterization for the tributaries of the river as well. The smaller streams are often similar to the upstream valley, bigger tributaries show transition like characters as well.

transition



A landscape with open/light and enclosed/dark, canyon like parts. The views are always quite limited. The character of the river is quite rough.

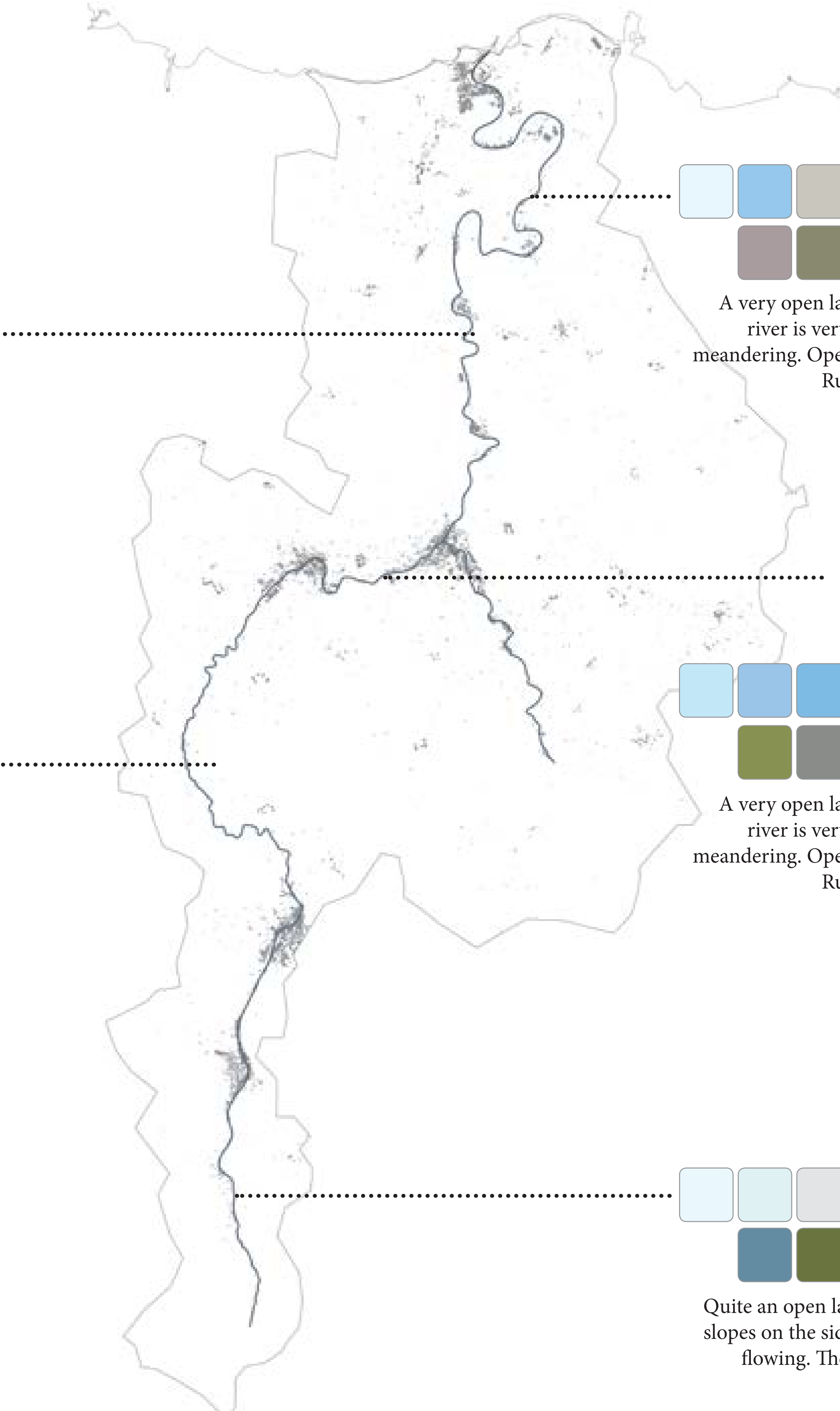
canyon



A very narrow valley, in which the river leads the way. It is a dark valley, with a rough and fast flowing river. Nature feels overpowering in this valley.

Synopsis

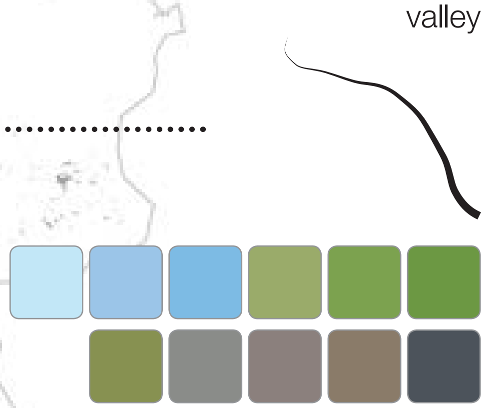
- There are several valley types that can be distinguished.
- Each valley has its own character of light/open, dark/confined, color and material pattern and presence of the river.
- Some valleys show similarities.
- The valley types of the main river can be found in its tributaries as well.
- The characters can be used as a basis for design.



meander/estuary

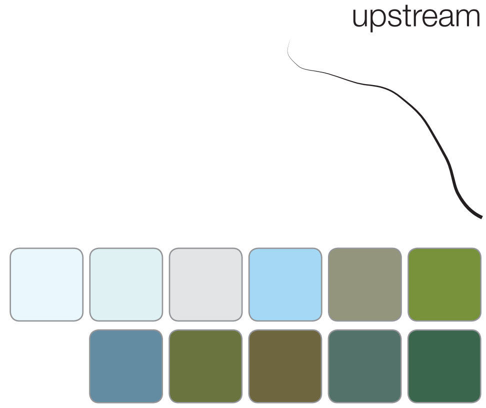
A very open landscape in which the river is very presented, calm and meandering. Open views are provided. Rural/natural character.

valley



A very open landscape in which the river is very presented, calm and meandering. Open views are provided. Rural/natural character.

upstream



Quite an open landscape, with rolling slopes on the sides. The river is gently flowing. The character is a mix of natural and cultural.

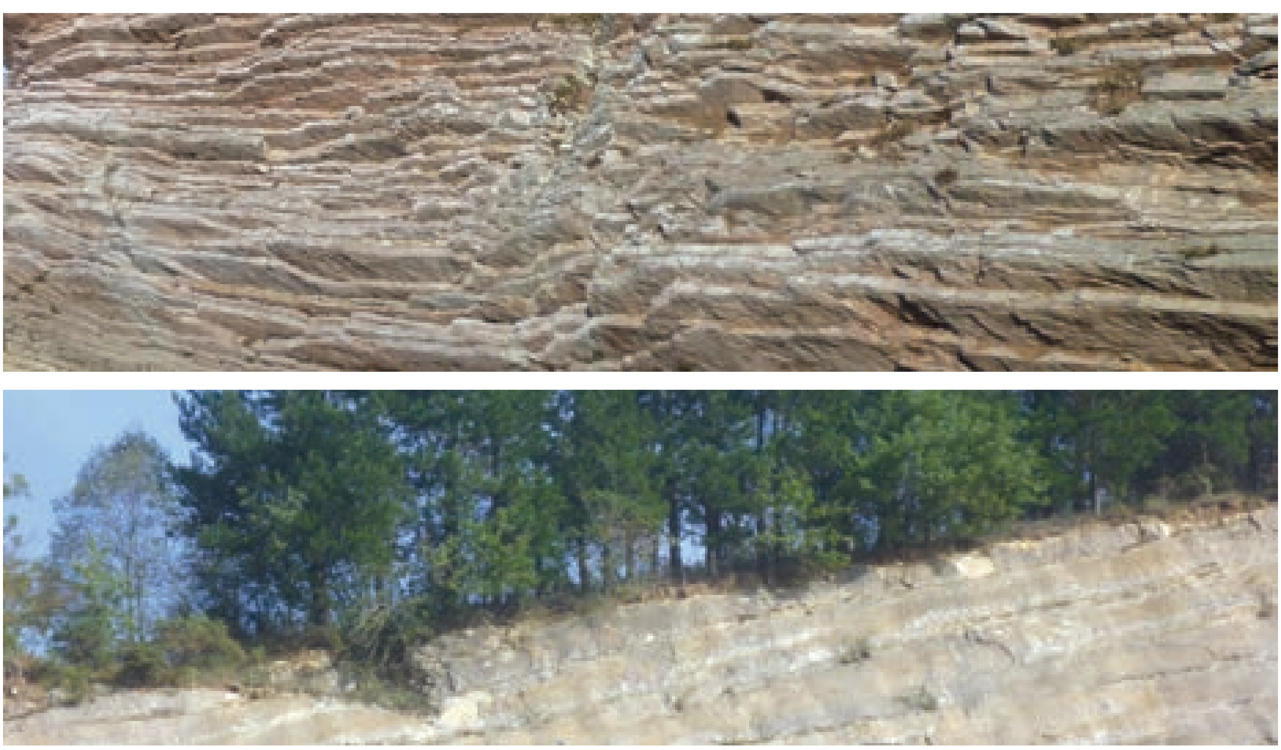
09 Landscape analysis

How the landscape of the Urola watershed works

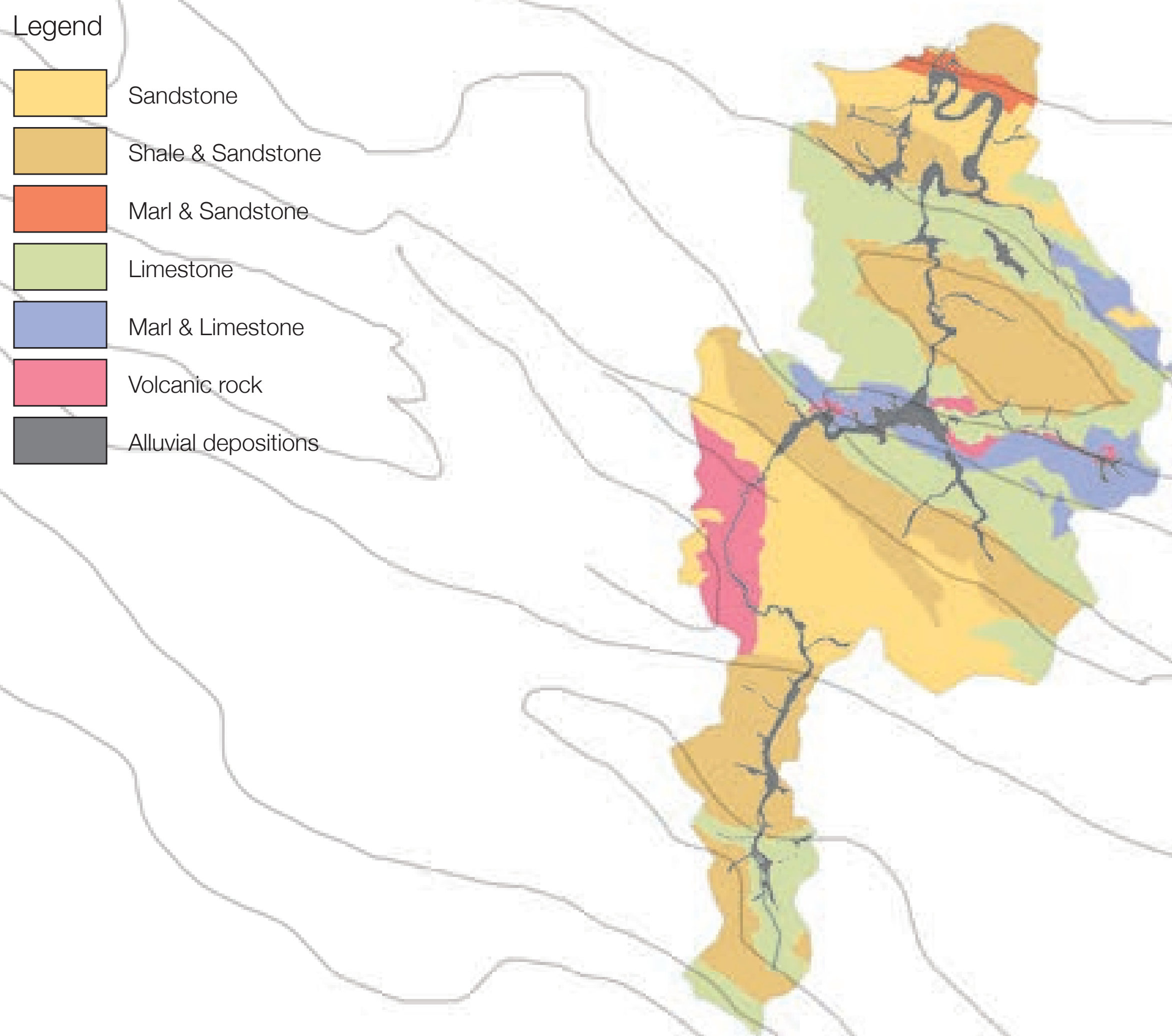
In this chapter the genesis of the Basque Cantabrian Basin, and especially the Urola watershed is explained. The Triplex model (Kerkstra et al., 1976) is used as the initial method to analyse how this landscape has been formed, and how human occupation patterns have developed.

The Urola watershed is part of the Basque Cantabrian Basin. The division between the Cantabrian Basin, which discharges into the Atlantic Ocean, and the Ebro Basin, which runs to the Mediterranean Sea has been created by the tectonic processes that formed the Cantabrian mountain range (or Cordillera Cantabrica) along the north coast of Spain, as well as the Pyrenees. Because this mountain range was once part of the seafloor, large parts of the subsoil consist of sedimentary lime- and sandstone layers. These horizontal layers have consequently been pushed up into vertical and diagonal directions [9.3] by the Pyrenean orogeny (Gómez, Vergés, & Riaza, 2002), creating mountain ridges parallel to the coast [9.4]. It also made the stratified subsoil visible in the landscape [9.1], like the famous Flysch cliffs of Zumaia, the small fishing port at the mouth of the Urola.

Rivers, such as the Urola, have been formed perpendicular to the coast. Finding their way between, and cutting through the mountain ridges, they have an important role in shaping the landscape. The continuous incising of the streams in the subsoil, along with different gradients and the variety of geological characteristics has resulted in a range of distinct river valleys, from narrow and deep canyons to open floodplains and broad meanders.



[9.1-9.2]



[9.4] **Tectonics shaped the land**

[9.4] **Geological layers in the Urola watershed**

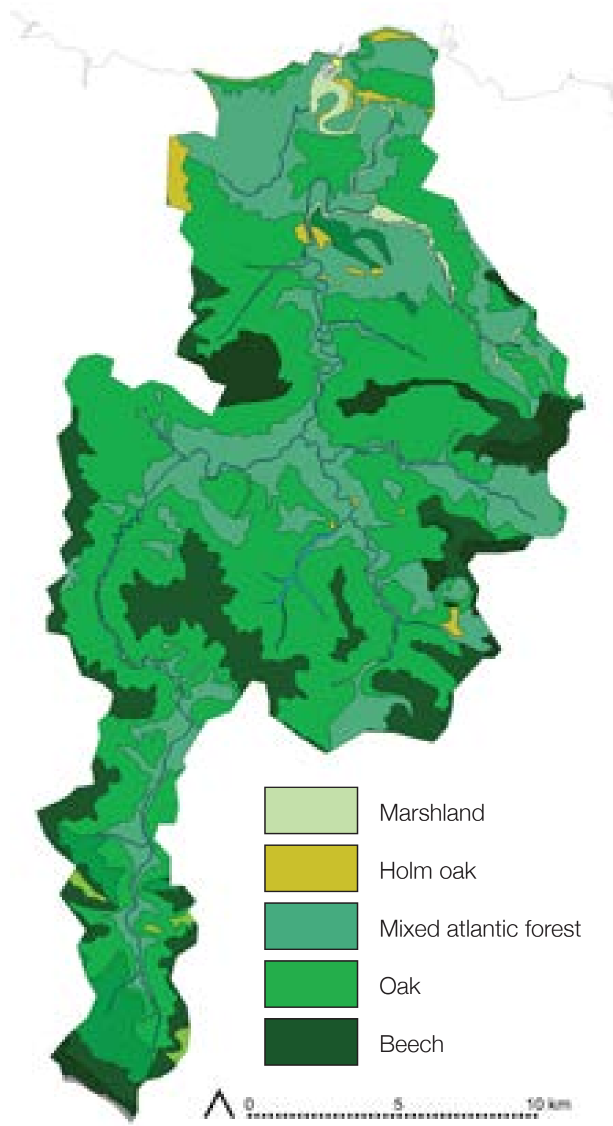
Erosive and sedimentary processes have formed a generally thin soil on the slopes of the Urola watershed, varying from bare rocks or very thin soil upstream [9.2] and on steep slopes, to thicker soils at the bottom of broad valleys with little gradient and the meandering valleys towards the river estuary. Most of these soils are characterized as cambisols or leptosols and have quite a low infiltration capacity (FAO/IIASA/ISRIC/ISS-CAS/JRC, 2009; Úr Agencia, 2012).. The thicker soils are mainly fluvial sediments that have a high infiltration capacity (FAO/IIASA/ISRIC/ISS-CAS/JRC, 2009; Úr Agencia, 2012). The subsoil consists of mainly impermeable layers of different types of material. (Úr Agencia, 2012)

The combination of soil typology and hydrological features defined the natural vegetation pattern, which is characterized by Alnus, and Fraxinus tree species in the wet valleys and on the lower slopes, and Quercus and Fagus forests on the higher slopes [9.5].

The Basque Country has been inhabited since prehistory. People lived in caves, such as Ekainberry, the oldest known dwelling place in the Basque Country, near the village of Zestoa. Because of the harsh living conditions in the Cantabrian Mountains, intensive occupation of the land and de development of agriculture were held back for a long time. When the Basque people became able to settle themselves in dwellings they would do so on the flattest parts, which are the rivers' floodplains (Gipuzkoako Batzar Nagusiak, 2006). These floodplains offered suitable building grounds and fertile soils for agriculture. The proximity to the river also provided easy access to water for drinking and washing. In many villages old public taps and washing places can still be found, as well as drinking facilities for livestock in the countryside [9.7-9.10].

With the development of this agricultural society, an infrastructural network arose along the valleys, which are the easiest accessible routes through the mountains [9.6]. Trade centers formed at intersections of these routes and became the origin of cities like Azpeitia, that is located where the Urola river is met by its main tributary, the Ibaieder.

The livelihood of people in the Urola watershed (and Basque Cantabrian Basin in general) has been dependent upon agriculture for a long time, but this changed around 1400, with the introduction of the watermill (ferrería in Spanish, zeharrola in Basque) as a tool to smelt and refine iron. The first ferrería was built in Legazpi around 1329 and many followed. The watershed owes its name to this invention, as Urola stands for water (Úr) and factory or mill (ola) in Euskara, the Basque ancestral language. Although the production of iron was already an important activity in the watershed since the Iron Age, the invention of the ferrería meant the rise of an 'iron industry'. The use of human labour in the production process was replaced by hydropower. Watermills used the energy of the rivers through



[9.5] **Natural vegetation**

[9.6] **Transport networks follow the valleys** a system of canals and waterwheels to power the bellows and hammers that were used to refine iron from iron ore.

This invention had a big influence on the anthropogenic pattern, as many of these ferrería's developed in the Urola watershed [9.00]. The 'iron industry' gave the economy of the region a large boost, and the shift of the iron production to the riverbanks, together with the complex system of dams, canals, and reservoirs, made a distinct transformation to the landscape. The ferrerías required a lot of firewood to smelt the iron. Large parts of the indigenous forest were cut down to provide this firewood, which resulted in very open valley slopes.

During the Industrial Revolution in the 18th century, hydropower and firewood were replaced by coal, and the ferrerías by blast furnaces (Azkoitikoudala.info, n.d.; AzpeitikoUdala, 2013; Gipuzkoako Batzar Nagusiak, 2006; Solsten & Meditz, 1988). This transition to the industrial age reduced the dependence on and disconnected human activities from the local landscape. Due to the industrial and technological development, humans became less and less restricted in the construction of roads and building by the physical characteristics of the landscape. The villages extended on large parts of the floodplain, both with residential and industrial areas. This industry was mainly focused on steel and textile (Azkoitikoudala.info, n.d.; AzpeitikoUdala, 2013; Gipuzkoako Batzar Nagusiak, 2006; Solsten & Meditz, 1988)

This development continued in the 20th century. Industries intensified, and villages extended simultaneously. As some industries demanded wood for their production processes, huge tracts of land were used for the plantation of pine trees, especially Pinus Radiata. The forested surface of the Basque Cantabrian Basin quadrupled in just a few decades. Furthermore, the steel industry demanded large amounts of water and to meet this demand large dams where build, whose basins provide the industry with water.

[9.7-9.10]

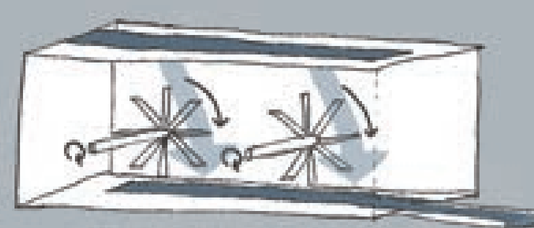
The ferrería

Iron was produced in 'ferrerías', which means 'iron factories'. A hydro powered ferrería is called a 'zeharrola' in Basque. Watermills used the energy of the rivers through a system of canals and waterwheels to power the bellows and hammers that were used to refine iron from iron ore, and to form the metal. The first known zeharrola of Guipuzkoa was the Gibelola, which was built in Legazpi in 1329. Over 200 more ferrerías were built in Guipuzkoa.

The water flows down the river.

Water from the river was collected behind a dam.

From the reservoir that was created behind this dam, the water was led to the antepara through a canal.

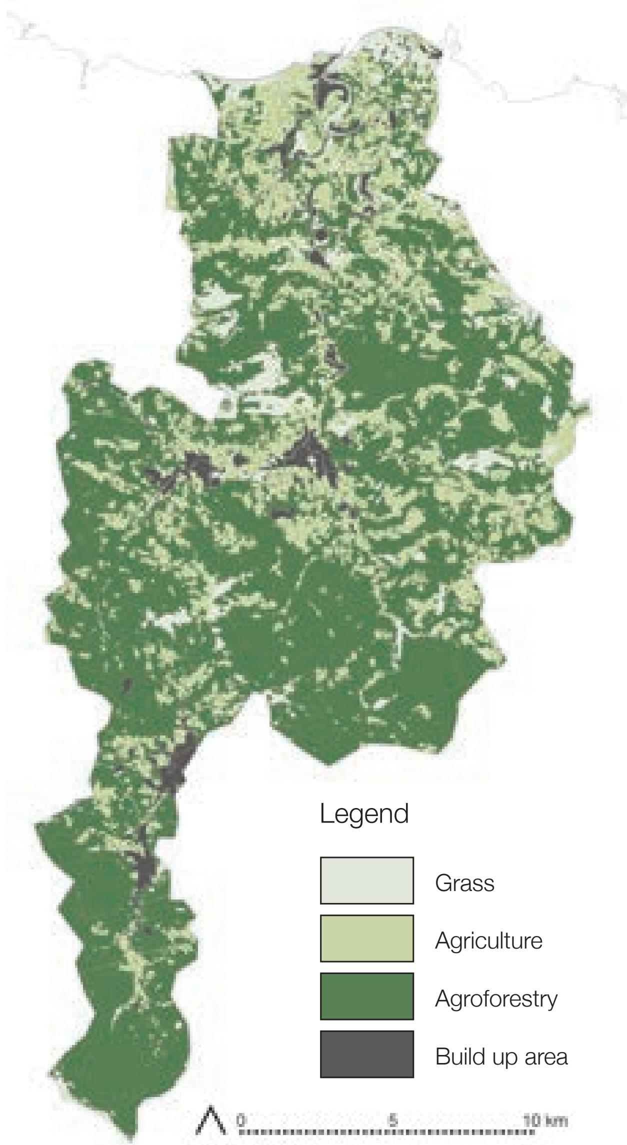


The antepara was a raised reservoir from where the water could be released on the water wheel in a regulated flow.

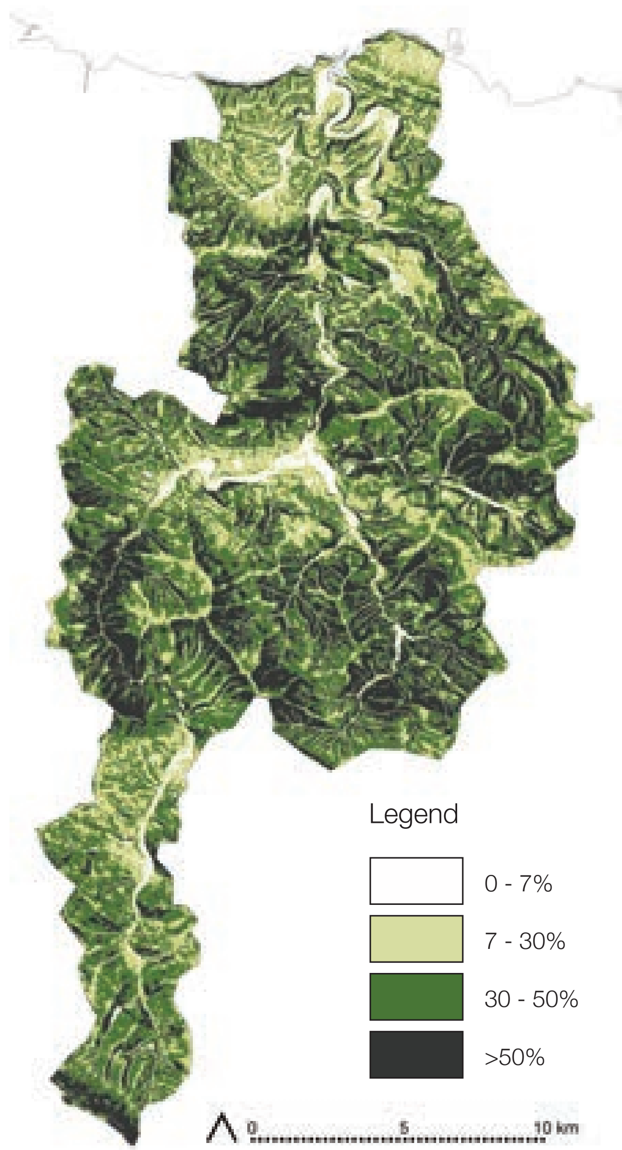
The driveshaft connected to the water wheel then powered the bellows and hammers used in the iron production.

[9.11] Former watermills

[9.12]



[9.13] **Land use in the Urola watershed**



[9.14] **Slope angles in the Urola watershed**

When looking the Urola watershed, a link between land use [9.13] and slope inclination [9.14] can be distinguished. Different slope angles all have their typical occupation pattern. The slope angles can be roughly divided into four classes:

Flat plains and undulating slopes (0-7%)

Rolling and hilly slopes (7-30%)

Steep slopes (30-50%)

Very steep slopes (>50%)

Most of the land on the floodplains has been occupied by both residential and industrial build up areas. The rest of the land of the floodplains is used for agricultural purposes and mainly cropland and grassland. This agriculture is of a small scale.

What can be noticed on the gentle and rolling hills is that the land is mostly open and in use for agriculture. The agriculture in this part of the landscape is very small scale and the typical Basseri (farmhouse in Basque) focuses on multiple activities, such as cattle, cropland, orchards and vineyards. This part of the landscape has been altered the least, but when a closer look is taken at the role of the water system here, a dramatic change becomes apparent. Most of the natural streambeds have been channelized above or underground, stimulating fast water runoff, and preventing the agricultural landscape from being drenched. A notable feature of this landscape type are small plots of pine trees, that are planted here by farmers as these trees ensure a certain income, which is often higher than the income gained out of other agricultural activities (Ruiz, Mandaluniz, Albizu, & Oregui, 1998).

[9.15] **Agroforestry**

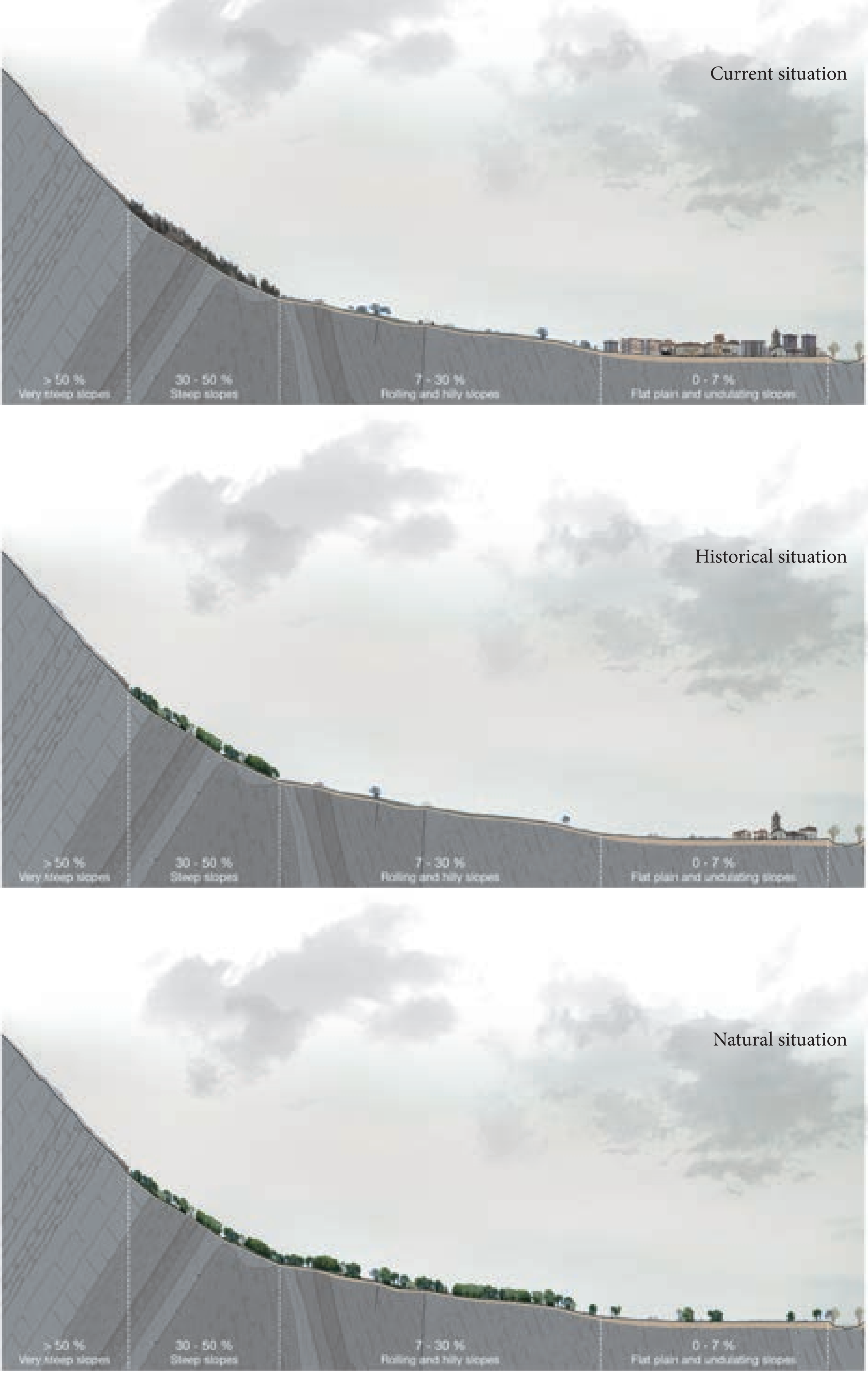
Large plots of pine forest, used for agroforestry, characterize the steep slopes [9.15]. Although this is a very intensive land use type, local people do not use this landscape often. The biggest disadvantage of this type of production forest over deciduous forests is that the roots of pine trees retain far less water, which causes a higher percentage of run-off water in cases of extreme precipitation. Furthermore, the methods for harvesting are focused on making as much money as possible. The whole tree is harvested, leaving the ground bare, affecting the soil badly (Artza, 2005).

The very steep slopes are partly bare rock that is not occupied by human land uses. People do use these areas for recreational purposes, such as climbing and hiking. The remaining part of the very steep slopes is used for agroforestry like the steep slopes. Very steep slopes are most noticeable in the high parts of the mountains, and in the deep canyons that form a distinctive landscape typology in the area.

An important land use activity, both culturally and economically are the so called Huertas (allotment gardens). Many people that live in the cities and villages own a small plot of land on which they grow their own food. The economic function of the Huertas lies not directly in the income that people gain out of their garden. It does however offer them a source of food in case of unemployment and a way of spending time. These Huertas show that some parts of the human organization are still closely linked to the natural system.

Varying combinations of these slope classes are found throughout the region, constituting different valley types. The north side of the Iraurgi valley is further examined because all four slope classes are present here [9.20] and the related land use is very exemplary.

Figure [9.16] shows the relation between slope class and land use over time.



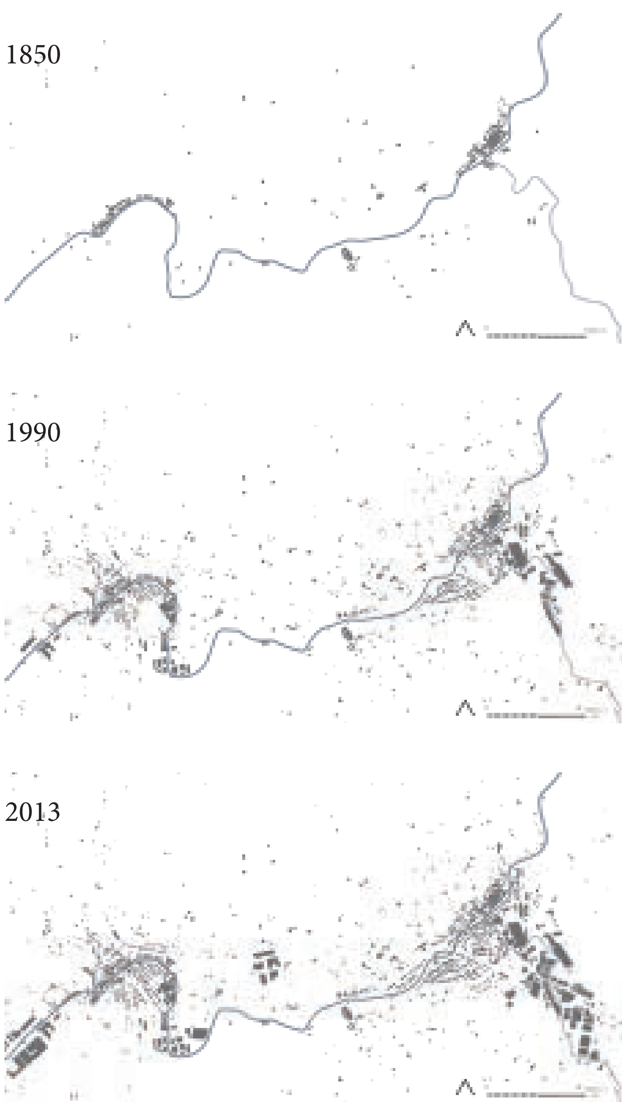
[9.16] Land occupation on the north side of Iraurgi valley

The aforementioned Iraurgi valley is further analysed to get a more detailed view on the landscape. Besides the presence of different slope classes it also is representative for other parts of the watershed in terms of flood problem occurrence [9.18], and the development of build-up areas and infrastructure [9.17].

The Iraurgi valley lies roughly halfway down the Urola river. Two of the larger villages of the Urola catchment, Azkoitia and Azpeitia, are located in this valley. The names of these villages that were established in the 14th century, translate as 'up the rock', and 'down the rock', which could refer to the Erlo mountain that confines the north side of the valley, and rises to a height of over 1000 meters. However, it is believed that the names actually mean 'upstream' and 'downstream', indicating the historical significance of the river for the local inhabitants. Azkoitia lies at the western end of the valley were the Urola emerges from a long and narrow canyon and meanders onto a floodplain. At the eastern end of the valley the Urola is joined by the smaller Ibaieder in the city centre of Azpeitia, before continuing north into the next canyon.

People have been living in and around the Iraurgi valley for thousands of years. Remnants of a settlement from the Iron Age can still be found at the Munoaundi site. An agricultural landscape evolved around the Urola on the low plains. Over the years the villages of Azkoitia and Azpeitia have been developing in a way that is characteristic for the development of the Urola watershed.

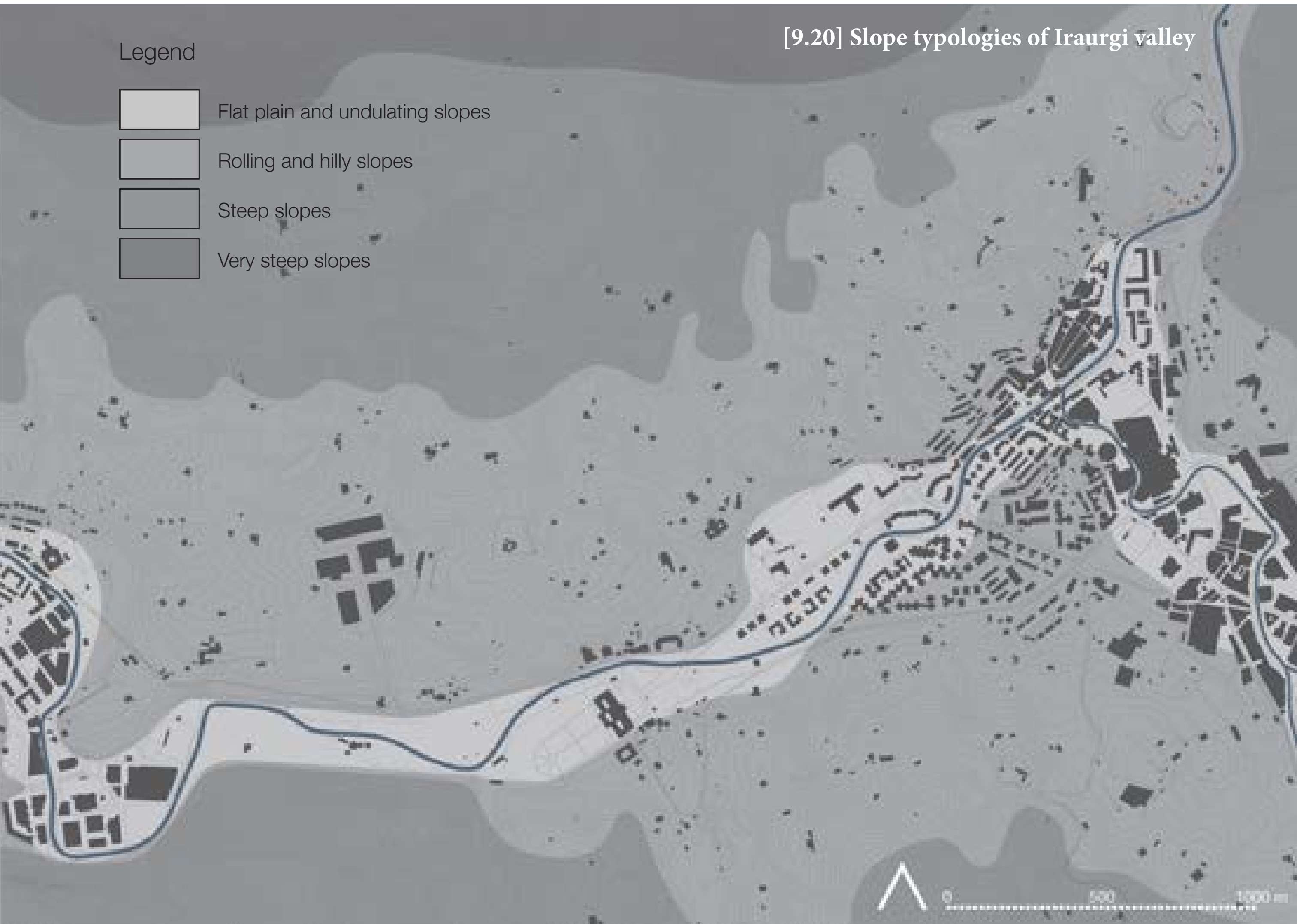
When looking closely at the defined slope typologies and related land use types, some finer distinctions can be made.
Runoff has incised in the slopes of the river valley, forming brook valleys. These valleys start at regular intervals high up the mountain as narrow streams in the forest and become increasingly wider and more visible down the slopes. Many of these streams however have been channelized and drained., which has increased the run-off. The consequences of this will be explained in the next chapter.



[9.17] **Development of Azkoitia and Azpeitia**

[9.18] **Flood map of the Iraurgi Valley**

[9.19] Satellite image of Iraurgi valley



[9.20] Slope typologies of Iraurgi valley

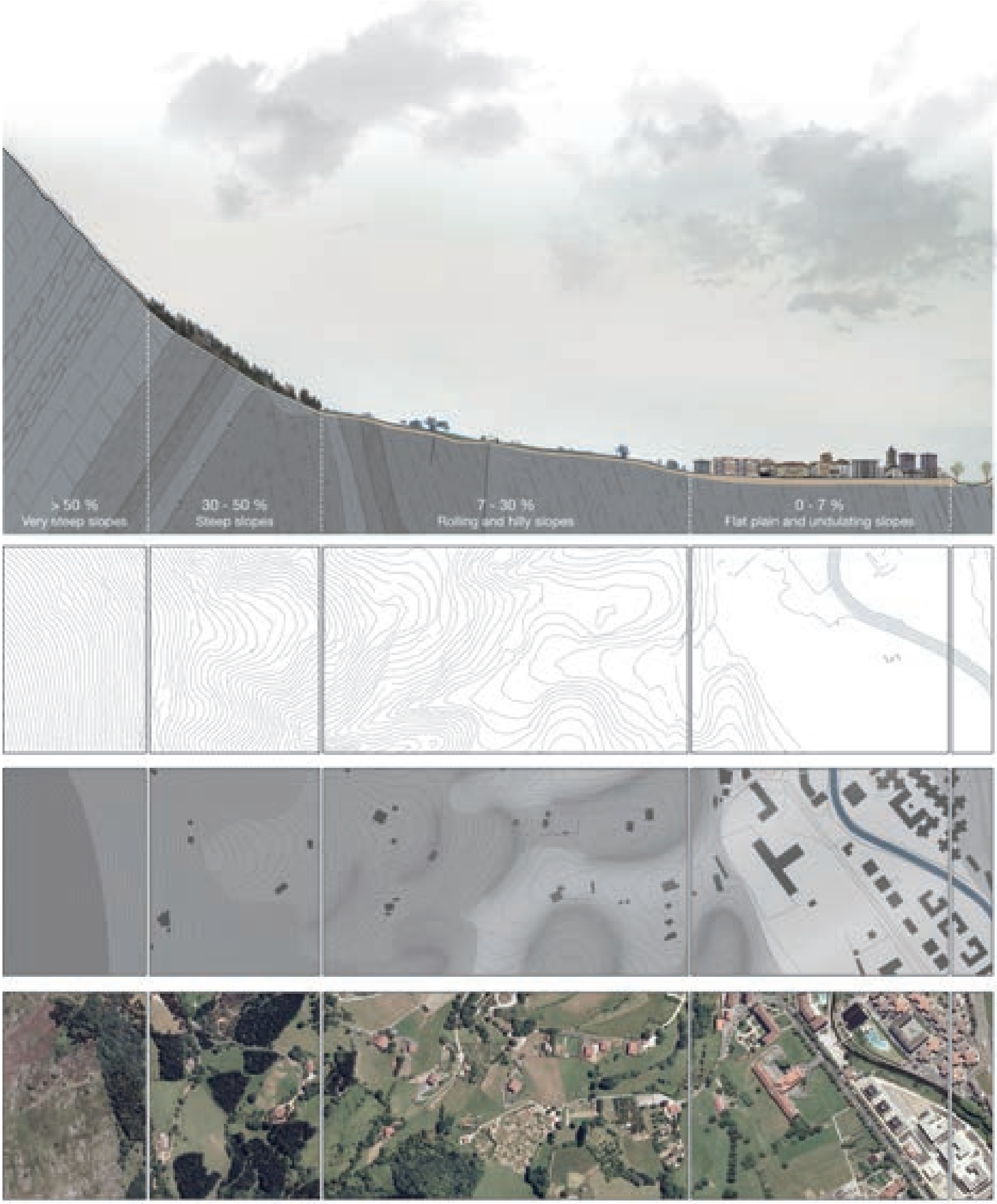
[9.21] **View at the north slope of the Iraurgi Valley**

On the gentle slopes the valleys are divided by higher spurs that protrude into the valley. These spurs and brook valleys used to be overgrown with deciduous forest, but were turned into grass- and cropland, a few centuries ago. In the current situation some (fruit) trees are found on the spurs, along with earth banks and most of the farmhouses. The brook valleys remain relatively open with grassland and some allotment gardens. [9.21-9.25]

[9.22] **Spurs and valleys of the gentle slopes**

Synopsis

- The Urola watershed is a mountainous landscape as a consequence of the Pyrenean Orogeny
- The water system used to have several functions, such as the remnants of ferreria's and washing places show.
- The human organisation of the Urola watershed has diverted itself from the natural (water) system.
- Still, a link between the slope angles of the landscape and the human land use can be distinguished.
- The Iraurgi valley is a respresentative area for many places in the watershed.
- Slope typologies and sub slope typologies can be distinguished.
- Most of the streams in the sub typology spurs and valleys have been drained or channelized.



[9.23] Slope angles in relation to land use and subtypologies

[9.24] Brook valley with allotment gardens

[9.25] Valley inbetween spurs

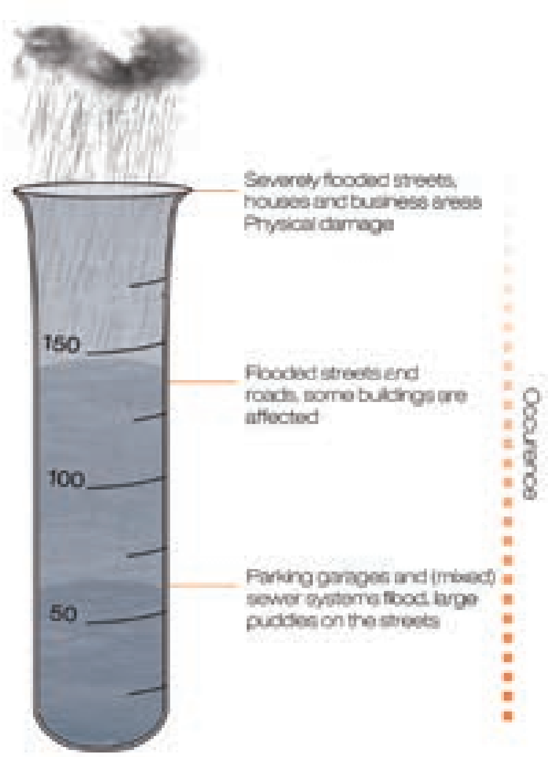
10 The water system

A technical analysis of system and conflicts

In this chapter the water system of the Urola water system is analyzed, together with an analysis of the conflict, problems and causes of the problem.

The Urola watershed has a surface of 230,32 km2 (Úr Agencia, 2001)It is a representative watershed for its surrounding watersheds in the Basque Cantabrian Basin. Its main river is the river Urola, with a length of over 50 kilometers. It has some smaller side rivers, such as Ibaieder and Larraondo. Each river is fed by its own source but also by several smaller creeks and streams with separate sources.

As every watershed, the river has an upper, middle and lower basin, which is determined on the sediment yield of the river., which is already described in chapter 10 (Úr Agencia, 2001, 2012). The upper basin (Tramo Alto) is the area around



[10.2] **Impact of precipitation events**

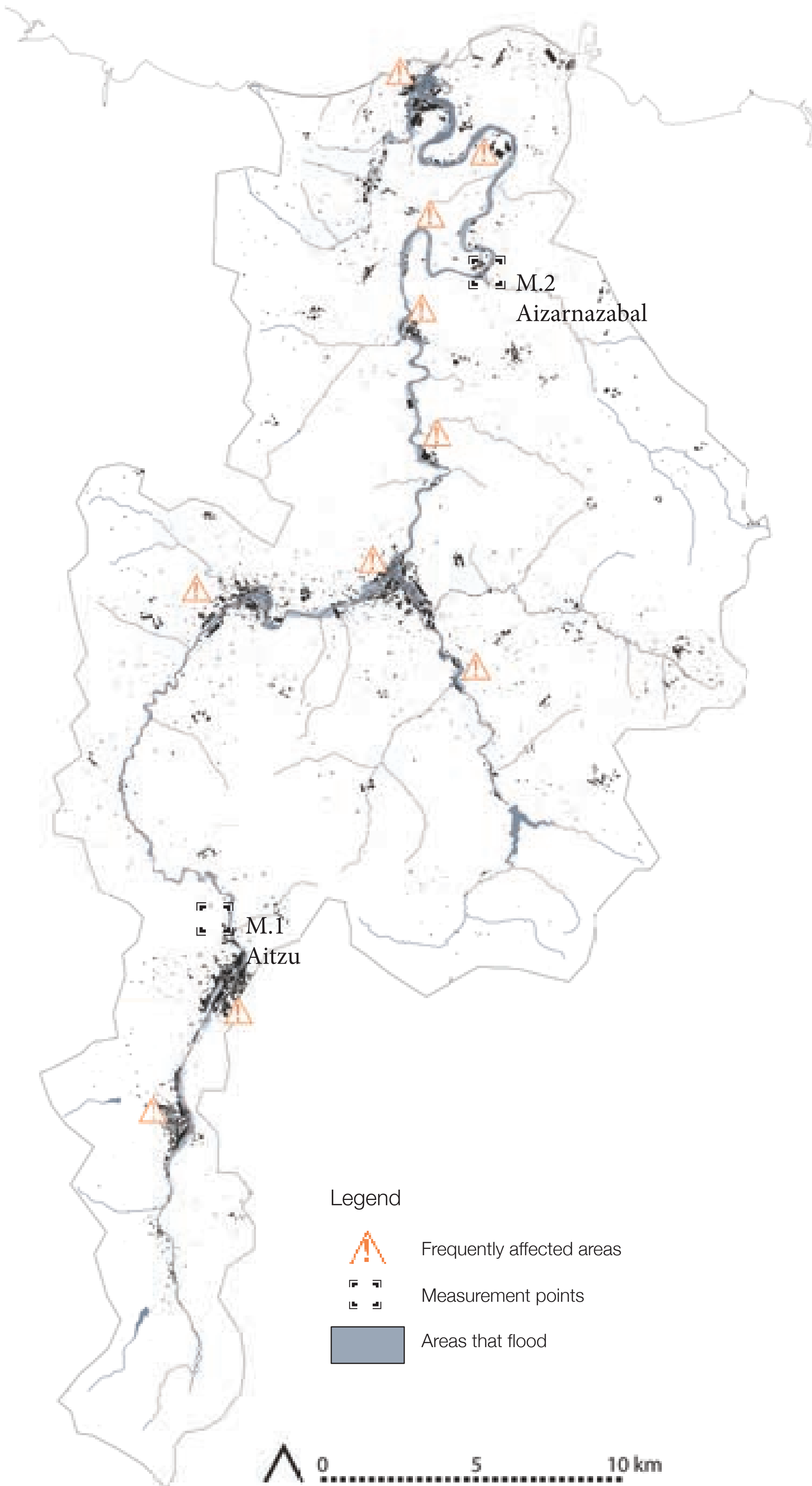
	T=10	*T=100*
Upstream	*125*	*200*
Midstream	*150*	*225*
Downstream	*175*	*250*

[10.1] **Categorization of rainfall events in parts of Urola (CAPV, 2001)**

Legazpi and upstream. This upper basin is the area in which the river subtracts most materials from the soil. The middle basin (Tramo Medio) is the area between Zumarraga and Azpeitia and the lower basin (Tramo Bajo)is the area between/around Zumaia and Zestoa. In the lower basin most of the earlier subtracted material is deposited again. In the upper basin the water flows fastest as the gradients is largest, as soon as the river enters the floodplain of the Iraurgi Valley, which is the area of Azpeitia and Azkoitia, the gradient is reduced and the speed of the water is reduced to, letting the water accumulate.

The annual rainfall in Urola watershed normally lies between 1500-1900 millimeters, for dry years it can be lower, between 1000-1300 millimeters a year(Ministerio Medio Ambiente, 1997; Úr Agencia, 2001)The rainfall events occur in the complete watershed Urola, although the amount of rainfall differs per area [10.1], with the highest amounts of rainfall in the upper basin and the lowest amounts of rainfall in the lower basin (Úr Agencia, 2001)

In the Urola watershed, extreme precipitation events are no exception. These extreme precipitation events cause the river(s) to exceed its banks, especially in the middle and lower part of the river, and flood the low lying areas next to the river. In [10.3] the spatial consequences of these exceeds are shown on the scale of the watershed, [10.2] shows the resulting damage of different sized precipitation events.



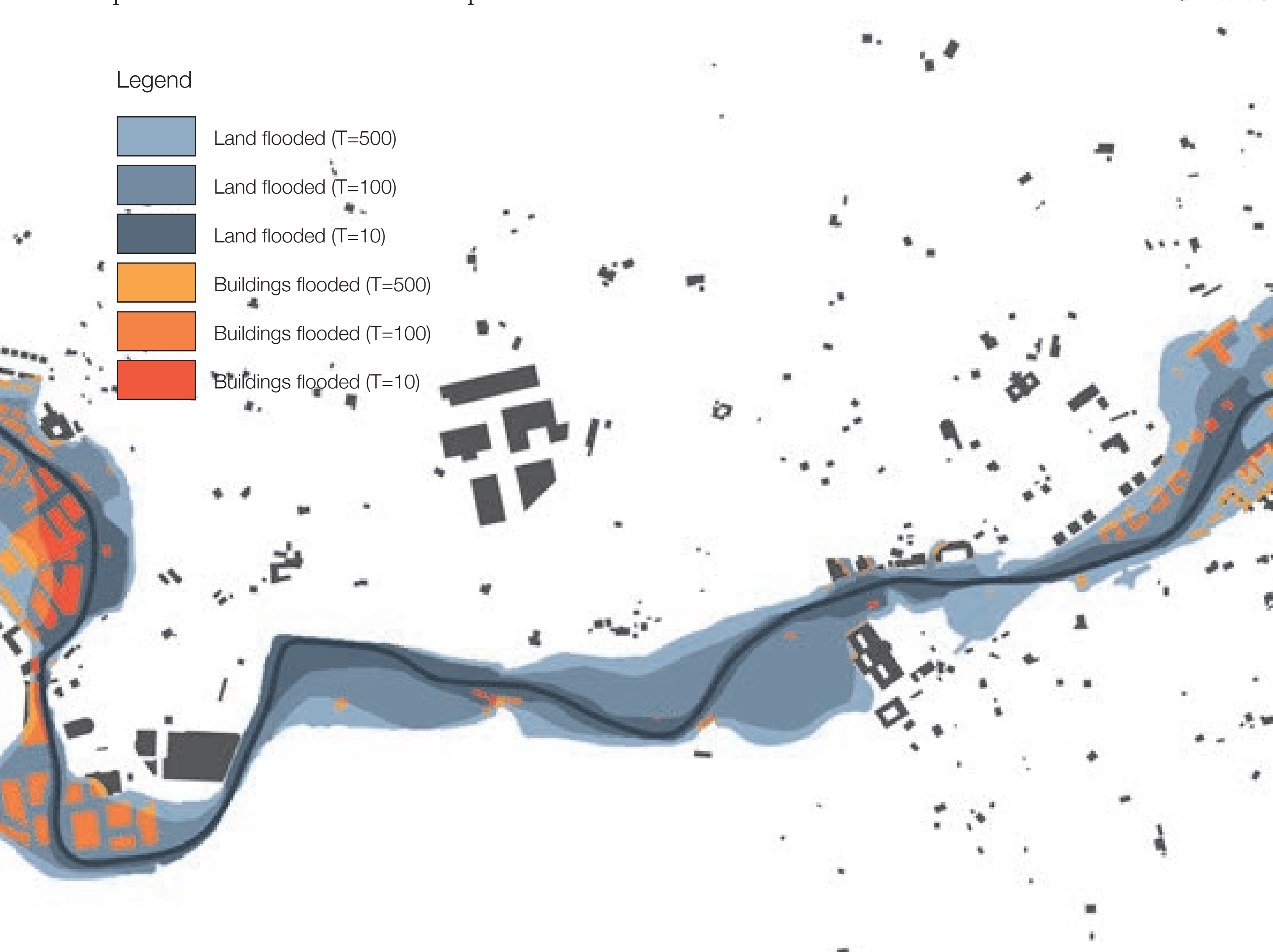
[10.3] **Flood map of the Urola watershed**

There are differences in the size of the problems and in the return periods for different cities. The villages of Zestoa and Urretxu for instance face flood problems mostly in cases of very extreme precipitation that have a return period of only once in hundred or once in five hundred years. The villages of Azpeitia, Azkoitia, Zumarragga and Lasao face a lot of flood problems in cases of extreme precipitation events with a high return period, such as occur once every year to 10 years (Eraso, Gallastegui, & Agirre, 2009). In [10.4] the Iraurgi valley is highlighted, showing the spatial consequences of the floods for the villages of Azpeitia and Azkoitia and the flat plain in between.

The differences in flood damage can be elucidated by the location of the villages. For instance for the villages of Urretxu and Zumarragga, which are located close to each other with the river separating them. Most of Urretxus' build up areas are located a little higher than the river, which secures them for floods with a high return period and a lower intensity, whereas Zumarragga has parts of its build up areas located next to or even on top of the river.

These areas are already prone to floods that are less intensive and have high return periods. The villages of Azpeitia, Azkoitia and Lasao are also located next to the river on its floodplains but also in the lower part of the watershed. This enlarges the problems for these villages as in this lower part there is a larger quantity of water that is discharged by the river and on the floodplains the flow speed is reduced, making the river broader. In cases of extreme precipitation its course becomes even broader, flooding its plains.

In practice the last big flood in the Basque Country took place in 2011. It was a devastating flood that damaged infrastructure and build up areas, caused landslides, [10.5-10.8] and killed one person, while a hundred people had to be evacuated and thousands were affected. (Egaña et al., 2013)
Next to the occurrence of these extreme flood events with a lower return period, there are also smaller, less extreme events with a high return period, that is almost yearly. These events damage build up structures and infrastructure as well and consequence crop failure.



[10.5-10.8] **Photos of the flood event at 6 november 2011 >**

	6-11-11
Aizarnazabal	92 (d.b. 110)
Aitzu	139 (d.b. 106)

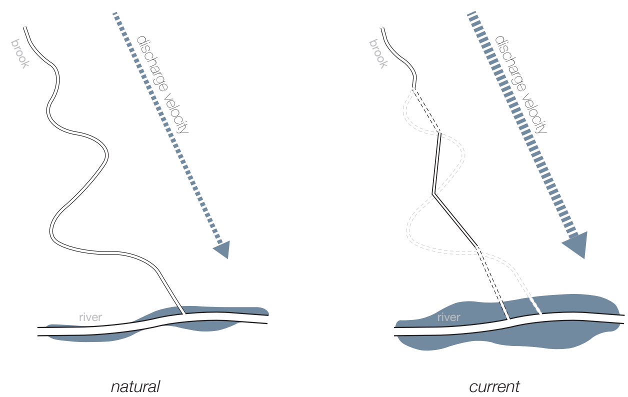
[10.9] **Monitored precipitation (mm) at the flood event of 2011 d.b.=day before**

[10.4] **Buildings and land affected by floods**

[10.10] **Natural streams**

As can be read in the introduction and previous chapter, the floods are caused by the landscape its disability to respond to the extreme precipitation events, due to the thin soils and impermeable subsoil. The thin soils have quite a limited infiltration capacity. During a precipitation event, the soil will get moist over time and eventually no water will infiltrate, but it will run-off as surface water (Boonstra, 1994). The function that a landscape is used for and the gradient of the landscape do also have influence on the run-off and infiltration. Forests, for instance, retain more water than cropland or paved surface and steep hills have a much higher run-off than flat land (Boonstra, 1994). The pine forests used for agroforestry in the area though have a less positive impact on the infiltration and run-off than the deciduous forests in the area do.

The run-off is also dependent on the management of people, as has been described in the theoretical framework of this thesis. In the current situation there is a decentralized management, as has been stated before. Most of the management is focused on the fast discharge of water into the main river. This is done by draining and canalizing run-off water in pipes and canal. This management increases the quantity of water that the river needs to discharge, causing an increased flooding of the floodplain and



[10.12] **Natural stream versus canalized stream**

[10.13] **Rainwater run-off canal in Zestoa**

[10.11] **Current drained and canalized streams**

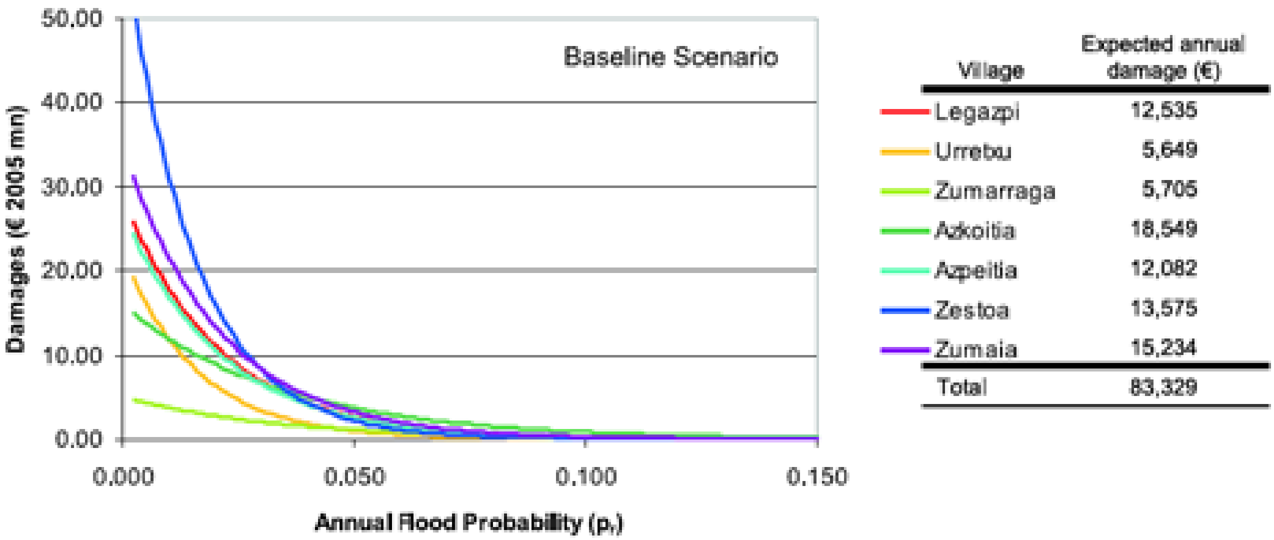
thus increasing the problems of villages such as Azpeitia and Azkoitia. [10.12-10.13]

In [10.10] and [10.11] it can be seen that many natural streams in the Iraurgi Valley are drained and canalized. Especially on the north side of the valley, which has been analyzed in the previous chapter, there are a lot of natural streams that have been drained and canalized. The situation in the Iraurgi Valley is representative to other areas in the watershed, where we observed many canalized and drained natural streams too.

With the knowledge of the landscape of the watershed Urola, the run-off during a precipitation event can be roughly calculated and estimated using the Curve Number method (Boonstra, 1994). When the maximum river capacity is distracted from this run-off the surplus of water is the outcome. This surplus of water will cause floods. In appendix 1 this calculation has been worked out for the Urola watershed. The outcomes of this calculation have been used to work with in this thesis. [10.14]

Event	*Surplus*
60 mm	518.636 m^3
80 mm	3.358.181 m^3
100 mm	6.197.727 m^3
147,5 mm (T=10)	12.870.658 m^3
225 mm (T=100)	23.589.942 m^3

[10.14] **Surplus of water in Urola watershed**



[10.15] Expected annual flood damage, current situation, calculated by the study of Eraso et al. (2009)

The annual costs for floods in the Urola watershed have been calculated to be around 83.000 euros, which are the costs for the main river and the largest seven villages located along its course (Eraso et al., 2009). For years with a severe and extreme flood event the costs will be much higher than this, whereas for smaller and less severe events the costs will be lower. There is also a division of costs between villages, as mentioned before, some villages have more damage for high return period floods, whereas others have more damage for low return period floods [10.15] (Eraso et al., 2009). The costs of the floods are expected to rise with about 15% due to the changing climate and linked increase of extreme precipitation events (Eraso et al., 2009; Galarraga, Osés, Markandya, Chiabai, & Khatun, 2011). Only recently (june 2013) new insights were published by the Úr Agencia, designating much higher costs than the costs calculated by Eraso. These new insights emphasize the urge of intervening in the research area.

The floods have a big impact on the everyday life of the people living in the villages. [10.16-10.17] Especially in the villages that have problems with high return periods, such as Azpeitia and Azkoitia. The flooding of parking garages, streets and sewer systems has a regular impact on their everyday life. For more severe events the Úr Agencia has an extensive evacuation plan to let everybody leave the area safely. Of course these evacuations do affect the everyday activities of the people, but it does secure their health and safety.

Conclusion

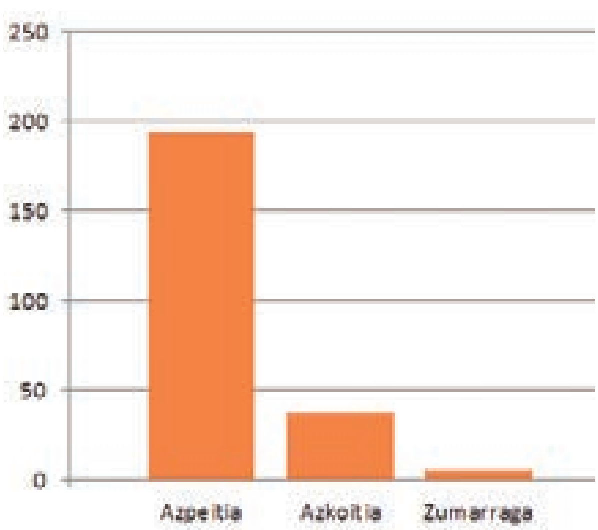
Due to the low infiltration capacity and the management of discharge most of the water in an extreme precipitation event needs to be discharged by the river, which does not have the capacity to do so, without using its (build up and intensely used) floodplains, causing floods and water problems in the human organization. Furthermore, there is a lack in water management on the watershed level.

The human organization is in need of a strategy that considers the whole watershed and that looks at landscape features and possibilities to increase the infiltration, retention and buffering capacity of the landscape. This will slow down the run-off, instead of speeding it up, hereby releasing the pressure off the water system when extreme precipitation occurs, and decreasing the occurrence of flood events.

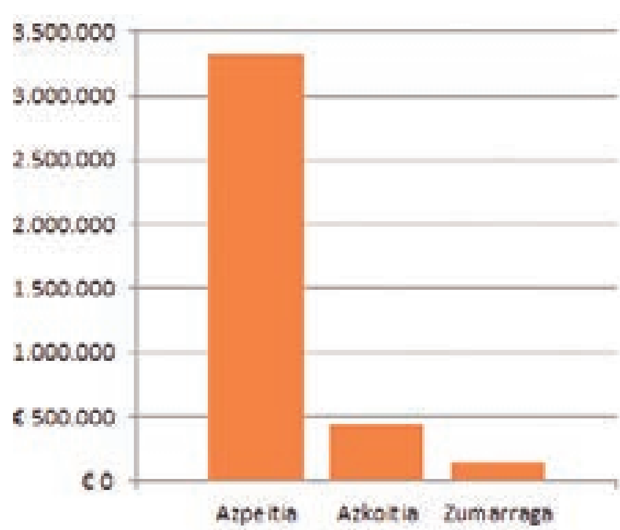
The strategy needs to have a focus on 'solving' events with a high return period, which will decrease the damage and caused. It will also soften the damages done by events with a low return period and will increase the time for evacuation, decreasing the chance on physical damage.

Synopsis

- Extreme precipitation events occur in the whole watershed, with larger events upstream than downstream
- Impact of event differs per area and village and is dependent upon their location in the watershed
- The villages located on the floodplain in the Iraurgi Valley, Azkoitia and Azpeitia, have large problems at both higher and lower return periods
- There is a lack in water management on the watershed level
- The decentralized water management is focused on getting rid of the water as fast as possible, increasing the run-off and flood problems
- The human organization is in need of a strategy that considers the whole watershed and that looks at landscape features and possibilities to increase the infiltration, retention and buffering capacity of the landscape.



[10.16] **Anually affected people according to the most recent studies**



[10.17] **Annual damage according to the most recent studies**

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Illustrations

7.10	http://blog.web-translations.com/wp-content/uploads/2009/11/plate-of-pintxos.jpg [Accessed on 6-10-2013]
7.11	Photo by Topagunea ; http://www.flickr.com/photos/topagunea/ [Accessed on 6-10-2013]
7.19	http://www.flickr.com/photos/basquemtb/5905864862/ [Accessed on 10-6-2013]
9.5	Adapted from gis database of Geo Euskadi; www.geo.euskadi.net
9.6	http://meta.gipuzkoakultura.net/bitstream/10690/91118/1/S19_003647.jpg [Accessed on: 6-10-2013]
9.10	Arkeolan. (n.d.). Ferrerias de Gipuzkoa. Retrieved July 15, 2013, from http://www.arkeolan.com/ferrerias-gipuzkoa/catalogo.php
9.13	Adapted from Geo Euskadi; http://www.geo.euskadi.net/s69-bisorea/en/x72aGeoeuskadiWAR/index.jsp?lang=en [Accessed on 6-10-2013]
9.14	Adapted from gis database of Geo Euskadi; www.geo.euskadi.net
9.15	Adapted from gis database of Geo Euskadi; www.geo.euskadi.net
9.19	Google Earth, 2013
10.3-10.4	Adapted from Geo Euskadi; http://www.geo.euskadi.net/s69-bisorea/en/x72aGeoeuskadiWAR/index.jsp?lang=en [Accessed on 6-10-2013]
10.5-10.8	http://www.diariovasco.com/multimedia/fotos/ultimos/87418-lluvia-provoca-graves-desperfectos-gipuzkoa-0.html [Accessed on 6-10-2013]
10.15	Eraso, N. O., Gallastegui, M. C., & Agirre, A. L. Flood risk and climate change. An estimation for the catchment area of the River Urola (2009).
10.16-10.17	Adapted from Úr Agencía, 2013; DEMARCACIÓN HIDROGRÁFICA CANTÁBRICO ORIENTALÁMBITO DE LAS CUENCAS INTERNAS DE LA COMUNIDAD AUTÓNOMA DEL PAÍS VASCO MAPAS DE PELIGROSIDAD Y RIESGO DE INUNDACIÓN, 2013

Part 4 Strategy & Design

In this part conceptual principles are developed from the conclusions of the part Understanding and the theoretical framework. These principles are translated into a strategy on the watershed level, which is then elaborated into a design (and detailed design) for the Iraurgi Valley and design propositions for the canyons and ferrerías.

11 Design principles

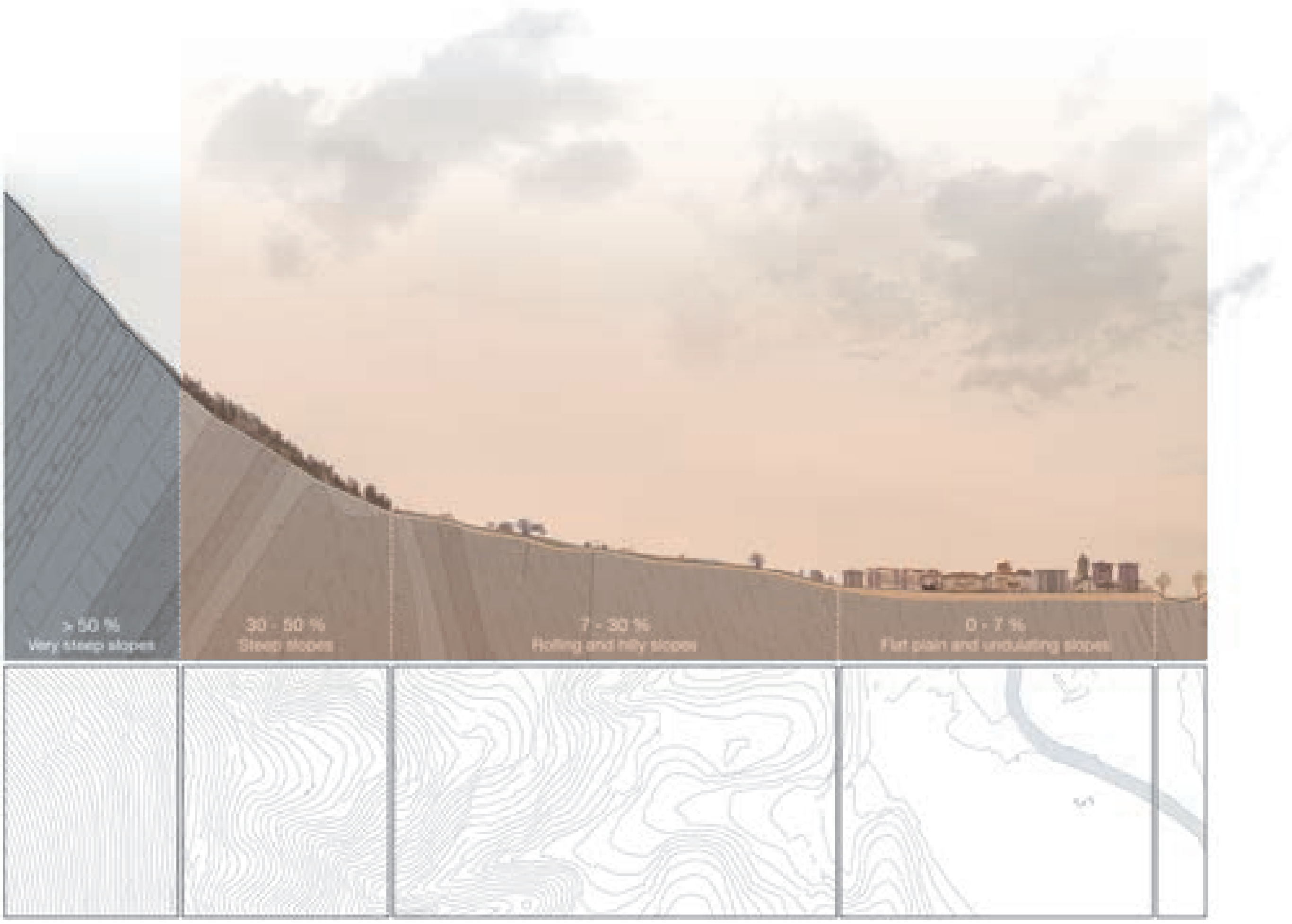
Conceptual onset towards solutions

This chapter combines the analysis with the theoretical framework and scope of this thesis to come to initial principles and guidelines that form the basis of the strategy. It embraces the principles of the landscape approach and related theoretical statements on what a resilient watershed and resilient watershed management are.
As has become evident from the theory, a resilient landscape needs to be based upon nature its generative and adaptive processes, as well as make these processes visible and possible to experience in order for them to be culturally sustainable. These two principles should form the basis of a strategy to come to a flood resilient landscape.

In the former part the Urola watershed has been analysed in several ways, giving insight in its landscape system, the life people live, the flood problems that occur and the way the river and water system can be experienced. In this part these insights are translated into guidelines for strategy and design, based on the principles stated above.

As mentioned in theory, adaptive and sustainable watershed management is focused on restoring natural streams and retaining/buffering water on logical places in the landscape. Furthermore it is important to consider the watershed as one system. In the former part it has been concluded that the Urola watershed (like other watersheds in the Basque Cantabrian Basin) is lacking both of the above.

The Urola watershed offers the potential to restore natural streams and create places to retain and buffer water. In [11.1] the slope typologies that have been determined in the former chapter are shown. Every type has its own characteristics and each of the types has its part in the flood problems: the steepest slopes generally feature bare rock and pine trees, which creates large amounts of run-off water; the steep slopes are covered in pine trees that reduce the infiltration capacity compared to deciduous forest; the gentle slopes have channelized and drained streams, and the floodplains are build up and do also have channelized and drained streams.



[11.1]**Area of intervention**

1. Intervene in the areas that are occupied and altered by humans

An important nuance between the causes of fast run-off on the four different slope types is that the bare rocks on the steepest slopes are not the consequence of human organization or occupation of the landscape, but are bare rock because of their steepness and are therefore not suitable for soils to form upon, as has been described in the former chapter as well. This nuance is the underlying argument to make the choice to intervene in the other three slope types [11.1], which can be seen as the first guideline. These areas are subject to the increased human occupation and its static water management, which is mainly focussed on increasing the run-off and discharge to optimize their land use activities. The water is merely seen as nuisance, whereas it offers a lot of possibilities.

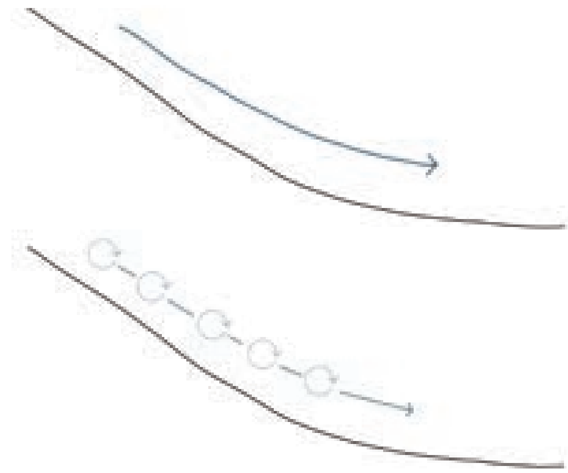
2. A strategy on the watershed level, management on the watershed level.

Apart from this static water management it has become clear from the research so far that the water management of the people in the Urola watershed, and Basque Cantabrian Basin in general, is mostly decentralized. This does not match to what the European Union and Robert Thayer describe as sustainable flood management (EUROPEAN COMMISSION, DIRECTORATE-GENERAL, & ENVIRONMENT, 2011; Thayer Jr., 2003). The proposed strategy and interventions of this research should reckon the whole watershed as an area of intervening and managing.

This strategy implies that people and villages in the upstream basin of the watershed should try to retain the water that precipitates in the area to reduce flood problems downstream. In general it is important that water that precipitates locally is retained locally [11.2]. It means a change of mind from increasing the natural run-off of water to decreasing the natural run-off and increasing the landscapes retention without wedging and damaging the local landscape. While the interventions are still local of character, the cooperation between upper, middle and downstream must be improved.

Interventions increasing the local retention of water can be implemented on all three types of the earlier mentioned typology, but the main focus will be in the areas in which the water system has been disturbed most. For the very steep and steep slopes, these are the agroforestry areas of Pinus Radiata. On the gentle slopes the main disturbance is the channelization and draining of the natural streams [11.6]. Furthermore in the current land use the water runs off fast from the spurs. On the floodplains, the main focus must be on reducing paved surface (within the cities) and again, the de-canalization of streams (in both the cities and the more agricultural areas).

For all the water that cannot be retained locally during an extreme precipitation event, the floodplains must be explored for parts that can have their function as floodplain restored with simple interventions [11.3; 11.5].



[11.2] **Principle of local water retention**

[11.3] **Principle of floodplain storage function**

[11.4] **Principle of retaining water in the riverbed**

Furthermore places within the riverbed must be selected that can be used for the slowdown and retention of water, without harming the ecological and natural function of the river [11.4]. The ferrerias and its reservoirs could be appointed for this, since dams already appear in the river at the places were these ferrerias where. Secondly well as the canyons, that can buffer a lot of water due to the large gradient of the river in these areas [11.7] It is important to keep the general flow of water and the riparian zone free from obstacles, in order to reduce disturbance for ecology.

The focus of this thesis excludes the urban areas. This is done on purpose, since making the urban areas 'Water Based' would be a master thesis subject in itself, as it implies a very specialized analysis and the need for other (theoretical) knowledge. However,

[11.5] **Map of floodplains in the Urola watershed**

[11.6] **Map of gentle slopes with disturbed natural streams**

[11.7] **Map of areas suitable for retaining water in the riverbed**

we reckon the fact that the urban areas of the Urola watershed and Basque Cantabrian Basin offer many possibilities to increase the local retention of water, since there is a lot of paved surface and drains. Possibilities can be found in green roofs, the increase in 'green'public spaces and a split sewer system. With its location on the floodplain it would also be advisable to restrict the possibility of extending the cities on the floodplains and to look for the possibility of more space for the river and the development of buffer areas within the cities, on empty spots or so called brownfields. Several researches have been done on fitting in solutions for sustainable water management in urban areas, such as Van Dijk & Veul (Water ways to climate adaptation, 2010), which might have solutions that can be adapted in the villages on the floodplains in the Urola watershed and Basque Cantabrian Cantabrian Basin in general.

3. Enhance the local landscape characteristics, its readability and its relation with the water

The first two guidelines' main focus is on creating adaptations towards extreme precipitation events. Seen from the landscape approach, the landscape characteristics and the integration (or even enhancement) in the landscape of interventions is of great importance. The characters that have been distinguished can be used as a basis and the interventions should enhance these characters [11.8]. Especially the appearance of the water in the landscape should be enhanced.

The upper reaches of the river have the character of the many ferrerías that where once the heart of the human activities in this area. The canyons are characterized by their wild character. The wide valley, meanders and floodplains naturally have a mainly wet character, whereas the gentle slope areas are characterized by the many natural streams that created small stream valleys and spurs but which have nowadays mostly been channelized and drained. These characters offer starting points for the embedding of the water system and related interventions into the landscape.

In enhancing the role of the water in the landscape it is important to consider the way people look to the landscape, which has been elaborated in the theoretical framework of this thesis. According to conservation psychologists people prefer to see landscapes with water, flowering trees, places to shelter and that are easy to navigate and oversee (Clayton & Myers, 2009; Heerwagen & Orians, 1993 as cited in Clayton & Myers, 2009). These criteria should be kept in mind when embedding the water system into the landscape. These criteria can also help to design successful points of interaction.

[11.8] Example of emphasizing the valleys in the gentle slopes (image adapted from Loidl & Bernard, 2003)

4. Create possibilities to interact at popular places that people often visit

To create a culturally sustainable landscape, the interaction and relation between humans and the landscape and water must be strengthened and re-introduced. In the chapter 'The everyday live' the characteristic outdoor life of people in the area live is highlighted. From this outdoor life, it becomes clear that it offers many possibilities to create interaction. First of all there are the many public gathering places, such as the squares, parks, schoolyards and streets. People visit these places every day, and a moment of interaction with the water could be created here.

Second, a link between the popular huertas and the water system might be possible. The water people use for their huertas is tap water, that people do not directly link to the local water system. By making a visual connection between the water people use for their garden and the local water system an interaction point can be established.

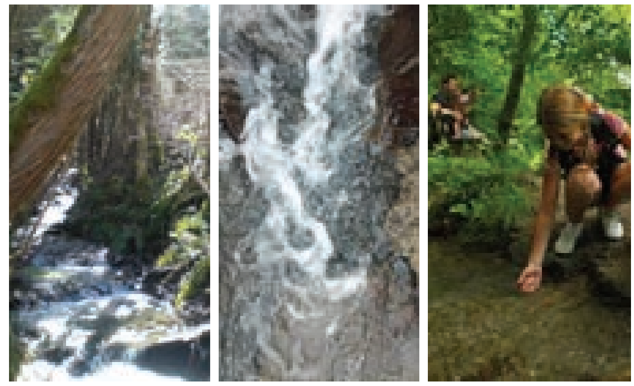
A possible third link might be between the (restored) natural streams and walking/biking routes might be possible, creating scenic views and places of interaction with the water. Linear water structures are very suitable to create routes along (Dee, 2001). People tend to look for the most logical and easiest places to walk along instinctively (Loidl & Bernard, 2003), which is underlined by the historical routes in the watershed that were mostly following the course of the rivers and streams. The creation of scenic routes asks for a clear controlled route that very carefully leads people from one scene to another, mixing these scenes up with focal points, points of interaction, which in this case can be linked to the water (system) [11.9-11.10].

[11.9] **Using the streams as a basis for scenic routes (adapted from Loidl & Bernard, 2003)**

[11.10] **Creation of focal points and scenes interacting with the water (adapted from Loidl & Bernard, 2003)**

Finally a link can be found in the historical land use relics, such as ferrerias and washing places. Their historical link with the water system might be restored in the form of a new function.

As has been stated in the theoretical framework the basic experience of the landscape can be distinguished in several elements that are linked to the sensory faculty and the strongest experiences are the ones that are multi-sensory (Saito, 2007). Seen from this perspective the interaction points with the water should favorably contain multi-sensory experiences. Catharine Dee writes about sensory experiences with water and the behavior it evokes with people (Dee, 2001) She specifically talks about three sensory experiences of water: seeing, hearing and touching water. In the creation of interaction points and moments with the water, these sensory experiences should be kept in mind [11.11-11.13].



[11.11-11.13] *Textural movements of water dramatise and animate. Water reflects the landscape surrounding it (Dee, 2001). Fast moving water and waterfalls fascinate people. A quiet and subtle sound of water relaxes people, though it needs a silent surrounding (Dee, 2001). Fast moving and vibrant water is fascinating to see. People like to make sound with water themselves. The sound of vibrant water can mask other sounds of the city (Dee, 2001). Water cools people when they touch it. It should be assumed that people want to touch water. When it is warm, people don't see a rain in their face by a fountain as unpleasant (Dee, 2001).*

5. Create new functions for the water system in the human organization, adapting old functions to it.

Existing functions in the watershed have to be adapted to the water system. On the steep slopes, a more sustainable agroforestry management would decrease the run-off. A more sustainable agroforestry management should be one of the adaptations in land use. A change in used tree species towards more deciduous species would improve the infiltration capacity of the soil and is recommendable as well.

On the gentle slopes and floodplains, the tradition of small scale agriculture and huertas can also be linked to the water system in functional way: the interventions might offer new possibilities for farmers to produce food and enhance the local food chain, the rainwater that is retained in the landscape could be used for irrigation or cattle drinking spots.

The tradition of building on the floodplain must be abandoned and new options for building must be explored.

There might also be possibilities to create new functions for the water system in the human organization. Such a function could for instance be the small-scale production of sustainable energy [11.14]. Another possibility could be to use the water system as a basis for a tourism route network since it has become clear that tourists mainly visit and stay at the coastal areas.

[11.14] Sketch of micro hydro power installation. It shows similarities to the classis Ferrerías.

6. Use of local labour, scale, expertise, and materials

The use of local labour, expertise and materials should be stimulated, since this will increase the involvement of people in their own landscape, which will in its turn lead to an increased cultural sustainability. Furthermore this will make the investment of the plan a boost for the local economy, since it creates employment for local people.

Another advantage of the use of local materials and techniques is that these will almost automatically 'fit' in the landscape, because of familiar colour, material, scale and texture to its surrounding landscape. This will assure that the interventions fit in the landscape and that the emphasis is on the water (system) and not on the intervention itself. If used in the right way, the use of local material will enhance the readability of the landscape.

Local materials that might be used are stones from the stone quarries or wood from the many production forests in the area. Many objects and buildings in the areas are built with local stones and wood. [11.15-11.35]

[11.15] **Stone quarries in Urola**

[11.16] **Stone quarry**

[11.17] **Lumber factory**

< [11.18-11.35] **Examples of local materials and terraces**

Synopsis

- Six main principles for the design and strategy hav been developed:
- Intervene in the areas that are occupied and altered by humans .
- Develop a strategy on the watershed level.
- Enhance the local landscape characteristics and its relation with the water.
- Create possibilities to interact at places that people visit often.
- Create new functions for the water system in the human organization, adapting old functions to it.
- Use of local labour, scale, expertise and materials.
- These principles will now be worked out into a design (for the Iraurgi valley, canyon and ferreria) and strategy for the watershed.

12 Watershed strategy

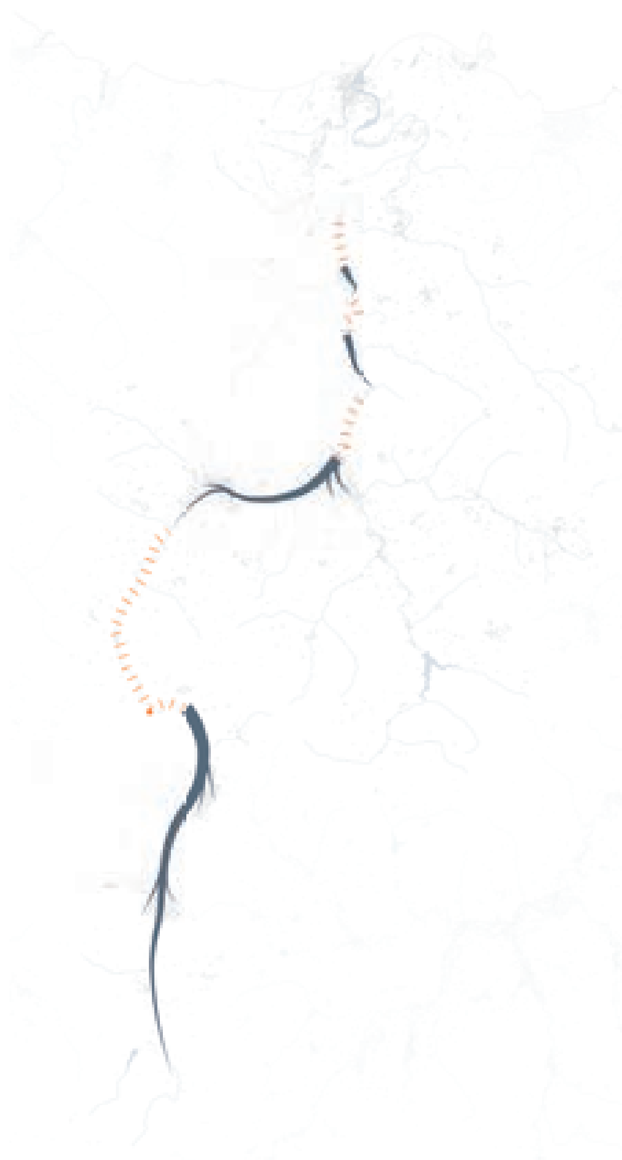
Local interventions: regional impact

This strategy is based upon the six principles that have been introduced in chapter 11. In this chapter the strategy will be explained, while the following chapters explore the spatial impacts on the local scale. The strategy has its focus on the Urola watershed, but it is a general strategy that is implementable in the surrounding watersheds in the Basque Cantabrian Basin, which will be set forth at the end of this chapter. The basis for the strategy is formed by these six principles:

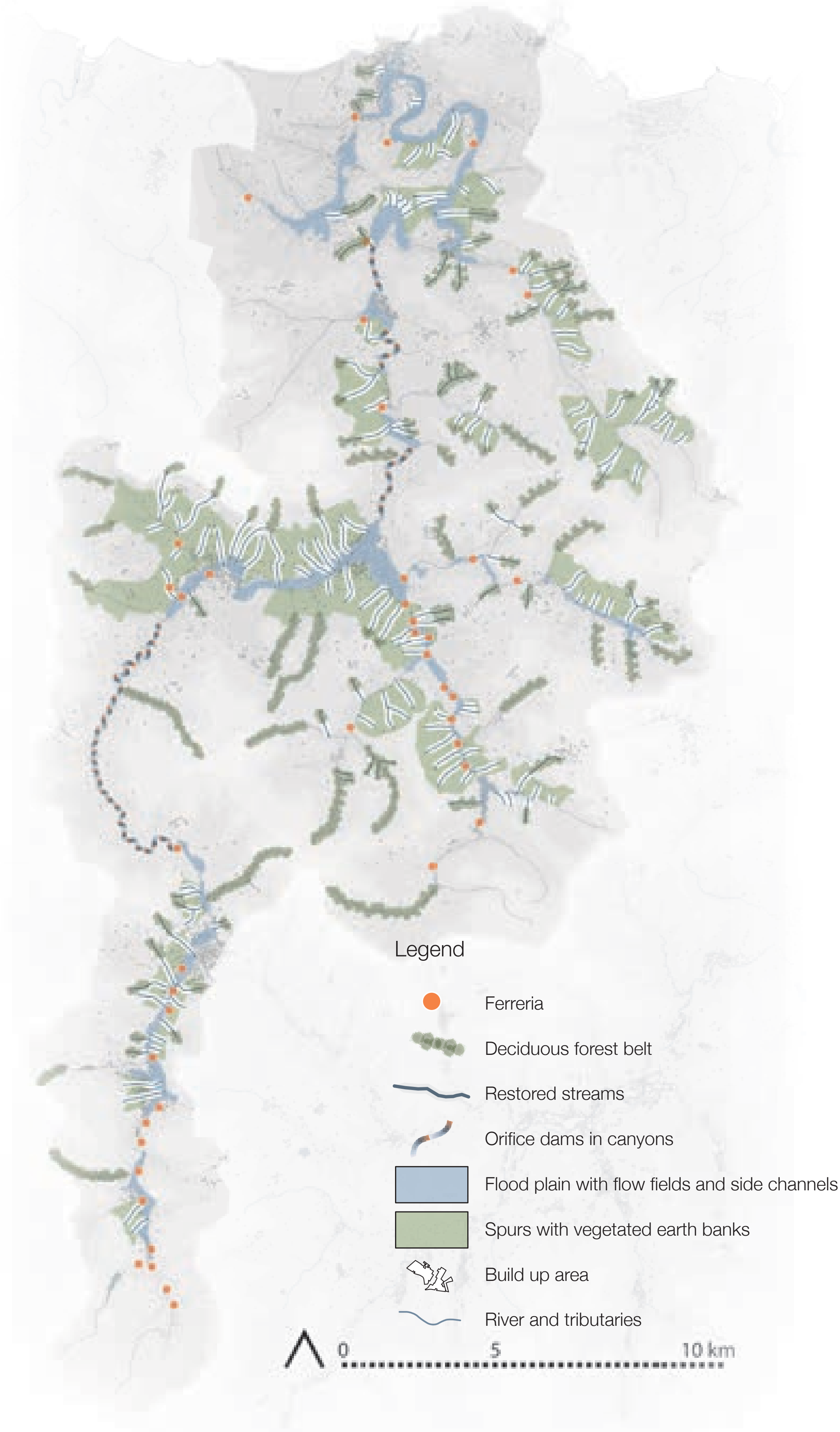
1. Intervene in the areas that are occupied and altered by humans
2. Develop a strategy on the watershed level.
3. Enhance the local landscape characteristics and its relation with the water.
4. Create possibilities to interact at places that people visit often.
5. Create new functions for the water system in the human organization, adapting old functions to it.
6. Use of local labour, scale, expertise and materials.

The strategy works from the idea that by doing many (small scale) local interventions, a regional impact can be created. In [12.2] the concrete design interventions are set out on the watershed level. Every farmer, house, settlement and village becomes responsible for the local retention of the water. By working together, the upstream areas can retain and buffer the water that has precipitated in their area, this way reducing the water that flows downstream and preventing or diminishing the flood problems in their own area and the areas downstream. In the Urola watershed the local water is captured in the cities and agricultural areas. Natural streams are recovered. The canyons are located in an ideal position to function as a retention area for the surplus of water that cannot be covered by the areas upstream [12.1]. The floodplains act as an extra buffer for the remaining surplus.

An advantage of the small scale interventions is that the government does not need to buy huge tracts of land, but can compensate people financially for creating a small intervention on their land. Furthermore, the small scale interventions do not require heavy materials or machinery to be transported through the though mountain landscape. The current infrastructure can be used and the sensitive soils are indulged and protected.



[12.1] **Canyons retain surplus upstream water**



[12.2] **Watershed strategy**

Achieved capacity

The capacity of all the local interventions add up to a total capacity for the retention and buffering of water [12.3]. The total capacity lies around 7.5 million cubic meters of water that can be retained and buffered. In comparison to the surplus of water that has been calculated before, it becomes clear that the proposed strategy can cover the surplus for precipitation events up to around 100mm [12.4].

The slowdown of run-off and increase of the infiltration capacity, which are the result of some of the interventions, are not included in the total retention and buffering capacity. These interventions make the landscape less high responsive to extreme precipitation events, this way reducing the impact of extreme precipitation events on the landscape and reducing the intensity of the floods.
The attained capacity and the positive effects on the responsiveness of the landscape ensure that the annual returning flood events are covered, as well as some larger events. This saves the costs that these floods would normally cause, which came both from physical damage as well as economic damage during the time the area was flooded.

For very intense and extreme precipitation events the system cannot retain or buffer all of the water, and as such these events will cause floods and damage. Still, the flood intensity and the damage it does are reduced a lot by the interventions done. Furthermore, the positive effects on the landscapes responsiveness ensure that the character of the floods is less sudden, but can be foreseen better and people have more time to take precautions. This results in a much smaller chance on physical damage and fatalities. This increased reaction time can be seen as a sort of 'safe to fail' principle: if the system cannot cover the surplus of water, people notice in time and can respond by evacuating or temporal flood resisting measures. The urban areas should be adapted to this principle, although it can be noticed that they already are adapted to some extent, considering the habit to build apartment buildings with an open ground level.

Weirs:	*750.000 m³*
Terraces:	*Slow down run-off Increase infiltration capacity*
Streams:	*Slow down run-off*
Sustainable agroforestry:	*Slow down run-off*
Change to decidious forest:	*Increase infiltration capacity Slow down run-off*
Dams in canyons:	*200.000 m³*
Ferreria dams:	*160.000 m³*
Total retention:	*1.070.000 m³*
Flow channels:	*400.000 m³*
Inundation of fields/flow fields	*6.000.000 m³*
Total buffering:	*6.400.000 m³*
Total capacity:	*7.470.000 m³*

[12.3] **Impact of interventions**

Event	*Surplus*
60 mm	518.636 m³
80 mm	3.358.181 m³
100 mm	6.197.727 m³
147,5 mm (T=10)	12.870.658 m³
225 mm (T=100)	23.589.942 m³

[12.4] **Surplus of water that needs to be buffered**

Cultural sustainability

The local interventions can be 'customized' for each area, to ensure that the interventions are embedded in the landscape and interacting with the everyday life of people. This can be seen in chapter 12, about the Iraurgi Valley, that shows how the interventions can be fit into the areas' landscape and the everyday life of people. This way, a broad impact can be made, gaining added value on other aspects than flood defence, making the proposed interventions and strategy 'culturally sustainable' and more resilient.

What can be noticed from the local design of the interventions is that the water system has a much more visible role in the landscape. It has become the backbone of the landscape: the spurs and brook valleys with its restored natural brooks, the wet floodplains, the rough canyons and the side channels of the ferrerías. The natural landscape features have become more visible and readable for people. The choice for local materials will help the actual interventions blend into the landscape, whereas the water is an outstanding feature.

The local character has been enhanced, first of all by enhancing the local food networks with the rows of fruit trees that ensure extra food production. This food production fits in the Basque culture of producing food. The link between the brooks and the huertas links the water system with this part of the culture as well. The extra food production also means an extra income for farmers, which compensates for the water running over their land. The ferrerías provide local sustainable energy for the nearby villages and farms, enhancing the link between the human organization and the water system.

[12.5] **Watershed walkways**

The Basque Cantabrian Basin is a very attractive landscape to recreate in, but not many tourists visit the inland and most of them stay at the coast. The extensive network of rivers and (restored) brooks offer the perfect opportunity to improve the accessibility of the watershed for tourists. As part of the interventions, the watershed will be easier and better to access for hikers, which can also be seen in the local designs of Iraurgi, the canyons and the ferrerías. There is an extensive route network, with the Via Verdes connected to the canyons, the Ferrería Walkways and the hiking paths along the brooks [12.5]. These routes can attract tourists from the coast into the area. Locals can anticipate to this by developing more facilities for tourists, such as bed and breakfasts and local food markets and restaurants that sell to these tourists. Using the rivers and its tributaries as a basis for walking and hiking is based upon the historical routes that all followed the rivers and streams and provided easy access.

Part of the strategy is that the implementation can be done by local people and companies. The proposed interventions are very low in technical complication and are often inspired by local techniques. Furthermore the materials for the interventions can be harvested local. This has several big advantages. The first reason has already been mentioned above: the local materials have the right structure and colour to fit in the landscape, whereas local techniques do also fit in the landscape and the knowledge for these techniques is available in the area.

A second reason is that if the government hires local people and companies and uses local materials, all the money that is invested is directly invested in the local economy, making the strategy a direct economic stimulus. As has been noticed in the part Understanding, many young people are currently unemployed, and by making the implementation of the watershed into an unemployment relief project, the government can reduce the costs of welfare expenditures.

The importance of active involvement of local people

A third reason is that the active involvement of local people in building the new water system, they will have a closer link to it and will most probably take better care for it, as has been described in the theoretical framework as well. This would enhance the cultural sustainability of the water system and thus enhance the resilience. This thesis recognizes the importance of the active involvement of people, although local people are not actively involved in this thesis, but this thesis can certainly help in getting attention for the problem and showing the people that they can actually benefit from a new system and water management.

Ecological impact of the strategy

The renewed water system enhances the ecology of the watershed. The transition towards deciduous forests strengthens the ecology of the area, as the indigenous deciduous trees have a longer lifespan than the agro forests that are harvested once in a while (Artza, 2005). Furthermore, the agro forestry is a monoculture, whereas the deciduous forests allow for the development of a rich habitat (Artza, 2005).

The ponds formed in the restored brooks offer a good habitat to flora and fauna. Since the size of the ponds varies and some are located in the shadows of a forest, whereas others are in full sun, this attracts different species. Furthermore, some ponds remain wet for most part of the year, whereas others are predominantly dry. The depth of the ponds differs as well. The low gradient of the banks improves ecological development.

The placement of the weirs in the canyons does not restrict the migration of fish, since the crevices in the dam allow the fish to swim through. The ferrería dams used to be an obstruction for migrating fish, but with the restoration of these dams a fish passage can be created. This optimizes the migration possibilities for the fish.

Because of the small scale of the interventions the need for heavy machinery and auxiliary structures during construction is reduced, therefore reducing the impact on the existing landscape and ecology.

[12.6] **The valley types of the Urola watershed relative to the Basque Cantabrian Basin watersheds**

A general strategy for the Basque Cantabrian Basin

The strategy proposed here is based upon the landscape and everyday life of the Urola watershed. During the fieldwork in the Basque Cantabrian Basin it became apparent that there are a lot of similarities in both landscape and everyday life between the different watersheds in the Basque Cantabrian Basin. This was already described in the introduction of this thesis. Hence, this strategy can be seen as a general strategy for the Basque Cantabrian Basin.

In [12.6] the similarities in landscape characteristics between the different watersheds are shown. Some of the watersheds have a more steep and canyon-like character, which implies that the interventions in these watersheds are more focussed on the canyons. Other watersheds are more gently sloped and contain a lot of floodplain, which would mean that the focus of the interventions is on the floodplains here.

Since the people in the Basque Cantabrian Basin share the same culture and largely had the same historical development, as can be read in the introduction of this thesis, there are a lot of similarities in the everyday life activities of people too. It can be noticed for instance that the huertas are a general phenomenon in the Basque Cantabrian Basin, as well as the local food markets and the remnants of ferrerías. Because of these similarities, many of the guidelines and proposed interventions can be used in the neighbouring watersheds.

Finally, it may be clear that every watershed has its own character and that within every watershed 'sub characters' can be recognised. Although this strategy is a general strategy for the Basque Cantabrian Basin, each watershed is in need for its own analysis and way of implementing, ensuring that the character of the watershed is enhanced and that the end result is a diverse landscape of several watersheds, instead of a generic solution.

13 Iraurgi valley

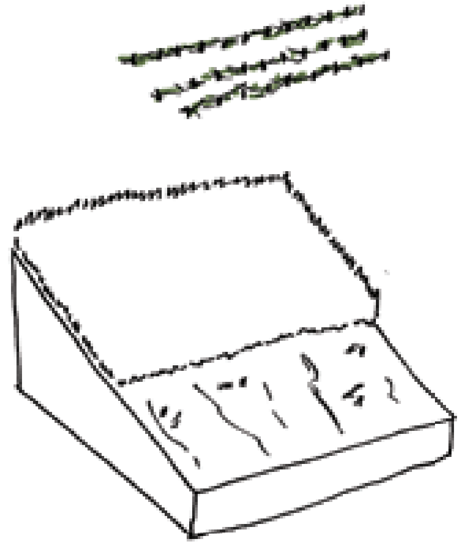
Local scale design

By making an elaborate design for the Iraurgi valley it is possible to explore how the design principles can be spatially implemented. The valley is valuable for the research because it represents a distinct type of river valley present in this region and it incorporates different slope types that are specified for intervention. A visible distinction between the different slopes of the valley helps clarifying the interventions. Another important feature of the valley is the urban area that puts pressure on the surrounding landscape. This calls for a firm landscape structure, but it also offers possibilities for integrating interventions into the social structure of the area.

The forest belt

On the steep slopes below the rocky peaks of mount Erlo a large agroforestry area covers the higher parts of the north slope of the valley. The vast majority of this area is planted with pine trees. The agroforestry causes a poor water retaining capacity of the soil, as explained before. In these forests most of the brook valleys begin to take shape. To improve the hydrological condition here, a shift to more sustainable deciduous tree production is needed (Artza, 2005). Because this cannot be achieved all at once, a first step towards more

sustainable management is proposed. The places were precipitation accumulates and starts forming brooks are crucial points in the system. By making the move to deciduous forestry and restoring natural brook beds in these places first, the water system can begin being improved. Creating a deciduous forest along the brooks has a positive effect on recreation as people associate these deciduous forests with wilderness and nature (Bell & Dean, 2008a). A positive aspect of mixing the traditional forest with the agroforestry practices is that it is easier for wildlife to colonize the planted forests from these traditional forests, this way the ecological value of the forest belt is improved (Bell & Dean, 2008b).



[13.2] **More sustainable forest management**

The agricultural hills

The gentle and hilly slopes feature a mosaic of crop fields, grassland and tree groves. Scattered farms and houses are interconnected by a fine-grained network of roads and footpaths. This area has a friendly and rural atmosphere, but is also rather cluttered. It is hard to distinguish the structure and landscape features. The implementation of water retention interventions can be tailored to the landscape features and strengthen the landscape structure.

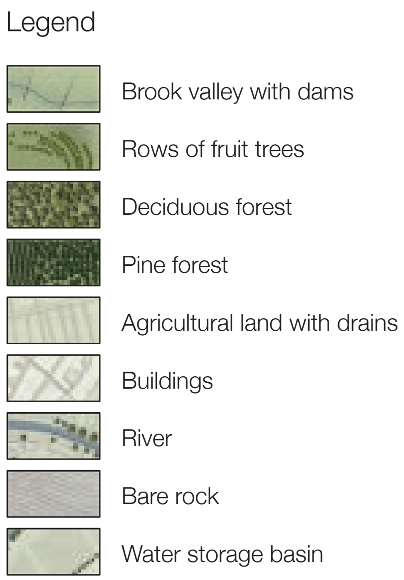
The brook valleys and spurs have determined the shape of the land. By emphasizing these elements the legibility of landscape can be increased. The brook valleys are linear structures that run perpendicular to the slope face. They have a relatively open, flat, and horizontal character. Restoring the watercourses of the brooks to a more natural situation slows down the discharge velocity, decreases the run-off, and also makes the continuous linear shape of the brook valley visible, from the forested steep slopes down to the river. The construction of orifice weirs that limit the flow volume further decreases the discharge velocity and provides room for water storage. These small dams form a sequence of horizontal lines that stress the open and wide appearance of the valleys. The ponds formed behind the dam can improve the ecological quality of the area, which will be explained later on in this chapter.

[13.3] **Sketch of the spurs and valleys**

The spurs are the higher ridges on the gentle slopes that divide the brook valleys. They generally have a more enclosed character than the valleys. Most of the buildings are located on these higher parts, together with small orchards and groves. A typical feature of the spurs is the presence of stacked walls and earth banks that form terrace-like elements. Placing earth banks planted with trees on the contour lines of the spurs amplifies the contrast between the flat, open valleys and the high and dense spurs. The use of vegetated earth banks reduces erosion and captures water running down the hill (WOCAT, 2012). The technique of vegetated earth banks is used on gentle and rolling slopes, with a thin to medium thin soil and is tolerant of a seasonal rainfall increase (WOCAT, 2012), such as occur in the area. By placing the earth banks on a slightly downward angle along the contour lines, the captured water is led back up the brook valley, slowing down the discharge. The trees on the vegetated earth banks can be fruit trees that enhance the local food network and provide the farmers with extra income; later on this will be explained into detail.

The floodplain

The floodplain is the flat area surrounding the river. Considerable parts of the floodplain are urbanized. The remaining area is used as grass- and cropland. The land is allocated in a rational parcelling pattern. Because the floodplain is flat, it offers good possibilities for water storage, which is its natural function too. The creation of side channels allows water from the river to be taken along the edges of the floodplain. From these channels water can be



let back into the river through small drains in reed beds that follow the parcelling pattern, using the technique of flow channels and flow fields (Baaijens, Brinckmann, Dauvellier, & Molen, n.d.). These reed beds both emphasize the naturally wet character as well as the agricultural pattern of the floodplain. Dykes bordering the riverbed are used to contain water on the floodplain when extra storage capacity is needed. Sluices with a predetermined flow capacity ensure that the retention basins fill up when more water is fed into the floodplain. Because the water is diverted through side channels the higher parts of the floodplain can also be used for water storage, which decreases the pressure on other areas. Existing farms and houses can be protected during floods by dykes, essentially turning them into temporary islands.

On the next pages the spatial principles that form the basis for the design are explained.

[13.4] Landscape design for the Iraurgi valley

Description

Function in water system

The trees of the forest plantation are planted on the contour lines. After harvesting the tree stumps and wood waste form barriers for sediment and run-off water along the contour lines. A transition from pine trees to deciduous trees increases the water retaining capacity. The first step in this transition is done next to the restored brooks. The plantation will look more naturally, and has an increased ecological value.

The drains and pipes are disconnected and natural brooks are restored, reducing the run-off speed. The linear structure of the water system becomes more visible to people and the system can be better linked to the everyday life.

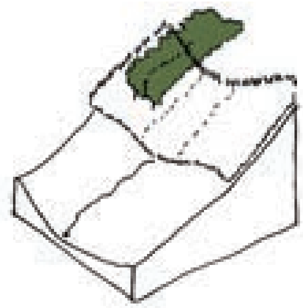
Weirs are placed in the brooks, to create retention ponds that decrease the run-off and discharge. In an extreme precipitation event, the brook cascades down from one weir, filling this up, to the next, etcetera. The sequence of the weirs enhances the valley in dry times. The horizontal lines emphasize the openness of the valley.

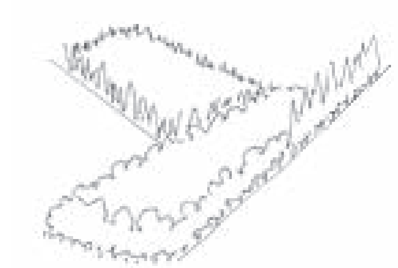
Vegetated earth banks on the contour lines, with a slightly declining line, capture water running down the spurs, and lead it back upstream into the brooks. Run-off speed is decreased. The vegetation on the earth banks emphasizes the contour lines and the height of the spurs and their contrast with the brook valleys.

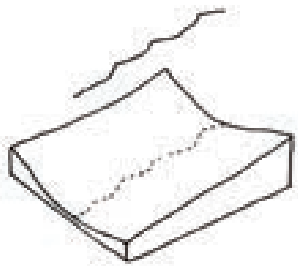
The surplus of river water is led into side channels parallel to the river, which feed drains on the floodplain, perpendicular to the river. The drains flow back into the river. In extreme cases, the drains flood the fields surrounding it. River discharge velocity is reduced and retention capacity is increased. The flat and wet character stresses the natural state of the floodplain.

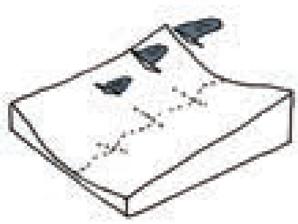
Technical intervention

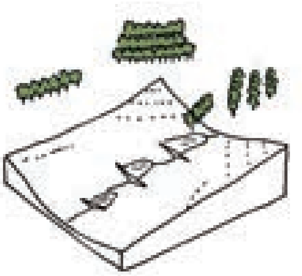
Visual effect

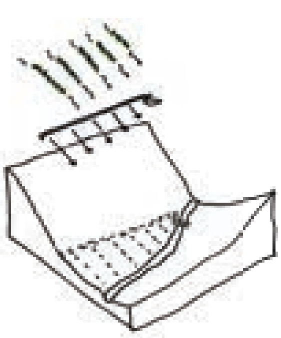












Effects

The interventions will have an effect on the retention capacity of the land. These effects result in a direct storage capacity caused by the physical retention spaces, and in an indirect capacity caused by the increase of infiltration and the decrease of run/off and discharge. The direct capacity can be expressed in m3, whereas the indirect capacity cannot be calculated without detailed hydrological study and modelling that would require a lot of time and expertise, which are beyond the scope of this thesis. However, it is expected that the indirect capacity has a large effect on the retention capacity and on the impact of flood events, although it is not expressed in numbers or data.

One of the direct effects that can be calculated is the capacity of the orifice weirs in the restored brooks. The water retaining capacity of the (orifice) dams can be calculated with the following formula [13.6]:

Cr=X*Y*Z*1/3

The average height of the weirs is between 1 and 2 meters (X), whereas its wideness depends on the gradient of the valley, but is estimated to be 50 meters (Y). The average length of the ponds is around 40 meters as well (Z).

Cr= 40*1.5*50*1/3
= 792 m3

An average brook contains around 8 dams, so in total an average brook has a retention capacity of 6336 m3. On the scale of Urola there are around 120 natural brooks that can be restored and that can be 'equipped' with orifice weirs. The total retention capacity of the orifice weirs on the scale of Urola is estimated around 750.000 m3.

A possible downside of the orifice weirs is that they will fill up with sediment over time. This will decrease the storage capacity of the ponds. It will however improve the infiltration capacity of the soil and the growth of vegetation will slow down the run-off of water. It is possible to dredge the ponds once in a while to sustain their retention capacity. The

[13.5]

reclaimed soil may be used for agricultural purposes.

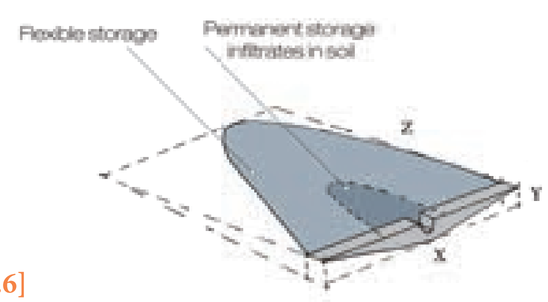
The capacity of the interventions on the floodplains can also be calculated. The flow fields' capacity can be calculated with the following formula [13.7]:

Cb=X*Y*Z

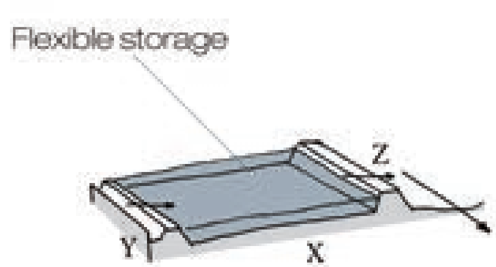
Of the total floodplain area (≈12 km2) approximately half could be adapted for water storage purposes. Assuming that on average the floodplain can be inundated by 1 meter, the total storage capacity will be:

6.000.000 m2 * 1 m2 = 6.000.000 m3

Storing water on the floodplain is an emergency solution, since the floodplains are also in use as agricultural areas and flooding the land every year would cause a lot of damage to the land and a lot of costs for the farmers. Using the floodplain as storing capacity will only be done in cases of extreme precipitation in which the retention capacity of the other interventions cannot succeed in retaining the surplus and preventing a flood event.



[13.6]



[13.7]

Embedding in the social organization

The above stated interventions interact with the human organisation at certain points. In case of the Iraurgi valley a special point of interaction can be the religious heritage in the area. As has been shown in the part understanding, the Iraurgi valley has a local food network, which can be an interesting point of interaction. Another important point of interaction can be the active outdoor way of living. There is a boulevard for walking, running and cycling between Azpeitia and Azkoitia, and many people like to walk up to mount Erlo even though they have to follow the roads and not a walking path. Other people like to mountain bike through the brook valleys and mountains. These features of the everyday life of the Iraurgi valley offer good starting points for a link between the water system and everyday life. These links are elaborated in the detailed designs.

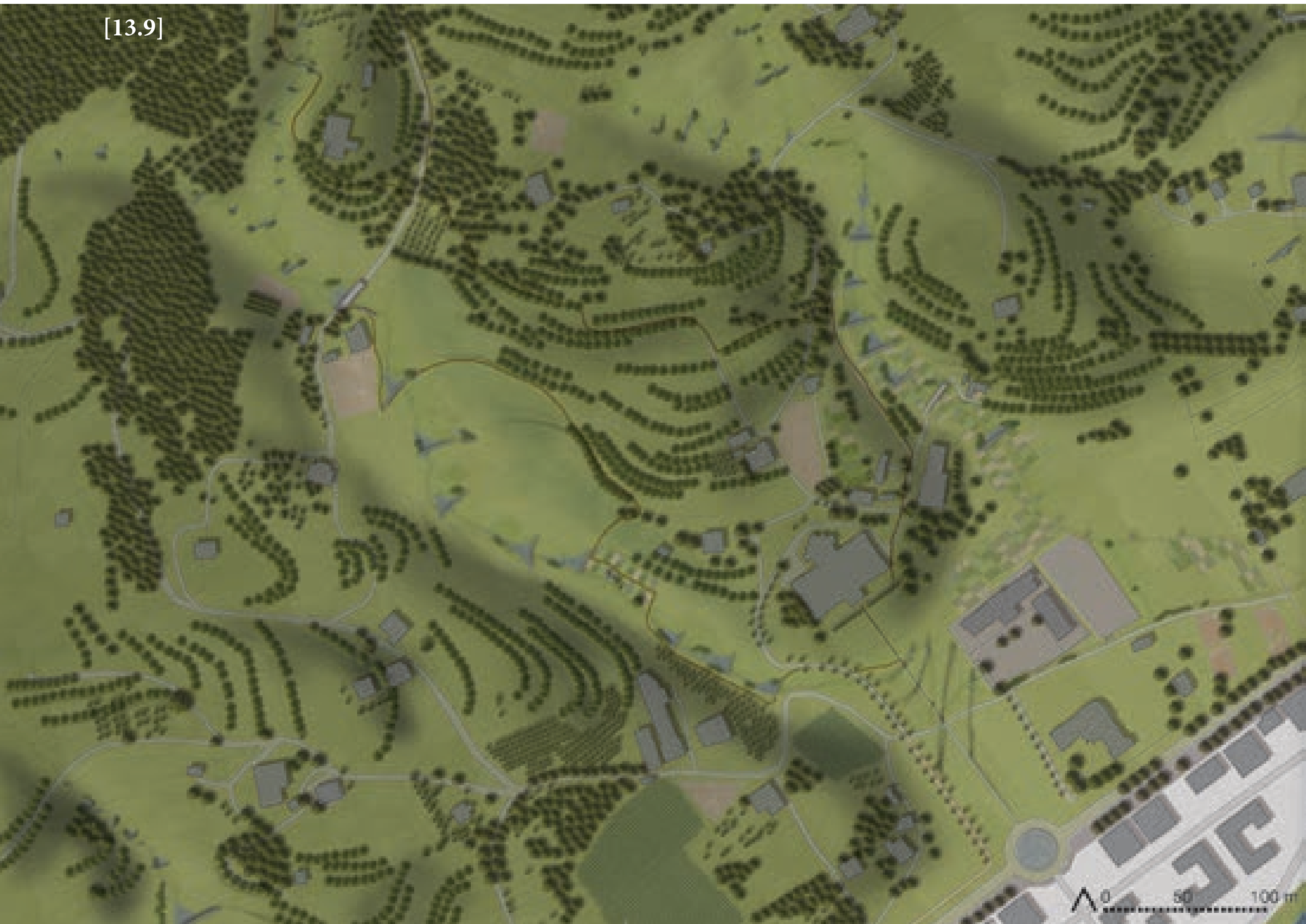
Brooks and spurs above Olatz Monastery

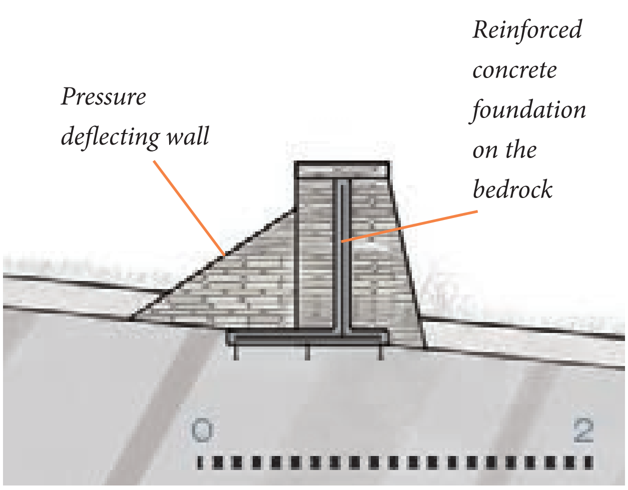
The spurs and valleys above the Olatz Monastry are currently a mainly agricultural area, with amostly meadow, some smalle cropfield, small orchards and (fruit) trees. The cropfields are mainly located aon the spurs, next to the basseri. The brooks are channelized and invisible in the landscape.

The restoration of brooks in the brook valleys in combination with the enhancement of the spurs with rows of fruit trees on earth banks create a legible landscape. The valley has a much wetter and more natural character, whereas it can still be used for the grazing of cattle. The ponds and stream provide for drinking spots for the cattle.

[13.8] **Location of detailed design**

[13.9]



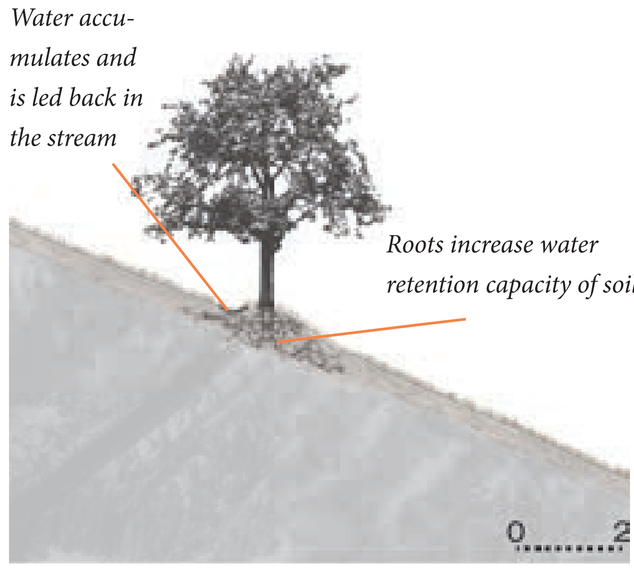


[13.11] Section of the weir

The weirs are created out of local stones with a basis of reinforced concrete that is secured to the bedrock. The character of the brook and the weirs are more structured and formal closer to the urban area, higher up the valley the brooks become more natural and the weirs are less like actual walls or weirs and more stacked stones, that slow down the water.

Legend

- Fruit trees on vegetated earth banks
- Weir
- Weir with pond
- Stacked stones
- Fountain
- Huertas
- Brook
- Water playground
- Ford in road
- Walking route
- Paved surface
- Buildings
- Vineyard
- Decidious trees



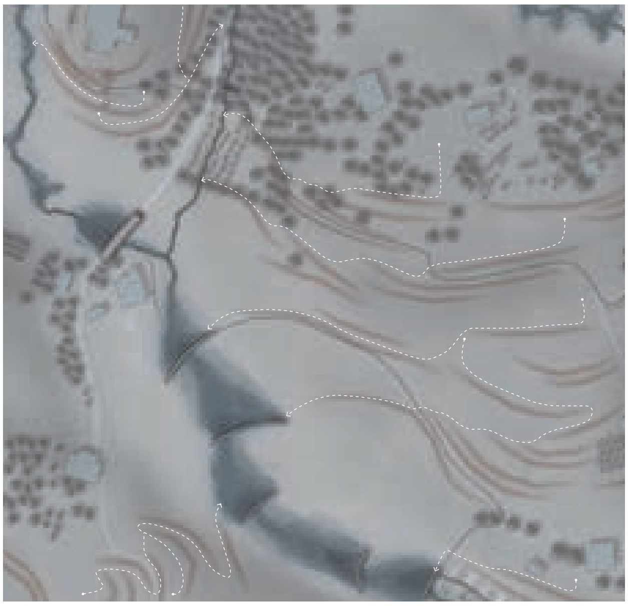
[13.10] Section of vegetated earth bank

The earth banks have been vegetated with fruit trees; this creates the impression of a fertile landscape, which has been stated to be favoured by humans in the theoretical framework. The fruit trees colour the spurs when they flower. The fruit trees also have an economical function: they produce food for the farmers, which they can sell on the local markets. The local food network of the Iraurgi valley can be reinforced by planting the fruit trees.

If implemented, a detailed analysis of the slopes should be made, since the banks are not suitbale for gradients of over 15%.

The sequence of the weirs enhances the valley form and accentuates the presence of a brook. The rows of fruit trees accentuate the heigher spurs. The decidious forest surrounding the banks of the brooks in the forest belt creates a more natural brook valley character.

After an extreme precipitation events, the run-off directly flows into the brooks from the upper reaches, from the spurs it is led into the brooks by the vegetated earth banks. The brook starts to flow and begins filling up the upper retention ponds, slowly cascading down to the river.



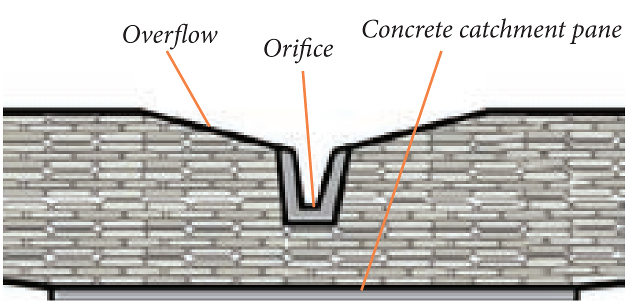
[13.12] **System of terraces and ponds**

[13.13]

[13.14] **The north slope in the current situation ^**

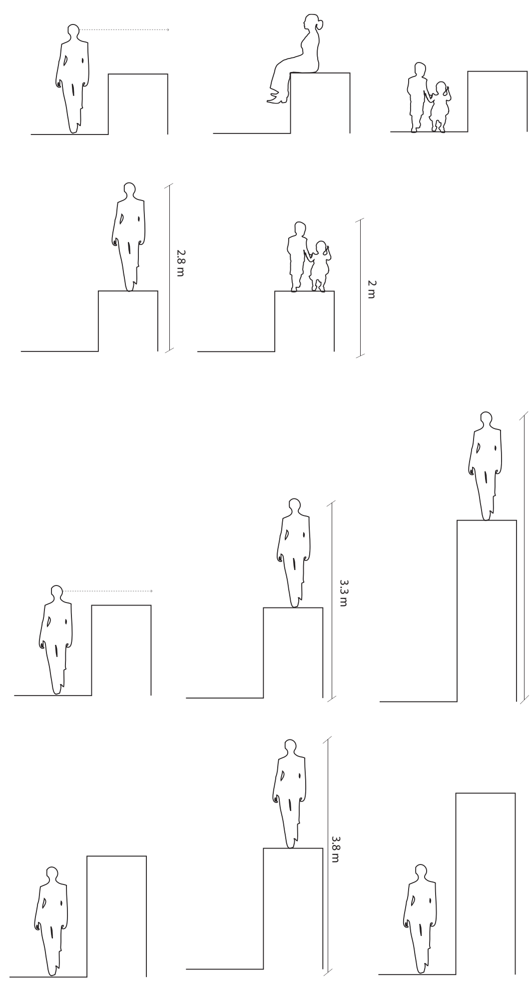
[13.15] **The north slope in the proposed situation ∨**

The scale of the weirs in the valleys is adjusted to both the human scale [13.18] and the scale of the landscape. To ensure that the weirs enhance the brook and valley as focial points, their height must be in line with the landscape. If the weir is to high, it will draw attention to itself, instead of the landscape surrounding it [13.17], if it is to low, it will draw no attention at all (Loidl & Bernard, 2003). For humans, a scale of around 0.5 to 1.5 meters is nice, as people can safely sit or walk on dams of this height and most people can see over them, which is important as they can see the pond and sequence of weirs. The eventual scale of the weirs is between 0.5 and 2 meters.

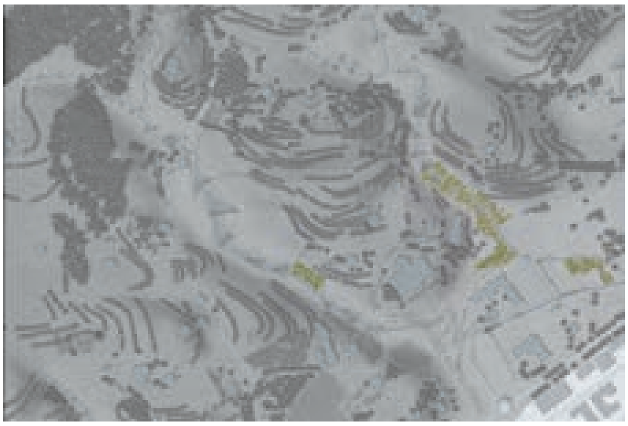


[13.16] Front sight of the orifice of a formal weir

[13.17] A high weir draws attention to itself, instead of the landscape surrounding it



[13.18] Sketching the scale of weirs



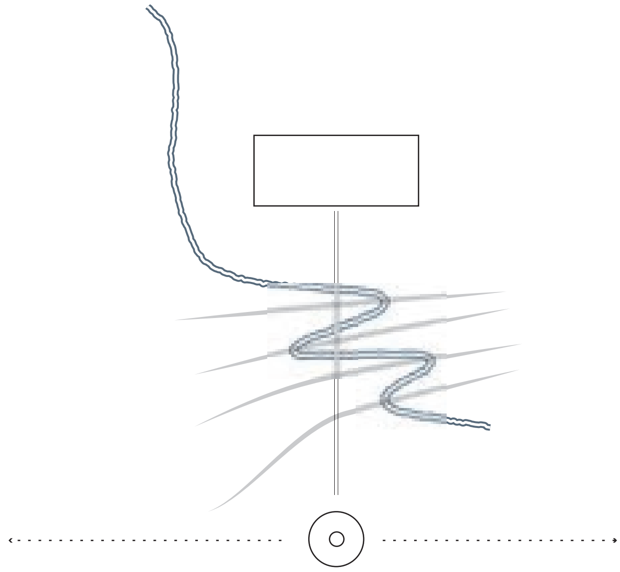
[13.19] **Huertas**

The brook is linked to the local food networks, as it flows through the huertas. Before or between the huertas, weirs can create ponds that can be used to water the crops on the huertas[13.19;13.20]. In this way, a direct link between the water system and the food production is created, in contrast to the current situation, where people use tapped water, unaware of the origin of the water.

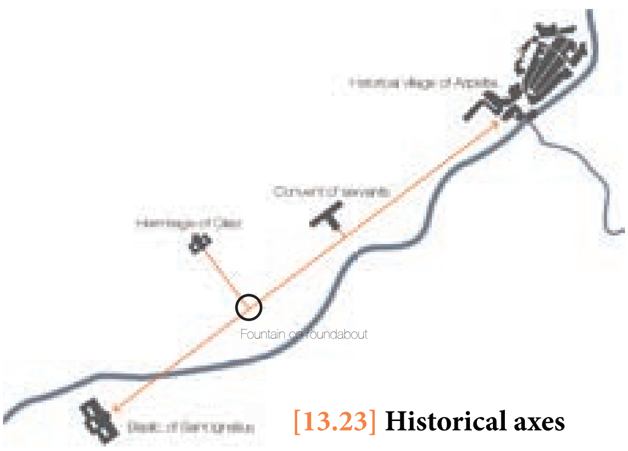
The brook valleys function as ecological stepping-stones and their ecological functions are enhanced by the brooks and the ponds. Various plant species can grow on the banks of the ponds [13.21] that have fluctuating water levels. The ponds are a suitable habitat for amphibians such as the endangered Pyrenean Brook Newt (European Environment Agency, 2009).

[13.20] **Impression of the huertas and pond**

[13.21] **Schematic section of pond with ecological banks**



[13.22] Schematic drawing of the Olatz Hermitage front yard



[13.23] Historical axes

Religious heritage as a focal point to interaction

A fountain is placed on the roundabout in the main road, which only sprays water during and after bigger precipitation events [13.24]. This fountain highlights the axis of religious heritage and links this heritage with the water system [13.23]. It works as a focal point that hooks the sightline of the hermitage of Olatz to the sightline between the Loyola Sanctuary and the Azpeitia city centre.

One of the walking routes starts in the front yard front yard of the Hermitage of Olatz, where the brook winds its way through, briskly flowing down the terraces [13.22], enhancing the sight of the brook from the main road. The brook through the front yard is an eye catcher that enhances the legibility of the water system in the landscape.

[13.24] The fountain on the roundabout, the brook in front of Olatz Hermitage is visible in the distance

Recreational routes

Along the brooks, through the brook valleys, recreational routes are created. These routes contain various scenes and focal points, which are points of interaction with the water. It contributes to the scenic experience of the water system and the route can help creating memorable experiences with the water system (Kent & Elliott, 1995). These scenic experiences and memorable experiences can improve the cultural sustainability (Saito, 2007), as described in our theoretical framework.

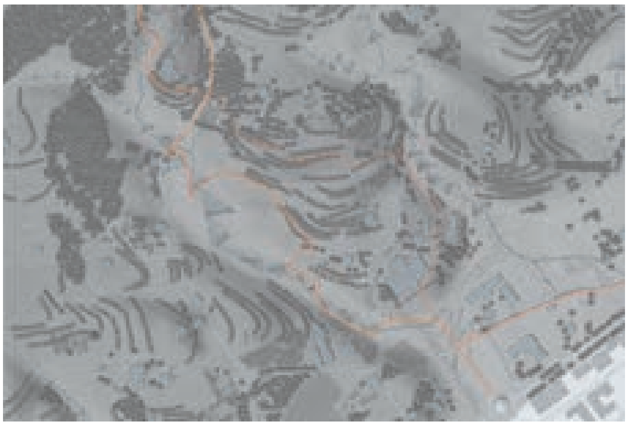
People can walk all the way up the stream, passing several dams that can be accessed sometimes. From the top of the hill the route continues to the next stream valley from where one can either choose to walk further up to mount Erlo, or to walk back down the other stream. The routes can be used as strolls by local people, or can be interesting loop trails for tourists. Creating loop trails makes the routes more interesting since no backtracking is needed (Hultsman, Cottrell, & Hultsman, 1998)

The ponds offer ideal locations for resting spots. [13.25] There are also possibilities for routes that are linked to the basseri, with farmers selling local products or even picnic baskets to hikers.

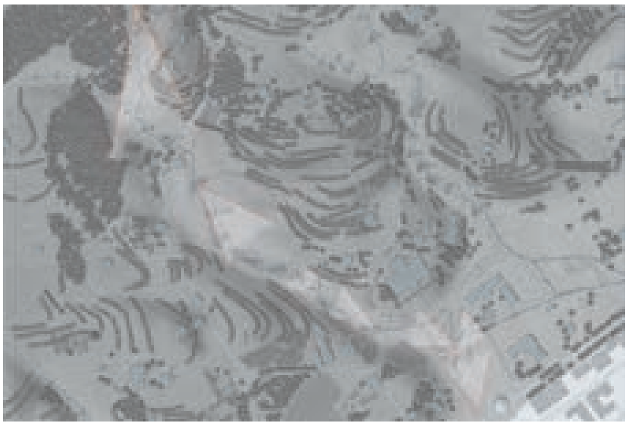
On the next page an impression of how the hiking route is linked to the restored brooks is shown. Other valleys can be linked to the popular sports of mountain biking [13.26]. This way, the network of routes for this sports can be extended, while at the same time the routes are linked to the water, adding the danger (and joy) of getting soaked and creating interaction between humans and the water system.

[13.25] **Resting places can be created at the dams**

[13.26] **Mountainbike trail through a valley**



[13.27] **Strolls and hiking routes**



[13.28] **Scenes and focal points along the route**

[13.29] For the adventurous walker the ponds can be crossed following stepping stones

[13.30] The ponds offer nice views while walking

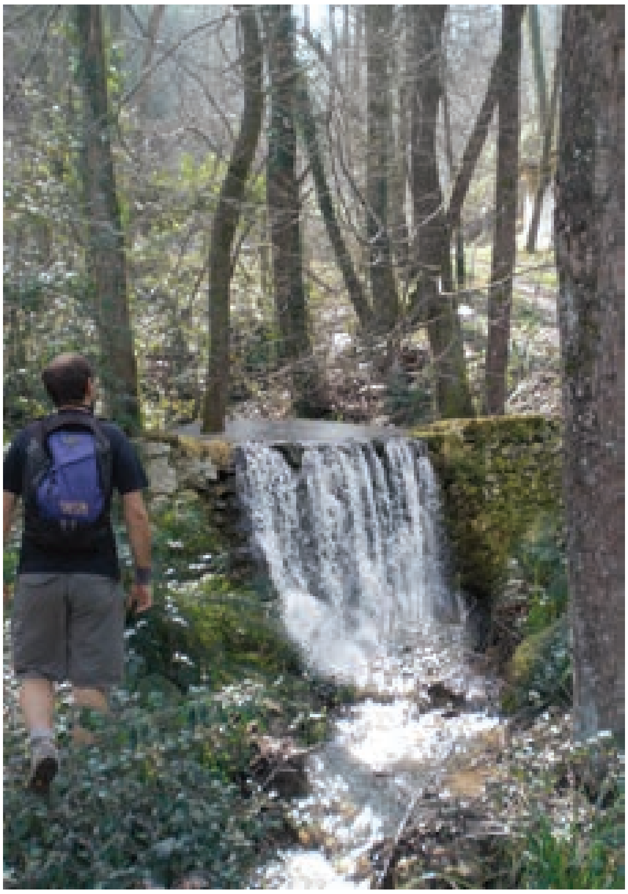
A hike to the source of the brooks

The hike starts in the front yard of Olatz, where a sand pad follows the course of the brook. While walking up, several dams are passed, some need to be crossed to continue the walk up [13.29]. The ponds behind the dams add to the diversity of the valley, with their smooth surfaces. They are reflecting Mount Erlo in the back [13.30]. It is a very scenic setting. If lucky, one can even see a Newt or other animal that has its habitat in and around the ponds. Walking further up, the brook gets a more natural character.

The path reaches higher and higher, sometimes crossing the water, via stepping stones. The brook flows briskly over the bedrocks, incising its way into the landscape. Once you turn around and take a moment to catch your breath, you see that you are already quite high and have a really nice sight on the valley and the floodplain below. The brook and the ponds sparkle in the sunlight [13.31] .

Now one enters the forest belt, where the sun, the leaves and the flowing water create an interplay of light. Stacked stones form a small dam, with a small pond behind it. In the shadows of the trees moss and ferns grow between the stones [13.32].

And then finally, after a long hike, the source of the brooks is reached at the foot of the bare rock of Mount Erlo. The run-off water from the bare rocks of the mountain is captured in a basin. The water here is cold and one can refresh in the ice cold water from the bassin, the source of Mount Erlo [13.33].



[13.32] Stacked stones form a dam in the forest belt

[13.33] The source of the brook at the lower side of the bare rocks

< **[13.31]Looking back down the brook valley**

The floodplain near the Loyola sanctuary

The floodplain between Azkoitia and Azpeitia is still an open agricultural area, although the expansion of the cities puts the area under spatial pressure. By reinforcing its open and wet character, preserving its agricultural function, and giving it an essential role in the flood prevention system, the floodplain can retain its value and be preserved from being build upon. The multifunctional use of the floodplain is important, because the storage capacity is essential to prevent floods, but the occasions that it is needed might be far between.

Water from the river is redirected into a side channel at the beginning of the floodplain. This side channel runs along the edge of the floodplain and feeds water into small drains perpendicular to the channel. These drains follow the rational parcelling of the area, which is a particular feature for this part of the watershed. The drains are planted with reed beds, which enhance the wet character of this

[13.34] **Location of detailed design**

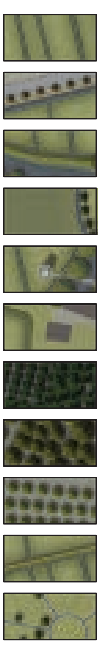
area. At the dyke running along the river a larger drain collects the water en eventually feeds it back into the river further downstream. The diversion of water is a continuous process that does not interfere much with the normal use of the land. When large amounts of water flow through the river and flooding is probable though, the increased

flow in and the restricted discharge of the channels and drains inundates the land, preventing floods elsewhere.

The natural levees and the upward sloping edges of the floodplain form the basis for dykes and embankments that confine the water storage basins. Due to a slight height difference on the north side, an extra dyke in the centre is needed to increase storage capacity. The dykes used for water retention double up as walking infrastructure and provide access to the farmland. The existing walking boulevard along the edge of the floodplain is linked to the side channel to make the water experienceable. Multiple design variations can increase the interaction between people and the landscape.

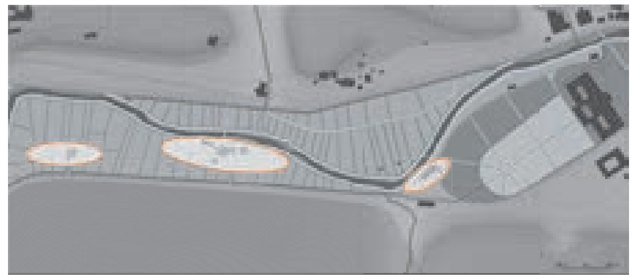
To link the area to the local culture, the grounds of the Loyola sanctuary are incorporated into the design. The garden of Loyola has a formal and open character. By removing the high wall and hedge around it, the openness of the floodplain is enhanced, and the sanctuary is more connected to, and better visible in the landscape. Because Loyola is an important tourist destination, it requires a lot of parking space. New parking lots are already planned

Legend



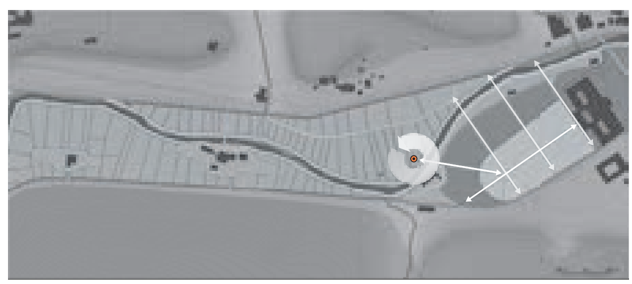
- Fields with reed bed drains
- Side channel along boulevard
- Retention dyke
- Storage basin next to Loyola garden
- Lookout tower and bridge
- Buildings on agricultural island
- Pine forest
- Deciduous forest
- Fruit trees on earth banks
- Middle dyke with footpath
- Loyola garden

< [13.35] **The floodplain in normal situation**



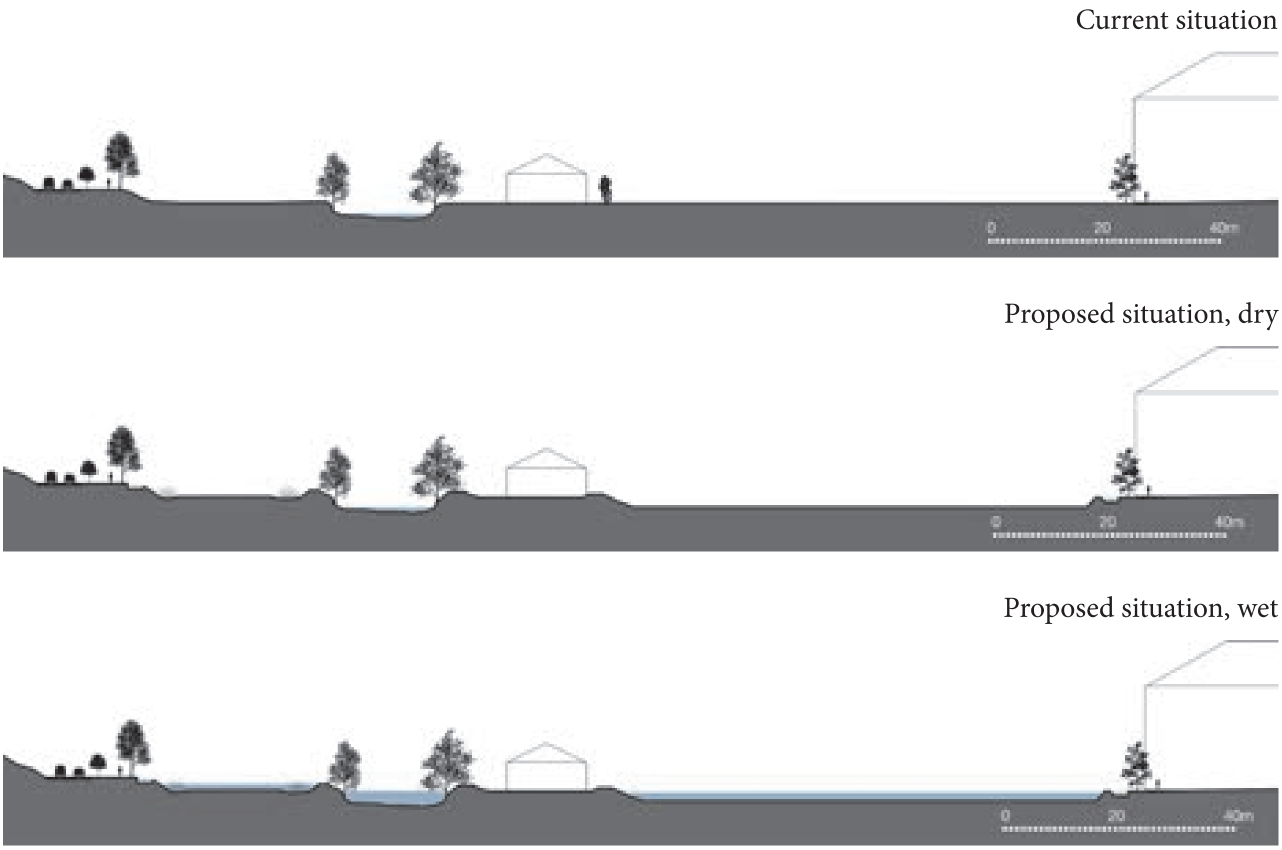
[13.36] **Farms as islands**

[13.37] **Removal of wall and hedge**

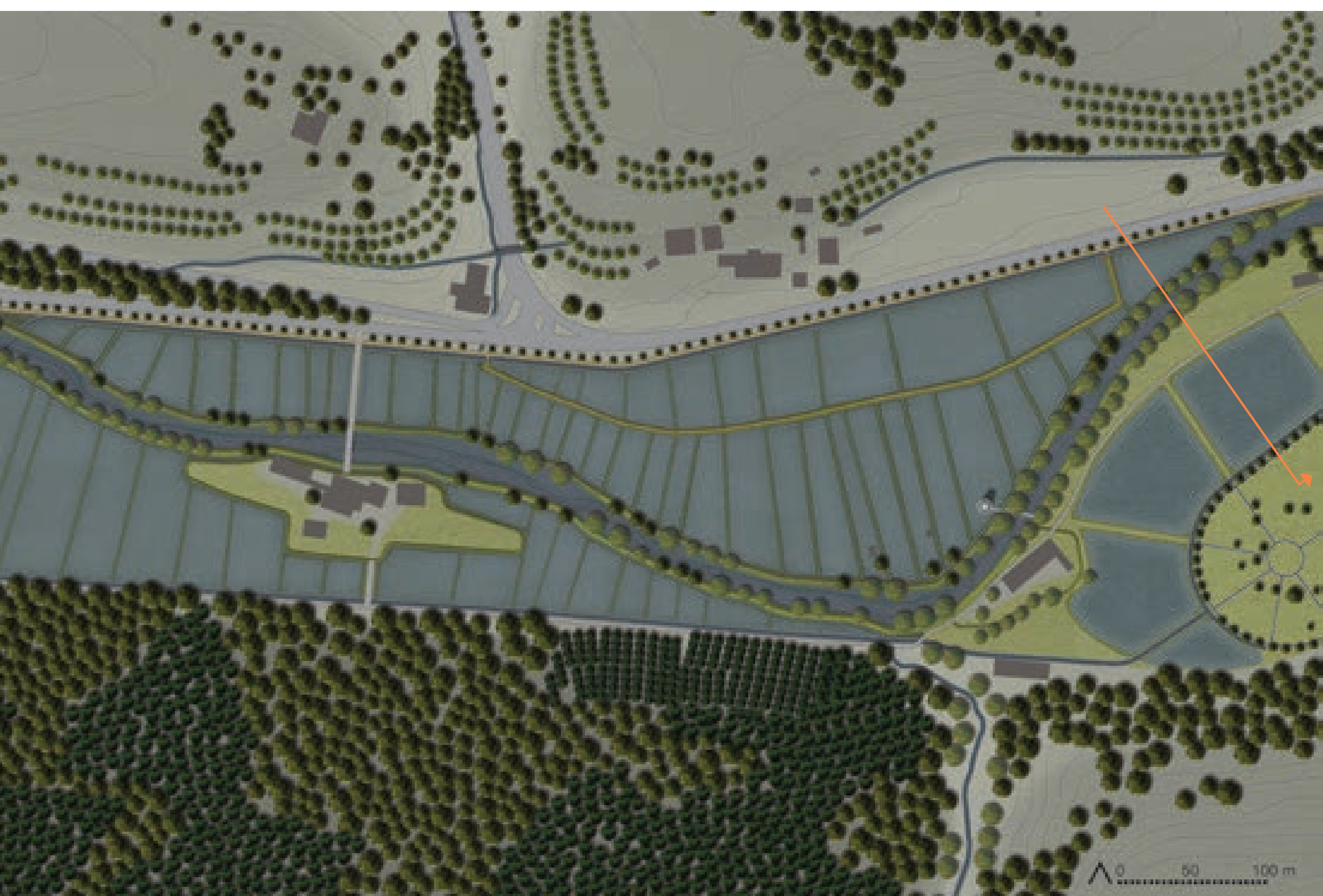


[13.38] **Extending lines of sight**

[13.39] **Routes**



[13.40] Section of the floodplain



around the garden on the floodplain. By sinking these parking area following the structure of the garden, parking space can be provided that can serve also as a retention area. The shape of these basins extends the structure of the garden, emphasizing it when filled with water. An additional benefit of the lowered parking is the decreased visibility of cars parked in the floodplain. The southern side channel is directed along the edge of the Loyola garden, after it runs toward the sanctuary on its visual axis. A small waterfall in the channel on this axis can increase the awareness of the water.

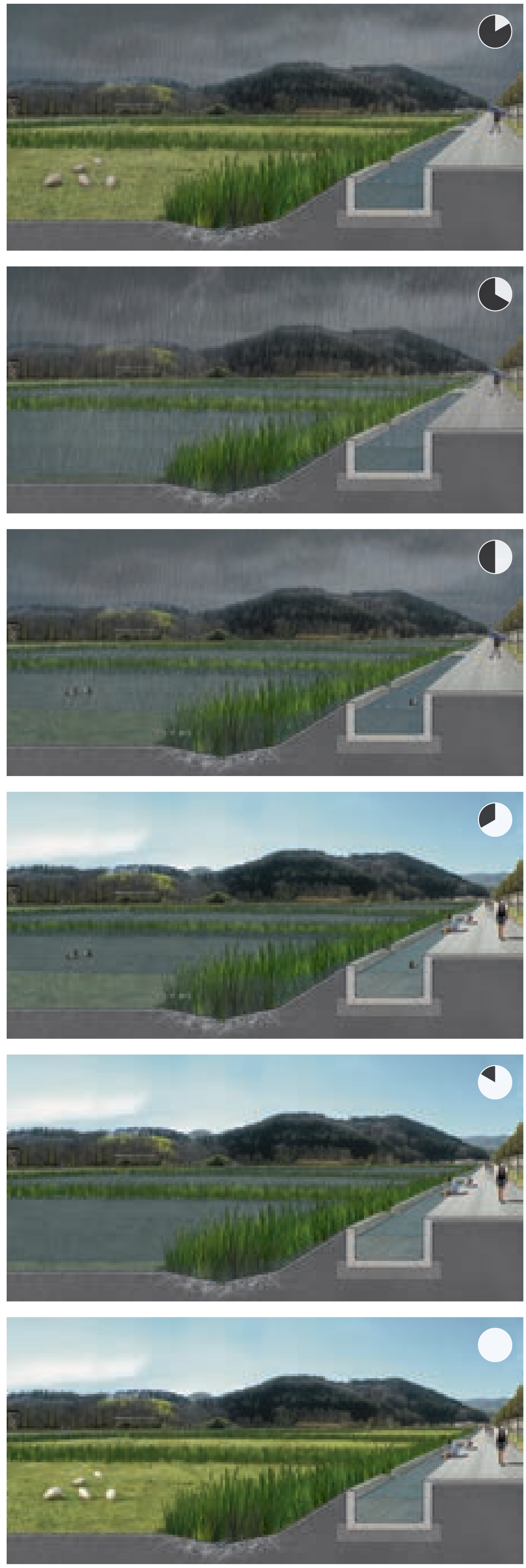
The floodplain is connected to the path structure of the Loyola garden by a bridge over the Urola. A lookout tower on the floodplain serves as landmark to direct visitors and to encourage them to extend their walk. The tower provides a wide view over the floodplain, which will be especially engaging during floods.

The existing farmhouses are protected from floods by dykes that turn them into islands during floods. The islands have an elongated shape, to further emphasize the wet character of the landscape and the flow direction of the river.

Legend

- Inundated fields with reed bed drains
- Side channel along boulevard
- Retention dyke
- Filled storage basin next to Loyola garden
- Lookout tower and bridge
- Buildings on agricultural island
- Pine forest
- Deciduous forest
- Fruit trees on earth banks
- Middle dyke with footpath
- Loyola garden

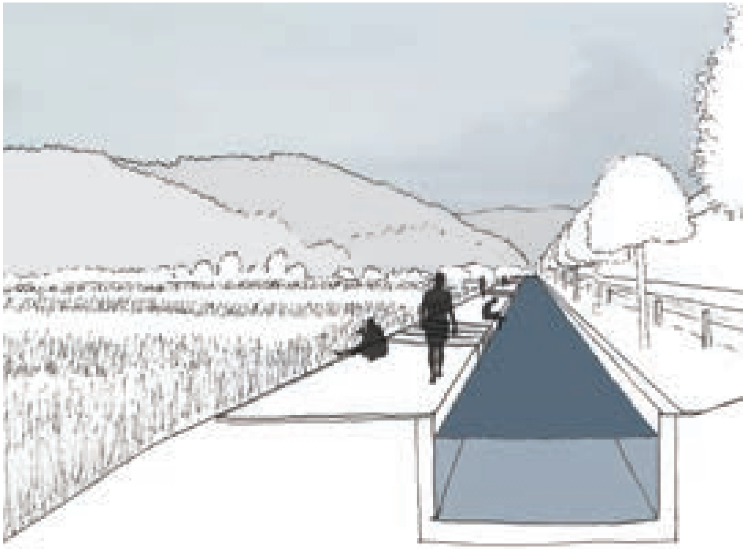
< [13.41] **The floodplain in inundated situation**



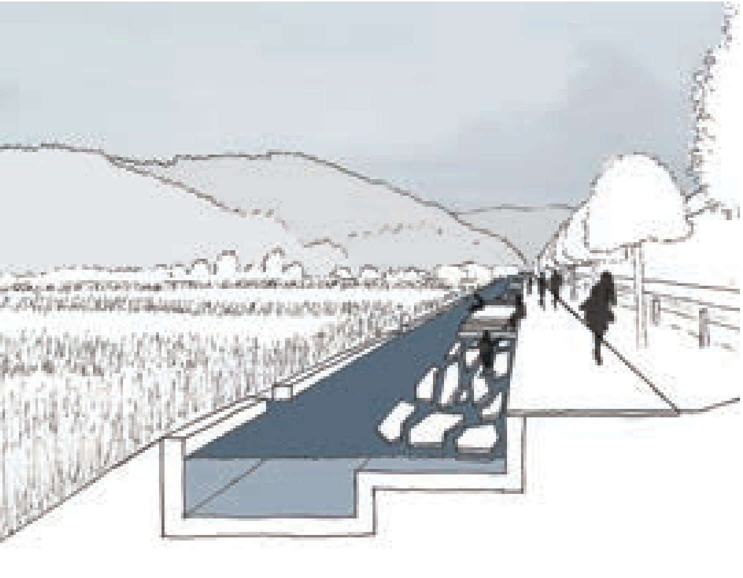
[13.42] **Inundation and draining of the floodplain over time reduces peak discharge**

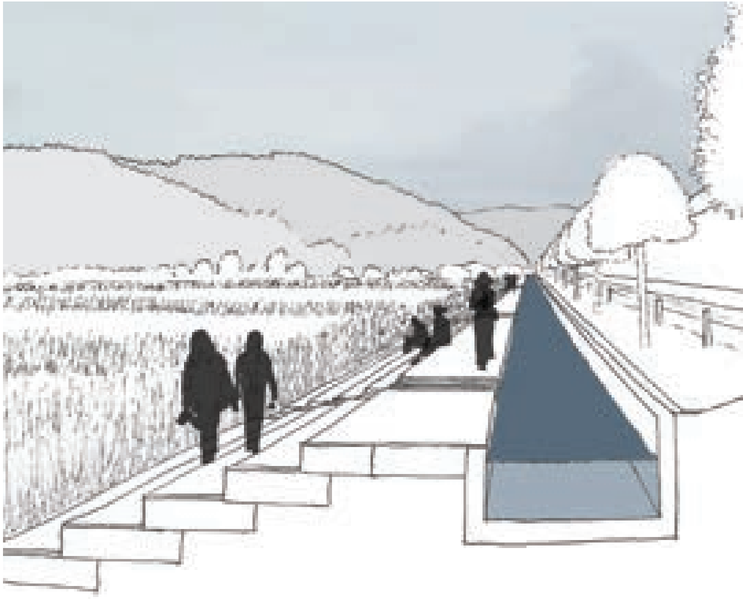
The floodplain boulevard

The walkway between Azpeitia and Azkoitia is a popular route among local people. Turning it into a boulevard connected to the side channel offers opportunities to make the water experienceable. Variations in profile and elements along the boulevard can create different possibilities for walking, sitting, and playing.



[13.43] Impression of the floodplain in normal situation





[13.44] Variations on the interaction of the boulevard and the side channel and flowfields

[13.45]

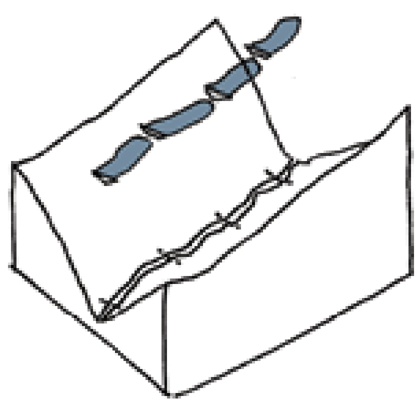
The Iraurgi valley offers a varied landscape of floodplains, valleys and spurs, which offer multiple possibilities and functions for people to interact with the water system and to benefit from this system. Recreational purposes (hiking, mountain biking), agricultural purposes (huertas, cattle drinking spots, orchards), sources of economic revenue (tourism, agriculture) link the water system to the landscape and everyday life of the Iraurgi Valley and its inhabitants.

walkers brook
huerta brook
huerta brook
religious axis
huerta brook
mountain bike brook

14 Canyon

Design propositions

In the Urola watershed one large and long canyon and several smaller canyons can be found. As has been stated in the initial principles, the steep gradient of the riverbed in these canyons makes it interesting to create retention areas within the riverbed.

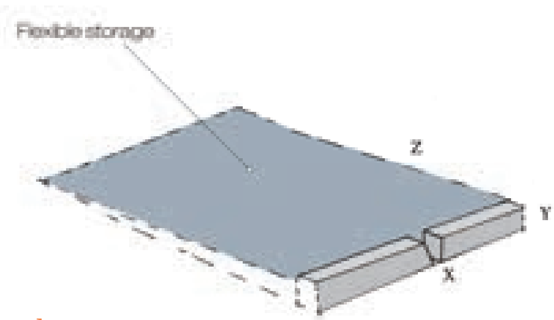


[14.1] **Sequence of dams in the canyon for the retention of water**

Used technique

The technique used for the retention of water in the riverbed are so called 'orifice weirs' (knijpstuwen in Dutch), which are dams that allow the regular everyday flow of water to flow through. This enables fishes and other fauna living in the river to migrate easily through the river, as is opposed to regular dams that would form a barrier for the river fauna. In case of an extreme precipitation event more water will flow through the river and the dams will push up the water, creating retention ponds behind it.

By creating these dams regularly after each other a sequence of dams is created [14.1]. These dams together create a retention capacity for surplusses of river water during extreme precipitation events.



[14.2]

Capacity

The water retaining capacity of the (orifice) dams can be calculated with the following formula [14.2]:

C_r=Y*X*Z*1/2

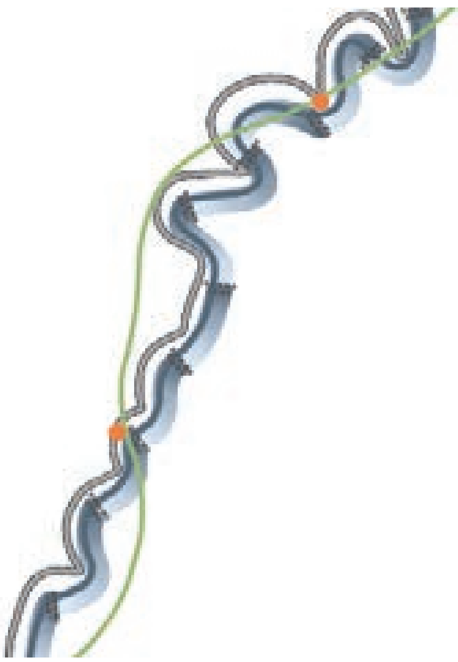
Considering that the average gradient is 2% we know that a dam of 2 meters high (X) could push the water upto 100 meters up the river (Z). The average width of the river is estimated to be 10 meters (Y). Finally, due to the gradient of 2% the total volume of X*Y*Z needs to be halved.

C_r= 10*2*100*.5
= 1000 m^3

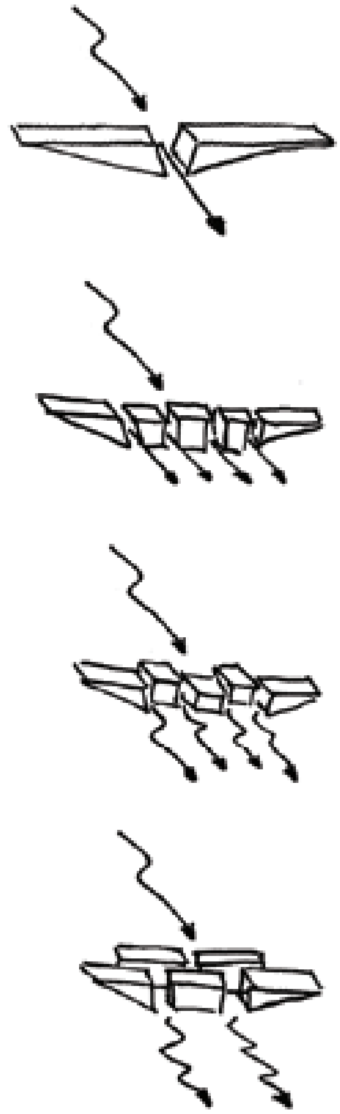
In total there is about 22 kilometers of canyon that is suitable for the intervention [14.3]. From this it can be concluded that the total retention capacity of this intervention is around 220.000 m^3.

[14.3] Canyons in the watershed

[14.4] **The canyon from the Via Verde, the river and road are clearly visible**



[14.5] **Sketch of dam as interaction point between the river, Via Verde and road**



[14.6] **Sketch of possible dams and interaction with water**

Interaction points

The interaction between the roads located next to the river will be enhanced. Car drivers on the road will get a better sight and experience of the briskly flowing river in the canyon, as the dams push up the water a little higher and make it churn through the narrow crevices in the dams. Resting places in the canyon are connected with the dams and viewing points can be created. For walkers and cyclists the connection between the Greenway (Via Verde) walking and cycling route [14.4;14.5] will be made to assure that they can enjoy the water as well.

Dams enhancing the wildness of the water

The orifice dams have been designed in such a way that the water has to seek its way past it, creating the briskly and wild character that is associated with the canyon. By creating multiple narrow crevices the general flow of water is forced to be churning to pass the dam [14.6-14.8].

The dams can be build using local stone a from the stone quarries. Combining these with concrete and steel constructions ensures the stability of the dams. The natural stone cuttings ensure that the color and structure of the dams will fit in the landscape.

[14.7] **Impression of the canyon in normal situation, seen from the Via Verde**

[14.8] **Impression of the canyon high river flow, seen from the Via Verde**

15 Ferreria

Design propositions

The Urola watershed is named after its historical watermills. Although many of these watermills have lost their function, their relics are still found in the landscape and the old dams of the watermills are often still in function. This led to the idea that the ferrerías could be restored to function in the new watersystem.

Used technique

The existing dams of the ferrerías are restored in their old buffering function, but the old dams are heightened. The extension of the dam is made following the technique of the orifice dam. This means that the regular flow of water can flow through, whereas the flow of water in cases of extreme precipitation will be held back by the dam, pushing up the water and retaining it. After the extreme precipitation event, the water level of the dam slowly lowers as the water flows out again.

Capacity

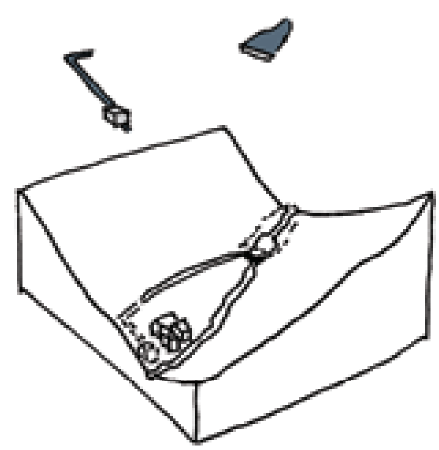
The water retaining capacity of the (orifice) dams can be calculated with the following formula [15.2]:

$C_r = Y*X*Z$

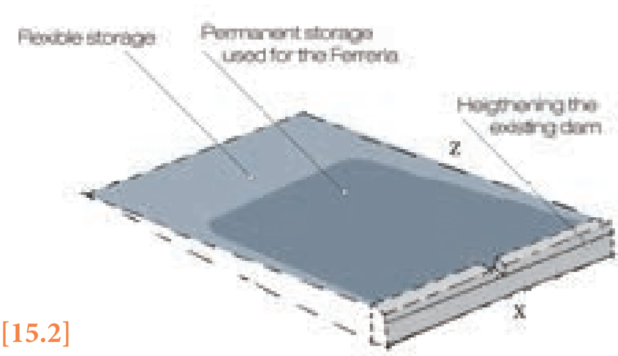
The existing dams will be heightened with approximately 2 meters (Y). The rivers broadness has an estimated average of 10 meters (X). The gradient of the riverbed in the areas of ferrerias is 1% average, meaning that a dam of 2 meter will push up the water up to 200 meters upstream.

$C_r = 10*2*200$
$= 4000\ m^3$

This would mean that one ferreria dam could retain about 4000 m³.In total there are 44 watermill remnants in the watershed. If all of these remnants are restored and heightened the total retention capacity of the ferreria dams would be around 160.000 m³ .



[15.1] Restoring the existing ferrería and extending its dam



[15.2]

[15.3] Ferreria locations in the watershed

[15.4] The ferreria dams have a height of between 2 and 3 meters in the current situation

[15.5] By heightening them in the form of orifice dams up to 4 meters retention capacity is created

[15.6] In extreme precipitation events this retention capacity fills up

New function: renewable energy

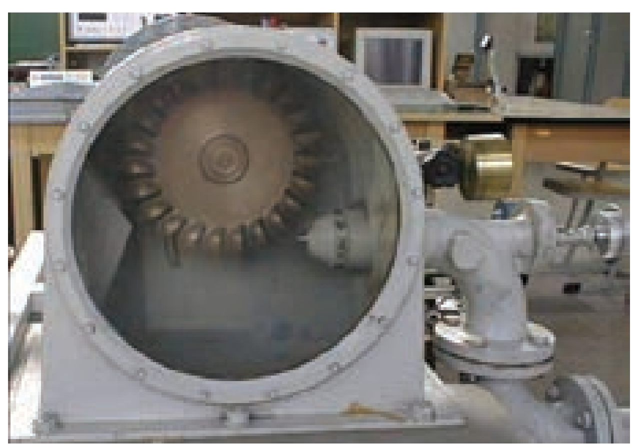
The ferrería system has a lot of similarities with the modern system of micro hydro power. Thus, when restoring the old ferrerías a micro hydro power installation can be installed. The old side channels and dam can be fully restored and connected to a micro hydro power installation, which is located in or near the old millhouse. This system can produce upto 500-1000 kW (Klunne, unknown) in energy that can be used by the households located next to the millhouse, the farms surrounding it, or in nereby villages.

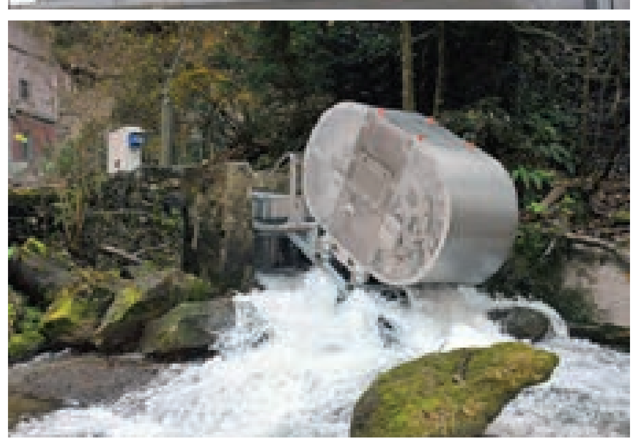
The hydro power installation can have several designs [15.8; 15.9], but it should have a visible function in the village, so that people know that their electricity is generated by the river they live along.

The Ferreria Walkways: recreation and tourism

The restored infrastructure of the ferrerías is used to create walking routes, the so called ferrería walkways. These walkways provide access for tourists and local people to walk through the watershed [15.7]. For tourists, the Ferrería Walkways can be interesting to walk along, showing them the beauty of the Basque landscape, combined with the heritage and the close link with the water system. A combination with historical education can easily be made along the route. People can walk from ferrería to ferrería, passing the dams, walking along the side channels and through the impressive valley landscape. The heightened dams offer an impressive waterfall during and after an extreme precipitation event [15.4- 15.6]. Some of the ferrerías are located in small villages and these villages can profit from tourists passing by, housing these tourists and selling local products to them. In [15.10-15.16] a storyboard shows an impression of the Ferreria Walkways.

[15.7] Ferreria walkways



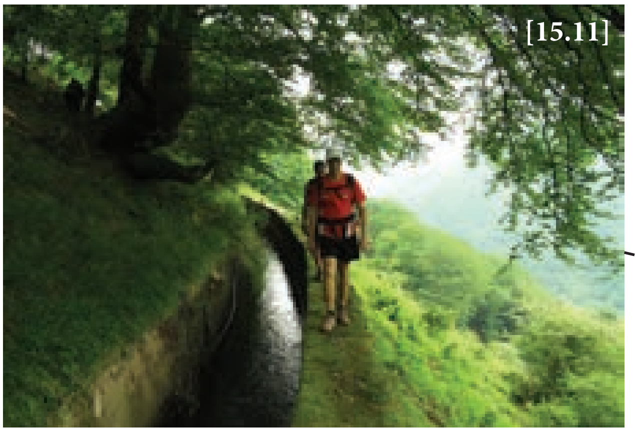


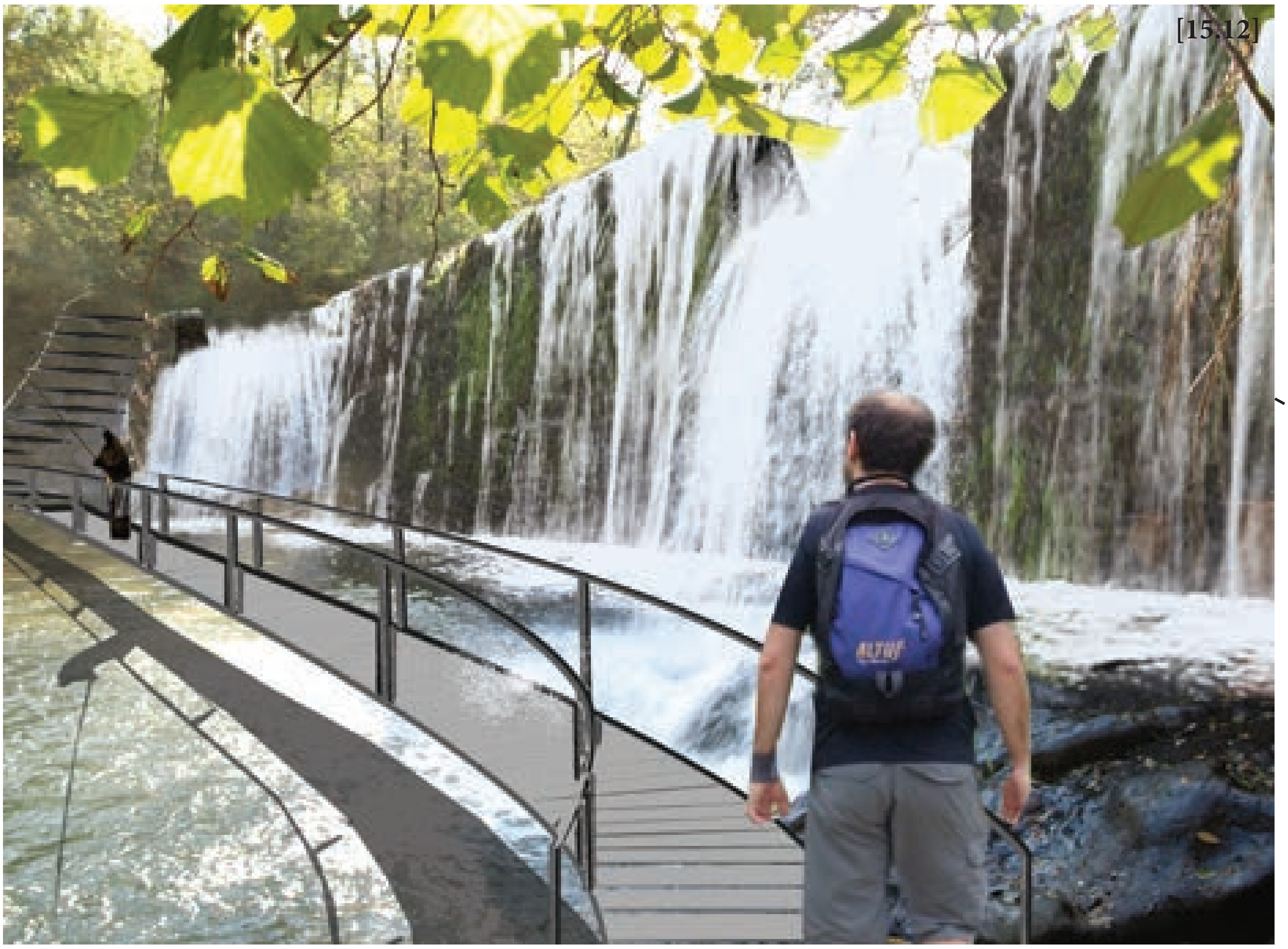
[15.8; 15.9] >

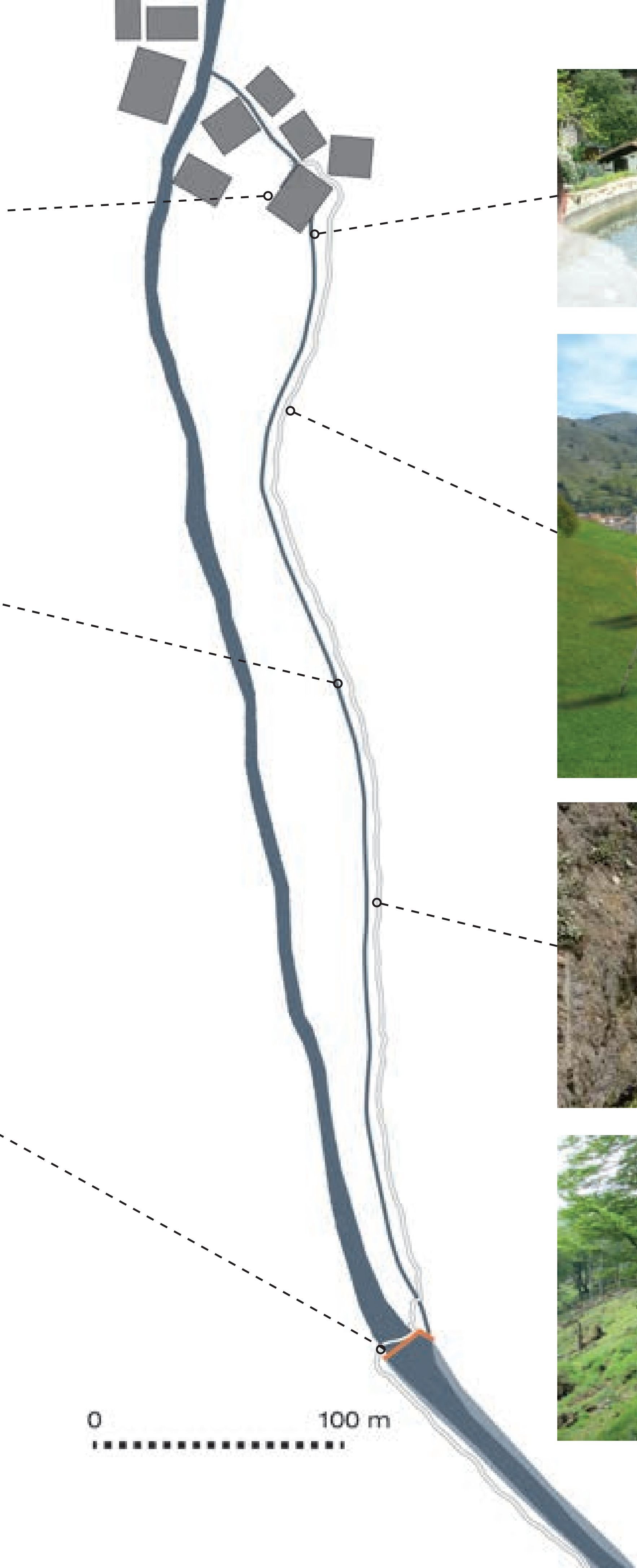
A walk along the historical ferrerías

With the restoration of the ferrerías, their dams and side channels, access to the upper reaches of the river is provided. One can walk from watermill to watermill. Starting at the dam, where the water gushes through, and even flows over the top of the dam after an extreme event. Walking closely past it, the water is quite impressive and one has to run through the moist, avoiding getting soaked [15.12]. Then one follows the side channel from the dam, sometimes a path lies next to it; sometimes the edge of the channel forms the path [15.11]. A small waterwheel in the side channel functions as a playful element to ensure that one is on the right track [15.15]. The channel leads ever higher up the valley, with the river below in the depth. Then, the ferrería village comes into sight in the distance [15.14]. When entering the village, the side channel gets broader, until it eventually leads into the ferrería house [15.13], where the waterwheels provide power for the village. Some villages provide the tourists with educational information on the historical function of the watermill [15.10], others offer sleeping spots and local food.


[15.10]


[15.11]

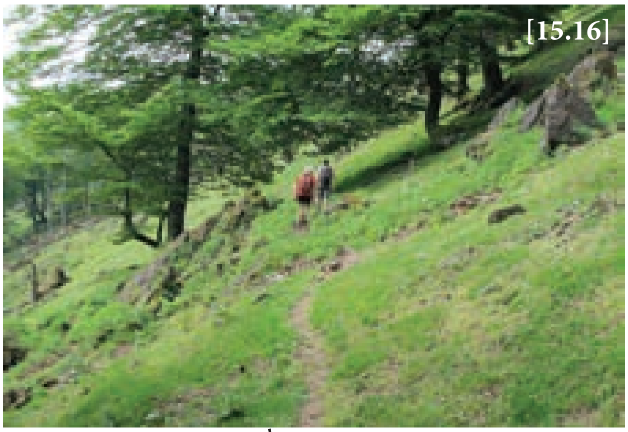

[15.12]




[15.13]


[15.14]


[15.15]


[15.16]

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Illustrations

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11.10 Loidl, H., & Bernard, S. (2003). Opening Spaces; Design as landscape architecture. Birkhäuser.
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15.13 https://picasaweb.google.com/urolagaraiaturismoaUROLAGARAIABarnealdekoXarma#5449622940874979906 [accessed on 6-10-2013]
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15.16 http://i660.photobucket.com/albums/uu327/cabrejano1/Circular%20Berroeta%202-6-12/circuberroeta069.jpg [Accessed on 6-10-2013]

Part 5 Conclusions & discussion

Now that a strategy and design have been proposed, and the impact and results of the design have been shown, it is time to draw conclusions and discuss the value and validity of the research.

16 Conclusions

Answer to the research question

The Basque Cantabrian Basin is a fascinating landscape, but highly responsive to extreme precipitation events. Damaging floods occur annually. This is caused by its natural characteristics, but also by the development of the human organisation which eventually led to a divergence between the natural and anthropogenic subsystems, which has been stated to be the overarching problem. The main aim of this thesis was to try and tackle this problem and find out how a highly responsive landscape, such as the Basque Cantabrian Basin, could be made resilient to extreme precipitation events. This has been done with a focus on the Urola watershed as a case study area and the associated main research question:

"What interventions have to be made to the landscape to create a flood resilient landscape in the Urola watershed?"

During the theoretical framing of the research it became apparent that a resilient system or landscape is more than sustainable flood management or an adaptive system. It became evident that cultural sustainability and embedding of interventions in the landscape are of significant importance for a resilient landscape. The divergence of the natural and anthropogenic subsystems cannot be counteracted by focussing only on the lack of room for the water, as the lack of interaction between the human organisation and the natural water system should be taken into account as well.

When we solely look at the results on the retention and buffering of water in extreme precipitation events, it can be noticed that the proposed interventions significantly improve the retention and buffer capacity of the watershed. The proposed small scale, local interventions together create a big regional impact. Every village of the watershed retains the local water and tries to buffer the surplus of water from their area before it gets to the next village. This way a strategy and management on watershed level is reached, that spreads the water and tries to retain and buffer as much water as possible with many small scale interventions. Especially for less intense floods with a high return rate the impact of the floods can be reduced to zero. For larger events the impact can be reduced to a smaller extend, but in such a way that the time people have to respond to these events increases. It can be concluded that the landscape has become for the most part resilient to extreme precipitation events.

If we now change to the broad perspective of a resilient landscape, it is much harder to evaluate if the embedment of the water system in the landscape and everyday life of people has succeeded as it is a much more qualitative aspect. However, the design shows that the local interventions can be 'customized': it can be embedded in the local landscape and the water system can interact with the people through their everyday activities. Thus it can be concluded that resilience has been reached in a broad perspective as well. The local interventions can be customized and fit in the landscape and everyday activities of people.

To show how both the embedding of interventions in the landscape and the cultural sustainability can be combined with sustainable flood management six guidelines have been proposed as a basis for a resilient strategy and design:

1. Intervene in the areas that are occupied and altered by humans
2. Develop a strategy on the watershed level.
3. Enhance the local landscape characteristics and its relation with the water.
4. Create possibilities to interact at places that people visit often.
5. Create new functions for the water system in the human organization, adapting old functions to it.
6. Use of local labour, scale, expertise and materials.

These six guidelines can help to create a flood resilient landscape in the Urola watershed and Basque Cantabrian Basin in general. First, these interventions create a water system that has a higher retention capacity and that offers more room for the water in the human organisation of the landscape. Second, the landscape can become cultural sustainable. The interaction between human activities and the water system is improved and the water system has multiple functions in the human organization, apart from flood protection. Third, the water system is embedded in the landscape and it enhances the landscape. This improves the cultural sustainability of the landscape even further, since it has a strong link with both the everyday life of the people and the local landscape. In general these three points, and the six guidelines related to it, contribute to the resilience of the Urola watershed and the Basque Cantabrian Basin in general. The above stated guidelines can also be used in landscapes with comparable characteristics that have to deal with extreme precipitation events. If the guidelines are applied to other cases, interventions will be different from the ones in Urola, as the conflicts, landscape characteristics and human organization of the landscape differ from the Urola watershed.

This thesis has shown that by coming with local interventions, which are embedded in the landscape and everyday life, and are connected on the regional level by a sustainable flood management and strategy, a resilient landscape can be created.

17 Discussion

Value of the research

In this chapter the validity, uncertainties and constraints of the research are discussed, and its value in the field of landscape architecture and in the general field of science is determined.

A number of factors have to be taken into consideration regarding this research. It is important to realize that the proposed interventions cannot be implemented immediately, as this was never intended. Its main objective has been to show a vision for a future landscape, to generate new ideas and to incite discussion among scientists in general as well as landscape architects.

This research was conducted with limited access to data on river flow and surplus of water at flood events. These data have been used with simplified formulas and general data to estimate the quantitative impact of processes in the water system and the impact of the proposed interventions. If these interventions would be implemented, it is recommended to gain more detailed data and calculation methods, performed by people with a more specialized technical background, to be able to make better-grounded statements.

New data obtained during the finishing stage of this thesis suggest that both the retention capacity of the landscape and the extent of the damage caused by floods are larger than assumed in this thesis. This increases the impact the interventions have on flood occurrence and emphasizes the need for a change to reduce losses caused by floods.

Limited knowledge of the Spanish and especially Basque language have constrained the interpretation and processing of data to some extent.

One could argue that a broad definition of the term resilience, including cultural sustainability is not appropriate since cultural sustainability as such has not been proved to exist in practice. However, the proposed strategy and design for a flood resilient landscape emphasizes the role of the everyday life of people in the resilience of a landscape, making this thesis an example of how cultural sustainability could be implemented in practice.

General knowledge

This thesis shows that solutions for flood problems are not only to be found in sustainable flood management, but that a broader perspective can reveal other possibilities and potentials. It can link a sustainable water system to the local landscape and the local way of living. One should not only look into the conflicts and problems when looking for a solution, but part of this solution might also be in highlighting the positive aspects of the water system and by highlighting these aspects new possibilities for an adaptive water system might arise. The discussion is opened up for a more broadly defined meaning of the word resilience. A meaning in which resilience is not only about withstanding natural deteriorating forces, but also about cultural sustainability as an important part of it.

General knowledge for landscape architecture

This thesis is an example of how the landscape approach as a theory can be translated into a design for a concrete climate change problem. It shows how technical design interventions can be linked with the local landscape and with the local way of living. The landscape approach has been viewed in a broad way. It follows the landscape approach in using natures' processes as a basis for design and making these processes visible, but it also proposes the idea that these processes can form the backbone for several human land use activities. The landscape approach is directly linked with cultural sustainability as described by Saito. Although this thesis is in line with the landscape approach as described by Jusuck Koh, it provides a new perspective on this approach.

Recommended future research

To strengthen the proposed strategy and to fill the gaps in this research it is recommended to do further research into the urban parts of this region and its more specific relations to the landscape.

It could also be valuable to investigate possibilities for participation and involvement of local inhabitants and other stakeholders to find ways for implementation of the strategy.

Due to the mostly explorative character of the design and research it is necessary to do more specific and small-scale design to make implementation of all the interventions possible.

Part 6 Glossary & Appendices

Insight has been given in the used definitions of words in the glossary, and in the data, calculations and analysis behind this research in the appendices.

Glossary

Buffering - Storing water for a short period of time in lower areas next to the river to reduce the peak run-off and to prevent floods downstream.

Case study - Focuses on getting detailed knowledge about a single instance or a set of related instances. The result of a case study should be a story to be told, the telling of the story can be a design (Hanington and Martin, 2012).

Cultural sustainability - survival that depends on human attention (Nassauer, 1997 as cited in Saito, 2007)

Discharge - The volume rate of water flow

Flow channel – A channel that is used to flow with the river, decreasing the rivers discharge.

Flow field – A field that is used to flow with the river, decreasing the rivers discharge, usually fed from a flow channel.

Orifice weir - A weir with a regulated flow through and a regulated conservation of water behind it.

Orogeny - The process of formation of mountains by folding of the earth's crust.

Research through design - this method recognizes the design process as a legitimate research activity. It bridges theory and builds knowledge. It integrates models and theories with technical knowledge into the design process (Hanington and Martin, 2012).

Retention - Slowing down local water for a short term (up to a couple of days), with the purpose of preventing floods downstream.

Run-off - Rainfall that is not absorbed by the soil and flows of over land.

Side channel – A channel that runs parallel with the river and flows with the river, used in watermill systems, but also for feeding flow channels and fields.

Triangulation - The process in which you use multiple methods to do an inventory or to do research (Hanington and Martin, 2012)

Watershed - The term watershed is interpreted as 'an area or region drained by a river, river system'.

Appendix

During our research we gathered and utilized large amounts of data and information, which have eventually not been included in the final version of our report. On the attached CD-ROM you can find the most important selection of this data. It includes the calculations of the surplus of water, early conceptual models, valley sections, an early landscape analysis and a series of videos taking you through the landscape of the Urola watershed.