



InVíkorate

Exploring self-sufficiency in a tourist-dependent Icelandic village

Master thesis in
Sustainable Urban
Design by Vera Wetzels

InVikorate

Exploring self-sufficiency in a tourist-dependent Icelandic village



Master Thesis in Sustainable Urban Design

School of Architecture and the Built Environment
Lund University, Sweden
January 2021

Author: Vera Wetzels
Supervisor: Misagh Mottaghi
Examiner: Louise Lövenstierne

Email: vera.wetzels@gmail.com

All artwork and photographs presented in this book are by Vera Wetzels unless noted otherwise.

Acknowledgement

First and foremost, I would like to express my gratitude towards my classmates who have always inspired and supported me throughout my Master's program. I am grateful for you always encouraging me and believing in my ideas for this thesis.

At the same time I would like to thank my supervisor Misagh who was always happy to help and inspire me during any struggles I found along the way.

I also want to thank Tóti for the great company and inspiring stories during my visit to Iceland. Last but not least, I want to express my gratitude towards my parents for always staying supportive, no matter how long the process.

“ Oft hefur ellin æskunnar not. ”

Old Icelandic saying: “The old can always learn from the new.”



Abstract

In a rapidly urbanising world, the importance of rural towns and villages is often forgotten. Many people see more opportunities for employment, social life and their children's future in the big city, leaving smaller, rural places empty and abandoned. This process of rapid urbanisation can in the long run result in the loss of many valuable villages, along with their local community and the traditions and aspects of the local culture they have kept intact over time.

This thesis emphasises on the necessity and possibilities to provide diverse opportunities for the future of a currently tourist-dependent Icelandic village, called Vík í Mýrdal. In order to achieve this, the concept of self-sufficiency as well as its possibilities for the village are explored. Additionally, the geographical, economical, ecological, social, historical and physical background of the village were looked into, resulting in an urban design proposal for Vík, that focuses on local food production, walkability, climate-responsive housing and small business opportunities.

Contents

Abstract	9	5. Reference projects	59
1. Introduction	13	5.1 Solheimar Ecovillage	60
1.1 Aim of the project	14	5.2 Friðheimar	61
1.2 Research questions	14	5.3 Nárpes Grönsaker cooperative	62
1.3 Choice of the site	15	5.4 Greenhouse home by Richard Weaver	62
1.4 Methods	16	5.5 Inspiration for Vík	64
2. Analysis: Iceland	19	6. Strategy and concept	67
2.1 Geography, climate and nature	20	6.1 National strategy	68
2.1.1 Geography	20	6.2 Local strategy	68
2.1.2 Climate	21	6.3 Concept for Vík	70
2.1.3 Flora	24	7. Design proposal	73
2.1.4 Fauna	28	7.1 Design principles	74
2.2 History and culture	28	7.2 Strategy	80
2.3 Farming	30	7.3 Masterplan	82
2.4 Economy and tourism	30	7.4 Detailed design	88
2.5 Renewable energy	31	7.4.1 Main square	88
2.6 Future challenges & opportunities	31	7.4.2 New neighbourhood north	94
3. Analysis of Vík and surroundings	33	7.4.3 Additional ideas	102
3.1 The region	34	7.5 Walkability	104
3.2 Vík	38	7.5.1 South Vík	104
3.2.1 History and development	39	7.5.2 Icelandic main road	105
3.2.2 Facilities and buildings today	40	7.6 Phasing	106
3.2.3 Demography	42	8. Conclusions	109
3.2.4 Public life	42	8.1 Conclusion	110
3.2.5 (Natural) threats	43	8.2 Reflection	111
3.2.6 Municipality's masterplan	44	References	112
3.2.7 Challenges & opportunities	47		
4. Analysis: Self-sufficiency for Vík	49		
4.1 What is self-sufficiency?	50		
4.2 Iceland's Ecological Footprint	51		
4.3 Food	52		
4.4 Water	54		
4.5 Shelter	54		
4.6 Energy	56		
4.7 Other	56		



01

INTRODUCTION

After the economic crash in 2008, tourism in Iceland has grown rapidly and even became the country's biggest economic sector since 2015. This means that the economy is strongly relying on the influx of visitors and where and how they spend their money. Since tourism's peak around 2017, the curve has started to flatten out (Arion Research, 2018). Something else very relevant which is happening at the time of writing this report is the coronavirus pandemic. Many tourist-related businesses need to shut down and there is no income for a large number of people. This clearly shows that it can be risky to have a country relying so strongly on one sector with its income, especially when the growth is becoming stagnant. Iceland will need a diversification of income sources on a national and local level, in order to sustain itself in the future.

Especially smaller Icelandic towns will experience a decrease in tourism the most. Small businesses are hit the hardest and there are less options for new job opportunities within the towns itself. Residents of villages will have to move to the bigger cities to find new livelihoods, only speeding up the current urbanisation rate further. Besides that, the bigger businesses that have more chance of survival often operate from the capital, Reykjavík, where the money will end up going to.

1.1 Aim of the Project

The aim of this project is to explore an urban design proposal that promotes self-sufficiency in an Icelandic village (Vík) located on a popular tourist route. The diversification of businesses and local supply of essential products will make residents of the village less reliant on tourism as their income source. The new local economy will provide options for current as well as new residents. While self-sufficiency will be explored, the design will still focus on the role of Vík as a popular tourist destination in Iceland, as well as focus on design guidelines for cold and windy climates.

1.2 Research Questions

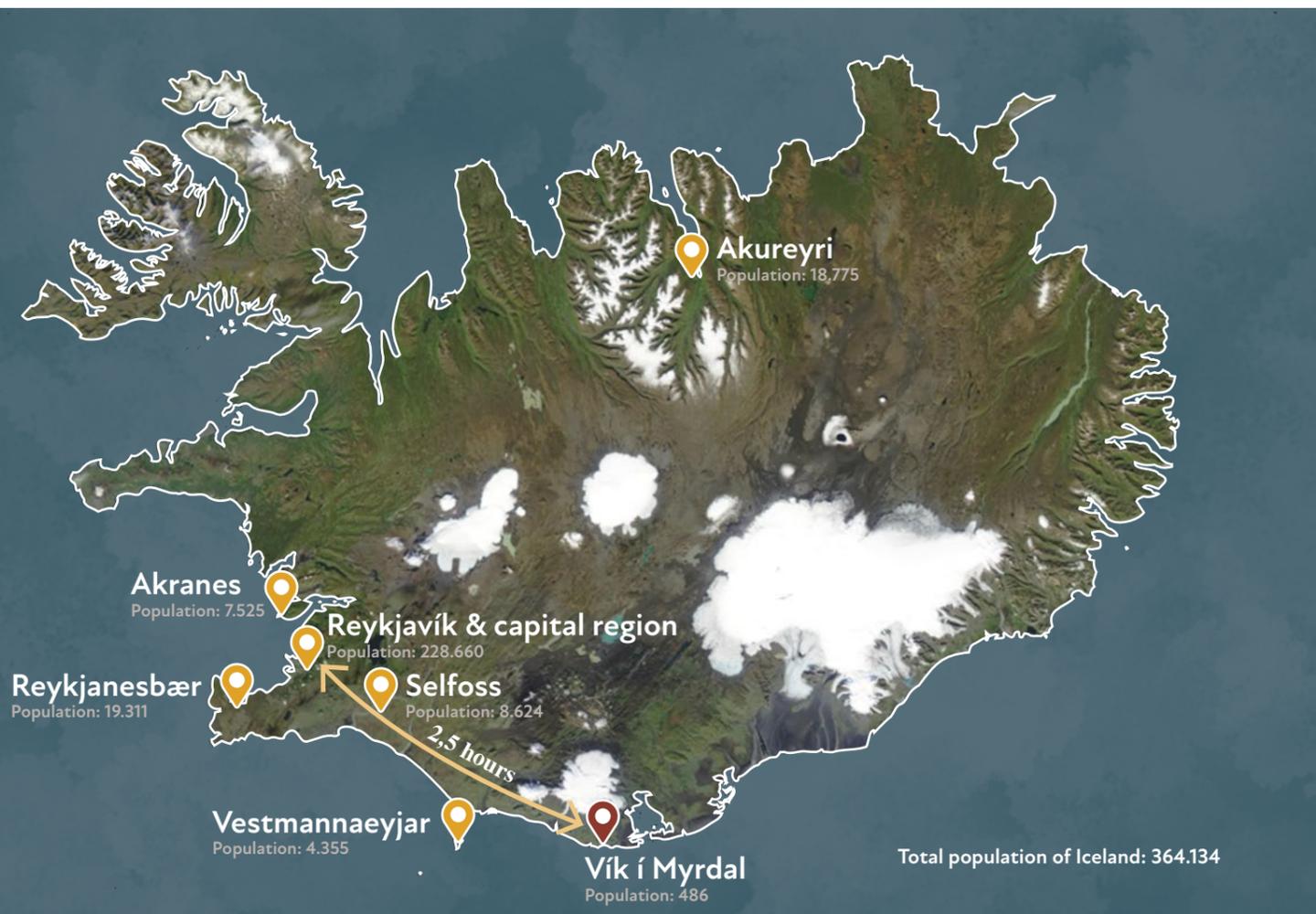
- What is self-sufficiency?
- What important information about Iceland and Vík can be applied in a new, more self-sufficient plan for Vík?
- To what extent can an Icelandic village be self-sufficient in modern-day culture?
- What design elements provide best for a local economy?
- What (design) tools can be used to improve local walkability?
- What (design) tools are needed to design in the Icelandic climate?

1.3 Choice of the Site

Nowadays more people live in cities than in rural environments, and the percentage of people living in cities is increasing. People move to cities for many reasons, which include better employment and education opportunities, social benefits and an overall more modern lifestyle. Many smaller communities are slowly going empty, farming shifts to monocultural mass production and cities are often getting overcrowded, accompanied by many other problems. But what if more opportunities are available in rural settlements too? What if people don't have to rely on the big city to ensure a prosperous future? What if the food that is grown on the other side of the world can be grown on the other side of your house just as well?

The project site of this thesis is Vík í Mýrdal in Iceland (usually referred to as only 'Vík'). It is a small village that has the main ring road of Iceland going through it. Many tourists go through Vík every day, but often stay in the village only for a quick stop or a strategically planned overnight stay. Vík already has many unique qualities as it is and at the same time there also is a demand for new housing, since Vík has been growing steadily since the rise of tourism in the country (VSÖ Ráðgjöf, 2020). However, now that the Icelandic tourism industry is becoming more stagnant and stopped growing (Arion Research, 2018), it is important to think about how smaller communities can sustain themselves in the future when their main source of income might become less reliable.

During the process of writing this thesis, the COVID-19 pandemic has taken control of the way the world as we knew it functions. Many people have passed away, lost loved ones or lost their business. This only proved the relevance of the topic of this thesis even more: local healthcare centres need to be able to take care of their people and residents of rural places will have to be able to take care of themselves with locally produced essential products.



Monocultural economy



Housing demand



Lack of clear connections



Strategic stop on the south coast

Working with the existing local qualities and combining it with a sustainable plan for the future, this project can serve as an example or inspiration for many other (Icelandic) villages that will most likely struggle with similar challenges in the future.

1.4 Methods

To gain a complete knowledge and understanding of the site and its relevant topics, four main research methods were used for the analysis:

1. Literature study
2. Site visit
3. Interviews
4. Reference project analysis

The literature study gave many insights into events, characteristics, trends, problems and history on a national, regional and local level. This prepared the site visit, where a better understanding of the physical characteristics of the village and its surroundings was established, but also tourist behaviour, the challenges and beauty of Icelandic winter and the experience of Vík. During the site visit, several very helpful interviews were conducted with George Frumuselu (planning and building representative of Mýrdalshreppur municipality), Antoine Blondé (Máni) (employee of the information centre), two employees of Sólheimar Ecovillage and a number of tourists who visited Vík. After the site visit an interview was carried out with Gunnar Þór Jóhannesson (professor at the Department of Geography and Tourism at the University of Iceland) which gave more insight into Icelandic tourism on a bigger scale.

The site visit served as great inspiration for the concept and further development of the design. After forming the first concept ideas, a further relevant literature study was carried out to define and support the vision for Vík. Several reference projects were analysed that are relevant to and can serve as inspiration for the site.



02

ANALYSIS OF ICELAND

Iceland is a Nordic island in the Atlantic ocean that was formed on a place where the Eurasian and North American tectonic plates meet. This makes for a very volcanic landscape with unique natural phenomena all around the country. These natural wonders attract many visitors each year, with 1,55 million tourists in 2016 alone (Arion Research, 2017).

There are about 370.000 people living in Iceland, of which two thirds live in the area close to the capital Reykjavík. With a population density of 3 persons per km², Iceland is the most sparsely populated country in Europe (Statistics Iceland, 2020).

Iceland has a high latitude and even reaches the Arctic circle in the north, but because of the influence of the North Atlantic Current, the climate remains temperate but chilly. The location in the Atlantic ocean causes weather to change fast and get quite extreme from time to time.

2.1 Geography, climate and nature

2.1.1 Geography

Iceland is located on the Mid-Atlantic Ridge with the western part of the island on the North American tectonic plate and the eastern part on the Eurasian tectonic plate (see figure 1). Each year these plates drift about five centimetres apart, which causes much volcanic activity in the form of volcano eruptions, geysers, lava fields and earthquakes (Inspired by Iceland, 2020).

Over 11 percent of the country is covered by glaciers, and the highlands, which are mostly uninhabited, make up half of Iceland's land area. The highest peak is Hvannadalshnjúkur, standing 2119 metres above sea level (Inspired by Iceland, 2020). Because of the rough landscapes it is mostly the coastal regions that are inhabited, especially around the capital city Reykjavík.

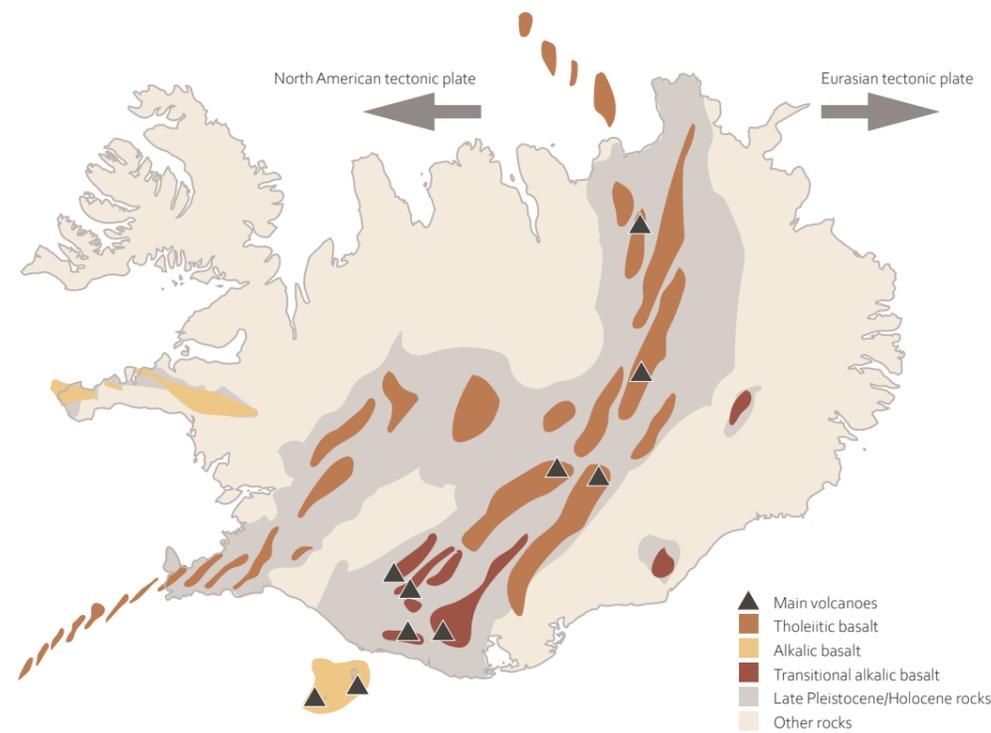


Figure 1: Map showing the two tectonic plates and the main volcanic zones of Iceland. Adapted from Wikipedia (2010).



Figure 2: Aurora Borealis (northern lights) can regularly be seen in the Icelandic skies, especially during the darker months. Image: Viator (2021).

2.1.2 Climate

Because of the influence of the North Atlantic Current, Iceland has a temperate climate despite its high latitude. The climate is characterised by cool and damp summers and relatively mild winters, however they get extremely windy from time to time. According to the Köppen Climate Classification, the majority of Iceland has a tundra climate. The coastal regions in the south-west and some other parts are classified as subpolar oceanic. Vík for instance has an average temperature of 11,5 °C in July and 2 °C in January (Mýrdalshreppur, 2012) (see figure 3).

Around midsummer, most of the country experiences two weeks of continuous daylight, because the sun only sets very briefly. During the winter months, the Aurora Borealis is often visible at night (see figure 2).

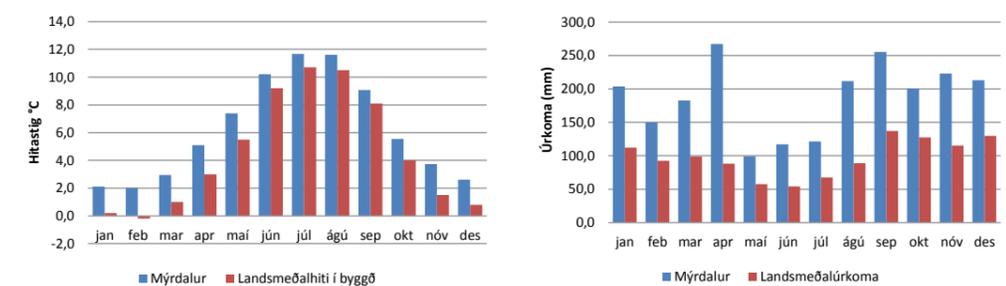


Figure 3: Diagrams showing the average monthly temperatures and precipitation of Mýrdalur (blue) and Iceland (red). Source: Mýrdalshreppur (2012).

The Icelandic Pledge

I pledge to be a responsible tourist.

When I explore new places,
I will leave them as I found them.

I will take photos to die for,
without dying for them.

I will follow the road into the unknown,
but never venture off the road.

And I will only park where I am supposed to.

When I sleep out under the stars,
I'll stay within a campsite.

And when the nature calls,
I won't answer the call on nature.

I will be prepared for all weathers,
all possibilities and all adventures.

(Inspired by Iceland, 2020)



2.1.3 Flora

The effects that farming has had on the Icelandic landscapes are very visible nowadays. 25-40% of Iceland was covered with birch forests and woodlands at the time when settlement began (see figure 4). Native species you could find around that time were birch (*Betula pubescens*), tea-leaved willow (*Salix phylicifolia*), rowan (*Sorbus aucuparia*) and very rarely some aspen (*Populus tremula*) (see figure 6). Depending on the location of the trees, often the birch and willow only grew in shrub-form due to their exposure to wind or their location in a wetland (Eysteinnsson, 2017).

After a long history of agricultural land use, the birch woodlands reached a minimum of less than 1% of the total land area around the mid-20th century. It was also around that time when forest protection and afforestation began. Nowadays some Icelandic forests are valued important for recreation, ecological diversity and as a remnant of what once covered a big portion of Iceland's land area (Eysteinnsson, 2017).

The Icelandic Forest Service (IFS) focuses on three aspects of afforestation: economical, ecological and social. Some examples of the goals of IFS's forestry strategy are:

- That at least 12% of Iceland will be afforested by the year 2100 through both planting and natural forest extension
- To develop sustainable forest utilisation and forest industry
- To improve public access to forests and increase the recognition and role of forests in public health
- To increase the role of afforestation in soil and water conservation, enhancement of biodiversity and amelioration of the environment
- To enhance the role of forests as carbon sinks and to adapt forestry to climate change

IFS emphasizes the importance of forests for the public's health and well-being, which is why IFS has a strong focus on planting forests close to urban areas and opening them to the public. Another strategy of the IFS is farm afforestation, where farmers are responsible for planting trees on their property. The farmers get 97% of the establishment costs subsidised. The main use of

Figure 4: What a big portion of Iceland used to look like. Image: Eysteinnsson (2017).

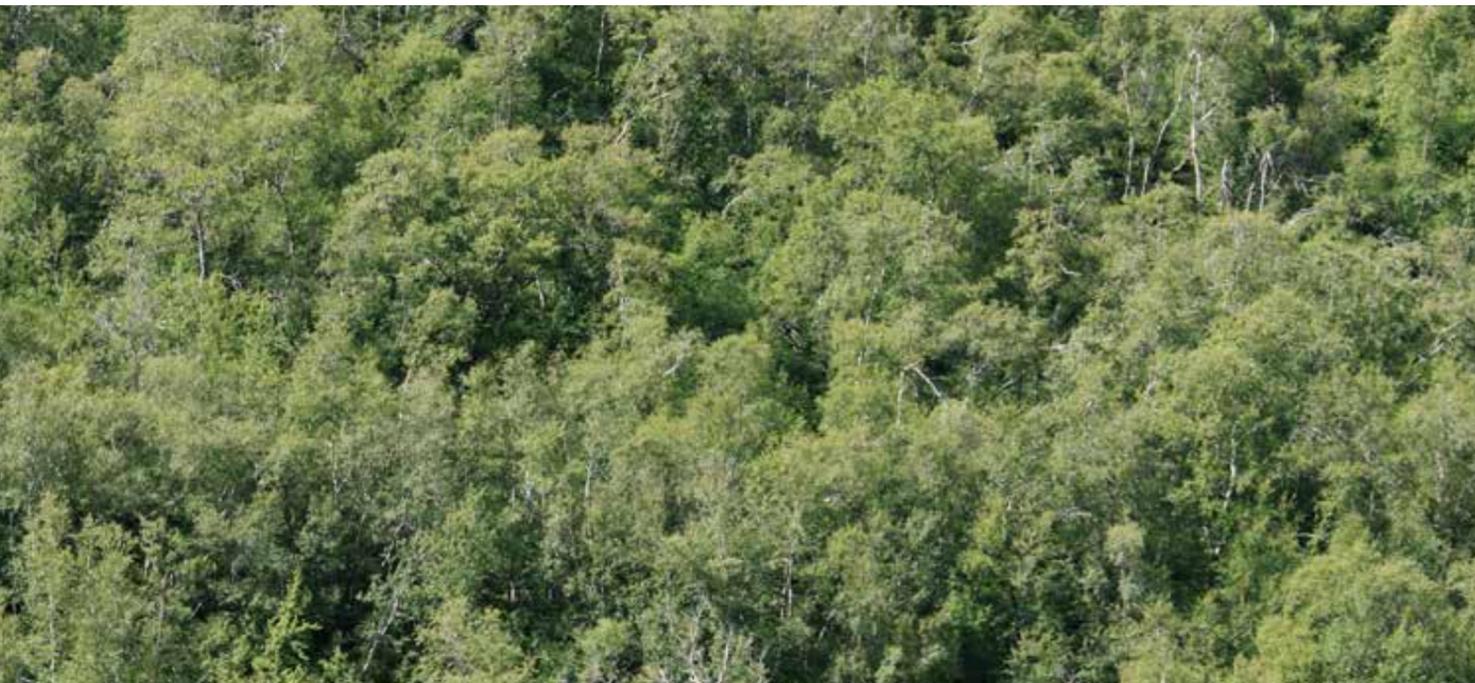


Figure 5: A common Icelandic landscape nowadays.

these trees is for timber production and the main species include: Siberian larch (*Larix sibirica*), Sitka spruce (*Picea sitchensis*), lodgepole pine (*Pinus contorta*) and black cottonwood (*Populus trichocarpa*). However, when winters will most likely get warmer due to climate change, the Siberian larch might have difficulties growing in Iceland in the future (Eysteinnsson, 2017).

The total vegetation cover of Iceland used to be about 65% (including the 25-40% forests) at the time of first settlement, which has changed to less than 25% in 1980, much of which belongs to farmers (Arnalds, 1987). Nowadays much of the Icelandic vegetation consists of mosses, flowering plants and berries.

Some common flower species are: mountain avens (*Dryas octopetala*), arctic thyme (*Thymus praecox arcticus*), sheep sorrel (*Rumex acetosella*), dandelion (*Taraxacum* family), caraway (*Carum carvi*), Angelica (*Angelica archangelica*) and lupine (*Lupinus nootkatensis*) (see figure 6). The last one is controversial, since it is a non-native species that was introduced to Iceland to fight soil erosion. Since its introduction, it has spread to many other places where it poses a threat to for instance native mosses that are known for being difficult to establish and recover. But despite the problems lupine flowers bring, they are also loved by many for the beautiful purple landscapes they create in the late spring (Björk, 2020).

Iceland is famous for its vast green fields that cover the mountainous landscape (see figure 5). In many places these fields include or consists only of mosses and lichens. Moss is known for recovering very slowly, which is why picking moss and walking and off-road driving on mossy areas is strongly discouraged. A well-known sight in the south of the country are the moss-covered lava fields. The wet, chilly climate is also a great growing place for many types of ferns. The most common one in Iceland is the brittle bladder fern (*Cystopteris fragilis*) (s.n., 2020).

A popular activity for Icelanders is to go berry picking in their free time. Some popular berries include: bog bilberry (*Vaccinium uliginosum*), bilberry (*Vaccinium myrtillus*), crowberries (*Empetrum nigrum*), redcurrant (*Ribes rubrum*) and stone brambleberry (*Rubus Saxitilis*) (Björk, 2020) (see figure 6).

Figure 6: An impression of the vegetation in Iceland.



Betula pubescens. Image: Van Den Berk Boomkwekerijen (2021).



Salix phylicifolia. Image: Salo (2009).



Sorbus aucuparia. Image: Giallopolenta (2006).



Picea sitchensis. Image: Tanglao (2010).



Pinus contorta. Image: Van Den Berk Boomkwekerijen (2021).



Populus trichocarpa. Image: Siegmund (2006).



Dryas octopetala. Image: Steinsplitter (2014).



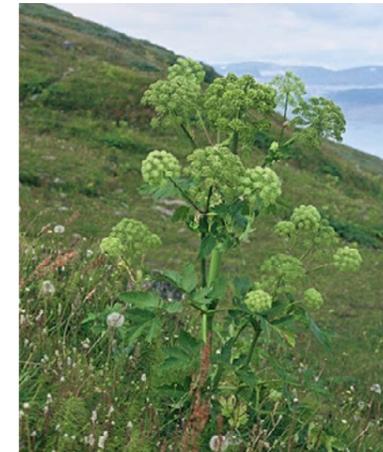
Thymus praecox arcticus. Image: Stein (2021).



Rumex acetosella. Image: Turner (2003).



Carum carvi. Image: Opiota (2016).



Angelica archangelica. Image: Anderberg (2004).



Lupinus nootkatensis. Image: Boyer (2014).



Racomitrium lanuginosum. Image: Nelson (2017).



Racomitrium canescens. Image: Seyriuen (2010).



Cystopteris fragilis. Image: Minnesota Wildflowers (2021).



Vaccinium uliginosum. Image: blanc (2016).



Empetrum nigrum. Image: Rønning (2010).



Ribes rubrum. Image: Grönbacka Plantskola Taimisto (2021).

2.1.4 Fauna

Before the ice ages, the climate of Iceland accommodated for many more and very different species than what can be found nowadays. Because of its isolated location, Iceland nowadays has a much lower biodiversity compared to other North Atlantic regions. Opportunities for smaller animals and invertebrates to reach the island were much smaller compared to these other regions. Around 2000 freshwater and terrestrial species and 2500 marine species are known to live in Iceland and its waters, however these numbers are much higher in reality, since many have only little been studied (Icelandic Institute of Natural History, 2020).

Some examples of well-known animal species that can be found in Iceland are the raven (*Corvus corax*), Arctic fox (*Vulpes lagopus*), puffin (*Fratercula arctica*) (see figure 7), grey seal (*Halichoerus grypus*), mink whale (*Balaenoptera acutorostrata*), wood mouse (*Apodemus sylvaticus*) and Arctic tern (*Sterna paradisaea*) (Icelandic Institute of Natural History, 2020).



Figure 7: An iconic bird for Iceland: the puffin. Image: Arctic Adventures (2019).

2.2 History and culture

Despite the relatively late human settlement compared to most other countries in the world, Iceland has experienced some major events during the past centuries that have shaped the society as it is nowadays. After being under the rule of multiple other countries, Iceland voted for independence in 1944 and has been independent ever since. During the Second World War, Iceland remained neutral, but Britain and the US partially operated from Iceland to protect their control over the Atlantic ocean. The Icelanders welcomed them in a polite manner, and still up to this day, from my personal experience, Icelanders are very welcoming people. Apart from that, Icelanders have dealt with the extreme living conditions during many centuries, which resulted in having to help each other out when someone is in need. During my visit I experienced how good Icelanders are at problem solving together and helping each other, as well as visitors, out when there is trouble.

70
million
B.C.

Geological formation

Iceland began to form from a series of underwater eruptions that formed the island.

9th
century

First inhabitants

Irish monks as first inhabitants of the island.

ca. 860

Garðarr Svavarsson discovers Iceland

Garðarr Svavarsson discovered Iceland, and called it Garðarshólmi (lit. Garðar's Islet).

Naddoðr discovers Iceland

Naddoðr discovered Iceland, and called it Snaeland (Land of snow).

ca. 870

Iceland given its name

Iceland given its name by Flóki Vilgerðarson. He was the first Norseman to deliberately set sail to Iceland.

874

First permanent settlers

Ingólfur threw two carved pillars overboard and would settle wherever they landed. Later on, the pillars were found in what is now Reykjavík, where he settled with his family. Ingólfur Arnarson is credited as Iceland's first permanent settler. Many Norwegian chieftains followed after him.

930

Establishment of Alþingi

All arable land in the country has been settled. The Icelandic Commonwealth was founded. The ruling chiefs established the Alþingi, which is believed by many to be the world's oldest nation-wide parliament.

995

Adoption to Christianity

Olaf Trygvason ascended the Norwegian throne and wanted to convert those under his rule to Christians. Þorgeir Þorkelsson decided, after long consideration, that Iceland should adopt the new religion in order to avoid civil war. He stipulated that pagan worship, infanticide (Icelanders believed the island could only hold so many people) and consumption of horsemeat should be allowed in private. Once the church garnered full control in Iceland, all of these practices were rapidly banned.

13th
century

Civil war

Civil war known as the Age of Sturlungs.

1238

Largest battle in Icelandic history

Battle of Örylgstaðir—the largest known battle in Icelandic history—where Icelandic chieftains battled over whether Iceland should become a subject of Hákon the Old, King of Norway. Sturla Sighvatsson, chieftain of the Sturlung clan and vassal of the Norwegian king, was defeated.

1262

Iceland became a vassal of the Kingdom of Norway

The Gamli sáttmáli ("Old Covenant") was signed. This agreement ended the Icelandic Commonwealth and the island became a vassal of the Kingdom of Norway.

14th
century

Iceland was granted to the Danish

Iceland was granted to the Danish. King Christian III imposed Lutheranism on the people, and to this day, most religious Icelanders remain Lutheran.

1783–
1784

Skaftá fires

Eruption of Laki volcano, known as Skaftáreldar ("Skaftá fires"), killing 9000 Icelanders. The loss of 80% of the country's livestock resulted in a famine that killed a quarter of Iceland's population.

1940

Britain occupied Iceland during WWII

The Nazi's invaded Denmark, limiting communication between Iceland and Denmark. Iceland turned down offers of protection by the British, because it would violate their neutrality. Britain decided to occupy Iceland in order to protect their control over the North Atlantic. Iceland welcomed the Brits in a polite manner.

1941

Iceland's occupation and defence handed over to the US

Iceland's occupation and defence was handed over to the US, and lasted throughout the whole WWII.

1944

Iceland became independent

Iceland became an independent republic after Icelanders voted 97% in favour of independence.

2008–
2011

Economic crisis

Iceland was hit by the economic crisis.

(Þorgilsson & Ellwood, 1898) (Chapman, n.d.)

2.3 Farming

In 874 Iceland got its first permanent settlers who came from Norway. During the following centuries, Iceland's population mostly worked as farmers and fishermen. The traditional farm often had animals such as sheep, cattle, horses and goats, and every animal served a specific purpose. The farming lifestyle drastically changed the landscape through erosion and deforestation.

In the 19th century the farmers made up 70-80% of the population. In the 20th century the industrialisation made way for changes and nowadays the number of farmers is about 5% of the Icelandic population.

2.4 Economy and tourism

After the economic crisis in 2008 and the eruption of Eyjafjallajökull in 2010, Iceland recovered and had a strong rise in tourism, which suddenly became the biggest economic sector. However after tourism's peak around 2017, the curve has been starting to flatten out (see figure 8). Also considering something similar to what is happening now, the coronavirus pandemic, it can be risky to have a country relying so strongly on one specific sector with its income. The other main export industries of Iceland are industrial goods (mainly aluminium) and seafood (Arion Research, 2018).

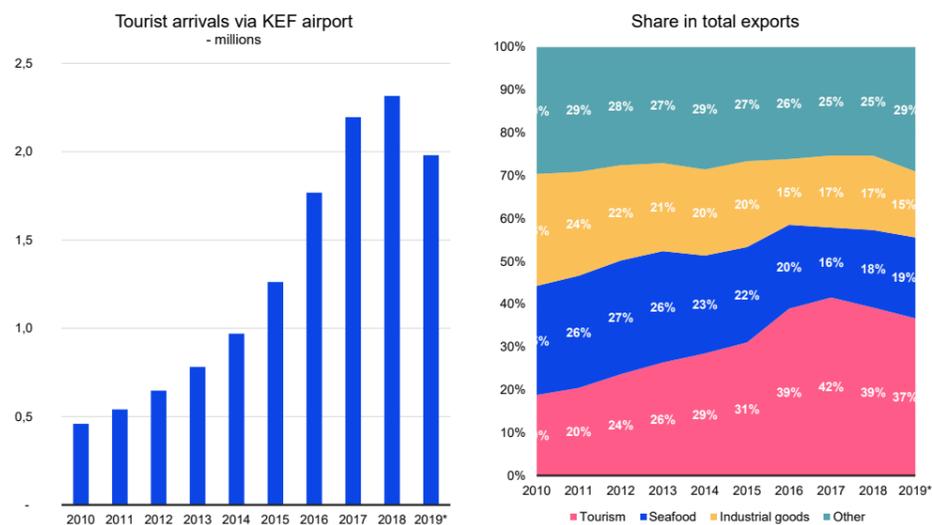


Figure 8: The number of tourist arrivals as well as tourism's total share in exports has started to decrease. Source: Arion Research (2018).

But what do these tourists do? The most popular is to go to Reykjavík, around the Golden Circle close to the capital and/or do a south coast trip, both either by organized tours or as a self-drive holiday, with the unique nature of the country being the main inspiration to come to Iceland (Icelandic Tourist Board, 2020). In the case of doing organized tours, often the visitors stay in Reykjavík and also book their tours from Reykjavík, which is where most of their money will end up going to. Most people visiting Iceland, regardless of their nationality, have an above average income (Icelandic Tourist Board, 2020). This makes sense considering hotel and restaurant prices in Iceland being amongst the highest in Europe, however the airfares are relatively cheap. The number of tourist arrivals is greatly dependent on these cheaper airfares, and a rise in flight ticket prices could mean a drop in tourist numbers and in their expenditure in many other tourist related businesses (Arion Research, 2018).

Most of the visitors arriving at Keflavík Airport are from the United States (23,4% of the total arrivals in 2019), followed by 18,6% from 'other countries', 13,2% from Great Britain and 7,0% from China (Icelandic Tourist Board, 2020). Almost 90% of foreigners visiting Iceland have a holiday as their reason for travel, and on average people stay in Iceland for 6 days. 92,7% of tourists visit the capital region, followed by 73,0% in the southern region and 56,3% in the Reykjanes peninsula. The southern region stands out from these three, receiving a rating of 4,81 out of 5 from tourists, being the highest rated region of the country (Icelandic Tourist Board, 2019).

2.5 Renewable energy

Around 85% of Iceland's primary energy supply comes from renewable sources, with 65% coming from geothermal power, 20% from hydropower and the remaining 15% from fossil fuels mainly used for transport. The electricity in Iceland is almost fully generated by renewable sources: 73% from hydropower and 27% from geothermal energy. On top of that, 85% of Icelandic houses are heated with geothermal heating (Government of Iceland, 2020).

2.6 Future challenges and opportunities

The main challenges Iceland is facing right now and will face in the future include the impact of tourism, both in the pressure it puts on natural sites and local communities, as well as in the dependency of many people's livelihoods on the tourism industry, when tourists numbers will drop. Also depopulation, especially of rural areas, is a threat that the Icelandic government wants to tackle. Iceland as a whole has many opportunities to explore and promote work in different sectors than the currently biggest ones.



03

ANALYSIS OF VÍK AND SURROUNDINGS

With its location on the most southern point of the south coast, which is well-known as a popular tourist route, Vík is a village that is greatly dependent on the behaviour of tourists. Along the south coast one can find many natural wonders, like geysers, volcanoes, glaciers, basalt columns and waterfalls. Vík is also surrounded by some of these spectacles, and as a village it forms a totally different atmosphere compared to the dramatic landscapes one will see on this route. The village consists of many small colourful houses, local businesses as well as larger businesses, and cosy guesthouses as well as more luxurious hotels.

3.1 The region

The south coast of Iceland is, together with the “Golden Circle”, the most popular region for tourists to explore during a visit to Iceland. The sights along the way, especially the landscapes, are very diverse: while the total driving time from Reykjavík until Jökulsárlon is about 5 hours (only with favourable weather conditions), you will come across waterfalls, geysers, black beaches, glaciers, geothermally heated swimming pools, volcanoes and much more. Figure 9 shows that in the countryside about 20-25% of all overnight stays are spent in the southern region. This number has increased over the past years, contrary to the goals of better distribution of the tourist flow throughout the country (Arion Research, 2018).

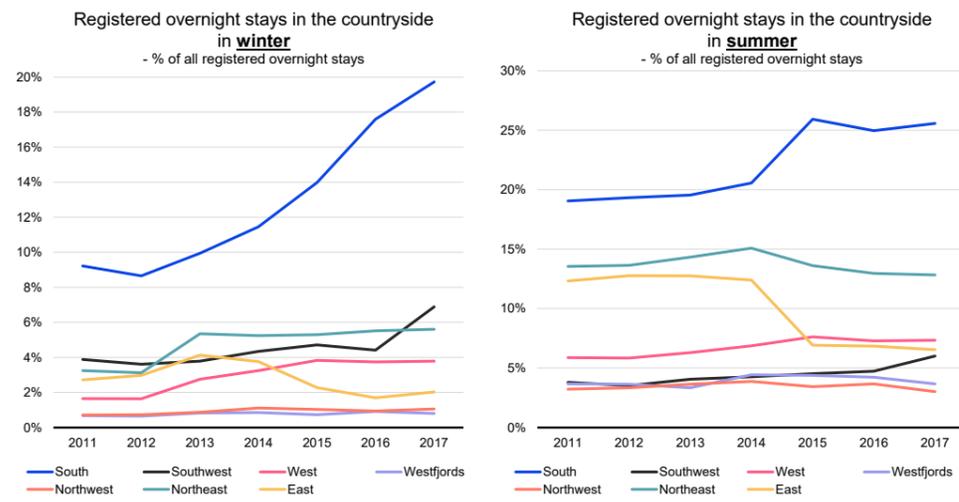


Figure 9: About 20-25% of overnight stays in the countryside are spent in the southern region. Source: Arion Research (2018).

Generally it takes tourists who do a self-drive trip from Reykjavík about a day to visit most of the sights until they reach the southernmost point of Iceland. This is when they arrive in Vík, which explains why many visitors stay a night in Vík and then continue their road trip the next day. Often visitors to Iceland book organised tours which usually operate from the capital. This is where they will stay, while they do day trips to the different sights that are within a decent distance from Reykjavík. This makes tours to the Golden Circle and the south coast a very attractive option. However, by choosing this method of transportation and activity planning, most of the tourists’ money will be spent in the capital. This is not only because of the accommodation, but also because most Icelandic tour companies operate from the capital.

The municipality in which Vík is located is called Mýrdalshreppur, and the most common places to visit in this municipality are Sólheimasandur (a black beach with a plane wreck from 1973), Sólheimajökull (a glacier accessible for guided walks), Dyrhólaey (a rocky cliff with bird colonies, including puffins), Reynisdrangar (basalt columns next to a black beach) and of course the village Vík (see figure 10).

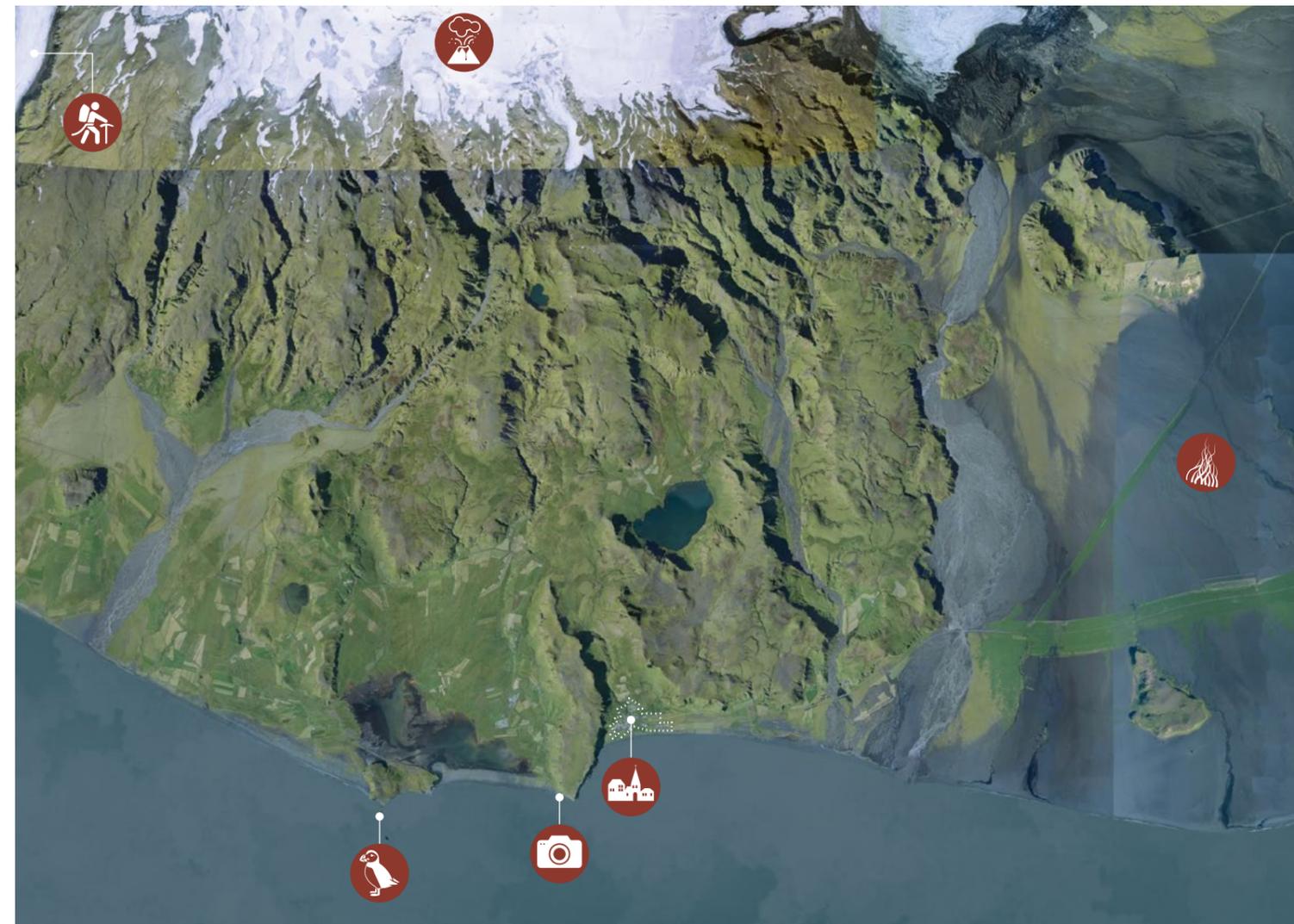
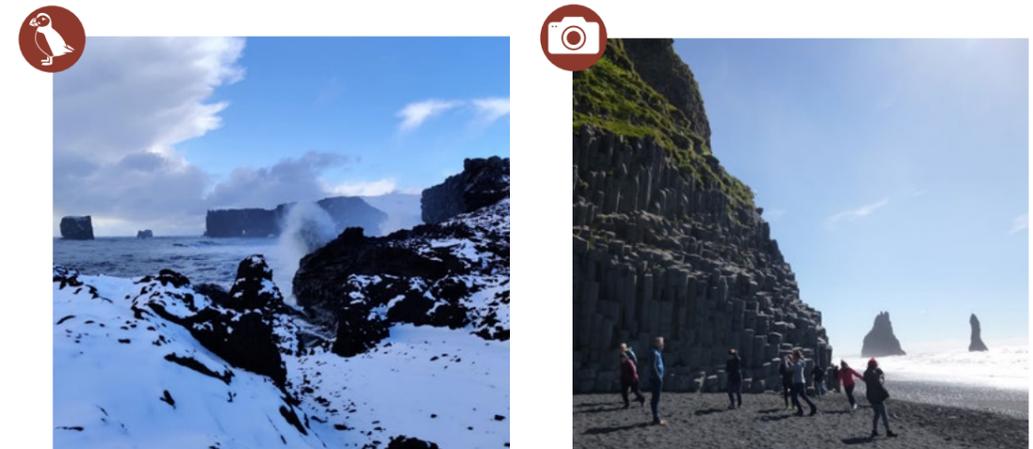


Figure 10: Aerial photo of the landscape in Mýrdalshreppur with the most famous attractions.

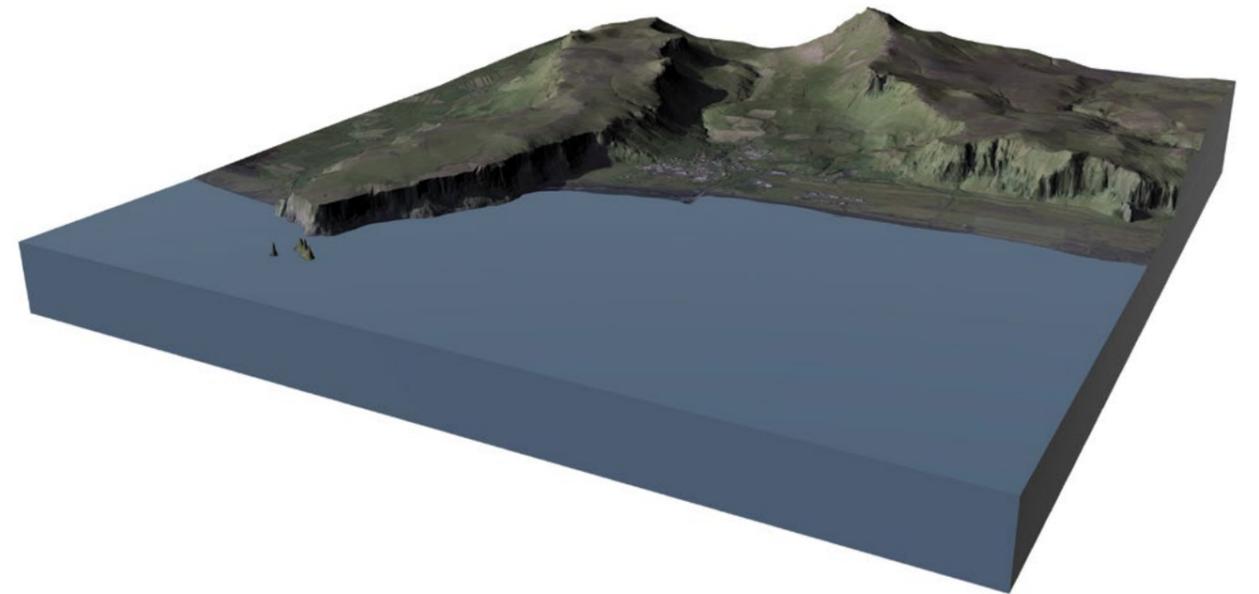
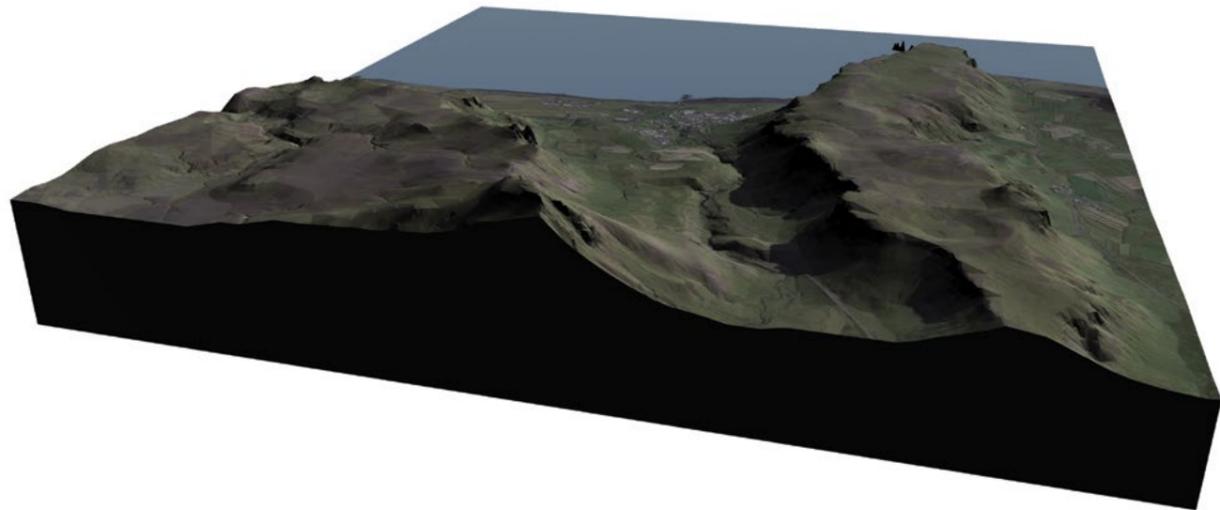
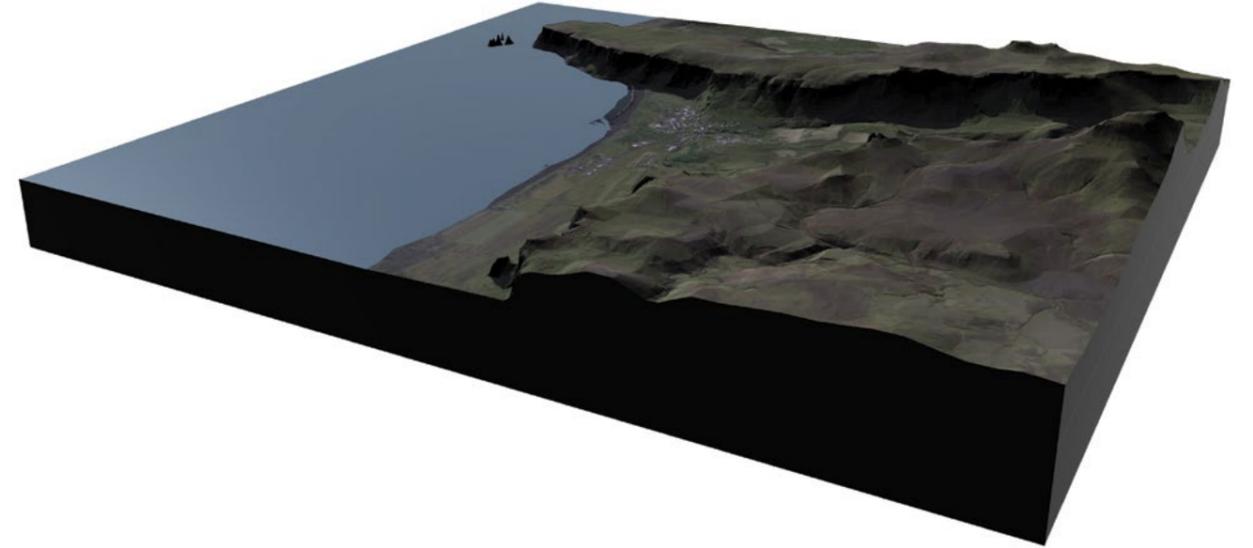
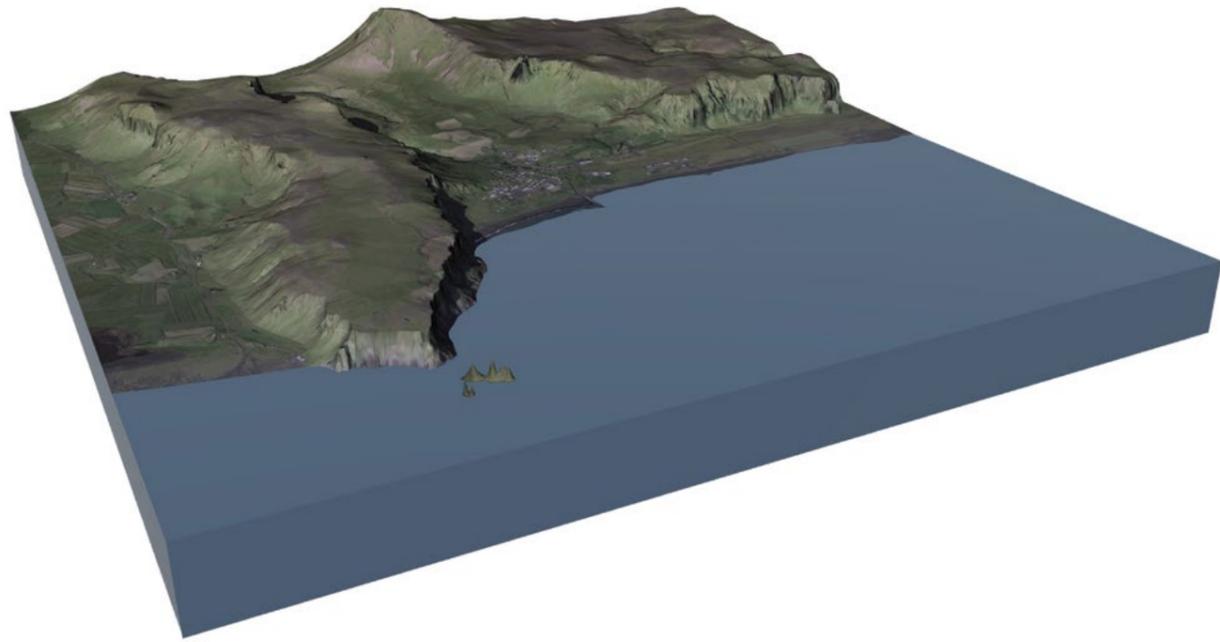


Figure 11: 3D model showing the topography and landscape around Vik.

3.2 Vík

Vík is a village of about 486 residents, located in the municipality Mýrdalshreppur which has a total of 769 residents and is expected to grow by about 150 residents in the next 7 years (VSÓ Ráðgjöf, 2020). Vík is the southernmost village of Iceland and is surrounded by a black beach in the south, mountains in the north and west (see figure 11) and a large glacial outwash plain further east. Further into the mountains in the north is the volcano Katla which is covered by the glacier Mýrdalsjökull. Katla used to erupt about every 50 years, but hasn't erupted since the last time in 1918 (Bird, et al., 2016).

Vík is by tourists well known for its picturesque church, the black beach and the Reynisdrangar rocks sticking out of the ocean. Many tourists who do organized bus tours will get a quick stop at the church and the supermarket area, because there is space for busses to park and they can visit the black beach and buy some food. Tourists who drive by themselves often stay a night in Vík, because it has a strategic location along the south coast and usually it takes tourists one day to do all the sightseeing between Reykjavík and Vík. The municipality report of 2012 predicted for the future that about half of the foreign tourists who come to Iceland will also be visiting, passing through or staying in Vík (Mýrdalshreppur, 2012).

Figure 12: Farming was the main occupation of the residents in Mýrdalshreppur. Image: Jónsson (2019).



3.2.1 History and development

Residents of Mýrdalshreppur municipality have traditionally been farmers (Bird, et al., 2016) (see figure 12). Before the settlement of Vík there were two farms operating in the north-western part of what is Vík today (1). The settlement of Vík started in 1895 with Bryde's shop that functioned as a trading point in the area (2). Nowadays the information centre can be found in this building. After the Bryde's shop, more businesses followed around the same spot (3). Up until 1916, all transport in this area was mostly done by horse or small boat, but the residents of Vík realised the importance of a motorised boat for their village. The boat Skaffellingur (4) started operating in 1916 and operated for different functions, including as a fishing boat, until 1963 and can nowadays be found in the Skaffellingur museum. The last eruption of volcano Katla happened in 1918 (5). Around 1925 the road between Reykjavík and Vík was built, which made the village less reliant on trade by boat (6). The iconic church was built in 1934 (7). (See figure 13).

Before the tourism rise of the last decade, Vík had a peak population of 362 in 1966. Since that moment especially young people were leaving the area because of the limited options of livelihoods Vík had to offer (Bird, et al., 2016). Nowadays tourism plays the biggest role in Vík's economy and there are many hotels, restaurants and guesthouses. In 2007 there were a total of 88 farms in the municipality, 42 of which operated on a regular basis (Mýrdalshreppur, 2012). Nowadays the most common crops that are produced in the area are swede, carrots and some barley. Many sheep, horses and cows are kept in the area, and a large number of those sheep grazes semi-freely in the more mountainous parts of the municipality. Also fishing is still an industry that is present in the area, with Arctic charr being the main species of fish being caught and sold.

The most notable recent changes are the fast development in east Vík and the fight against coastal erosion. Vík's coastline has fluctuated a lot over time, but because of the volcano eruption in 1918 sediments supplied the coast until 1971. Since then the coast has decreased sometimes exceeding 8m/year. Because most of Vík's development is located within the risk zone for flooding after another volcano eruption, the municipality has evacuation strategies for these scenarios.

Figure 13: Important places and events that shaped Vík over the years.



3.2.3 Demography

As of November 1st 2020, the total population of Mýrdalshreppur is 769 (Mýrdalshreppur, 2020) of which 486 people live in Vík í Mýrdal (Statistics Iceland, 2020). These numbers have been growing steadily since the rise of tourism in the past decade. On top of that the municipality is expected to grow by another 150 people in the next 7 years. This growth is due to the work opportunities that tourism has brought to the region, which also explains why there is a higher percentage of people aged 20-35 living in Vík compared to the national average (VSÓ Ráðgjöf, 2020).

3.2.4 Public life

Locals living in Vík make good use of the facilities that the place has: many people do golf, horse riding, swimming and other sports at the sports centre next to the beach. Apart from sport facilities, Vík also has a music school, women's club, library and of course the church that many locals visit during regular services. Close to the information centre there is also has a small wool gallery with locally crafted products that is opened during summer. Some yearly events are organised, which include a cultural festival in October and a week-long event called 'Spring in Vík' (Mýrdalshreppur, 2020). Since Vík is such a small village, most residents know each other, which is why you will often see staff at one of the restaurants or cafes having a chat with locals who enjoy visiting these places.

Regarding outdoor public life that does not involve an organisation, people often enjoy the surrounding nature by going on a hike on the beach or designated paths around Vík (see figure 16). Not always are these paths very clear or clearly connected, especially in winter when they are covered by snow, or at the beach where many 'elephant paths' are created by tourists walking from the parking lot directly to the beach, affecting the local flora and fauna. Swimming in the ocean is prohibited, because of the dangers of the strong current.

For children, there is one playground next to the primary school. Apart from that, children can often be found playing along the stream or on the hillside, or elsewhere in the village away



Figure 16: Many residents as well as visitors enjoy the beach by horse or by foot.



Figure 17: The parking lot at the supermarket as the main gathering point of Vík. Image: Icewear (2017).

from the main road. Vík doesn't have a main designated outdoor gathering space, or any other clearly defined public outdoor spaces. One could even say that the parking lot at the supermarket and at the church are the main outdoor meeting spots nowadays (see figure 17), simply because this is where visitors arrive due to the availability of a parking spot.

3.2.5 Natural threats

Because of Vík's location just south of Katla, the most hazardous volcano of Iceland, many outsiders would assume at first that the volcano is the biggest natural threat to the village. However, what really has been the most challenging is the erosion of the coast. Vík's coastline has fluctuated a lot over time, but because of the volcano eruption in 1918, sediments supplied the coast until 1971 (see figure 18). Since then the coast has eroded again, sometimes decreasing with more than 8 metres per year. This process is likely to speed up in the future due to climate change related sea level rise as well as associated storm surges. With most of the village's buildings being less than 400 metres away from the coast, this can become a danger in the near future (Bird, et al., 2016).

A study on the vulnerability and risk perception of people living close to Katla (Jóhannesdóttir & Gísladóttir, 2010) showed that, regardless of people's knowledge about the volcano, many residents believe the volcano is no longer active. Katla used to erupt about twice a century, but the last eruption was in 1918. Eruptions of Katla have caused small tsunamis in the past, creating a flooding danger to the buildings close to the coast. Residents of Vík are well aware



Figure 18: Coastline fluctuations from 1904 until 2005. Adapted from Bird, et al. (2016).

of and regularly practice the evacuation plan for these kinds of situations. People living in the region know that an eruption of Katla would create local flooding dangers and the tephra could also be dangerous to the area, but many still argue that an eruption would also be a positive thing for the region. Not only will it attract tourists who want to experience this unique event, the sediments of a new eruption would also help combat the erosion problem at Vík for a while.

Another threat to Vík is something that occurs regularly: snowfall and ice. Since Vík is so dependent on the connection over the national main road, it will lose supply of goods as well as new visitors coming in to the village when the roads are inaccessible. The Icelandic Road and Coastal Administration often has to temporarily close off roads during the winter season all around the country. Preparing for my study trip to Iceland, I kept a close eye on their website road.is, where I often saw warnings and short closures of the road I had to travel to get to Vík. Not surprisingly, the last part of the road between Reykjavík and Vík got closed off due to extreme winds during my bus trip in that direction, resulting in me and many other travellers to be stranded in a small village on the way.

3.2.6 Municipality's masterplan

In Mýrdalshreppur's masterplan for the whole municipality (Mýrdalshreppur, 2012), many topics relevant to the region are discussed. Some main focuses that are highlighted are to strengthen the business in tourism, agriculture and services. The future development of the municipality is based on the unique qualities of this region and existing knowledge. There are opportunities to improve traditional agriculture, focus on different forms of innovation and work with research institutes. The report mentions a lot of improvement in the south can mostly be achieved with safer and faster transport, better vehicles and improved road conditions.

The municipality also realises the threat of small communities shrinking in the future. This is because the world is very well connected nowadays, which means many people, especially the younger generation, might decide to move to another more populated area with more diverse opportunities and facilities. The goal of Mýrdalshreppur is to provide basic services and strong business life based on agriculture, nature, tourism and human resources. The municipality realises that the south of Iceland has the most visited natural wonders and the most agricultural land of the country. While bigger cities have certain strengths and opportunities, small communities have their own unique ones. These will be focused on in the municipality masterplan.

A big point of discussion has been the diversion of the main ring road of Iceland within Mýrdalshreppur municipality. The report shows that there is a higher frequency of accidents on the part of the ring road around Vík. This is mostly due to a dangerous turn just north of Reynisfjall, locally higher wind speeds and higher amounts of precipitation, thus causing more slippery road conditions. A solution that is presented for this is to divert the road, and

therefore avoiding this dangerous turn going up the mountain. The road will instead go through the marshlands, cut through the mountain Reynisfjall via a new tunnel and will be closer to the eroding coast along Vík. Along with improving traffic safety, the municipality also uses pedestrian safety and noise reduction within built areas as an argument. The report brings forward many reasons as for why a diversion of the road would be the safest option, however upon further personal research this seems to have more negative than positive effects, and the mentioned problems can be solved with cheaper, safer and more environmentally friendly options.

The report arguments placing a new road along an already fast eroding coast, by mentioning that there would be a need to build stronger coast protection structures in the future anyway. However, a point that is only minimally touched upon is how this diversion of the road will spatially cut the village off from the beach, one of the most important natural assets of the area. Having the ring road of the country between the inhabited part and one of the most noteworthy assets of the area will bring new problems along, like people crossing the big road wherever it creates the shortest route.

Another argument for moving the road towards the coast in Vík, was that the noise will be reduced and it will be safer in the village. However, a significant noise reduction can be achieved by simply lowering the maximum speed (currently at 50 km/h), which will at the same time make it much safer and reduce noise-induced health effects (Rossi, Vienneau, Ragetti, Flückiger, & Rösli, 2020). Also more and better crossings can be placed along the existing road, to ensure enough safe places to cross the road and at the same time reducing the traffic speed even further. Trees and buildings can be used as a noise barrier for the rest of the village behind it. On top of that, the southern part of Vík where currently most of the buildings of the village are located, will actually be the same distance from the road, if not even closer.

The new road would be connected back to Vík in the eastern part, where there are the most businesses that need to be easily accessible, according to the report. However not only industries need to be easily accessible by car or truck in Iceland. An unwanted effect this could have on the village, that nowadays relies mostly on tourism and people who move around by car, is that for the smaller businesses in the area further away from the new road, there might be a decrease in spontaneous visitors. Drivers will be even more likely to just have a quick stop at the supermarket and continue their trip, without exploring what the rest of Vík has to offer.

The western part of the road diversion is where it will lead through marshlands and valuable agricultural land. While the municipality argues the importance of the unique qualities of southern Iceland (natural wonders and agricultural lands), this is exactly what will be disturbed by placing the Icelandic main road through it. These areas are important habitats for birds that will be disturbed by the new road plan. The argument used in the report that "the nature area was already disturbed in previous road works" is not an argument to disturb it further. Building a road on marshlands is already a dangerous plan that will need a lot of extra reinforcement and maintenance.

The new highway will also cut through Reynisfjall, where a tunnel needs to be built. The total

effects of this project are unclear, but it is certain that it will have an impact on the bird nesting area that are the cliffs towards the coast. Also avalanches and falling rocks will be a new danger that is added to this highway when realising the new plan.



Figure 19: Example for the improvement of traffic safety at Reynisfjall, where a small mountain pass will bridge the height difference over a much longer distance, eliminating the dangerous turns on ground level. Image: flipflops (2021).

Finally, the main reason for the diversion of the ring road, the dangerous turn north of Reynisfjall, can be solved in a different way. What is the main problem here, is that the road has a double turn on a steep part. Here one can also experience strong wind speeds and precipitation, making it more difficult to control the vehicle. A solution much cheaper and much less dangerous than the proposed plan, can be to simply tackle only this turn. This can be done by constructing a small mountain pass, that will bridge the difference in height over a longer distance, so that the incline is reduced and the turns are not necessary anymore (see figure 19). This solution will be costly, but nowhere near as costly as the proposed plan. If the main problem is the accidents occurring at this turn, that means this turn needs to be adjusted. It does not mean that a big portion of the Icelandic ring road needs to be diverted through marshlands, protected bird areas, agricultural lands, a mountain and be placed along an eroding coast.

3.2.7 Challenges and opportunities

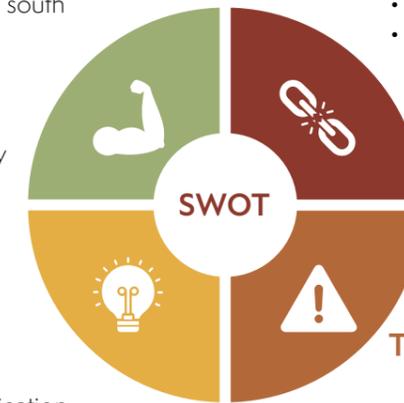
To summarize the research, Vik has the following:

Strengths:

- Dramatic landscape
- Picturesque church
- Black beach
- Calm village environment
- Good location on south coast
- Stream
- Hiking trails
- Local businesses
- Renewable energy

Weaknesses:

- Tourist-dependent
- Erosion
- Supermarket area as main stop
- Buildings in evacuation zone
- Tourists doing a quick stop



Opportunities:

- Economic diversification
- Main square
- New housing
- Connecting Vik as a whole
- Katla eruption
- Farming history
- Forestry
- Pool

Threats:

- Decline in tourists
- Road closures
- Further coastal erosion
- Katla eruption



04

ANALYSIS: SELF-SUFFICIENCY FOR VÍK

Opportunities for the prosperity of a village like Vík can be found in becoming more self-sufficient, mostly meaning the village, together with the rest of the municipality, will be able to provide itself better with essential products. This is not only necessary for extreme situations, but will in an everyday situation strengthen the community and provide for more livelihood opportunities. In the long run, this will prevent the village from going empty and ensure its survival. Apart from those benefits, it will also decrease the ecological footprint and lower the pressure on the environment on a larger scale.

4.1 What is self-sufficiency?

According to the Cambridge Dictionary, self-sufficiency can be described as:

- the quality or state of being able to provide everything you need, especially food, without the help of other people or countries
- the quality of being able to take care of yourself, to be happy, or to deal with problems, without help from other people

You can see that the first definition focuses more on the basic needs, like food, while the second focuses more on psychological needs, like happiness and self-confidence. Both are important, and can be found in Maslow's hierarchy of needs (see figure 20) (McLeod, 2018). Here you can see that physiological and safety needs are considered the basic needs; love, belonging and esteem are considered psychological needs; and self-actualisation is part of the self-fulfilment needs. In this hierarchy, needs lower down on the pyramid have to be fulfilled first before being able to achieve the next one higher up.

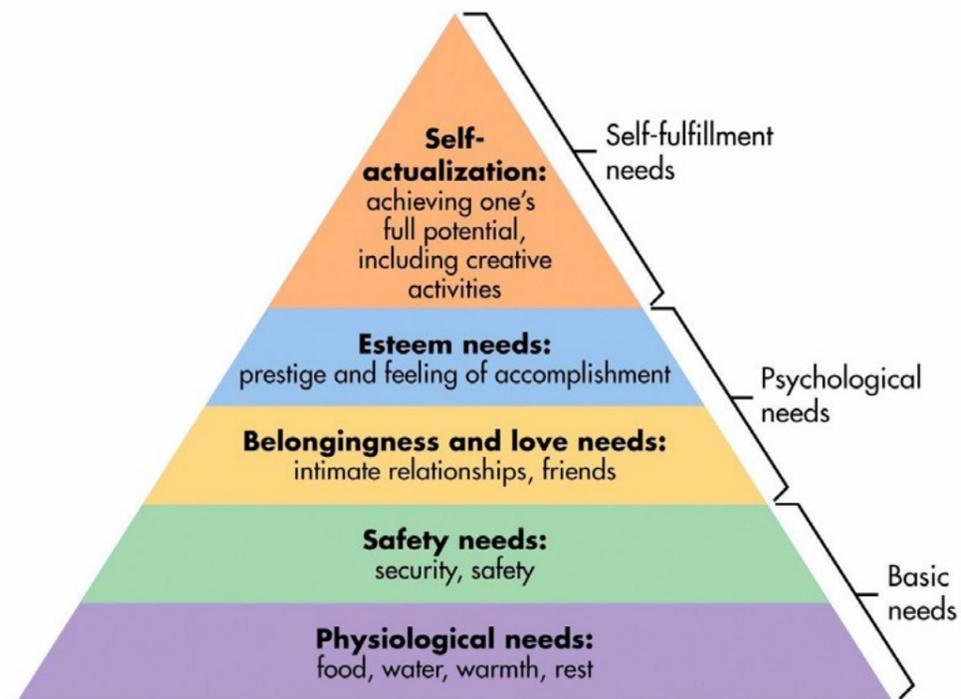


Figure 20: Maslow's Hierarchy of Needs. Source: McLeod (2018).

Nowadays the needs at the bottom of the pyramid are often met by goods from all over the world. People are dependent on the products that are available in and can be transported to their country, as well as to what extent the country or region they live in can provide for their own food and materials.

One level up in the safety needs, one can usually link this back to the management of their country. (Wealthy) countries that can provide a certain level of security and a social safety net

often ensure that this level of the hierarchy is met as well.

On the next level it becomes more complex and more intimate. Meeting these needs is dependent on one's (family) relationships, one's ability to connect with other people and one's level of isolation in society.

The fourth level is often connected to someone's job, volunteering work or hobbies. These are often the things that people get a feeling of achievement from. It can be divided into two categories: the esteem for oneself and the desire for reputation or respect from others.

The top level is different from the other four, in the way that the others be described or experienced as a deficiency when the needs are not met. However the fifth level is dependent on someone's personal need for self-actualisation and desire to "become everything you are capable of becoming": this differs from person to person.

The next subchapters focus mostly on the bottom levels of the hierarchy of needs, but also take the third and fourth into account. Especially in a smaller village it is important to provide not only the basic needs, but also ensure a good social structure and provide for people's esteem needs.

4.2 Iceland's ecological footprint

Iceland belongs to the top 10 in the world when looking at wellbeing, life expectancy and equality, but on the contrary the country is also in the top 10 of countries with the largest ecological footprint. According to the Happy Planet Index, Iceland ranks 39th of 140 analysed countries. The number one on the list is Costa Rica, which has very similar numbers to Iceland regarding the topics where Iceland scores well. The thing bringing Iceland down in the ranking is the large ecological footprint of 6.4 global hectares per person. That is more than double compared to the ecological footprint of Costa Rica. According to an article that measures Iceland's sustainability performance (Olafsson, Cook, Davidsdottir, & Johannsdottir, 2014), Iceland can improve its environmental impact by:

1. Reducing SO₂ emissions: even though Iceland has abundant renewable energy resources, the expansion of geothermal power plants has led to an increase in SO₂ emissions.
2. Lowering PM (particulate matter) and CO₂ concentrations by reducing soot emissions from engines, using more durable asphalt and promoting greater use of low-emission vehicles and fishing boats.
3. Afforestation and re-vegetation programmes: since about 95% of Iceland's forest cover was lost since the settlement, afforestation and re-vegetation will provide carbon sequestration, future productive land resources, biodiversity and soil and water conservation.
4. Reducing waste and managing waste sustainably
5. De-carbonising the aluminium industry: the metal production sector is the largest source of CO₂ emissions in the country. Regardless of the availability of renewable energy in Iceland, the aluminium smelters currently still have high CO₂ emissions, and a shift towards low-carbon/carbon-free technology for these smelters would greatly reduce its environmental impact.

The points that can be addressed either directly or indirectly within urban design are 2, 3 and 4. By creating a local economy, a walkable street-network and the option of electric car-sharing, point 2 can be tackled. Forests and different types of native vegetation can be planted to address the third point, as well as simultaneously create economic and social benefits. Point 4 can be handled by providing neighbourhoods with shared composting and recycling stations and the use of shared tools. Local production will also require less packaging and food waste will be reduced in smaller scale production.

4.3 Food

One point that is missing in the list in the previous paragraph is the impact of dietary choices on the ecological footprint. As can be seen in figure 21, mainly animal products have a very high carbon footprint compared to plant products. Traditionally the Icelandic diet has consisted mostly of lamb, dairy and fish, which were the most easily available products in the

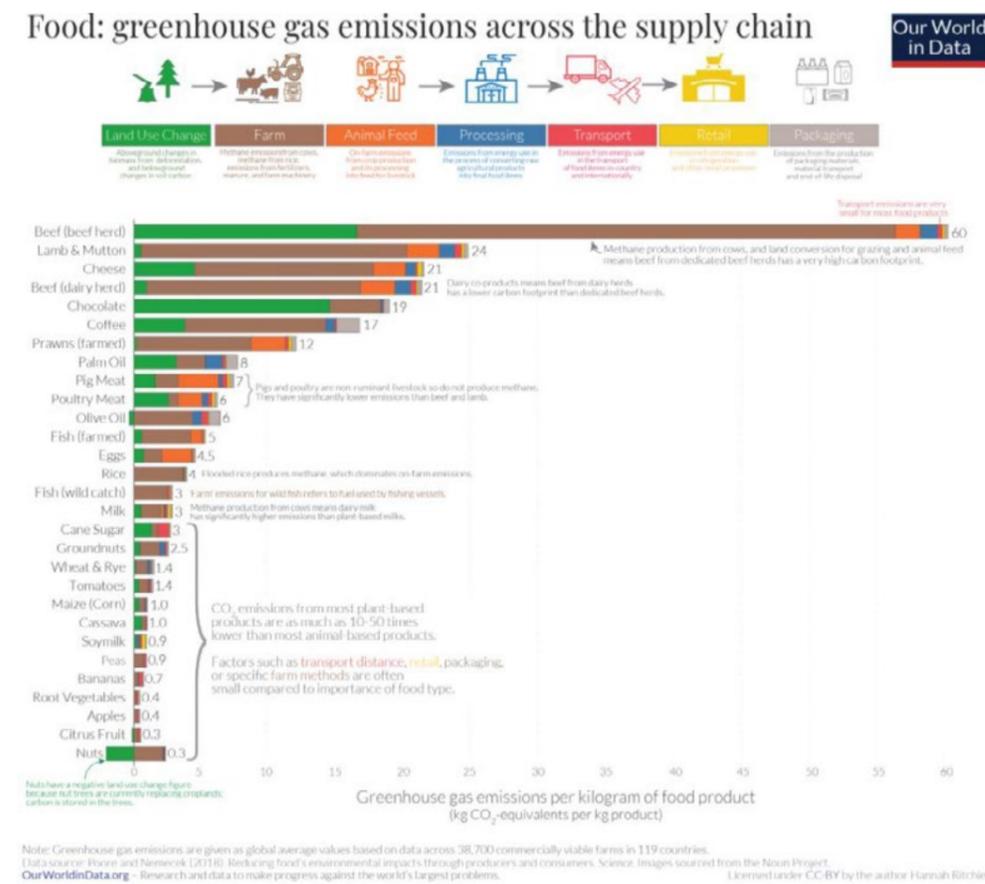


Figure 21: Greenhouse gas emissions of different food types across the supply chain. Image: Ritchie (2020), showing data from Poore & Nemecek (2018).

harsh climate. However nowadays when products grown all over the world are accessible in Iceland, the diet has changed towards one which includes more plant products and less fish than before. Still, compared to other European diets, the Icelandic diet contains high amounts of animal products. According to an article about the environmental impact of dietary change (Hallström, Carlsson-Kanyama, & Börjesson, 2015), the land necessary for food production can be reduced by up to 50% when changing from an average affluent diet to a diet with lower amounts of meat, no meat or no animal products at all. Also the greenhouse gas emissions caused by the diet can be reduced with up to 50% when these dietary changes are applied.

Another topic that should be taken into account is the fact that Iceland is an isolated island in the Atlantic ocean, which means that many goods that Icelanders want nowadays need to be imported by airplane or container ship. Focusing on local production, where possible, will limit the impact of transport and packaging on the total greenhouse gas emissions of the production of certain types of food that can be grown locally if the right growing conditions are applied (for instance in greenhouses).

On average, the land needed for European diets ranges between 1500-3000m² per person. The examined diet most similar to the Icelandic one, which is the Norwegian diet, is shown in the the study of (De Ruiter, Kastner, & Nonhebel, 2014) to need about 1800m² of cropland per person. If, according to the percentages mentioned earlier, the Icelandic diet would change to one that partially replaces meat with plant-based foods, the land needed for one person's diet could go down to 1500m² per person. When the Icelanders would change from their current omnivorous diet to a vegetarian diet, their necessary land could decrease with 40% to 1080m² per person.

My suggestion for ensuring success in the vision to move towards a self-sufficient Vík is to focus on promoting a diet that includes more fruits and vegetables and less meat and fish. This way Vík can make sure to keep the space necessary for sustaining a steady food supply to its residents within manageable boundaries. With the food production technologies available nowadays, growing more exotic crops in the Icelandic climate will be possible in different types of greenhouses. This way people living in Vík will be able to produce their own food locally, while still retaining the 21st century luxury of having access to many different types of food that can be found in modern-day supermarkets. Of these 1080m² mentioned earlier, some crops simply can't be grown in the Icelandic climate, either indoors or outdoors. This means that some products will still have to be imported if locals don't want to give up their access to some products they are used to in current supermarkets.

Volcanic products, such as pumice, can be used as a growing medium for the crops. Geothermal energy will heat the greenhouses when solar heat is not sufficient, artificial lighting will allow crops to grow all year round and the large amounts of rainwater and snow can be collected for irrigation of the greenhouses.

4.4 Water

Since Vík is the rainiest place in Iceland, freshwater supply is abundant. The only thing that should happen in order to make more use of this is to provide a system that collects the water for use of different purposes. This can be done by leading the runoff of roofs to a communal water tank. This water only needs to be mildly treated and tested in order to use it safely for irrigation. However if Vík wants to be self-sufficient regarding its total water supply, the collected rainwater that would be used for cooking, washing and drinking should first be treated in a local water treatment plant. Also greywater should be treated locally in a wastewater treatment plant.

Placing a water treatment plant in Vík might be an undesirable option, since the quality of the water system in Iceland is high. Therefore domestic water use should still be connected to the national water system in order to provide locals with the same quality of water as can be found elsewhere in the country. It will be more sustainable to stay connected to the existing high quality water system, than to build a local water treatment plant for Vík and its surroundings. However with the new added functions in Vík, mainly the function of (indoor) agriculture, the total water use is likely to increase. For this reason, the suggestion is made to focus on the before mentioned option: local water collection and minor treatment and testing of the water quality, which then will be used for agricultural functions. This water can also be used for example to flush the toilet. However this requires changes to the water system of every house. It might be better to keep this option as an individual choice residents would want to make to lower their ecological footprint.

In case of extended periods of drought, which is uncommon in Iceland but with climate change more likely, the water from the stream Víkurja that runs through Vík can be used for irrigation and household use after going through the same processes as the collected rainwater.

4.5 Shelter

Traditional Icelandic houses were built with timber, stones and mostly turf. This type of building is nowadays undesirable as a place to live in, because they were very cold, damp and dark. Because of the fast decline of forests in Iceland after settlement, timber became a more difficult to obtain building material. Over the centuries, most of the timber used for building in Iceland has been imported. Approaching the 20th century, the use of corrugated iron took off in Iceland. The iron was imported from England and replaced some of the use of timber as a building material. More and more this became a popular building material. Especially after severe fires in the bigger cities, the use of timber even became prohibited in some areas. During the 19th century, stone became a somewhat more commonly used building material. It was fairly expensive and slowly lost popularity after that. Building with concrete rose fast in popularity in the 20th century and became the most commonly used material (Jóhannesson, Stefánsson, Kristjánsdóttir, Másson, & Ólafsdóttir, 2000).

The most commonly used building material, concrete, is made up of aggregate and cement. Iceland has many aggregate extraction sites, including some close to Vík. One of these is the big 'sandur' area east of Vík where a glacial river flows towards the sea and deposits sand and gravel. The aggregate from this sandur can be extracted and used for locally produced concrete (Sveinsdóttir & Wigum, 2001). The cement necessary to make concrete in Iceland is nowadays usually imported from Norway (Sims & Poole, 2017).

The production of cement emits large amounts of greenhouse gases and this makes concrete an unsustainable building material. However, this is what is most easily available in Iceland at the moment. Timber as the main building material would be the most sustainable option in Iceland with the technologies available nowadays, but it takes time to grow the forests that produce enough building material for new housing in Vík. In the future locally grown timber will be the main building material, and while the production forests are still growing, concrete made with locally mined aggregate can stay the main building material for some time. The CO₂ sequestration of the growing forests will compensate for the emissions of the concrete production during this time.

Another sustainable option for Vík is to focus on recycling existing concrete structures that have outgrown their function, and turning them into new usable building material. This can be done with the concrete recycling machine called 'SmartCrusher', which works on making concrete a circular building material. The SmartCrusher separates the aggregates as well as the cement, without breaking or polluting these compounds. This way the compounds can be mixed together again into concrete in the desired shape for its new function. So instead of needing new cement for all the new concrete that is being produced, which is very unsustainable, this method totally recycles all the compounds and reuses them. The technologies connected to this invention are still being developed with the final goal of being climate neutral and 100% circular (Schenk, 2020).

Sustainable insulation materials that can be produced locally in Vík are wool and cellulose (paper based) insulation, inspired by the techniques used in Sólheimar (see chapter "5.1 Sólheimar Ecovillage"). The cellulose can be extracted from recycled paper. The wool can be harvested from the sheep that are kept in the area. The roofs can be insulated by adding turf roofs. They hold the heat collected during the day and emit it at night. It also provides more habitat for small flora and fauna and somewhat filters the rainwater that falls on the roofs before it will be used for greenhouse irrigation.

By attaching food production greenhouses to a south-facing wall of a (residential) building, it collects the solar heat and limits the heat loss from the house through the south-facing wall. This way the greenhouse keeps the building warmer and the building keeps the greenhouse warmer. The glass needed for the greenhouses can be purchased from Icelandic glass producers.

4.6 Energy

Currently the energy used in Vík comes from the company Orkusalan, which runs several hydropower stations across the country. The energy is distributed by a company called Rarik. Because of the many waterfalls and rivers in Iceland, hydropower is widely used in the country. Also the geothermal activity makes it possible for Iceland to transform this into a renewable energy source and to use the heat for the supply of warm water. The hydropower plants have been a very controversial topic, since they have a lasting or permanent impact on the environment. A study about the wind energy potential of Iceland (Nawri, et al., 2014) has shown that the wind power potential in Iceland is well within the highest wind power class in Western Europe. The good location at the coast and the topography surrounding Vík makes for even better wind conditions. A small number of moderately sized wind turbines would already cover most of Vík's energy needs and should be considered as a serious addition to the current energy system that relies mostly on hydropower, which has been the reason of heated discussions in Iceland for many years. Both wind power and hydropower have their own advantages and disadvantages, but for the specific case of Vík (or perhaps the municipality on a larger scale) these should be put into perspective.

4.7 Other

Of course there are many other things that should be taken into account when looking at self-sufficiency. These things include clothing, household goods, transportation, personal hygiene products, work-related equipment, educational items, toys, sports equipment and so on.

For many of these topics I suggest creating a space where items can be exchanged, inspired by the 'Little Free Library' (Little Free Library, 2020). For the exchange of books, the exact same method of the Little Free Library can be used: providing a small weather resistant 'house' where you can leave a book you finished reading and take another book home. Something similar can be done for furniture and bigger household items. In that case a small building should be provided where you can leave stuff that you no longer need, but someone else might be interested in.

Apart from self-sufficiency regarding physical products, it is equally as important, if not more important, to provide enough opportunities for leisure and employment. Some ideas on this have been discussed in the previous chapters and will be touched upon further in the design chapters.



05

REFERENCE PROJECTS

During the field trip to Iceland, I visited two reference projects which are called Sólheimar Ecovillage and Friðheimar, which both were very interesting and succesful realised projects with a great philosophy and tradition behind it. Additionally, I knew about the greenhouse home designed by Richard Weaver, which can serve as a good example on how to achieve this type of building as a private project. While searching for other relevant examples of related projects online, I found out about the Närpes Grönsaker Cooperative that revived the local agricultural business by modernising the system and working together.

5.1 Sólheimar Ecovillage

During the interview with an employee from Sólheimar Ecovillage, I learned that it was founded by Sesselju Hreindís Sigmundsdóttir 90 years ago as a house for orphans. Along with taking care of and providing a home for the children, she wanted to grow vegetables for them on the property. She believed, unlike many other Icelanders at that time, that the traditional Icelandic diet was lacking in nutrients coming from vegetables. The Icelandic diet mostly consisted of fish, potatoes and meat around 90 years ago. The village expanded and turned into the oldest eco-community of Iceland, and is even believed to be the beginning of organic farming in the Nordic countries.

Nowadays there is a diverse group of residents living in the ecovillage, most of which are people with a disability. Apart from living in Sólheimar they have a normal work week where they make all kinds of products, including ceramics, paintings, woodworking products, candles, weaving art and herbal products. These are sold in the shop inside the village, along with local produce from the greenhouses and even roasted coffee (see figure 22). On the lands that are part of Sólheimar, a lot of trees are planted and sold as well. The village hosts weekly live performances and some yearly events which are open to the public and attract a lot of visitors from all around the region. The events are more known among the Icelanders than the tourists.

Environmental awareness is part of the long tradition of Sólheimar. Emphasis is placed on sustainable buildings, own energy generation, organic farming, the use of products from natural raw materials and recycling. The construction of sustainable buildings has become an important focus throughout the years. The main visitor's centre is a sustainable building made of timber, insulated with wool and cellulose and a turf roof. The building is geothermally heated and electricity is generated through the solar panels. Water from the toilets is even used to irrigate and fertilise the flower greenhouses.

A motto of Sólheimar Ecovillage is: "We did not inherit the land from our ancestors - we borrowed it from our children." (Sólheimar, 2020)



Figure 22: Products produced by the residents of Sólheimar on display in the shop.

5.2 Friðheimar

Another place I visited during my study trip which was very valuable as inspiration for this thesis was Friðheimar. Friðheimar is a family business in the south-west of Iceland that mostly focuses on greenhouse horticulture. The main crops are four different kinds of tomatoes that are grown all year round, despite the long, dark Icelandic winters. Inside the greenhouse you can also find a restaurant (see figure 23) where visitors can enjoy the tomatoes in many different forms, but they are most famous for their tomato soup. There is also a shop in the greenhouse where other products are sold. Apart from the tomato greenhouse, a horse breeding facility is another part of Friðheimar's business. Horse shows are held here which attract many visitors, but the greenhouse still surpasses that: during the summer months the greenhouse restaurant is usually fully packed, and in winter they still get many visitors every day.

Many people might think Iceland would not be a suitable place in the world for greenhouse horticulture, but the opposite is actually true. Because of its isolated location on a high latitude, Iceland has very little pests and weeds. The geothermal energy makes it possible to create suitable growing temperatures inside the greenhouses, while still only using renewable energy. The crops receive plenty of light to grow from the lighting that is powered by renewable energy as well. Also volcanic products, like pumice, are used as a growing media instead of soil. At Friðheimar bees are used to pollinate the plants inside the greenhouse.

The Adaptation Agreement was signed by the government and the Farmers' Association of Iceland, with the goal of increasing the competitiveness of Icelandic farmers with domestic import. Farming has become more efficient, prices of produce have gone down significantly and the income basis of local farmers has been secured. (Friðheimar, 2020)



Figure 23: Eating fresh tomato soup surrounded by tomato plants in the restaurant section of Friðheimar's greenhouse.

5.3 Närpes grönsaker cooperative

Another example is Närpes municipality in Finland, where after struggling economically for a long time, a modernisation of the local farming community managed to get Närpes back on its feet. The Närpes Grönsaker Cooperative works together with local farmers, and in figure 24 you can see an example of one of their farmers presented on the website. The cooperative consists of 37 greenhouse farmers and is nowadays the biggest supplier of tomatoes in Finland. Some examples of partners they work with is a local restaurant and a hotel. 95% of the vegetables are grown with the help of renewable domestic heat, and many of the growers work as a family business (Närpes Grönsaker, 2020).

HANS GRANBORG



Hans Granborg har sina växthus i Närpnäs där han odlar paprika. Han har varit medlem i Andelslaget Närpes Grönsaker sedan 1987. Hans fru Eva-Stina som delägare och även några skolelever under sommarmånaderna ryms med.

Vid sidan av växthusen har Hans en verkstad där han jobbar med bl.a. egna reparationer, konstruktioner, maskinbearbetning och spikmaskinen. Spikmaskinen är en maskin som Hans själv har konstruerat. Den är enkom framtagen för att spika växthuslister för plastväxthus.

Största delen av fritiden tillbringar han i sin verkstad. Han är utbildad traktormontör och har tidigare jobbat på diverse bilverkstäder och på NTM i några år, innan han 1982 ville testa på växthusbranschen och byggde växthus.

Hans är intresserad av det mesta som har med teknik att göra och tycker om att utveckla olika lösningar. Man kan se honom som en riktig uppfinnare.

Även ett jord & skogsbruk hinner Hans sköta. Bland familjen Granborg bor 4 generationer.

Namn:
Ort:
Odlingsår:
Odlingsort:
Area:
Växthusets byggår:
Generation:
Uppvärmningssätt:
Miljöaspekter:

Hans Granborg
Närpnäs
227
Gul paprika
1.320m²
35
1982-1983
1
Flis
I odlingen används biologisk bekämpning. Baddspecifik bevattning, odling i torvunderlag, traditionell "sommars" odling.



Figure 24: Hans Granborg's page on the website of Närpes Grönsaker, as an example of the 37 farmers involved in the local cooperation (Närpes Grönsaker, 2020).

5.4 Greenhouse home by Richard Weaver

Another valuable reference for this thesis is an initiative from Richard Weaver, who turned his father's garage into an off-grid home with attached a half-buried greenhouse (also called a walipini). The surrounding land is used to grow food with the local community using permaculture methods (see figure 25). The change Richard Weaver has brought to his inherited plot of land really stands out from the rest of this golf-oriented community.

The greenhouse is attached to the building that was previously an RV garage. Nowadays no one lives in the house permanently, because the house itself is not heated during the cold Montana winters. It is mostly used as sort of a summer house. The greenhouse however catches plenty of sun which raises the temperature with about 11 °C. The greenhouse is equipped with a large number of vents to ensure good ventilation and temperature regulation in case it gets too warm in summer. The house has solar panels on the roof which provide electricity for the lighting in the greenhouse, as well as some electrical appliances inside the house. Water is collected from the roof and stored for later use.

On the land outside the greenhouse, the community of the valley takes care of the permaculture garden together. Permaculture here means that guilds of plants that work in a synergistic way are placed together: they support each other and all have a different function/quality. Richard Weaver calls the people working together on the garden a "bonded tribe", because according to him it's a group of people working on making a living together, in this case growing food. This bonds people in a different and stronger way than for instance watching football together on the couch.

Quoting Richard Weaver from the video, he says: "I think I did a calculation once, that if we have a thousand 2000-square foot greenhouses, we could produce a substantial amount of our fruit without having to truck it in. You'd need a thousand of them for 100,000 people, so we would need a completely different economic model than we currently have." This project is a valuable example and could be seen as a start of how it is possible to adjust the economic model Weaver talks about. (Dirksen, 2020)



Figure 25: Richard Weaver's 3 acre project including his greenhouse home. Image: Dirksen (2020).

5.5 Inspiration for Vík

One obvious similarity one can find between the four reference projects is that they revolve around greenhouses. But apart from that, they all have a different story, purpose and way of functioning. The reference projects all serve a different part of the inspiration for Vík, where they all show a possibility on how to improve the self-sufficiency and sustainability of the topics that were discussed in the previous chapter.

Sólheimar for instance, teaches an important lesson about what it can mean to think out of the box in a certain period of time. At the time when Sólheimar was established, it was not so obvious to promote the production of vegetables. However, over time diets change depending on what is available in the area due to (international) trade and the development of technology, as well as what is still considered 'normal' regarding diets.

A similar story can be found in the case of Weaver's greenhouse home, but instead of standing out because of the products it generated, it stood out more because of the different use of land and space compared to the golf-oriented neighbourhood it is located in. At first it might seem like a strange sight for the neighbours to see a man transforming his neatly mown lawn into an "overgrown" vegetable garden. But over time the neighbours have grown more and more attached to this garden, working on it together and sharing the food it produces. It brought the neighbourhood together by doing something different.

Weaver's project also can serve as inspiration for people already living in Vík or planning on moving there, to see examples of how it is possible for one person to build a fully functioning greenhouse attached to an existing building. By exchanging knowledge about horticulture, electricity, water systems and building techniques, you can achieve a very successful project with just a handful of people.

Friðheimar took this a bit further, and made their greenhouse into a business. Its location in Iceland brings it one step closer to a new reality for Vík. A country with such a unique geographical influence also brings unique opportunities to utilise this. With the constant presence of geothermal heat in a cold country, and with the right technologies available to make use of this, you can create the perfect growing conditions all year round in a sustainable way. When visiting Friðheimar in March, it felt great to be able to sit down inside the restaurant section of the greenhouse and feel the warmth as a contrast to the cold Icelandic winter outside. The greenhouse was not only a productive space, but also functioned as a warm, green oasis compared to the places you would visit during the rest of your (winter) trip in Iceland.

The example of Närpes not only shows what the influence was of a modernisation of the agricultural system, but also what the effect can be for a municipality to work together in a business cooperation. Before the establishment of the Närpes Grönsaker cooperative, the municipality was struggling economically. If no change had been made, the towns could have

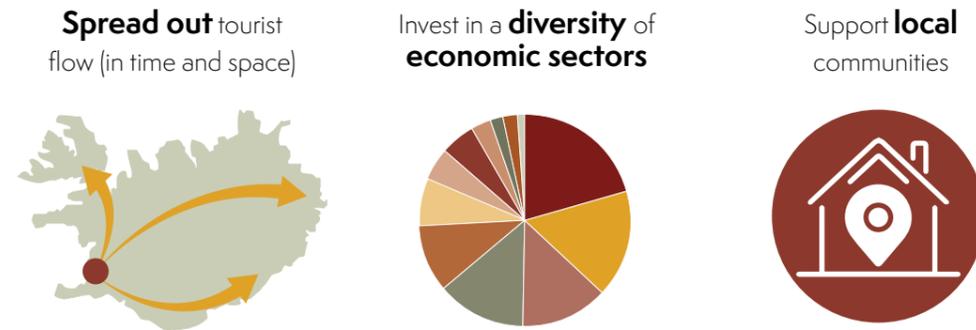
gone empty because of people looking for job opportunities elsewhere. When the old way of doing things does not seem to work anymore, a change is needed, especially in smaller communities that are often relying more on one industry alone compared to a bigger city.



06

STRATEGY AND CONCEPT

6.1 National strategy



Iceland's current strategy is to spread out the tourist flow in both time and space. This process has been difficult so far, but it is something that needs more attention and tourists also need to be made more aware of this in order to (hopefully) adjust their travel plans accordingly.

Considering tourism being past its peak as well as the danger of relying strongly on one sector, it is important that Iceland will focus on the changes within tourism in the future. This means it could happen as a shift in types of tourism, for instance shifting the promotion of large company bus tours to local ecotourism. It could also mean that once Icelanders truly realise their main source of income is declining, they will need to focus on making tourism their secondary source of income. This ensures a slow shift towards a society being less dependent on one sector.

With current systems and tour companies often operating from the capital, it is important to focus on and support smaller communities in the countryside to ensure their survival when tourism will decline. The national strategy should not only be put in words, it should also be put to action.

6.2 Local strategy

For a place like Vík in particular, it is important to diversify people's income sources, making them less dependent on tourism and creating a more local, self-sufficient economy.

This can be done by taking inspiration from what used to happen in smaller towns like Vík before local residents were dependent on tourists spending their money in the area. In Vík this was farming, fishing and trading goods. Locals were able to sustain themselves with these businesses without the influx of tourists, which means it was a stable income source at that time on the same location, and can be used as inspiration for a shift in business types. Combining this with new technologies and systems that have been established during the past decades, a modernised version of those kind of livelihoods can create a new, sustainable business model for the area.

Tourism becomes the secondary source of income, not the primary. It is an extra asset of living and making a living in this area. Tourism can be used as a kick-off for a new business, by for instance organising tours, workshops and educational activities or by aiming the sale of products towards tourists, alongside the start of the new aspect of the business. Once the core of the new business is established, the export of the products/services can expand further than Vík, really putting Vík and the businesses on the map on a national and international level, while still maintaining a strong function in the local business scheme (see chapter "7.1 Design principles"). Tourism can become a side aspect of the business, or be completely separate from it: see an example in chapter "5.2 Friðheimar" where the reference project of Friðheimar shows how the business is one of the main tomato producers of the country, while also providing services and selling products to tourists visiting the business. The two support each other, but without one of them the owners of the company will still have an income.

Putting this into an urban design perspective, the following challenges of Vík could be solved through the design proposal in this thesis:



Walkability plays a big role in this, because this is what will help in the kick-off phase of the businesses. In a small village like Vík, every business should be easily reachable by foot. By stimulating visitors to walk around and explore, they will reach businesses a bit further away from the arrival point as well.

6.3 Concept for Vík

Self-sufficient Vík in the modern-day world

What does that look like in the setting of Vík?

Imagine you are now 60 years old and you have lived in Vík your whole life. You own some hotel cabins close to the church and decided to add greenhouses to it that are geothermally heated. You sell the food you produce to your neighbours, local restaurants and the local supermarket. Visitors love to learn from your knowledge of the greenhouse.

Your daughter lives in the same street and takes care of the sheep on your property. Their wool is used to make many useful products, including souvenirs you sell next to your house. Every now and then your daughter organizes a guided tour where she teaches tourists about Icelandic wool production. After the tour she serves fish stew with fish caught by your friend Helga who lives down at the beach.





07

DESIGN PROPOSAL

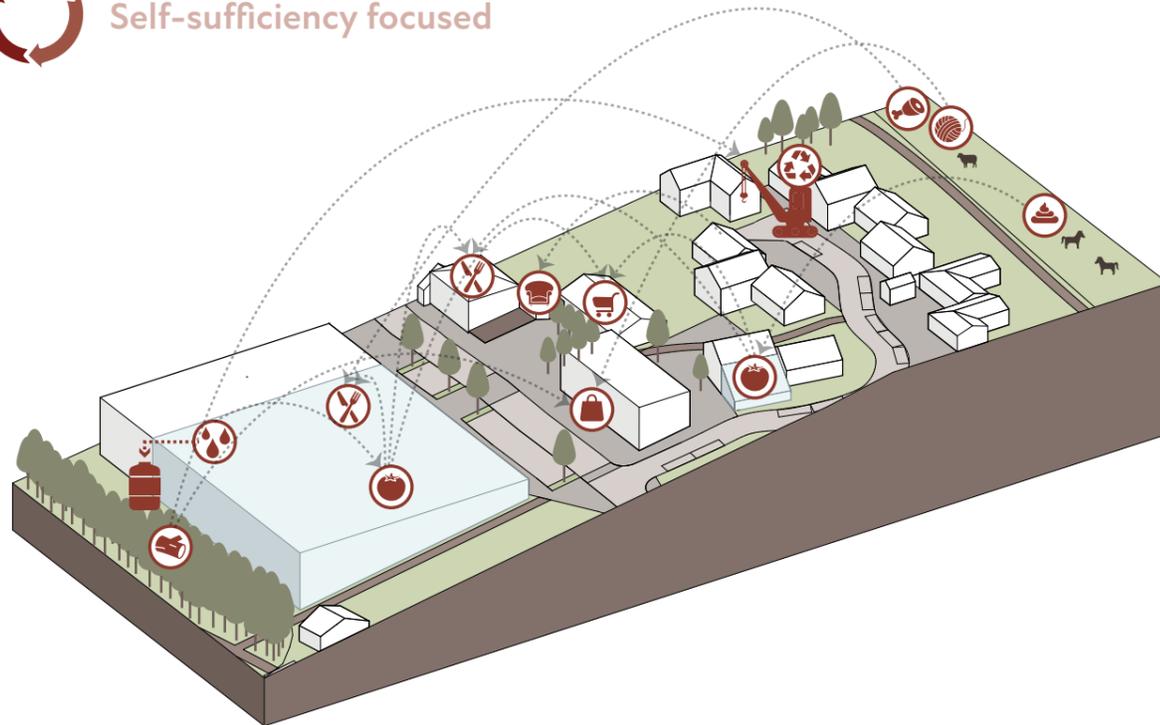
This chapter presents the design proposal for Vík, which focuses on self-sufficiency, walkability, forestry and weather resistance. Some important aspects that can be found in multiple places within the design are creating a typology of indoor and outdoor public spaces, connecting the production of food back into the village and improving pedestrian and traffic safety. The food production will mostly take place in a special type of greenhouse that functions well in the Icelandic setting.

The new neighbourhood in the northeast will blend in with the rest of the village and promotes the new or current residents that will move in to mix with the existing local community. Many new spaces for businesses are created, accompanied by a central market street where people from the municipality can rent small shops to sell and promote their products.

7.1 Design principles



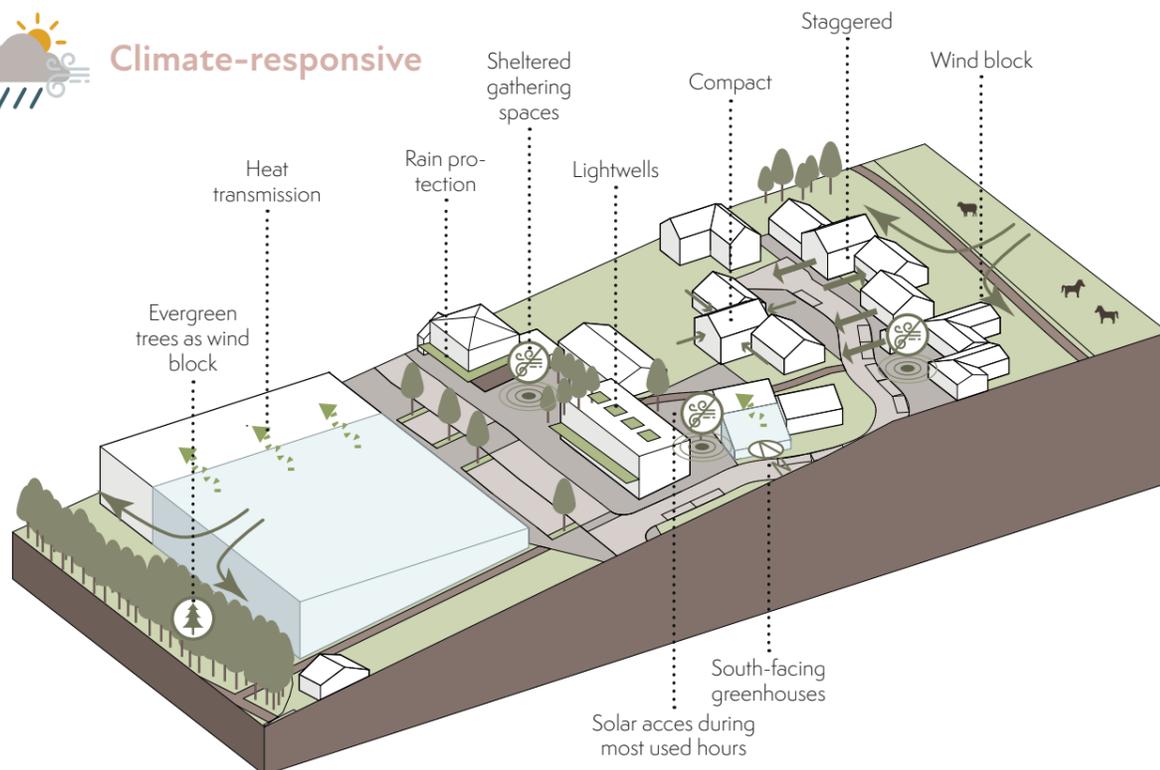
Self-sufficiency focused



- **Local production:** food, building materials, energy
- **Spaces to produce and sell products:** greenhouses, local market, local supermarket, storage, pastures
- **Shared knowledge:** central business meeting spot, greenhouse home prototype building
- **Recycling:** building materials, trash to treasure, feces to fertilizer, rainfall to irrigation, furniture exchange

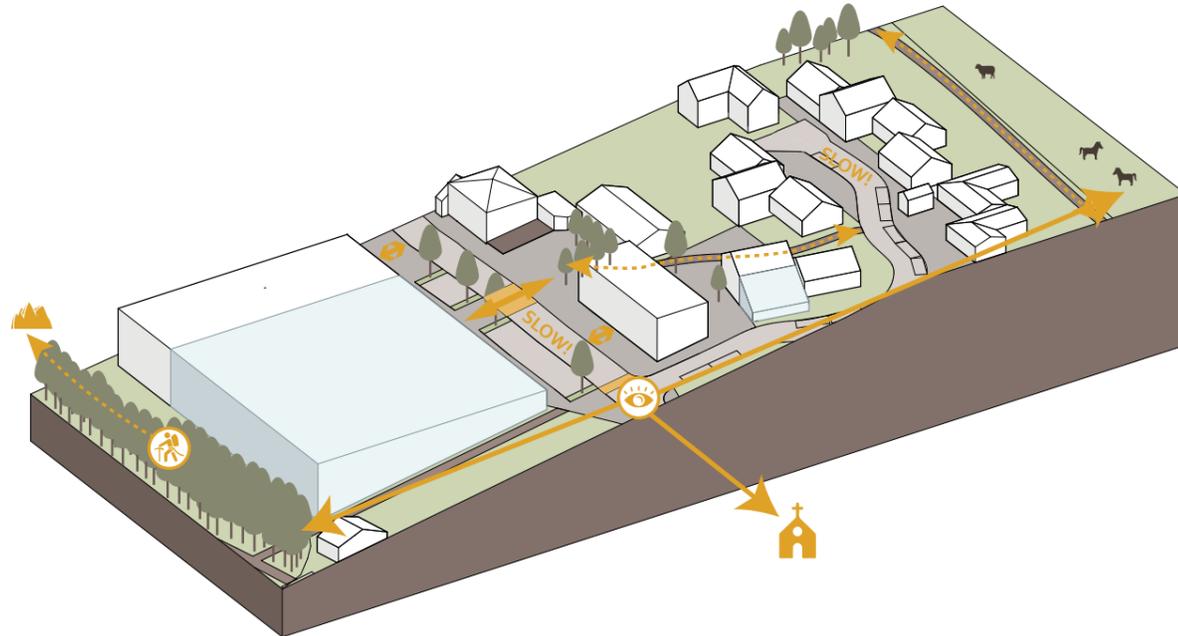


Climate-responsive



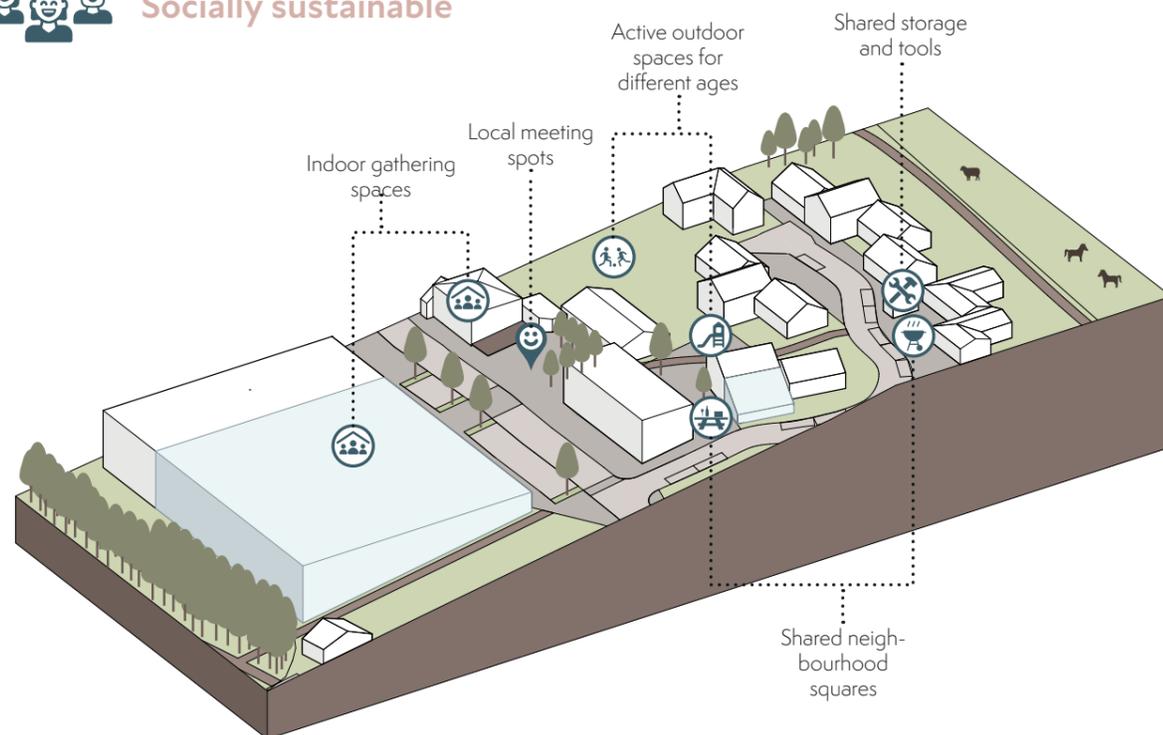
- **Wind protection:** barrier for north-east winds, staggered houses, low houses, sheltered public spaces, evergreen trees
- **Solar access:** southern homes detached, south-facing greenhouse homes, big windows south and small windows north, lightwells, south-oriented public spaces, deciduous trees where winter sun is needed
- **Heat retention:** compact building shapes, greenhouses (attached to buildings), attached buildings
- **Precipitation protection:** indoor public, semi-private and private spaces, roof structures in public spaces
- **Space for snow:** wide pedestrian paths, flexible snow collection spots
- **Utilising the extreme climate:** rainwater collection, shared kick-sleds, ice skating rink

 Walkable



- **More space for pedestrians:** widened pedestrian paths, slower and mixed traffic, one-way streets
- **Clear wayfinding:** clear signing, trees as guiding elements
- **Easy-to-cross main road:** reduced speed (30 km/h), road narrowing at main pedestrian crossings, speed bumps entering Vik, raised crossings
- **Visual stimulation:** views to iconic landscapes/landmarks, colourful and diverse architecture, embracing seasonal change, easy access to surrounding nature

 Socially sustainable



- **Indoor gathering spaces:** covered market, neighbourhood greenhouse, more restaurants/cafes
- **Small shared neighbourhood spaces:** playground, barbecue area, football field, garden, greenhouse
- **Shared workshops and tools:** gardening tools, construction tools

Business network

As highlighted in the axonometric about self-sufficiency, many of the businesses will be interconnected in a network where one person's "trash" is another person's treasure. By creating a circular system, the business network in Vík and its surroundings will be much more efficient compared to when certain products need to be imported or be disposed of, simply because there is no use for it in the area. The business network shown in figure 26 gives an example of how the future businesses imagined in Vík can work together. Many of the elements needed to realise this network are already present in the area, but they simply have to be connected and get some small additions. This checklist shows what is already present and what is still needed to realise the business network:

- Residents thinking about their future
- Builders
- Tourists
- Greenhouses
- Animals
- Geothermal energy
- Central gathering space
- Interested new residents

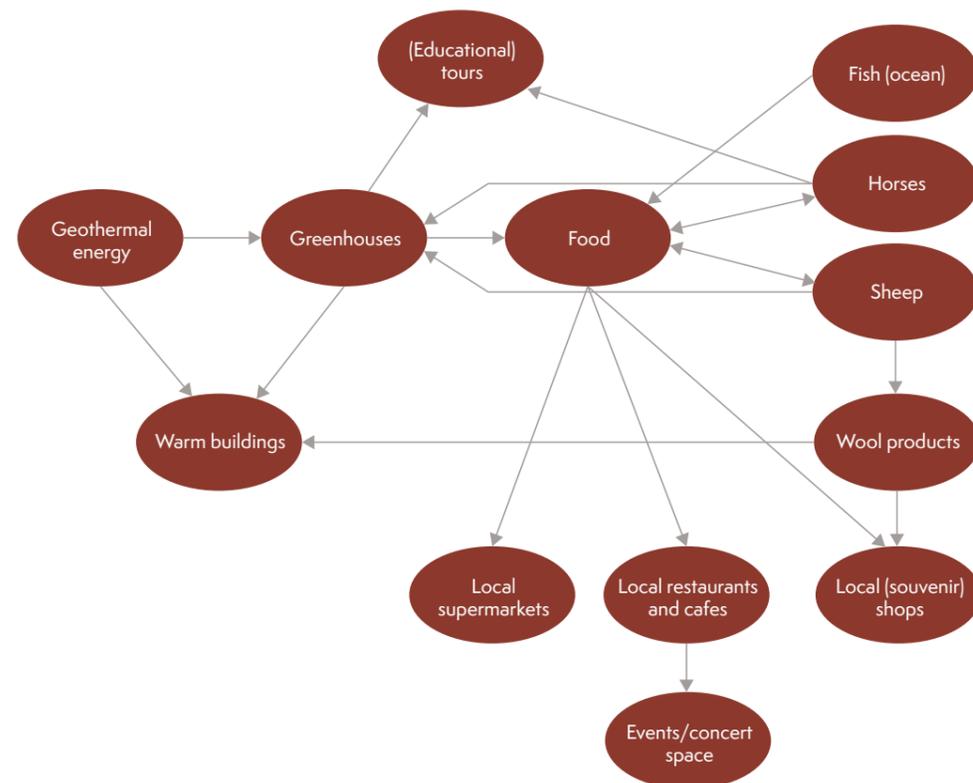


Figure 26: Future business network for Vík and surroundings.

7.2 Strategy

Applying the design principles in the spatial context of Vík, it is important to first create a central gathering space. Today the main arrival spot of Vík is the supermarket area, because this has the biggest parking lot and many busses make a quick stop here for people to buy some food and visit the beach. By changing the main arrival spot to something more central, the businesses in old Vík can also benefit more from short term visitors and the highlights of Vík are easier to reach.

From there I worked with existing directions and created clearer and more walkable connections between them. Next I made sure to provide opportunities for new businesses as well as provide new housing. Most of this is done higher up the hill to make sure it is not within the evacuation zone. A diverse collection of landscape types that produce as well as add recreational value will support the village. Last but not least I made sure to keep but also create interesting sightlines to the main existing qualities of this place.

Step 1: new heart



Step 2: clear connections



Step 3: options for businesses



Step 4: response to housing demand



Step 5: diverse landscape types



Step 6: sightlines to iconic features



- Existing building
- New building
- New greenhouse
- Road
- Pedestrian path
- Unpaved pedestrian path
- Row of trees
- Forest
- Livestock fields
- Topogrphahy lines
- Stream



7.3 Masterplan

The new main square will have a bus stop next to it which will shift the arrival point of most visitors by bus from the supermarket area to a more central spot. People travelling by bus will arrive and get off the bus here and the busses can still park for more long-term at the supermarket.

From the new main square, logical, functional, visual and spatial connections were made throughout the whole village and extending into the surrounding landscape. Visitors are promoted, guided and stimulated to explore and walk around the village more, and also the infrastructure is much more accommodating for this in the new masterplan. Pedestrian paths have been widened and added and the rows of trees (including *Betula pubescens* and *Sorbus aucuparia*) highlight the main routes inside the village. Apart from the pedestrian paths itself, also the crossings are much safer and can be found in many more places than before, with better designs (more on this in chapter "7.5 Walkability"). On top of that, the maximum speed of the main road, which was marked as a danger to the residents of Vík, is lowered from 50 to 30 km/h inside Vík's boundaries.

Also new, more diverse businesses will start. This goes hand in hand with the improved walkability, because in the first phases the tourists will be the main target groups. The businesses can sell products, organise tours, do workshops etc. for tourists, while their business grows and can become more self-sufficient and less dependent on tourism. You need the tourism to start off in a small village like this if you want to focus on self-sufficiency/local production as the end goal.

In several places, greenhouses of different sizes are proposed that will provide the village with food. These greenhouses will have the right growing conditions, because of lighting from

renewable energy and geothermal heating keeping the greenhouses at a suitable temperature. This enables high food production all year round. Rainwater is collected from the roofs and stored in tanks, so that it can be used for irrigation of the greenhouse crops (see figure 27). Many greenhouses are also attached to (residential) buildings, which provides people with a semi-indoor/outdoor space that they can enjoy all year round, independent of the weather conditions.

All buildings have been placed carefully in order to allow enough sunlight not only into the greenhouses, but also into the residential homes. The buildings have been placed in such a way, that they will also block the strongest and most frequently occurring winds at the same time. One of the few places in the village that has been left relatively open and exposed, is the area around the church. This is because it is an iconic feature on the hill and the sightlines to and character of this church should be maintained.

Apart from production in greenhouses, the surrounding landscape is nowadays already used as a production landscape where possible. This can be diversified and integrated more into the village structure. For instance, while nowadays many animals are kept further away from the village, they can be kept closer to it and be mixed more. The connection with where your food and other resources come from is stronger when you can actually experience and see it up close. Apart from animals and crops, also production forests will be planted containing *Picea sitchensis*, *Salix phylicifolia*, *Betula Pubescens*, *Pinus contorta* and *Populus trichocarpa*. These forests not only provide the area with building materials, but also prevent erosion, provide new habitats, create new recreational possibilities, block strong winds and sequester carbon dioxide. Not only the landscape can sustainably be used as a resource, also the ocean in this area is full of fish. Currently there is a fishing business operating from Vík, which can be included in the circular business network that was proposed in chapter "7.1 Design principles".

A threat to Vík that has been highlighted in chapter "3.2.5 Natural threats" is of course the erosion. A solution could be to extend the eastern groyne further into the sea, similar to the western groyne that has been successful in capturing sediments at the beach. Also more lyme grass will be planted in the dunes and on the beach.

A very important point to discuss is how an urban design is in fact different from a rural design or 'village design'. A small change in a small town will often result in having a big impact. For this reason, the choice has been made to work as much as possible with what is already there, meaning no homes were moved or marked to be demolished and many parts of the masterplan could be called 'acupunctural interventions'. The new plan only adds to the village, moves some key functions to a more suitable place and provides new elements that it was lacking before. The masterplan works with, and weaves into the existing village structure. It is crucial to maintain and further strengthen the collaboration of the community. Therefore spaces that promote getting together and sharing knowledge, dreams and ideas are essential.

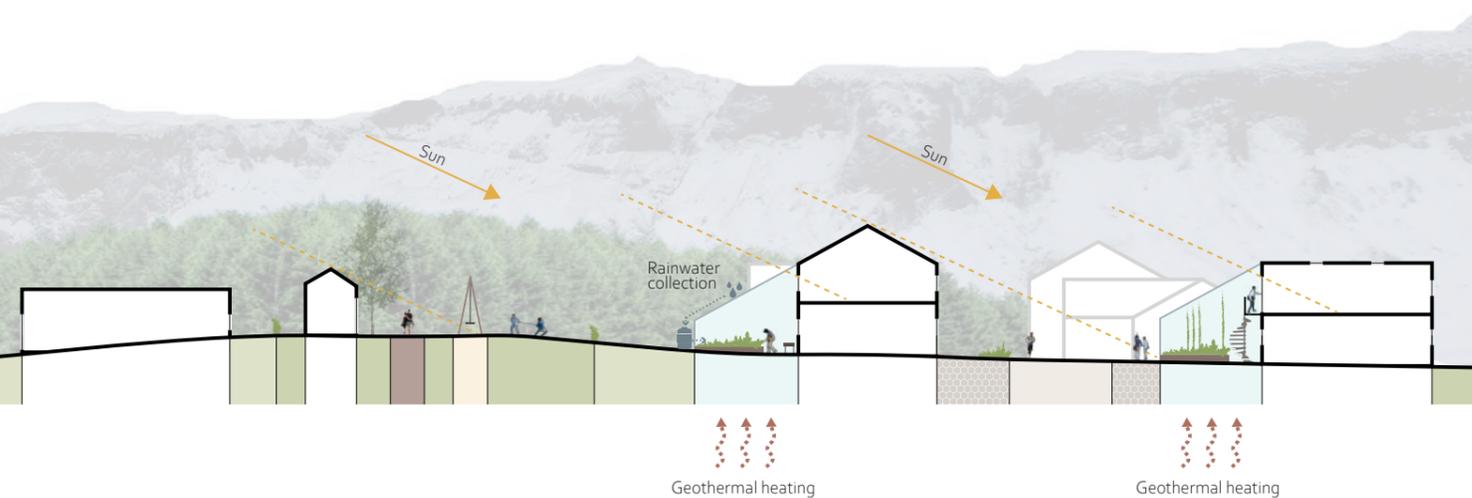


Figure 27: The south-facing greenhouses are attached to homes, in order to catch sunlight and exchange warmth with the house. Water that falls on the roofs is collected and used in the greenhouses for irrigation.

Buildings



99 new buildings of which: 1 town hall, 1 police-, fire- and rescue station, 18 boutiques/small cafes, 3 restaurants/bigger cafes, 1 hostel, 2 small local supermarkets, 1 prototype greenhouse home, 2 farms, 4 apartment buildings, 7 detached houses, 66 attached houses (with possibilities for attached B&B or other), 1 furniture exchange station, 4 shared sheds

Pedestrian network and main flows



Sightlines



Landscape types



7.4 Detailed design

7.4.1 Main square

When looking at only the section of the plan that is highlighted in figure 28, you can see that many main functions in the new plan can be found along this direction, with the new square in the centre. Nowadays the roads of south Vik are oriented in the same direction, towards the church. With the addition of an arcade exactly following this line, you can experience a very clear sightline from inside the arcade all the way towards one of the iconic features of the village.

The arcade functions as a small scale indoor shopping street, with small boutiques that can be rented by residents of the municipality as a place to sell their products and advertise their business. By making this market street indoors, the use of this space is not dependent on the weather. Inspiration has been taken from the Markthal in Rotterdam and Borough Road and Brixton Market in London (see figure 29). The arcade connects to the bigger production greenhouse, where visitors can walk around the greenhouse and learn about greenhouse horticulture in colder climates and how the products are used throughout the village. The arcade also connects to the existing soup restaurant and the Lava Show. The place where

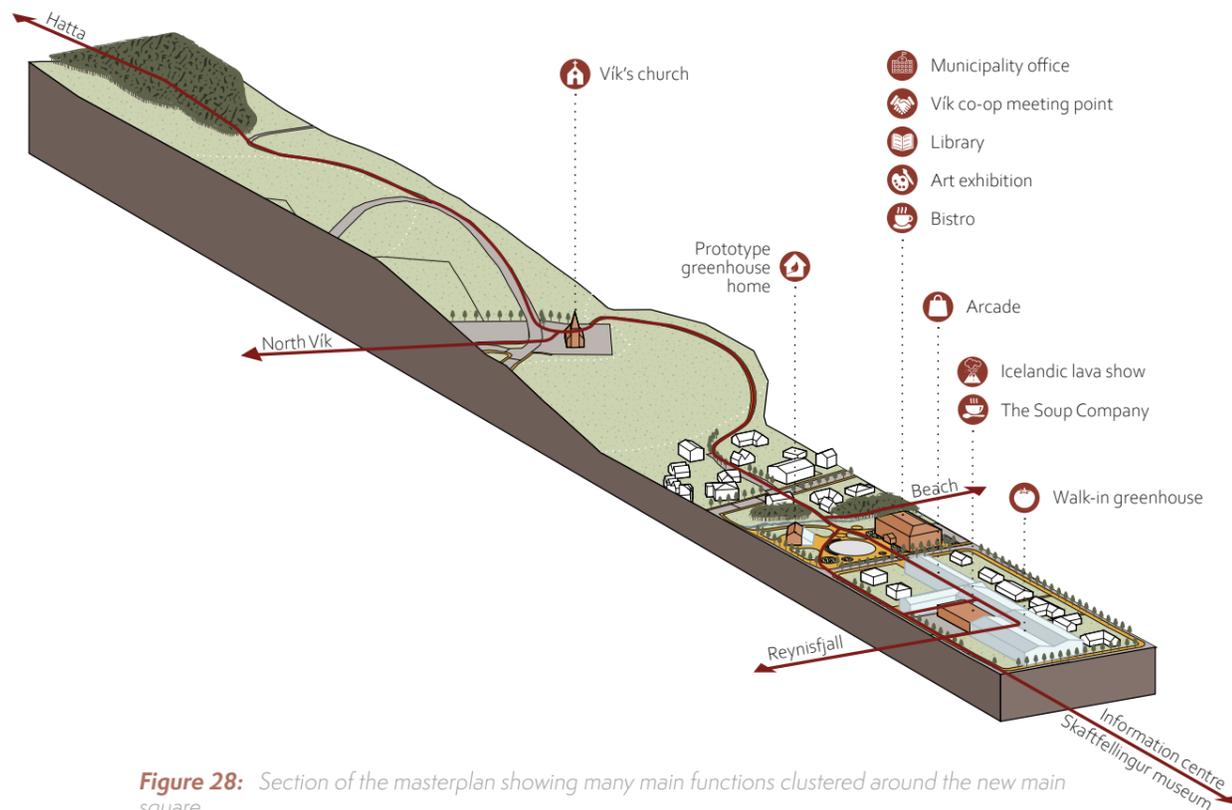


Figure 28: Section of the masterplan showing many main functions clustered around the new main square.

the arcade connects with this existing building creates a great opportunity for the Soup Company to make an indoor terrace at the place where a small greenhouse pocket park is proposed (see figure 30).

The arcade will guide people towards the rest of Víkurbraut, where for instance the information centre and Skaftfellingur Museum are located. On the other side it makes the walk towards the church much clearer because of the sightline and the new pedestrian connection that is made exactly along this line. At the spot where this connection crosses the main road, an elevated crossing with several ways to slow down traffic is proposed, to make the walk across this road much safer for both tourists and locals (more about this topic in the chapter "Walkability").



Figure 29: Brixton Market in London as inspiration for an indoor market. Image: A Lady in London (2020).

Figure 30: View towards Vik's church from the arcade. On the left you can see the new terrace of the existing Soup Company.





Main crossing towards church

Prototype greenhouse home

Snow mound (winter)

Seasonal square

Fireplace

Bus stop

Town hall

Dream guesthouse Vik

The Soup Company

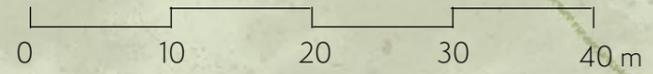
Icelandic Lava Show

Arcade

Boutiques etc.

Indoor pocket park

Path towards beach



The main square is located on a place where nowadays the bank, liquor store, police station and library can be found in one building. However, to create space for the main square at a logical location, this building was re-moved and the functions were moved to other places. The bank and liquor store are moved to the supermarket building, the police station will move to a new building replacing the old post office and municipality buildings and the library will move to the new town hall proposed at the new square. Other functions that can be found in the town hall will be the municipality office, a bistro, a business co-op meeting point connected to the bistro and an art exhibition hall showcasing local artists. This way both locals and tourists will have a logical gathering place, both indoors and outdoors at the main square.

Another building that can be found at the new square is a prototype building showing how a greenhouse can connect to a residential home. This is something that is proposed in the masterplan on several places through-out the village. The prototype building is meant to serve

as inspiration and as an informative “help desk” for residents of Vík to try this way of building a productive greenhouse for themselves and perhaps start a new business with it. Inside the building people can learn about how this type of building works in detail and why it is a great way of building greenhouses in a colder climate.

The outdoor space of the square consists of the bus stop, seating along the stream as well as several other spots on the square and a flexible area in the middle (see the previous pages). In summer this can function as the out-door seating space of the bistro in the town hall, and in winter it can transform into an ice skating rink (see figure 31 and 32). Other things you can find at the square are a small playground, a firepit and native seasonal plants. On the other side of the stream you can see a newly proposed strip of forest, through which a path connects all the way down to the beach, following the stream that flows out into the Atlantic ocean.



Figure 31: View of the main square in summer showing the square being used as a meeting spot for locals as well as tourists. The central circle can be used as outdoor seating by the bistro.



Figure 32: View of the main square in winter showing the use of the central circle as ice skating rink, place for snow storage and a small coffee truck.

7.4.2 New neighbourhood north

Since the eroding coast is one of Vík's biggest threats, one of the design guidelines was to build only outside of the evacuation zone in case of a volcano eruption. These eruptions cause small local "tsunami's" and might flood the houses in the lower part of town. Therefore most of the new development happened in the north of Vík, connecting to the existing newer part of the village.

The main inspiration for the typology of the new proposal has been taken from the evolution of Icelandic houses. The Vikings that settled in Iceland took their building traditions with them to their new land. An example is the Viking longhouse, which houses all functions under one roof: a family sleeps, eats, works, keeps animals, bathes and cooks all in the same space. Later this type of building adjusted to the Icelandic climate, as well as to the shortage of building materials. As explained in chapter "2.1.3 Flora", the first settlers had to utilise so much of the local forests, that at one point there were barely any forests left. Turf, stones and driftwood were used as building materials instead. Instead of having all functions under one roof, the longhouse transitioned to several smaller houses with different functions, connected through a central hallway (van Hoof & van Dijken, 2008). Some of these building types can still be found across Iceland, one example is Glaumbær. At many other places, especially traditional farms, you can see that the buildings started to become separate buildings, instead of being connected through a hallway. Still they were placed in clusters, protecting the inner yard from the harsh winds. Nowadays it is still common in Iceland to build houses in clusters. Different from the courtyard typology you can find across for instance Copenhagen and Barcelona,



Figure 33: Illustration of the evolution of building types in Iceland.

the Icelandic clusters are more open and consist of multiple separate buildings surrounding a small inner space (see figure 33). The benefit of this is that more sunlight is able to reach all the buildings.

The clusters proposed in the new neighbourhood (see the next pages) are created in such a way, that the prevailing winds from the east are blocked, as much sun as possible reaches each building and they are all placed around a small neighbourhood square. This way, there is always a neighbour close by if you need any help with something. Each house also has a view towards either the mountains in the north, Reynisfjall, Reynisdrangar, the animal fields or the church.

The neighbourhood squares are simple yet effective. They provide the basics for a space to hang out in (protected from wind, access to sun, seating and a place to prepare food) and they also include a shared shed, where people can borrow common tools for for instance gardening. More on the back side of the houses, there are some more spacious public spaces where you can find for instance a small football field or a natural playground. The sun reaches each type of public space at a different time: the moment of the day when it is used the most. For instance the central square gets sun all afternoon, while the shared garden next to the apartment block mainly gets sun around lunchtime (see figure 35).

The neighbourhood is connected to the new proposed forest in the north and west, the animal fields in the east (accessible by footpaths leading through the fields) and the church in the south. The main road of this northern neighbourhood creates a straight view towards the church and a sheep farm open for tours on the other end.

Figure 34: Impression of one of the small neighbourhood squares: simple yet effective.





Tomato farmers

Florist

Sheep farm with tours

Paprika farmer

Shared shed

Sheep & horse pasture

Apartments

Hobby gardeners

Cafe

Furniture swap

Local supermarket

Greenhouse restaurant

Boutiques & apartments

Aquaponic greenhouse experiment

B&B attached to owner's home

Butterfly keepers

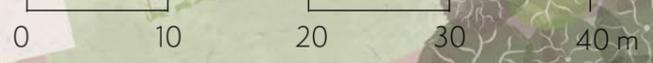


Figure 35: Solar analysis for the new neighbourhood in north Vik.

Midsummer



23-6 at 9:00



23-6 at 12:00



23-6 at 15:00



23-6 at 18:00

March equinox



20-3 at 9:00



20-3 at 12:00



20-3 at 15:00



20-3 at 18:00

Midwinter



21-12 at 9:00



21-12 at 12:00



21-12 at 15:00



21-12 at 18:00

The centre of the neighbourhood contains some basic functions, like a local supermarket, café, some boutiques and a place to exchange items like furniture pieces. These functions surround a small local square that is protected from the wind and contains some roof structures that protect people from wind. On the opposite side of the square is another bigger production greenhouse. This one is connected to a restaurant where, inspired by Friðheimar, the seating area of the restaurant is inside the greenhouse, surrounded by the plants. Apart from bigger production greenhouses, you can also find several of the greenhouse homes as mentioned earlier (see figure 36). Some functions I imagine taking place in these greenhouses are written down in the detailed plan, but in the end this is all up to the people who will move to this area.



Figure 36: greenhouse attached to a home will create a semi-outdoor space to enjoy, even in bad weather. Not only can it function as a place to grow food all year round, it can also be an extension of your house, or an extension of your garden into your house, depending on how you see it. It can be a private greenhouse, or one shared with your neighbours as a more private meeting place. On top of that, the northern lights can be watched no matter the weather!

The benefit of these greenhouse homes is that the people living here can produce food all year round and enjoy their semi indoor/outdoor space even when the weather is bad. Also a spectacular phenomenon that takes place in Iceland, the northern lights, can be seen very well through the glass roof of the greenhouses, while still being in the warmth of the building. This is because the greenhouses are heated by geothermal energy, keeping it at a stable and comfortable temperature.



Figure 37: Example of what a greenhouse attached to a two-level apartment building can look like. Image: Williams College (2020).

The greenhouses can be attached to different types of homes. The main building types are apartments, attached houses, (bigger) detached houses and L-houses (see figure 38). In figure 37 an example is shown of what it could look like to have a shared greenhouse attached to a two-level apartment building.

Because of the lack of locally produced timber, the first building phases will include buildings made of mainly locally recycled concrete (see chapter "4.5 Shelter"). Once the forests have grown big enough, the following building phases can include more and more buildings made of local timber.

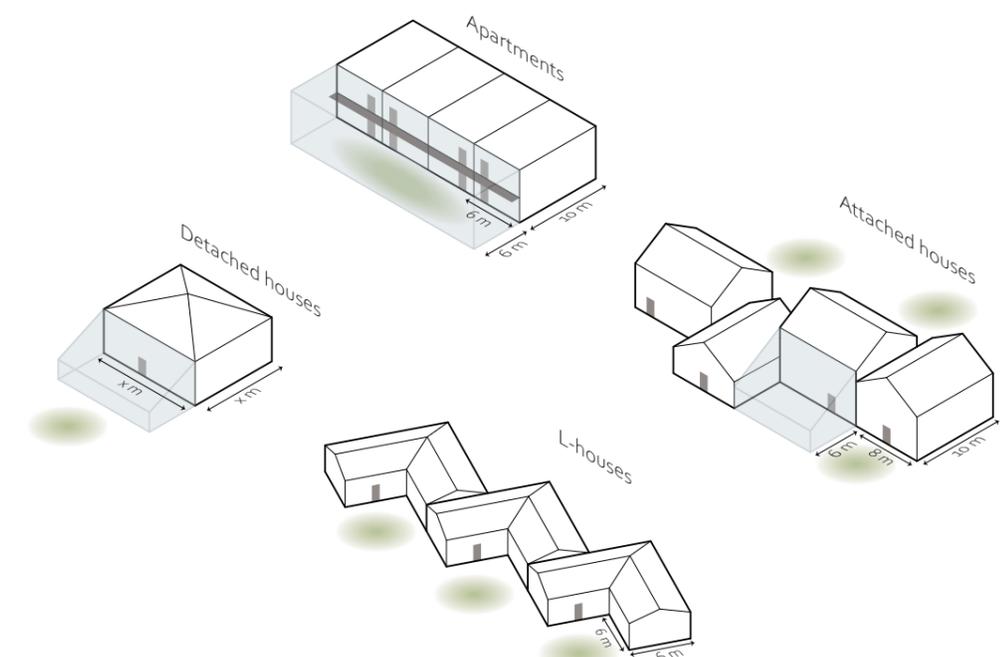


Figure 38: The different new building types, all kept compact and easy to build. Many can have a greenhouse attached to it, either shared or private.

7.4.3 Additional ideas

Apart from the main aspects of the design proposal for Vík, some smaller ideas for the village were developed simultaneously. These might not directly fit in with the overall concept of self-sufficiency, but will add a great value to the life in Vík.

One of these ideas was related to the swimming culture of Iceland. For Icelanders, going to the swimming pool is almost like going to the pub: you go there to relax after a long day of work or to catch up with your friends. Vík's swimming pool is simple but efficient, however it can use an upgrade, especially since the pool can be seen as an important meeting spot in the village. Apart from upgrading and perhaps expanding the current swimming pool, an additional idea was inspired by the ocean rock pools in Sydney (see figure 39). These are strong pools created along the coast where sea water flows into and out of the pool, making it almost zero maintenance. In the specific location at Vík, where swimming directly in the ocean is too dangerous, the added pool could make the ocean more accessible and interactive. Obviously the pool could only be opened when the waves are only mild, but the water temperature should not be an issue. The pool can be seen as an "ice bath" you take in between sauna sessions, but also since cold water swimming is becoming quite popular, it might encourage people to try out this tradition here in Vík.

Another idea related to the ocean is to operate the amphibian vehicle that is located at Vík again (see figure 40). It used to go into the ocean every now and then as an attraction, but it stopped operating. If the vehicle is still functioning, it would be great to organise rides into the ocean again.

Some extra ideas were to place a sign for "Vík" in the pasture where people drive into the village, to start a forestry education/research centre along with the new forests and to have sledges to lend in winter.

Last but not least, it would be good to provide some sort of guidebook on how to build a greenhouse in Iceland (attached to or detached from a building). This will make the start for someone to begin building a project like this easier and will ensure a higher rate of success when people share their existing knowledge on the topic.



Figure 39: Ocean pool at Bronte beach in Sydney, Australia. Image: Scanu (2020).



Figure 40: Additional ideas to reactivate the ocean and boost Vík's public life.

7.5 Walkability

7.5.1 South Vík

The main problem of the southern part of Vík is the lack of space for pedestrians. It is a very car-focused area nowadays, that doesn't invite for a nice stroll around the block. The proposal for this area focuses mainly on creating a one-way traffic flow and wider pedestrian paths within the boundaries that the road section has nowadays (see figure 41). Since the area that these roads reach into is fairly small, changing to one-way traffic only has a very small influence on travel time by car. There will be much more space for street furniture, trees and parking closer to the main attractions of Vík. This makes it safer for people to reach these attractions when the weather is very bad, as well as it leads more people to these attractions, since transport by car is still the most common form of transport in Iceland. Narrower roads will also slow down traffic, making it more comfortable to walk along and cross this road. Using the 5-minute walk concept, one will find out that in the current design of Vík, where the supermarket area is the main arrival point, only the beach, big hotels and horse stable can be reached within five minutes. Changing the arrival point to the new proposed main square, all attractions in the southern part of Vík can be reached, as well as the church and the start of the main road in the new neighbourhood up north. Also applying the general theory of walkability discussed in Jeff Speck's "Walkable City" (Speck, 2013), the main flows from the new arrival point check all boxes, which are that a walk has to be safe, comfortable, useful and interesting.

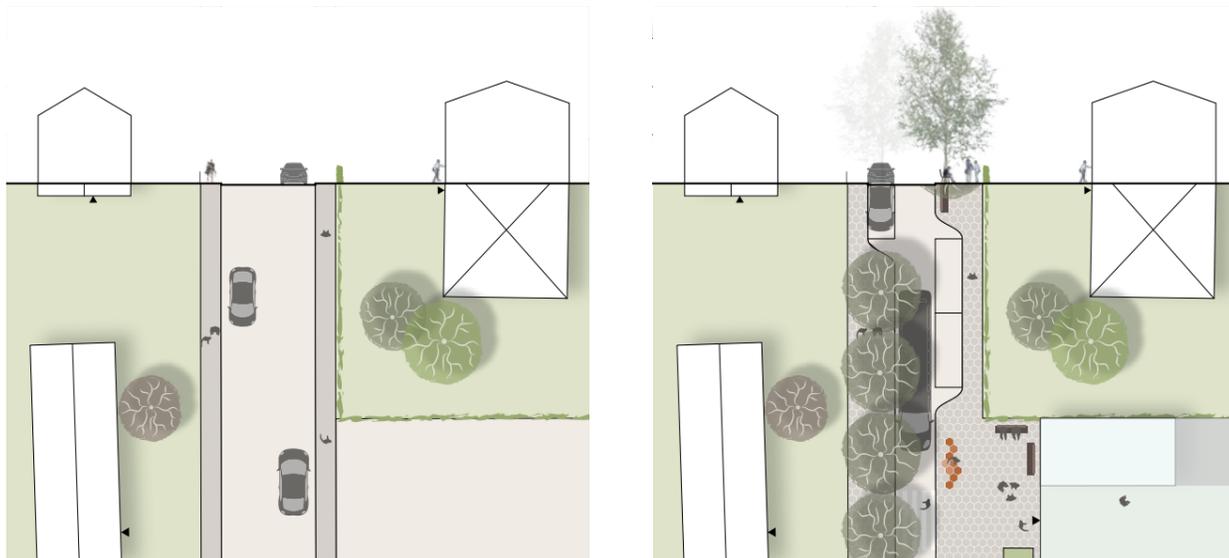


Figure 41: Adjustments to the road layout, while staying within existing boundaries.

7.5.2 Icelandic main road

As discussed in chapter "3.2.6 Municipality's masterplan", there are different solutions to the problems that were used as arguments for the diversion of the Icelandic main road. In that chapter, an alternative solution for the dangerous turn (the main reason of the road diversion) was discussed and some examples of how to improve safety at the main road in Vík were touched upon.

An important first change would be to lower the maximum speed to 30 km/h, which is nowadays at 50 km/h. This will make it much safer to cross and walk alongside the road, as well as decrease noise-induced health issues. Placing trees and buildings closer to the road in the new masterplan will also make the road appear narrower, ensuring that people will stick to the 30 km/h speed limit. Especially when the road conditions are very slippery, it is important that all vehicles, including heavy trucks, can get their vehicle to a quick stop when necessary. To encourage vehicles lowering their speed to 30 km/h on time when entering the village, speed bumps are placed already some distance outside of the built area, preventing people from speeding into the village.

On top of that, more crossings were added inside Vík and they are marked much clearer with lights, signs, different surface types and speed bumps. The elevated crossings will also ensure that the runoff of melting snow will not stay at the spots where pedestrians want to cross the road. The new crossings will also be at logical locations, preventing pedestrians from crossing the main road wherever seemed logical before.

7.6 Phasing

The development of Vik's masterplan proposal will need to happen in several phases. In the following images you can see the current situation marked as phase 0, followed by phase 1-4. The steps per phase are as follows:



Phase 0: existing situation and some small acupunctural improvements

- Acupunctural improvements include: signage, temporary pop-up square, move bank to supermarket building, improve microclimate at camping site, give some buildings a fresh coat of paint.
- Extra: prepare residents with workshops about vegetable growing, organise music evenings, find interested residents for the first building phase, prepare them and support them to create perhaps a new business plan.



Phase 1: Quick actions (2-5 years)

- Establish new heart
- Experiment with greenhouses
- Plant first forests
- Plant trees on main roads
- Add new pedestrian structure
- Keep animals in some existing fields
- Extend right groyne



Phase 2: The new neighbourhood (5-10 years)

- Start new development in the north
- Plant more forests
- Add individual houses inside village



Phase 3: Final touches (10-20 years)

- Expand new development, depending on demand
- Add more tree rows in south-Vik
- Plant more forest



Phase 4: What's next? (20+ years)

- Plant more forest
- Building in north-west, depending on demand
- Adding the rock pool



08

CONCLUSIONS

8.1 Conclusion

This thesis examined past, current and expected future developments on global, national and regional level, all linking back to Vík í Mýrdal and its possibilities for a new, more self-sufficient masterplan. Many topics needed to be taken into account when looking into self-sufficiency in a smaller village. On a global level it is clear that more and more people are moving to bigger cities for many reasons, bringing rural villages in a difficult position where the younger generation moves away and might not move back. Often these rural areas are places that have carried on traditions and important parts of cultures throughout the centuries, and are now going empty and risking abandonment. By continuing to do things the way these people have always been used to, this process unfortunately won't be reversed. But by applying the knowledge they already have to a slightly adjusted form of living, they can carry on their traditions and make a living in a slightly different way. It is important for rural places to be less dependent on products and people from bigger cities in order to ensure survival of their community in the future. This is where self-sufficiency plays an important role: being more self-sufficient regarding food, shelter, clothing, employment, entertainment and social life. The level of self-sufficiency that can be achieved in the 21st century is different per country, per region and per village specifically.

Vík is currently very dependent on tourism with its income, meaning the residents of the area rely on the influx and behaviour of people mostly from other countries. The number of tourists arrivals in Iceland is likely to decrease in the future, and especially in 2020 the COVID-19 pandemic has brought this number down drastically. This thesis analysed the current "level of self-sufficiency" of Iceland and the possibilities for Vík in particular to improve this, being less dependent on other countries and other people. Concluding the research, it is clear that there are many opportunities for local food production in particular. Other topics that can easily be improved with some changes to the urban design of Vík are the walkability (promoting people to go by foot within the village and exploring the place more) and providing indoor as well as outdoor public spaces (as places to meet, support businesses, exchange knowledge, etc.). Growing food in Mýrdalshreppur municipality is possible outside in the Icelandic climate, however this includes only a very limited selection of products. Greenhouse horticulture is

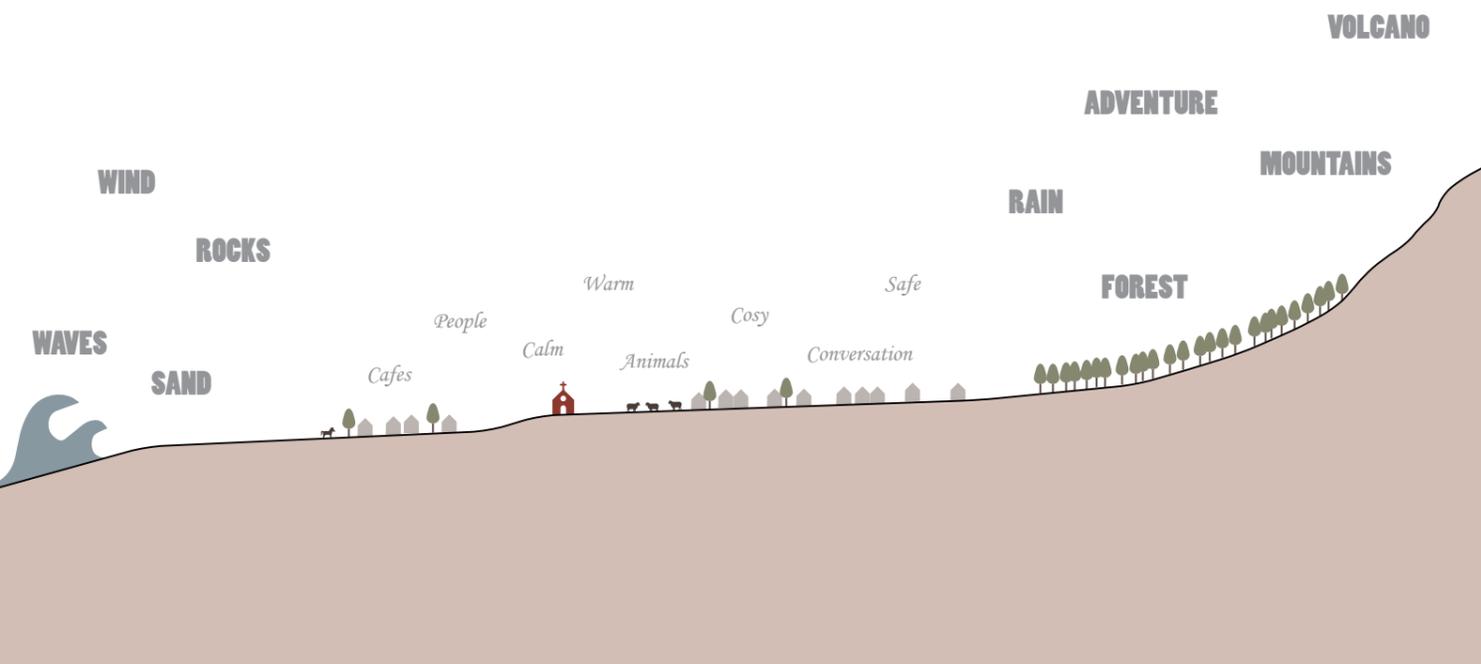
where the possibilities are, providing a suitable growing environment for many different crops all year round. During the research for this thesis, several reference projects were analysed which all showed inspirational examples of greenhouse horticulture in colder climates. The geographical advantages of Iceland are that geothermal heating can be used as a sustainable way to keep the growing environment at the correct temperature, as well as the electricity generated from hydropower can be used for additional lighting in the darker months. Connecting these greenhouses to residential homes will also reduce heat loss and provide a semi-indoor/outdoor space as an extension of your house, or an extension of your garden into your home, depending on how you look at it. This way you will still be connected to the outdoors even when the weather is being "typically Icelandic".

One of the main things that was lacking in the current design of Vík is a central meeting place, for locals as well as visitors. Creating a clear central starting point will promote visitors to explore the village (by foot) and will bring locals together in a place where knowledge and business ideas can be exchanged. The small boutiques will make it possible for people who can't afford to buy a new home or a whole shop in the village, to sell products and promote their business to visitors of Vík.

Last but not least, an extra goal of this thesis was to provide an alternative solution to the plan for the main road diversion. By tackling the core of the problem, the dangerous turn, a complete road diversion will not be necessary as long as pedestrian safety is improved inside Vík as well.

8.2 Reflection

During the time I worked on this project, one assumption I had about myself became extra clear: when I am very interested in a topic, I could go on forever researching all different aspects of it. In this case the same happened with my thesis village Vík: I fell in love with the place and wanted to know everything about it, as well as research all possible additions to the current way Vík is designed and is working. Because of this, I worked on my thesis a bit longer than originally planned. Also having started a full-time job in the process of this, I had to try hard to find the time to finish my thesis project. In the end I am very proud of the design proposal I made for Vík and the research I have carried out to support it. I hope the project will inspire the people who live in Vík, are planning to move to Vík and people who live and work in similar villages around the world.



References

- Arion Research. (2017). *Tourism in Iceland: Here to stay?* Arion Bank.
- Arion Research. (2018). *Tourism in Iceland: Soft landing or belly flop?* Arion Bank.
- Arnalds, A. (1987). Ecosystem Disturbance in Iceland. *Arctic and Alpine Research*, 508-513.
- Bird, D., McLeman, R., Gísladóttir, G., Kelman, I., Næss, M. W., & Jóhannesdóttir, G. (2016). Climate change and settlement level impacts. In *Settlements at the Edge* (pp. 293-320). Cheltenham: Edward Elgar Publishing.
- Björk, K. (2020). *Plants in Iceland | Flora Under the Arctic Circle*. Retrieved from Guide to Iceland: <https://guidetoiceland.is/best-of-iceland/plants-in-iceland>
- Chapman, M. (n.d.). *The History of Iceland*. Retrieved from Guide to Iceland: <https://guidetoiceland.is/history-culture/history-of-iceland>
- De Ruiter, H., Kastner, T., & Nonhebel, S. (2014). European dietary patterns and their associated land use: Variation between and within countries. *Food Policy*, 158-166.
- Dirksen, K. (2020, 03 08). *Sunken greenhouse wraps home & feeds suburban antifragile co-op*. Retrieved from Fair Companies: <https://faircompanies.com/videos/mt-polyfarm-underground-lodge-make-suburban-coop-self-reliant/>
- Eysteinnsson, T. (2017). *Forestry in a Treeless Land*. Egilsstaðir: Icelandic Forest Service.
- Friðheimar. (2020). *A glimpse of life and work at Friðheimar*. Retrieved from Friðheimar: <https://www.fridheimar.is/en>
- Government of Iceland. (2020, 12 13). *Electricity*. Retrieved from Government of Iceland: <https://www.government.is/topics/business-and-industry/energy/#:~:text=About%2085%25%20of%20the%20total,domestically%20produced%20renewable%20energy%20sources.&text=Renewable%20energy%20provided%20almost%20100,and%2027%25%20from%20geothermal%20power.>
- Hallström, E., Carlsson-Kanyama, A., & Börjesson, P. (2015). Environmental impact of dietary change: a systematic review. *Journal of Cleaner Production*, 1-11.
- Icelandic Institute of Natural History. (2020, 10 25). *Fauna*. Retrieved from Icelandic Institute of Natural History: <https://en.ni.is/fauna>
- Icelandic Meteorological Office. (2020, 04 09). *Climatological Data*. Retrieved from Icelandic MET Office: <https://en.vedur.is/climatology/data/#a>
- Icelandic Tourist Board. (2019, 11). *Tourism in Iceland in figures - November 2019*. Retrieved from Icelandic Tourist Board: <https://www.ferdamalastofa.is/static/files/ferdamalastofa/talnaefni/ferdatjonusta-i-tolum/2019/november/november-2019-en.pdf>
- Icelandic Tourist Board. (2020, 12 7). *Number of foreign visitors*. Retrieved from Icelandic Tourist Board: <https://www.ferdamalastofa.is/en/research-and-statistics/numbers-of-foreign-visitors>
- Icelandic Tourist Board. (2020, 12 7). *Visitor surveys*. Retrieved from Icelandic Tourist Board: <https://www.ferdamalastofa.is/en/research-and-statistics/visitor-surveys>
- Inspired by Iceland. (2020, 10 25). *Geography*. Retrieved from Iceland: <https://www.iceland.is/the-big-picture/nature-environment/geography#:~:text=Iceland%20is%20the%20least%20populated,%2C%20including%20Europe's%20largest%2C%20Vatnaj%C3%B6kull.>
- Inspired by Iceland. (2020, 12 22). *The Icelandic Pledge*. Retrieved from Inspired by Iceland: <https://visiticeland.com/pledge>
- Jóhannesdóttir, G., & Gísladóttir, G. (2010). People living under threat of volcanic hazard in southern Iceland. *Natural Hazards and Earth System Sciences*, 407-420.
- Jóhannesson, D., Stefánsson, H., Kristjánsdóttir, M., Másson, N. Ú., & Ólafsdóttir, S. (2000). *A Guide to Icelandic Architecture*. Reykjavík: The Association of Icelandic Architects.
- Little Free Library. (2020, 6 4). *Little Free Library*. Retrieved from Little Free Library.org: <https://littlefreelibrary.org/>
- McLeod, S. (2018). *Maslow's Hierarchy of Needs*. Retrieved from Simply Psychology: <https://www.simplypsychology.org/maslow.html>
- Mýrdalshreppur. (2012). *Aðalskipulag Mýrdalshrepps 2012-2028*. VSÓ Ráðgjöf.
- Mýrdalshreppur. (2020). *Mýrdalshreppur*. Retrieved from Mýrdalshreppur: <https://www.vik.is/is/index.php>
- Närpes Grönsaker. (2020, 12 7). *Grönsaker med mer smak*. Retrieved from Närpes Grönsaker: <https://www.narpesgronsaker.fi/sv>

Nawri, N., Petersen, G. N., Bjornsson, H., Hahmann, A. N., Jónasson, K., Hasager, C. B., & Clausen, N.-E. (2014). The wind energy potential of Iceland. *Renewable Energy*, 290-299.

Olafsson, S., Cook, D., Davidsdottir, B., & Johannsdottir, L. (2014). Measuring countries' environmental sustainability performance – A review and case study of Iceland. *Renewable and Sustainable Energy Reviews*, 934-948.

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360(6392), 987-992.

Rossi, I. A., Vienneau, D., Ragetti, M. S., Flückiger, B., & Rössli, M. (2020). Estimating the health benefits associated with a speed limit reduction to thirty kilometres per hour: A health impact assessment of noise and road traffic crashes for the Swiss city of Lausanne. *Environment International*.

s.n. (2020). *Informatie over de vegetatie van IJsland*. Retrieved from Natuur van IJsland Site: http://www.iceland-nh.net/plants/znl-background_plants3.html

Schenk, K. (2020, 6 2). *Groen betonrecycling - c2c - milieuvriendelijk met de SmartCrusher*. Retrieved from SmartCrusher bv: <https://slimbreker.nl/index.html>

Sims, I., & Poole, A. (2017). *Alkali-Aggregate Reaction in Concrete: A World Review*. Boca Raton: CRC Press.

Sólheimar. (2020). *Sólheimar Sjálfbært Samfélag*. Retrieved from Sólheimar: <https://www.solheimar.is/>

Speck, J. (2013). *Walkable City*. New York: North Point Press.

Statistics Iceland. (2020, 11 24). *Population by urban nuclei, sex and age 1 January 2001-2020*. Retrieved from Statistics Iceland: https://px.hagstofa.is/pxen/pxweb/en/lbuar/lbuar__mannfjoldi__2_byggdir__Byggdajarnar/MAN030101.px/table/tableViewLayout1/?rxid=9620a8d0-c36a-422a-ad6d-536652045943

Statistics Iceland. (2020, 10 25). *Population development in Iceland 1841-2066*. Retrieved from Statistics Iceland: https://px.hagstofa.is/pxen/pxweb/en/lbuar/lbuar__mannfjoldi__1_yfirlit__yfirlit_mannfjolda/MAN00109.px/table/tableViewLayout1/?rxid=59f2d628-fbd3-4d33-828b-91f2c5a5453b

Sveinsdóttir, E. L., & Wigum, B. J. (2001). *Aggregate Production in Iceland*. Reykjavik: Public Roads Administration.

Porgilsson, A., & Ellwood, T. (1898). *The Book of the Settlement of Iceland*. s.l.: T. Wilson, Printer and Publisher.

Van Hoof, J., & Van Dijken, F. (2008). The historical turf farms of Iceland: Architecture, building technology and the indoor environment. *Building and Environment*, 1023-1030.

VSÓ Ráðgjöf. (2020). *Mýrdalshreppur: Húsnæðisáætlun 2020-2023*. Reykjavik: VSÓ Ráðgjöf.

Wikipedia. (2010, 3 30). *Volcanic system of Iceland*. Retrieved from Wikipedia: https://commons.wikimedia.org/wiki/File:Volcanic_system_of_Iceland-Map-en.svg

Images

Figure 2: Viator. (2021, 1 31). *Northern Light Small-Group Minibus Tour vanuit Reykjavik*. Retrieved from Viator: <https://www.viator.com/nl-NL/tours/Reykjavik/Northern-Lights-Small-Group-Tour-from-Reykjavik/d905-48100P4>

Figure 3: Mýrdalshreppur. (2012). *Aðalskipulag Mýrdalshrepps 2012-2028*. VSÓ Ráðgjöf.

Figure 4: Eysteinnsson, T. (2017). *Forestry in a Treeless Land*. Egilsstaðir: Icelandic Forest Service.

Figure 6: Left page:

Van Den Berk Boomkwekerijen. (2021, 1 31). *Betula pubescens*. Retrieved from Van Den Berk Boomkwekerijen: <https://www.vdberk.nl/bomen/betula-pubescens/>

Salo, A. (2009, 5 30). *Salix phylicifolia*. Retrieved from Wikispecies: https://species.wikimedia.org/wiki/Salix_phylicifolia#/media/File:Salix_phylicifolia_19676_Kiiltopaju_C.JPG

Giallopolenta. (2006, 9 8). *Sorbus aucuparia growing with Mountain Pine in the Italian Alps*. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Sorbus_aucuparia#/media/File:Sorbus-aucuparia.JPG

Steinsplitter. (2014, 7 4). *Weißer Silberwurz (Dryas octopetala)*. Retrieved from Wikipedia: [https://nl.wikipedia.org/wiki/Zilverkruid#/media/Bestand:Wei%C3%9Fe_Silberwurz_\(Dryas_octopetala\)_2.jpg](https://nl.wikipedia.org/wiki/Zilverkruid#/media/Bestand:Wei%C3%9Fe_Silberwurz_(Dryas_octopetala)_2.jpg)

Stein, P. (2021, 1 31). *Thymus praecox*. Retrieved from Freenatureimages: <http://www.freenatureimages.eu/plants/Flora%20S-Z/Thymus%20praecox/index.html#>

Turner, M. (2003, 7 10). *Rumex acetosella*. Retrieved from Turner photographs: <https://www.pnwflowers.com/flower/rumex-acetosella/gallery/0311513>

Nelson, C. (2017, 5 13). *Moss covered lava field*. Retrieved from Chris Nelson: <https://chrisnelson.ca/photos/Iceland/20170513-DSC06329>

Seyriu-en. (2010, 12 22). *Racomitrium canescens*. Retrieved from Wikipedia: https://commons.wikimedia.org/wiki/File:Racomitrium_canescens.jpg

Minnesota Wildflowers. (2021, 1 31). *Cystopteris fragilis (Fragile Fern)*. Retrieved from Minnesota Wildflowers: <https://www.minnesotawildflowers.info/fern/fragile-fern>

Right page:

Tanglao, R. (2010, 6 6). *Wild Pacific Trail, Ucluelet, British Columbia*. Retrieved from Wikimedia Commons: https://commons.wikimedia.org/wiki/Picea_sitchensis#/media/File:Picea_sitchensis_Wild_Pacific_Trail,_Ucluelet_1.jpg

Van Den Berk Boomkwekerijen. (2021, 1 31). *Pinus contorta*. Retrieved from Van Den Berk Boomkwekerijen: <https://www.vdberk.nl/bomen/pinus-contorta/>

Siegmund, W. (2006, 5 2). *Populus trichocarpa 05897*. Retrieved from Wikimedia Commons: https://commons.wikimedia.org/wiki/File:Populus_trichocarpa_05897.JPG

Opiola, J. (2016, 12 5). *Carum carvi a1*. Retrieved from Wikimedia Commons: https://en.wiktionary.org/wiki/File:Carum_carvi_a1.jpg

Anderberg, A. L. (2004, 9 3). *Angelica archangelica L.* Retrieved from Den virtuella floran: <http://linnaeus.nrm.se/flora/di/apia/angel/angearc.html>

Boyer, J. (2014, 6 8). *Arctic lupin in Vik*. Retrieved from Flickr: <https://www.flickr.com/photos/jenniferboyer/19401993638>

blanc, I. (2016, 8 14). *VACCINIUM ULIGINOSUM - GENTO - IB-916 (Nabiu uliginós)*. Retrieved from Wikimedia Commons: [https://commons.wikimedia.org/wiki/File:VACCINIUM_ULIGINOSUM_-_GENTO_-_IB-916_\(Nabiu_uligin%C3%B3s\).jpg](https://commons.wikimedia.org/wiki/File:VACCINIUM_ULIGINOSUM_-_GENTO_-_IB-916_(Nabiu_uligin%C3%B3s).jpg)

Rønning, A. (2010, 8 2). *Empetrum nigrum*. Retrieved from Wikimedia Commons: https://commons.wikimedia.org/wiki/File:Empetrum_nigrum.JPG

Grönbacka Plantskola Taimisto. (2021, 1 31). *Punaherukka | Ribes rubrum 'Punahilkka'*. Retrieved from Grönbacka Plantskola Taimisto: <https://gronbacka.fi/fi/butik/punaherukka-ribes-rubrum-punahilkka/>

Figure 7: Arctic Adventures. (2019, 3 5). *PUFFINS IN ICELAND - EVERYTHING YOU NEED TO KNOW*. Retrieved from Arctic Adventures: <https://adventures.is/blog/puffins-in-iceland/>

Figure 8: Arion Research. (2018). *Tourism in Iceland: Soft landing or belly flop?* Arion Bank.

Figure 9: Arion Research. (2018). *Tourism in Iceland: Soft landing or belly flop?* Arion Bank.

Figure 12: Jónsson, E. (2019, 11 9). *Gamlar myndir og minningar úr Mýrdal*. Retrieved from Facebook: <https://www.facebook.com/photo.php?fbid=2723394317711731&set=g.385301128727651&type=1&theater&ifg=1>

Figure 17: Icewear. (2017, 10 6). *Icewear*. Retrieved from Facebook: <https://www.facebook.com/icewear/posts/10154967958616334/>

Figure 19: flipflops. (2021, 1 31). *The amazing South Island of New Zealand*. Retrieved from flipflops: <https://flipflops.blog/en-south-island-of-new-zealand/>

Figure 20: McLeod, S. (2018). *Maslow's Hierarchy of Needs*. Retrieved from Simply Psychology: <https://www.simplypsychology.org/maslow.html>

Figure 21: Ritchie, H. (2020, 1 24). *You want to reduce the carbon footprint of your food? Focus on what you eat, not whether your food is local*. Retrieved from Our World in Data: <https://ourworldindata.org/food-choice-vs-eating-local>

Figure 24: Närpes Grönsaker. (2020, 12 7). *Grönsaker med mer smak*. Retrieved from Närpes Grönsaker: <https://www.narpesgronsaker.fi/sv>

Figure 25: Dirksen, K. (2020, 03 08). *Sunken greenhouse wraps home & feeds suburban antifragile co-op*. Retrieved from Fair Companies: <https://faircompanies.com/videos/mt-polyfarm-underground-lodge-make-suburban-coop-self-reliant/>

Figure 29: A Lady in London. (2020). *Lady's Guide to the 14 Best London Markets*. Retrieved from A Lady in London: <https://www.aladyinlondon.com/2015/06/14-best-london-markets.html>

Figure 37: Williams College. (2020). *Sustainability*. Retrieved from Williams: <https://sustainability.williams.edu/files/2013/07/permaculture-2.jpg>

Figure 39: Scanu, G. (2020, 3 5). *gæbscanu*. Retrieved from Instagram: <https://www.instagram.com/p/B9XhphUJcnM/>

