TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

MASTER-/DIPLOMARBEIT

The Shelter with Aquaponics

focus on Yeonpyeong-Island in South Korea

ausgeführt zum Zwecke der Erlangung des akademischen Grades
einer Diplom-Ingenieurin unter der Leitung von

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E253 - Institut für Architektur und Entwerfen

eingereicht an der Technische Universität Wien
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Wien, am _____
Datum

Abstrakt

Nach der Beschießung der Insel Yeonpyeong am 23. November 2010 wurde festgestellt, dass die Unterkünfte zu diesem Zeitpunkt nicht ordnungsgemäß funktionierten. Aufgrund der geringen Nutzung in Friedenszeiten waren die Unterkünfte auf der Insel Yeonpyeong über einen langen Zeitraum hinweg nicht gewartet worden und für die Unterbringung von Evakuierten nicht geeignet.

Unterkünfte sind Orte, die vorübergehend Schutz vor widrigen Wetterbedingungen oder Gefahren bieten. Ein gut gewarteter Unterkunft ist daher in der Lage, seine Funktionalität zu maximieren und den Bewohnern zu helfen, im Falle einer plötzlichen Katastrophe sicher zu leben. Der Zustand von Notunterkünften steht in direktem Zusammenhang mit ihrer ständigen Wartung, aber in vielen Fällen werden sie vernachlässigt und funktionieren nicht, wenn die Menschen sie brauchen.

Diese Diplomarbeit befasst sich mit der Idee, das Umfeld von Notunterkünften auf natürliche Weise zu verbessern, indem ein Aquaponiksystem in den normalerweise als leer und wirtschaftlich unrentabel empfundenen Schutzraum eingebaut wird, um dessen Nutzung in Friedenszeiten zu erhöhen.

Für die Bewohner des Grenzgebiets, die im Falle einer Provokation durch Nordkorea ihr tägliches Leben unterbrechen und aus Sicherheitsgründen evakuieren müssen, ist das Aquaponik-System in der Schutzeinrichtung angesichts feindlicher Bedrohungen stabiler als andere Fischerei- und Landwirtschaftsmethoden und kann den Bewohnern der Insel Yeonpyeong, die überwiegend am Meer leben, eine Vielfalt an wirtschaftlichen Aktivitäten bieten.

Abstract

After the shelling of Yeonpyeong Island on November 23, 2010, it was pointed out that the shelters were not functioning properly at the time. Due to low peacetime utilization, the shelters on Yeonpyeong Island had been left unmaintained for a long period of time and were not suitable to accommodate evacuees.

Shelters are places that provide temporary protection from adverse weather conditions or hazards, so a well-maintained shelter will be able to maximize its functionality and help residents cope safely in the event of a sudden disaster. The conditions of shelters are directly related to their constant maintenance, but in many cases, they are neglected and do not function when people need them.

This diploma thesis deals with the idea of naturally improving the environment of shelter facilities by adding an aquaponics system to the shelter space, which is usually perceived as empty and economically unprofitable, to increase its peacetime utilization.

In addition, for the residents of the border area who must stop their daily life and evacuate at the moment of North Korea's provocation for safety reasons, the aquaponics system in the shelter facility is more stable in the face of enemy threats than other fisheries and agriculture and can provide diversity of economic activities to the residents of Yeonpyeong Island, who mostly live by the sea.

Contents

01 Introduction

Disaster is distinguished from an ordinary accident by its suddenness and unpredictability, and by the fact that it is a sudden large-scale event.

1.1

Bombardment of Yeonpyeong

Bombardment of Yeonpyeong was a surprise, undeclared attack by North- Korean forces on the South Korean Yeonpyeong-island on November 23, 2010.

It was the first attack on a civilian residential area since the 1950s, when the Korean-War ceased, and a ceasefire was established.

On that day, North Korea fired about 170 shells in two rounds toward Yeonpyeong Island in an hour and a half. Dozens of people were killed or injured in the attack, buildings were damaged, and many people were displaced and most of the residents of Yeonpyeong Island left and lived as refugees in other areas.

About 1,700 residents were evacuated to air-raid shelters under the guidance of soldiers. However, immediately after the outbreak, all routes to Yeonpyeong Island were closed, and some residents escaped from the island with privately owned fishing boats, but the remaining residents were able to evacuate to the mainland only after a day.

Dozens of people were killed and wounded, buildings were damaged, and many were displaced.

The island residents evacuated to land over three days and returned two months later.

Fig.1 Yeonpyeong-Island under attack

Fig.2 Yeonpyeong-Island under attack

Fig.3 Yeonpyeong-Island under attack

Fig.4 Yeonpyeong-Island under attack

1.2

Backgrounds

Korean-Peninsula is a peninsula located in East Asia. It covers a total area of 223,646km² and is bordered by the Yellow Sea, the South Sea, and the East Sea, and bordered by China in the north by the Amnok and Tuman rivers. The Korean Peninsula stretches from north to south and has a wide range of climates, including temperate, subtropical, cold, and boreal, with large temperature variations between seasons. 70% of the Korean Peninsula is mountainous.

In 1945, the Korean Peninsula was divided between the United States and the Soviet Union under military rule, resulting in the establishment of two states with different ideologies in 1948, and on June 25, 1950, the Korean War broke out. After three years of war, the Korean Peninsula was divided, with the Republic of Korea(ROK) in the south and the Democratic People's Republic of Korea (DPRK) in the north, based on the current armistice line. The Korean Peninsula has been in a state of truce since the 1953 armistice. However, it is only a pause in the war, and the situation is strictly a state of war. The tension has taken a huge cost on both sides, including astronomical defense spending.

North Korea has provoked South Korea in a variety of ways since the start of the Korean War. It has consistently fired missiles and artillery shells near South Korean territorial waters in artillery drills and sent spies to monitor South Korean affairs. South Korea has warned of North Korea's provocations and responded with joint exercises with the U.S. Forces Korea and drills to counter North Korean provocations.

For nearly 70 years, the two Koreas have been engaged in this kind of confrontation, which has taken its toll on the people, especially those along the border. The five islands in the West Sea have always been the frontline of the conflict between the two countries, as they have been the site of frequent North Korean provocations until recently. Unlike other border areas, the five islands, including Yeonpyeong Island, have been the site of direct clashes and skirmishes between South and North Korea. This is due to a disagreement between the two Koreas over the northern limit of the West Sea. Since the end of the Korean War, North Korea has consistently denied the northern limit of the West Sea set by South Korea and UN.

Fig.5 Korean-Peninsula

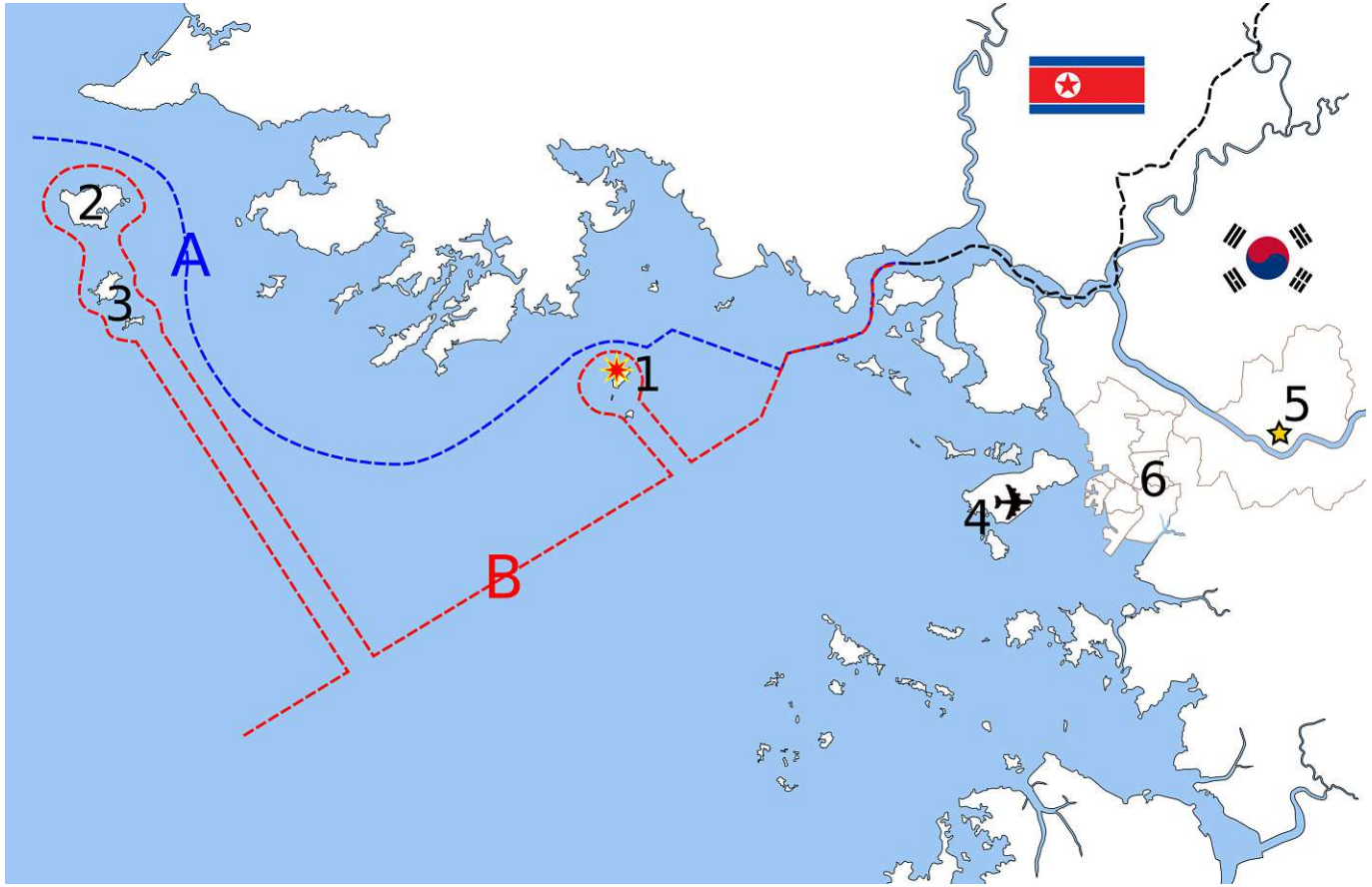


Fig.6 Northern Limit Line

The disputed maritime border between North and South Korea in the West Sea

A : Northern Limit Line (NLL) established by the United Nations Command in 1953
B : Maritime Demarcation Line(MDL) claimed by North Korea since 1999

1 – Yeonpyeong
2 – Baengnyeong
3 – Daecheong
4 – Incheon airport
5 – Seoul

Fig.7 North Korea's invasion

Fig.8 Korean axe murder incident

Fig.9 Battle of Yeonpyeong

1.3

North Korea's major provocations (1953-1999)

17.11.1956	Raided 2 friendly airplanes in Western Airspace
16.05.1957	Hijacked fishing boat on Yeonpyeong-Island
24.05.1958	Hijacked 1 fishing boat on Yeonpyeong-Island
24.08.1960	North Korean armed vessel invades waters off
23.12.1962	North Korean armed vessel engage, 6 casualties
20.03.1964	Hijacked 2 fishing boat on Baengnyeong-Island
29.10.1965	North Korea Kidnapped 109 fishermen
17.06.1968	North Korea Kidnapped 44 fishermen
05.06.1970	North Korea hijacked navy broadcasting ship
09.07.1970	Hijacked 5 fishing boat on Baengnyeong Island
06.01.1971	North Korea shelled S.Korean fishing boats.
04.02.1972	Hijacked 5 fishing boat on Daecheong-Island
01-07.12.1973	North Korea, 11 times, 10 ships invaded
15.02.1974	Hijacked 2 fishing boat on Baengnyeong-Island
26.02.1975	10 North Korean ships invaded
24.03.1975	30 North Korean fighter jets invaded
09.06.1975	2 MiG-21s invade over Baekryeong Island
23.01.1976	2 North Korean fighter jets invaded
12.08.1981	MiG-21 invade over Baekryeong Island
26.08.1981	Missile attack on a U.S. aircraft SR-71
31.01.1983	IL-28 invaded over Baekryeong Island
05.02.1985	Hijacked 2 fishing boat on Baengnyeong Island
13.04.1991	1 North Korean patrol boat Invaded NLL
21.06.1993	1 North Korean patrol boat Invaded NLL
19.04-27.08.1996	13 times Invaded NLL in 1996
29.05.1997	1 North Korean patrol boat Invaded NLL
05.06.1997	1 North Korean patrol boat Invaded NLL
02.07.1997	1 North Korean patrol boat Invaded NLL
04.07.1997	1 North Korean patrol boat Invaded NLL
24.11.1998	30 appearances, including a spy ship
07.06.1999	9 North Korean patrol boat Invaded NLL
15.06.1999	North and South Korean naval bombardment in the waters northwest of Yeonpyeong Island

Timeline of N.Korea's major provocations
in the NLL in the West Sea
(omitting small-scale conflicts)

2022 N.Korea's West Sea Shelling Log

30.03.2022	4 multiple rocket launchers were fired from somewhere in South Pyongan Province into the West Sea.
12.06.2022	About 5 multiple rocket launchers were fired into the West Sea.
10.07.2022	About 2 multiple rocket launchers were fired into the West Sea
11.07.2022	Probable launch of multiple rocket launchers into the West Sea
14.10.2022	390 shots were fired, including 90 shots from Haeju Bay in the West Sea and 210 shots from the western area of Cape Jangsan in the West Sea.
18.10.2022	About 250 shots, including about 100 shots, were fired into the West Sea.
19.10.2022	More than 100 shots were fired into the West Sea.
24.10.2022	10 missiles were fired into the NLL Northern Maritime Buffer Zone in the West Sea

02 Yeonpyeong-Island

Fig.10 Northeast Asia, Yeonpyeong Island

Distance between Yeonpyeong Island and N.Korea

2.1

Geopolitical Location

Yeonpyeong-Island is an island under the jurisdiction of the **Republic of Korea**, covering an area of 7.01 km² and located just 1.5km from the **NLL**(Northern Limit Line).

The sea route from Incheon Port is 122 km, but it is only 12 km away from the North Korean mainland, and because it is geographically close to the NLL, it is frequently damaged by North Korean provocations.

For this reason, the Republic of Korea Marine units is stationed to defend this place. Recently, there were two naval battles and the 'Yeonpyeong Island Bombardment' in the sea around the island, and each time, Yeonpyeong Island fishermen were banned from fishing, and their daily lives were disrupted.

The total population of Yeonpyeong-myeon at the end of December 2022 was 2,138, and about 1,500 Marines who are not included in the population are staying together.

It is one of the areas with the highest tension between North and South Korea.

Fig. 11 N.Korea seen from Yeonpyeong Island

Fig. 12 Yeonpyeong Island Soldier 1

Fig. 13 Yeonpyeong Island Soldier 2

Fig. 14 Yeonpyeong Island military base

Yeonpyeong Island topographic map

2.2

Populated zone of the island

Military Zone

Civilian residential area

Yeonpyeong-Port

Military Zone

0.5 1km

Fig. 15 Civilian residential zone

Revetment and Breakwater

2.3

Coastal structures

Fig. 16 Northeast asia map

Height of tsunami waves by region (Yeonpyeong-Island)

Origin	Virtual earthquake strength	Height of tsunami waves
Ryukyu Trench, east of Taiwan	9.20	14~17 cm
Northeast Ryukyu Trench	9.20	31~32 cm
Bohai Bay	8.00	10~14 cm
East of Renyun River	8.00	8~11 cm
East of Shanghai	8.00	6~8 cm
Northwest of Hongdo-Island	7.53	10~11 cm
West of Incheon	6.90	9~22 cm

Average annual sea level rise over the last 30 years

= 3.31 mm (per year)

Fig. 17 Yeonpyeong Island Port

Fig. 18 Yeonpyeong Island coastal terrain

03 Situation Analysis

3.1

Problems with Shelters

(Abandoned and neglected shelter)

Well-maintained shelters can be useful for residents during emergencies. There are 17,153 civil defense evacuation facilities nationwide, including Yeonpyeong Island, as of 2019, but they are not well managed due to lack of budget and manpower, and some areas are virtually neglected, with only two people in charge of 224 facilities, and have been featured in the media.

On the day of the shelling of Yeonpyeong Island, there were 19 shelters, 13 of 33 square meters, three of 66 square meters, and three of 100 square meters, all built in 1974-75. They were constructed of 40-centimeter-thick concrete in a box shape on a hill about 30 to 40 meters from the village.

They have not been renovated in 35 years. For the past 20 years, the village had repeatedly requested the government to repair the facility, but it was not accepted. As a result, only four of the shelters had electricity at the time of the shelling of Yeonpyeong Island, and they lacked toilets and running water.

Most of the shelters are semi-underground, and the roofs have not been covered with more than a meter of earth, making them unsafe in the event of direct shelling, the official explained.

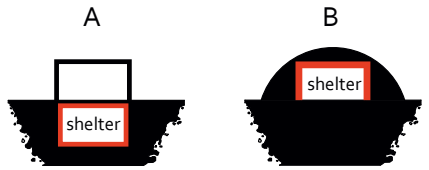
Fig. 19 Yeonpyeong Island Temporary Shelter 1

Fig. 20 Yeonpyeong Island Temporary Shelter 2

Fig. 21 Yeonpyeong Island Temporary Shelter 3

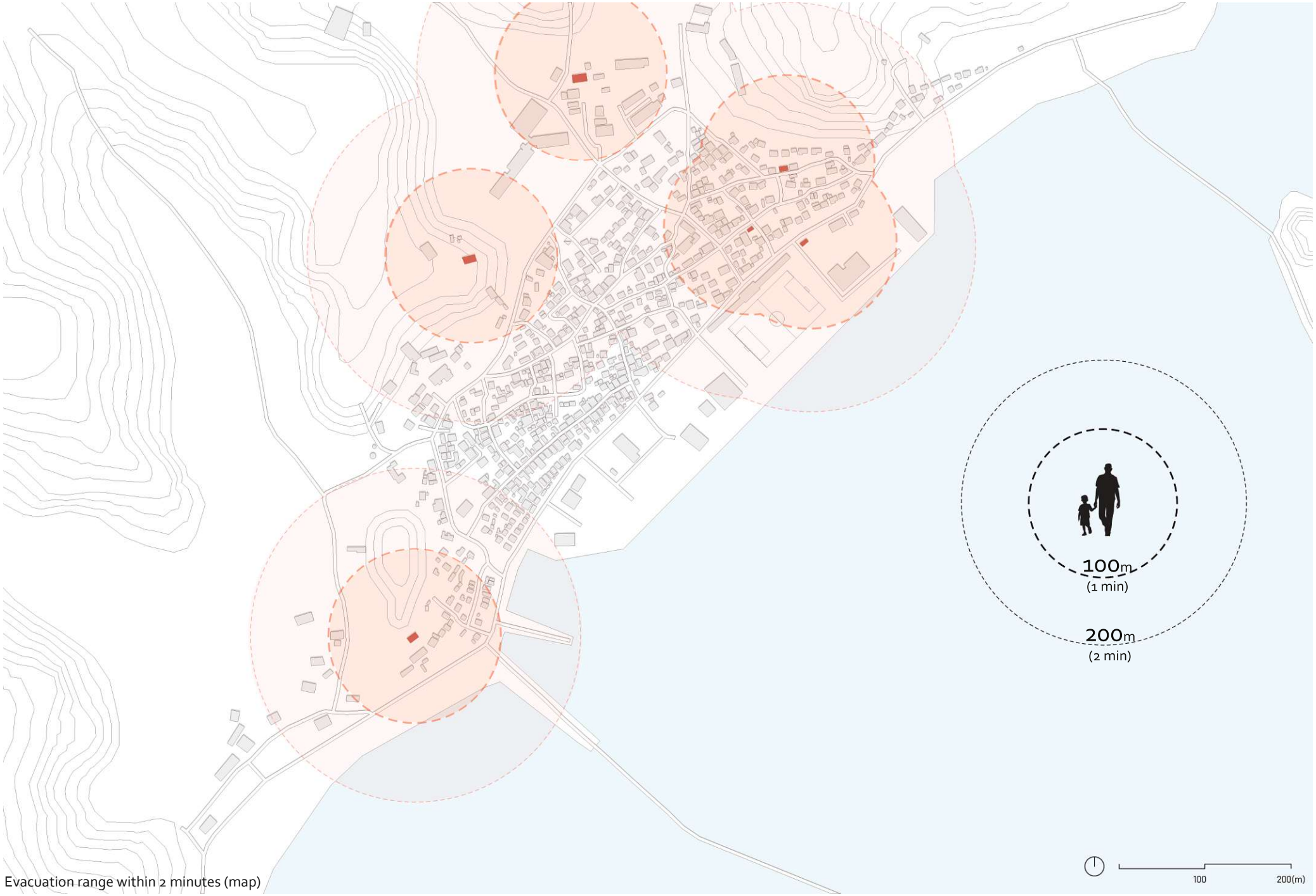
Location of Yeonpyeong Island's new shelter

Since 2011, the government has built seven new modern shelters on Yeonpyeong Island and remodeled existing facilities. Among them, there are a total of 6 existing shelters and new shelters located in civilian residential areas, many of which are located in the basements of buildings, and large shelters are located on the outskirts of the village where cover is possible using the topography. However, after a few years later, the shelters have fallen into the same state of neglect as before the shelling, and some have been so poorly maintained that they cannot be used for any purpose.



(No. / Area /Capacity / Category)

No.7	169(m²)	118	Type A
No.0	215(m²)	260	Type A
No.3	169(m²)	118	Type A
No.7	331(m²)	231	Type A
No.1	666(m²)	465	Type B
No.2	275(m²)	192	Type B



Evacuation range within 2 minutes (map)

In general, if the warning system worked properly after a missile was launched from North Korea, South Korean residents would have about 3 to 5 minutes to evacuate. However, in the case of Yeonpyeong Island, North Korea's coastal artillery shells reach Yeonpyeong Island within approximately 15 seconds after firing. Since provocations always occur suddenly, what residents need is a temporary shelter nearby.

Most of the evacuation shelters on Yeonpyeong Island are located on the outskirts of the village, so there are vulnerable areas that cannot be evacuated within 2 minutes. It is further away from the coastline. If village residents are working in the coastal mudflats, evacuation time becomes longer and residents are fully exposed to danger.

3.2

Livelihood activities concentrated on the sea

(Lack of variety, Frequent work stoppages)

Fig. 22 Yeonpyeong Island fishing boat 1

Fig. 23 Yeonpyeong Island fishing boat 2

Fig. 24 Residents working in the mudflats 1

Fig. 25 Residents working in the mudflats 2

Until 1950, before the division of Korea, Yeonpyeong Island was practically an island close to the mainland. It was easy to obtain foodstuffs due to easy and active communication with the mainland, and the agricultural population was quite large at the time. However, due to the division of Korea, the island became isolated with less interaction with the mainland as the nearby land fell to North Korea.

Over time, only a few people cultivate fields on Yeonpyeong Island, and the agricultural products produced on the island are small, so most people buy their food on the mainland, where it is much cheaper than on the island. (The distance from Incheon Port is 122km and takes about 2 hours and 20 minutes by ferry, which runs twice a day) Today, the main source of income for the residents of Yeonpyeong Island is fishing, so most of the residents rely heavily on the sea for their livelihood.

The people of Yeonpyeong Island, who depend on the sea for their livelihood, are naturally sensitive to marine weather conditions such as tides, temperature and waves. With only 180 days of day and night fishing available per year, and different seasons for different species, missing a fishing season can be devastating for fishermen. However, unlike other common regions, residents of Yeonpyeong Island are always on the lookout for another factor.

As Yeonpyeong Island is protected by the military, fishing activities at sea are also controlled due to safety reasons. If an evacuation order is issued, residents should immediately seek shelter. Evacuation orders are issued not only in the event of a direct attack by N.Korea, but also in the event of their fire drills and S.Korea's military fire drills, joint military training with the United States, and N.Korea's provocations against S.Korea.

Fig. 26 Yeonpyeong Island seaweed farm

Fig. 27 Evacuation drill 1

Fig. 28 Evacuation drill 2

Fig. 29 Yeonpyeong Island fishing boat 3

Fig. 30 Evacuation drill 3

The time residents must stay in shelters depends on the situation. Fire drills to prepare for a N.Korea's surprise attack usually last about two hours and are announced to residents in advance. Although the drill is scheduled for 2:30 p.m., residents must evacuate by 10 a.m. They would then have to stay in the shelters for anywhere from 4 to 9 hours. If there is a direct attack from N.Korea, the period will last until the situation ends.

Unlike S.Korea, which announces its drills in advance, N.Korea conducts drills without warning. When artillery fire is heard, the local office sends out evacuation announcements to residents on the island, and the coast guard also contacts vessels operating in the vicinity and instructs them to enter the harbor. Then, even if the fishing season is in full swing, ships will have to stop fishing and return to port in a hurry.

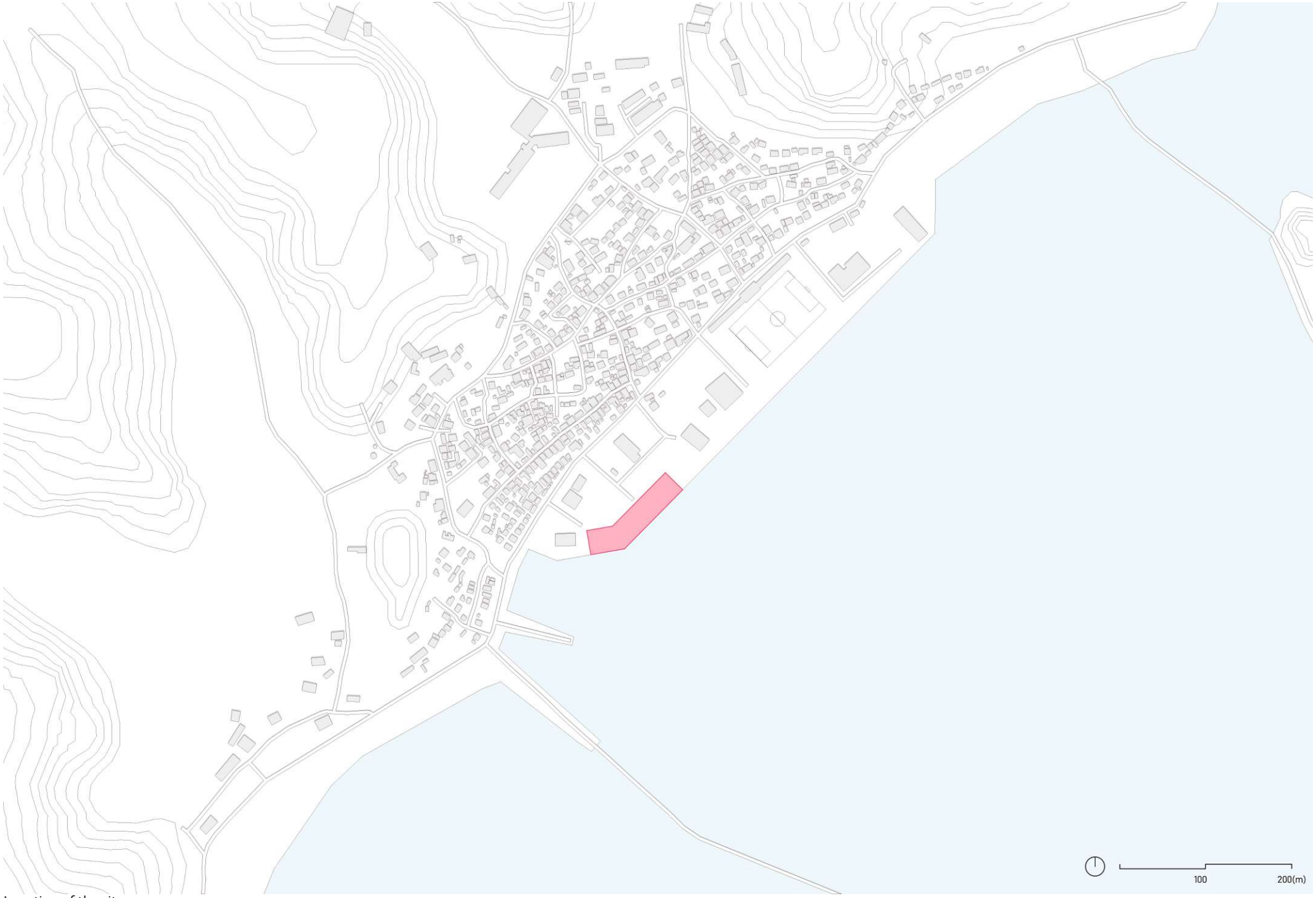
As a result, fishing is often interrupted, and villagers whose livelihoods depend on the season and timing of fishing suffer economic losses. This repeated situation is a daily routine and dilemma for Yeonpyeong-Islanders that they would like to avoid. When an evacuation order is issued, not only fishing boats but also passenger and cargo ships cannot dock at Yeonpyeong Port and must return. Residents bring in most of their daily necessities by ship, and it is important to keep food fresh, so any disruption in transportation will disrupt their daily lives. This fishing-based livelihood cannot provide a stable income for the local population in the long term, and other options for self-sufficiency on an isolated island in the event of an emergency are essential. In addition, it is necessary to add various programs to improve shelters so that students who were urgently evacuated during the class, and residents who remained on the island can continue their daily routines without spending hours in shelters meaninglessly.

3·3
Site analysis

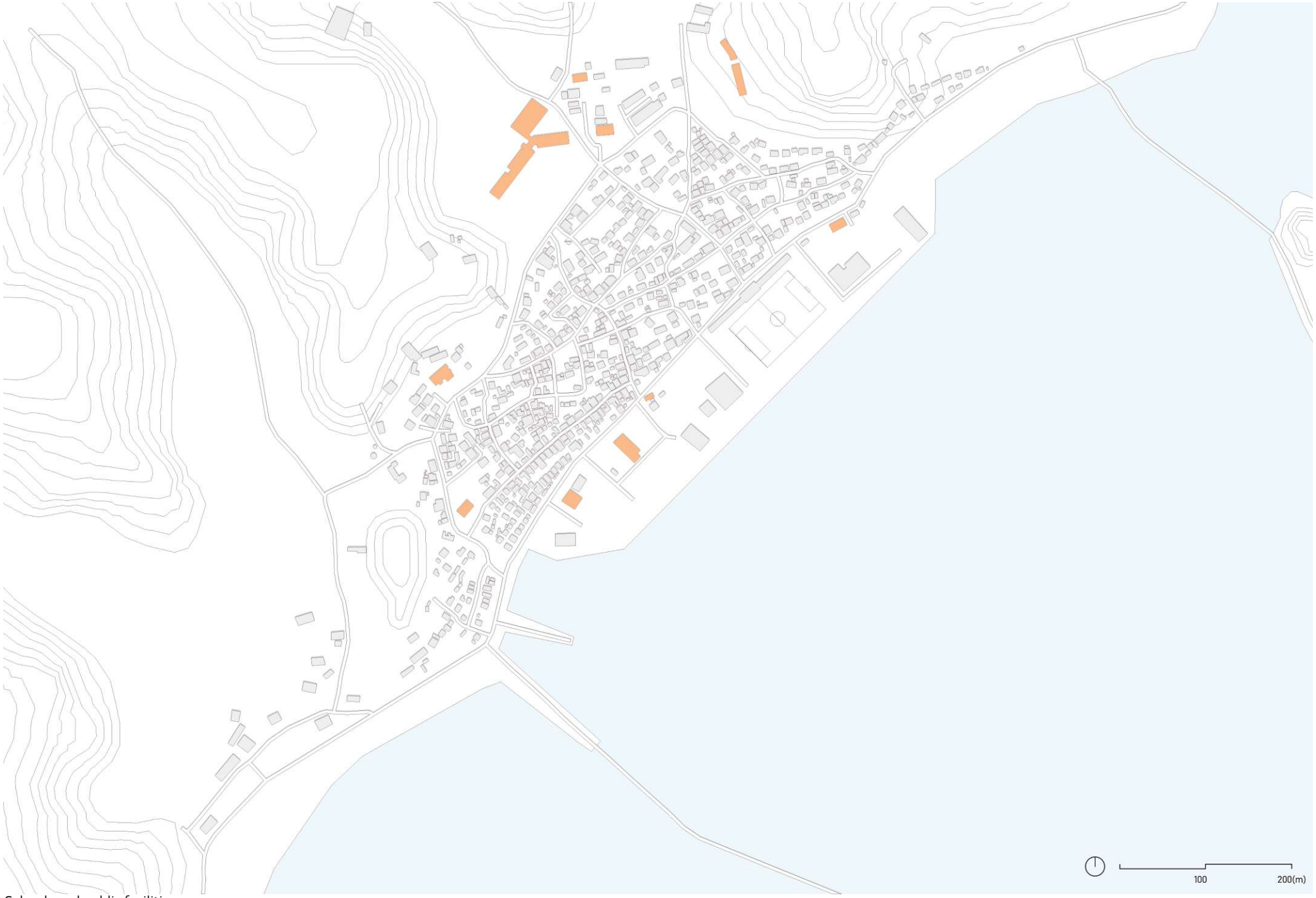
The building site is located in a revetment area created by the accumulation of soil from dredging. Originally, the site was a large empty space where fishing equipment was stacked but after a new dredged soil disposal pond was created the site was reorganized and public facilities moved in.

The current building site faces the coastline and tidal flats to the south, with a revetment about 5 meters high. To the north of the building site are the residential areas of Yeonpyeong Island.

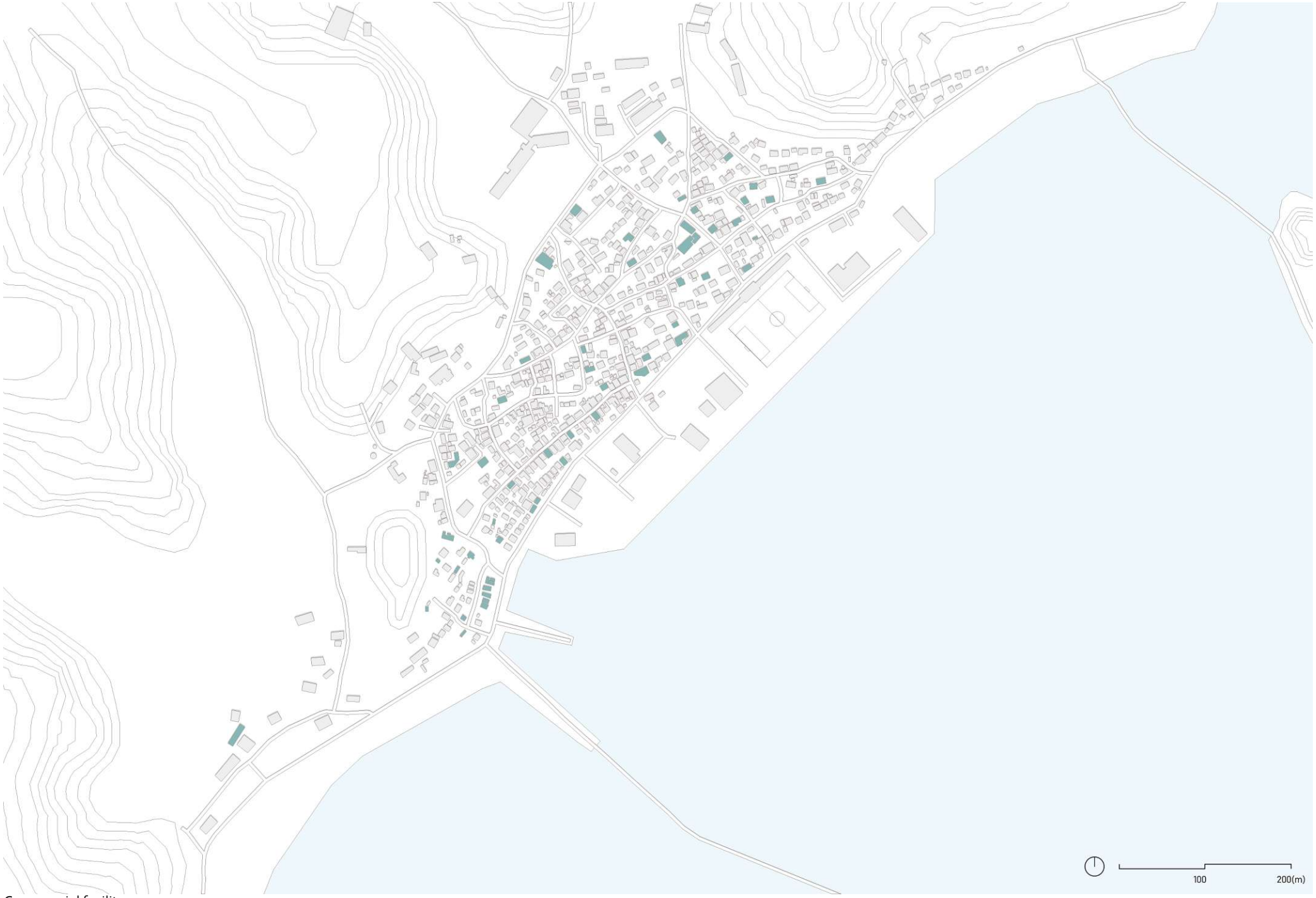
The site is located near the Yeondo-Bridge, which connects the main island to the harbor, making it one of the most active areas on the island and a great added value due to its high accessibility.



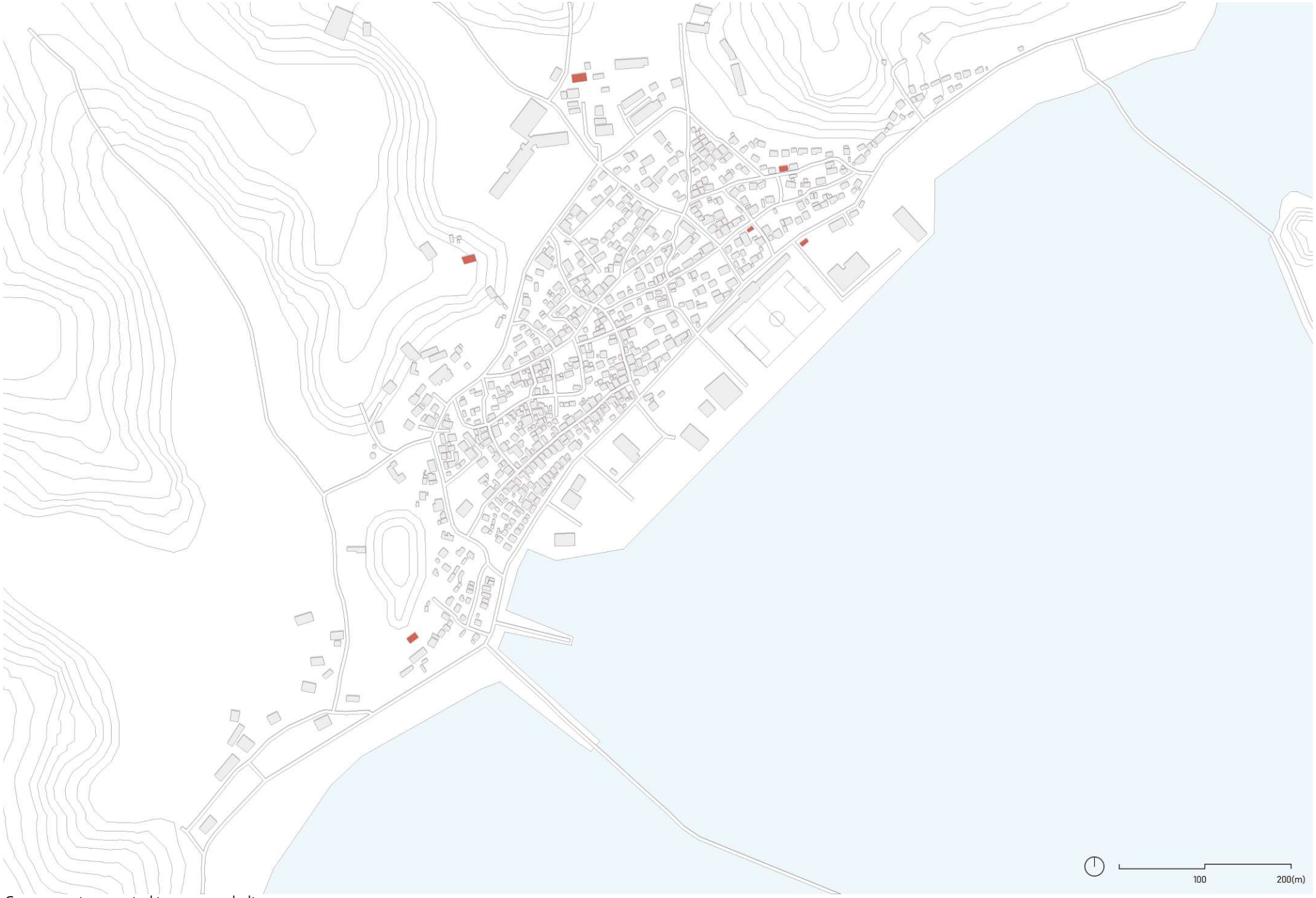
Location of the site



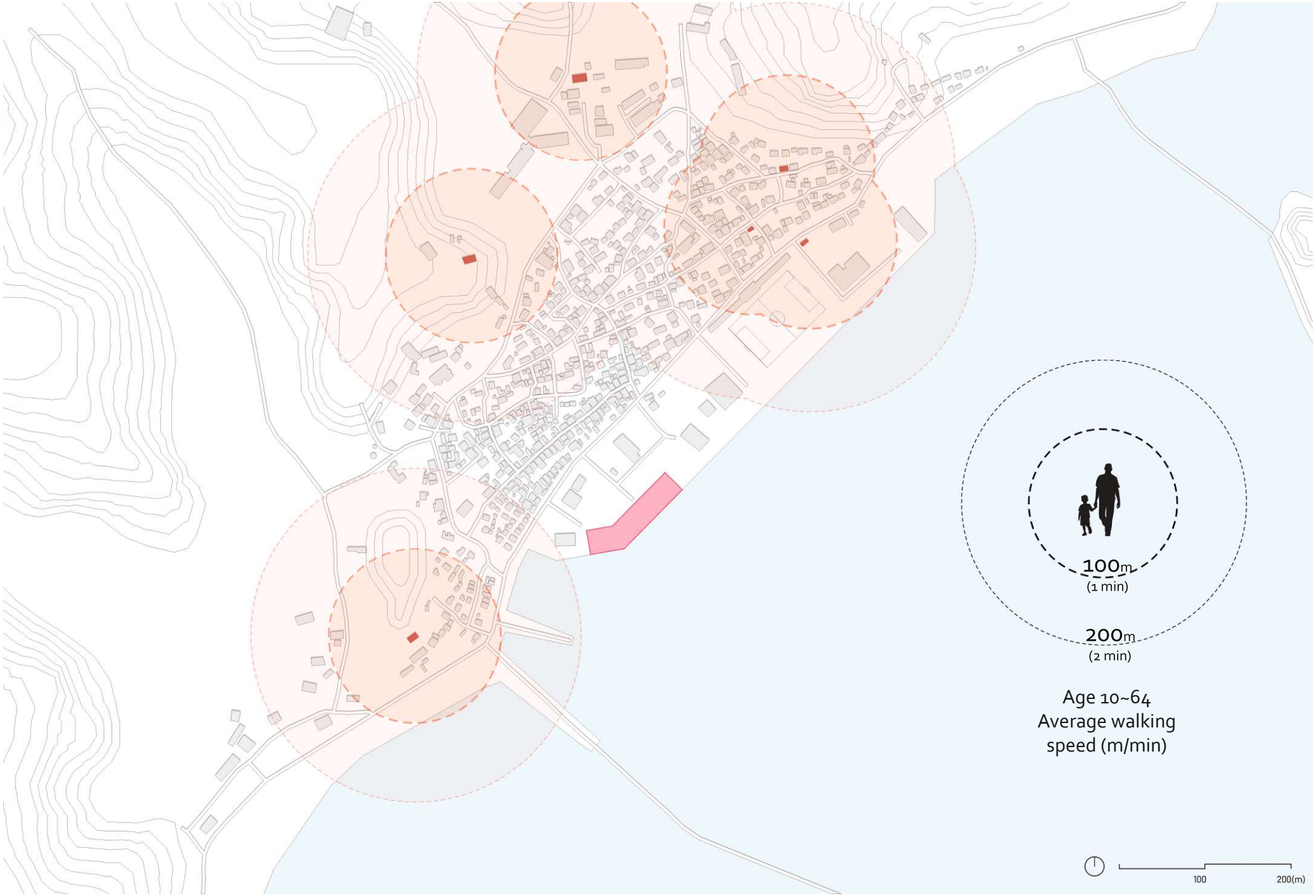
Schools and public facilities



Commercial facility



Government-supported temporary shelter



Zone where residents can reach shelters within2 min

3.4
Aquaponics

Aquaponics is a new approach to hydroponic systems that combines aquaculture and hydroponics. While conventional hydroponics requires mineral fertilizers to provide nutrients for plants, aquaponics systems treat water from fish farms to provide nutrients for plant growth, which in turn purifies water for aquatic life, making it a sustainable and eco-friendly agricultural technology. It can be produced in many parts of the world regardless of climate, reduces chemical fertilizer use and water consumption, and is considered a major technology that can be used to reduce wastewater pollution from fish farms.

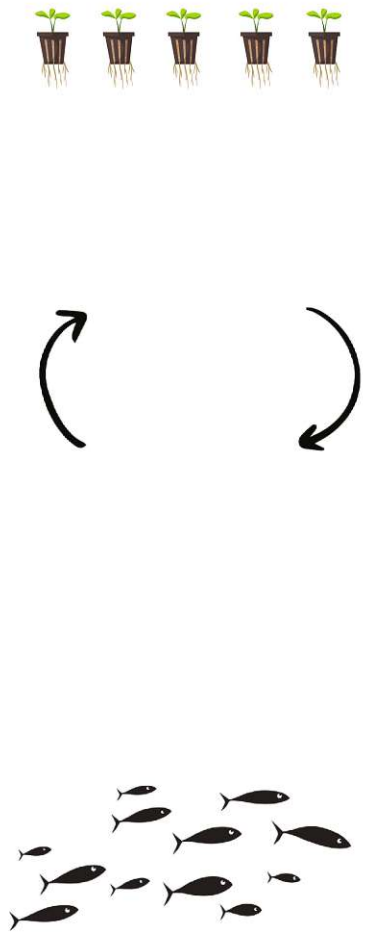


Fig. 31 Aquaponics Concept

3.4.1

How aquaponics systems work

Aquaponics is a technology that encourages symbiosis between fish, microorganisms, and plants, recycling resources to provide quality nutrients for plants and a clean habitat for aquatic life, thereby reducing the energy losses required to grow plants and encouraging high crop productivity.

The principle of aquaponics is shown below (Figure 32).

To explain how it works, ammonia is produced in the water environment due to the secretions produced during the process of raising fish. Since the feces of aquatic organisms are rich in organic matter that plants need, microorganisms or bacteria first induce a reaction that converts ammonia into nitrate, which is not toxic to aquatic organisms and remains in the water, and these organic reactants are circulated by a pump, absorbed by the roots of plants, and provided with quality nutrients.

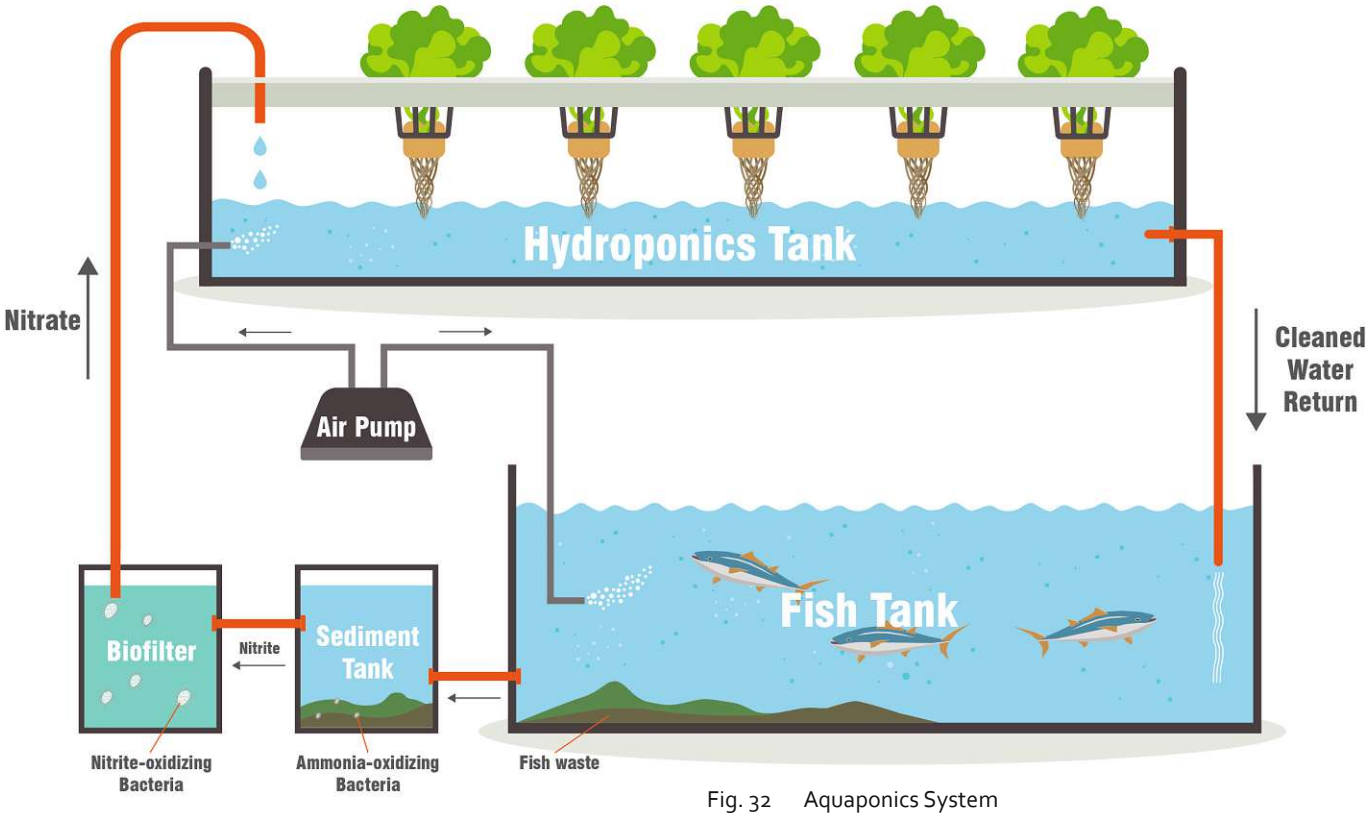


Fig. 32 Aquaponics System

3.4.2

Advantages of Aquaponics

Traditional agricultural techniques damage the environment in many ways, but aquaponics is a microcosm of a natural ecosystem and everything recirculates within the system. No additional fertilizers or compounds are needed in the process, so the whole system doesn't contribute to environmental pollution. There are no breaks in the fertilization of the land and the system can operate independently without any additional external factors, allowing for sustainable agriculture that is not affected by seasons and weather.

Fig. 33

Water is indispensable on the island. Groundwater can be pumped up and used as living water, but it is not possible to use it in sufficient quantities. As a result, water for agriculture is also in short supply. In aquaponics, plants use only as much water as they need to grow. The water is then recirculated for the growth of the fish, rather than being used and wasted as in conventional hydroponics, so it does not cause additional water consumption. Water requirements are therefore reduced by at least 80-90% compared to conventional farming.

Fig. 34

Plants grow much faster, healthier, and larger with aquaponics systems compared to soil-based agriculture due to the benefit of plants having 24-hour access to nutrients. Vegetables and herbs grew up to four times faster in aquaponics systems. Common plants grew up to 25% faster in aquaponics systems and were on par with soil-grown plants in terms of quality.

Fig. 35

Fertile land is essential for increased production. It needs plenty of sunlight, water, and drainage. However, with aquaponics, you don't have to worry about fertile soil because it doesn't require any land at all. Compared to conventional farming, an aquaponics system can produce the same amount of plants in 8 to 10 times less space. Aquaponics can be successfully practiced on any land that is difficult to use for a conventional farm, even drought land. For this reason, it can also be installed in the middle of cities, minimizing distribution costs.

Fig. 36

In an aquaponics system, pesticides, insecticides, and other chemicals cannot be used to maintain the plants. The chemicals used are deadly to the growth of the fish, and without the fish, the entire system cannot be maintained, and in turn, the plants cannot grow. That's why plants and food harvested from aquaponics systems are organic.

Fig. 37

There are a lot of repetitive tasks that require human involvement in general cultivation or agriculture. In aquaponics, where automation systems can be applied, the number of tasks that need to be handled by humans is significantly reduced compared to conventional farming methods. It is also economically beneficial because it does not require a large area to manage and can be operated with a small number of people.

Fig. 38

3.4.3
Suitable fish for Aquaponics


Fig. 39 Goldfish


Fig. 40 Trout


Fig. 41 Catfish


Fig. 42 Whiteleg shrimp

Fish species suitable for aquaponics should be fast growing, not difficult to keep, and have good meat quality.

Tilapia, bluegill, and Murray cod are examples of this, but they are not familiar in Korea and are relatively neglected by the consumer market. In terms of popularity in the Korean consumer market, freshwater eels and loaches are popular, and white-legged shrimp, which can also be cultivated in freshwater, have recently been used in aquaponics.

https://www.ecolifeconservation.org/updates/the-top-5-aquaponics-fish-species-for-your-system/


Fig. 43 Carp


Fig. 44 Freshwater eel

3.4.4

Suitable Vegetables for Aquaponics

In theory, almost every plant can be grown aquaponically. However, different plants have different optimal requirements, so plants that are not demanding and have strong viability have an advantage.

Aquaponics can efficiently produce animal resources (fish) and vegetable resources (vegetables) in a limited space, and it has the advantage of obtaining fish and vegetables at the same time.

Fig. 45 Tomato

Fig. 46 Cucumber

Fig. 47 Lettuce

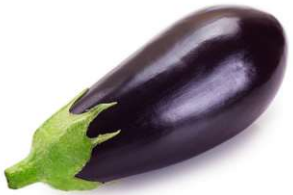


Fig. 48 Egg plant

Fig. 49 Radish

Fig. 50 Cabbage

Fig. 51 Spinach

Fig. 52 Strawberry

Fig. 53 Broccoli

Fig. 54 Kale

3·5
Bunker

A bunker is a defense structure intended to protect people and facilities from airborne bombs and other attacks.

Bunkers designed for warfare are primarily underground and are generally considered safer the deeper underground they are located. Therefore, bunkers, other than structures with a specific offensive purpose, are hidden and concealed in the basement of buildings, in the ground, and in the terrain.

Bunkers built above ground, where there is no terrain advantage, have thicker walls to protect against air strikes.

The thickness of the skin surrounding the bunker space is determined not only by the size and shape of the bunker, but especially by the explosive power of the weapons used by the enemy.

In general, bunkers used by civilians are called air defense shelters and are intended to provide temporary shelter from the elements. They are usually built for purely defensive purposes.

CASE I

Covered by
Protecting structure

CASE II

Basement

CASE III

Covered by earth

CASE IV

Underground

Bunker Type


Fig. 55 Hochbunker_1


Fig. 56 Hochbunker_2


Fig. 57 Hochbunker_3


Fig. 58 Basement Bunker_1


Fig. 59 Basement Bunker_2


Fig. 60 Basement Bunker_3


Fig. 61 Bunker with terrain_1

Fig. 62 Bunker with terrain_2


Fig. 63 Bunker with terrain_3


Fig. 64 Underground Bunker_1


Fig. 65 Underground Bunker_2


Fig. 66 Underground Bunker_3

3.5.1

U-boat bunker

Compared to World War I, when bombs were light enough to be dropped by hand from a fighter jet cockpit, by the 1940s the methods of delivery and the power of the bombs had improved dramatically. Germany recognized this and built and operated bunkers for U-boat protection in Norway, France, and Germany. Examples include Brest, Saint-Nazaire, La Rochelle, Lorient, and Bordeaux on the west coast of France, bremen in Germany, and Trondheim in Norway. Each of these fortresses attempted to prevent enemy air attacks by strengthening core structures such as exterior walls and ceilings to protect internal facilities and submarines. The conventional earthquake bombs Tallboy and Grand Slam were developed by British aeronautical engineer Barnes Wallis, and these 5.0- and 10.0-ton bombs were used to attack German military structures.The U-boat bunker at Brest was attacked more than 80 times by the Allies and nine times by TALLBOY in 1944, but there was no fatal damage and no submarines inside were lost. Bunker VALENTIN was attacked 12 times in 1945 by 18 bombers with 13 Grand Slams, 4 Tallboys and 500 kg bombs. In the end, two grand slams penetrated the 4.5 meter thick ceiling by 2 meters. Bunker KONRAD received several attacks from 591 Allied bombers, but it did not collapse and was demolished in stages after the war.

Fig. 67 U-boot bunker lorient

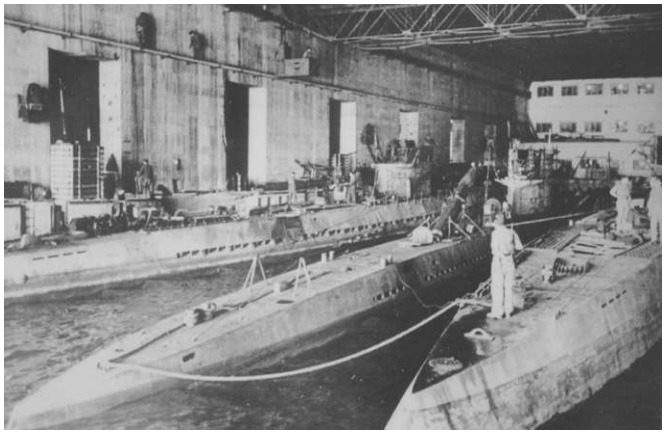


Fig. 68 U-boat

Fig. 69 Tallboy

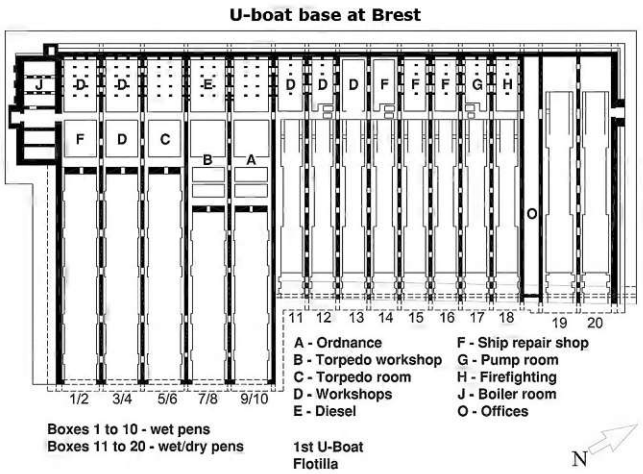


Fig. 70 U-boot bunker Brest

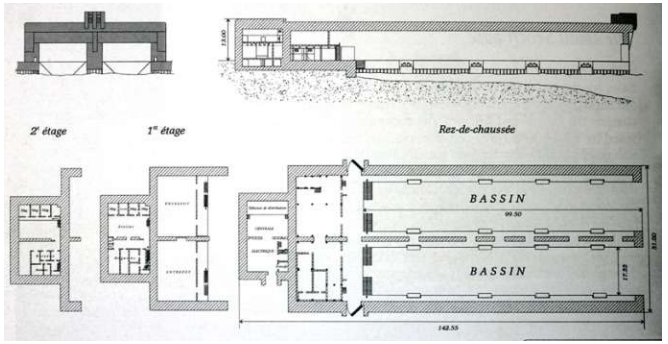


Fig. 71 U-boot bunker Scorff

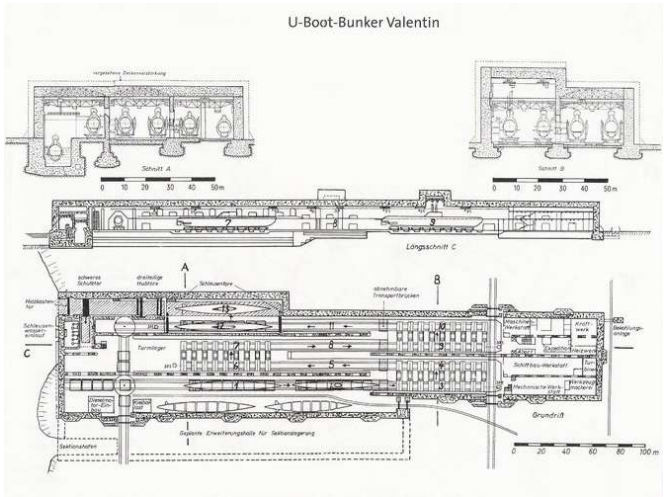


Fig. 72 U-boot bunker Valentin

Location City	Bunker name	length(m)	Width(m)	height(m)	Thickness (m) Ceiling	Thickness (m) Exterior wall	Thickness (m) Inner wall	Span Width (m)	Cells Number	Construction
Bergen	Bruno	131	143	20.2	6	2.5	-	17	6(7)	1941-1944
Bordeaux	-	245	165	19	3.6-5.6	3	1	20	11	1941-1943
Bremen	Hornisse	362	68	-	4.5	3-6	-	-	2	1944 (Unfinished)
Bremen	Valentin	450	97	30-33	4.5-7.3	4.5	2	28	3	1943 (Unfinished)
Brest	-	333	192	17	3.6-6.2	2.5	1.25	24.64	15	1941-1942
Hamburg	Elbe-II	137	62	-	3	2.5	2.5	22.5	2	1940-1941
Hamburg	Fink-II	151	153	-	3,6	2.5	2.5	27.5	5	1940-1942
Helgoland	Nordsee III	156	94	17.3	3	2.5	1	22	3	1939-1941
Kiel	Kilian	176	79	23.5	4.8	2.5	1	23	2	1941-1943
Kiel	Konrad	163	35	13	3.5	3.5	-	28	1	1943-1944
La Pallice	-	195	165	19	7.3	3.5	2	17	10	1941-1943
Lorient	Keroman I	1195	85	18,5	3.5	3.5	2	15	5	1941
Lorient	Keroman II	128	138	18,5	3.5	3.5	2	15	7	1941
Lorient	Keroman III	138	170	20	6.4-7.5	2.5	1.25 - 2	27	7	1941-1943
Saint Nazaire	-	291	124	18	7	2.5	2	19	14	1941-1942
Trondheim	Dora-I	153	105	22	3,5	3	1.25	17	5	1941-1943
Trondheim	Dora-II	167	102	23	3,5	3.5	1.25	24	4	1942 (Unfinished)

3.5.2

Bombs used to destroy the bunker

Fig. 73 Bombs

	Tallboy (Bomb)		Grand Slam (Bomb)
Designed	1942 (Barnes Neville Wallis)	Designed	1943 (Barnes Neville Wallis)
Length	6.35 (m)	Length	7.74 (m)
Diameter	950 (mm)	Diameter	1,170 (mm)
Mass	5,443 kg	Mass	10,160.6 kg
Warhead	2,358 kg	Warhead	4,144 kg
Hitting Speed	1,210 km/h	Hitting Speed	1,150 km/h
Type	Earthquake bomb	Type	Earthquake bomb

3·5·3
Structure against Bombs

After the appearance of bombs with higher explosive power in World War II, passive reinforcement was required for the protection of all bunkers and a roof layer was added to absorb the blast impact and prevent damage to the roof.

The first layer is a concrete slab with 2.8-meter-thick steel beam trusses. The second layer is a 30 cm granite layer, the third is a reinforced concrete layer with an air chamber in between, which absorbs the impact. The last layer is a layer of horizontally placed reinforced concrete girders (Fangrost), the purpose of which is to detonate the bomb before it reaches the first layer, thus weakening its explosive power. In the last bunker, Dora-I, the Melan-träger were replaced by prestressed concrete beams (spannbetonträger) due to their high steel consumption. In practice, this structure proved effective in protecting the inside of the bunker from repeated bombings and powerful bombs.

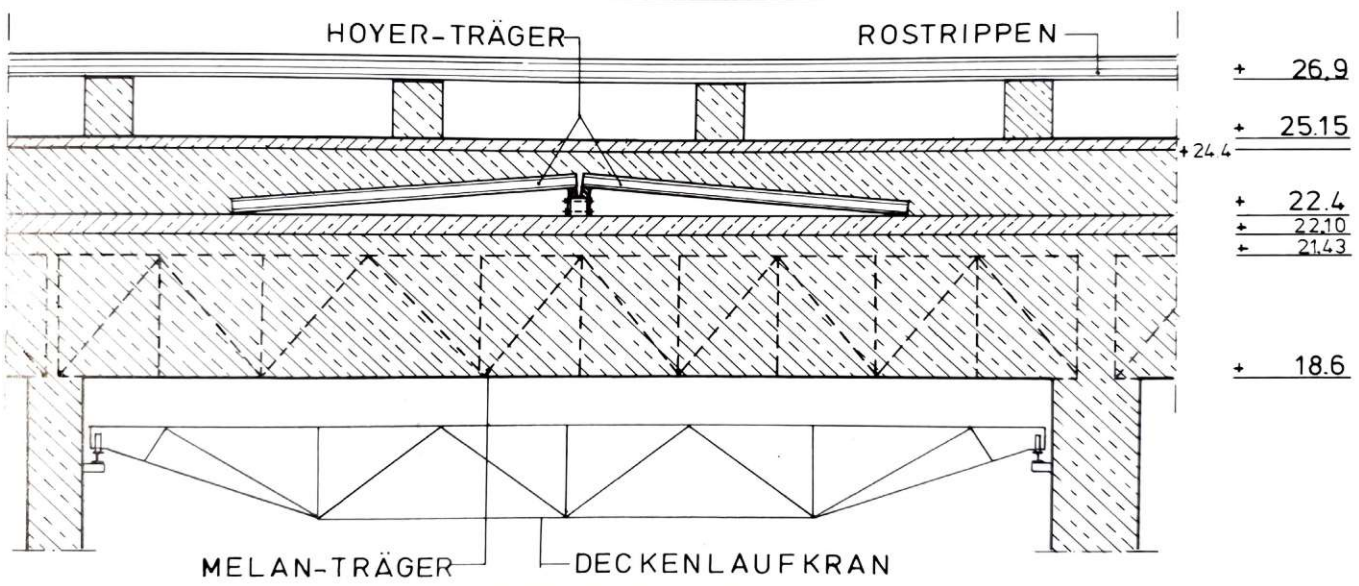


Fig. 74 Die Deckenverstärkungen

Fig.75 Die Decke des Ubootbunkers in Bordeauxpage

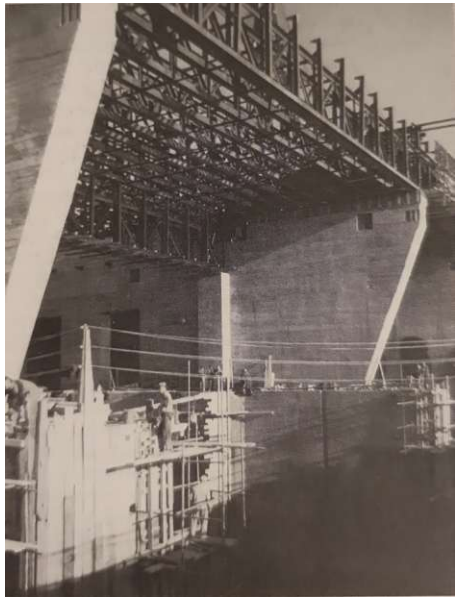
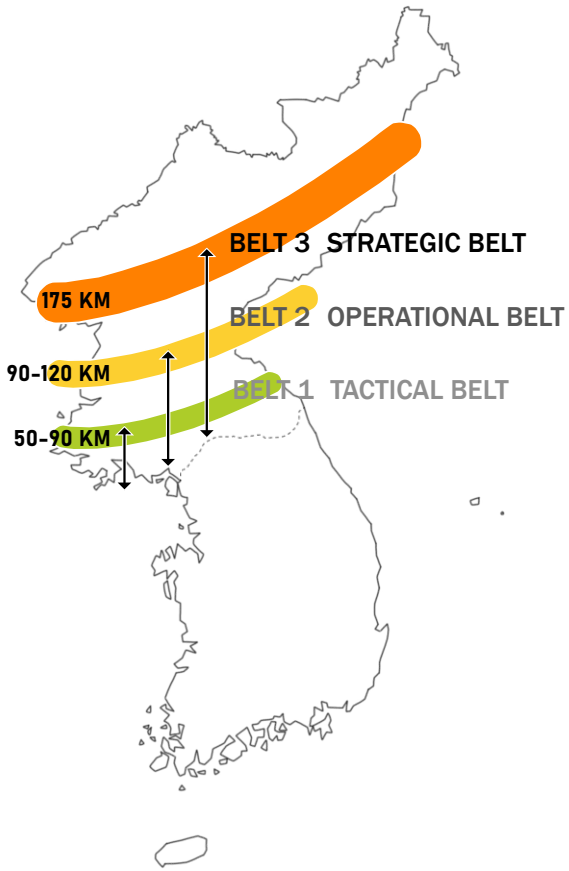


Fig.76 Melan-Träger Über der Box des Bunkerspage

3.6

Threats to Yeonpyeong Island

(What threats are bunkers prepared for?)



North Korea's missile belt

Fig.77 North Korea's ballistic missiles

N.Korea's missile belt is divided into three stages across the country. The first, the Tactical Belt, near the Demilitarized Zone(DMZ), concentrates short-range Scud missiles, while the second belt around Pyongyang, 120 kilometers north of the DMZ, is home to Nodong missiles. The third and final stage, the "Strategic Belt," has long-range missiles.

In response, S.Korea has developed a defense network by introducing missile interception systems such as the Patriot PAC-3 CRI with an interceptor altitude of 30km, the PAC-3 MSE with an interceptor altitude of 40km, and the M-SAM Block-II with an interceptor altitude of 20km.

THAAD (Terminal High Altitude Area Defense), which is temporarily deployed in S.Korea, has an interceptor range of 40 to 150 kilometers. In addition, the long-range high-altitude interceptor systems L-SAM, L-SAM 2, and the S.Korean Iron Dome are also under development.

N.Korea's well-known nuclear and high-powered missiles have their own interceptor systems, and new countermeasures are constantly being developed. However, N.Korea's radial artillery is low-altitude, with many shells firing simultaneously, so neither S.Korea nor the U.S. military has a suitable defense.

And from N.Korea's perspective, conventional weapons with sufficient range to reach the Seoul metropolitan area are more effective weapons to threaten the South than ballistic missiles, which would be internationally condemned.

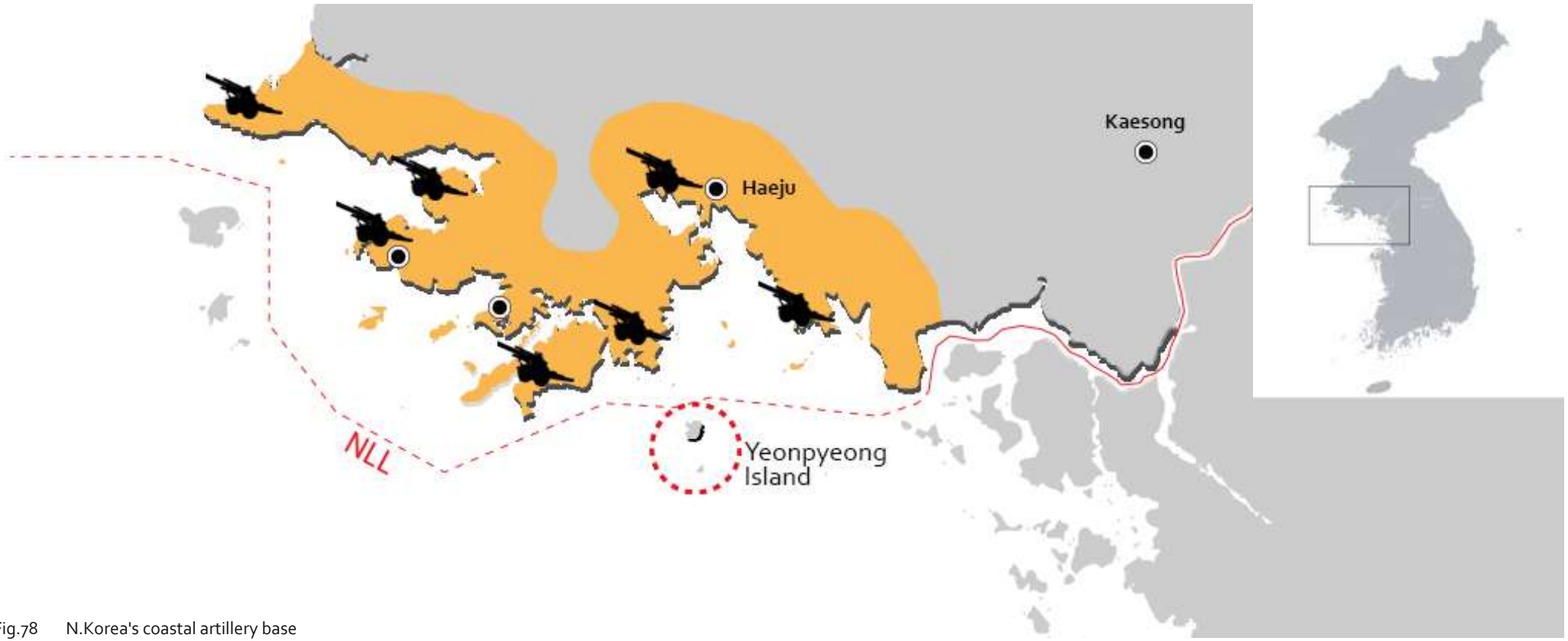


Fig.78 N.Korea's coastal artillery base

76 mm divisional gun M1942 (ZiS-3)

Fig.79

Max. firing range	13.29 km

122 mm field gun (D-74)

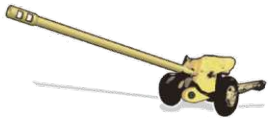


Fig.80

Muzzle velocity	885 m/s (2,907 ft/s)
Max. firing range	24 km

130 mm towed field gun M1954 (M-46)

Fig.81

Muzzle velocity	930 m/s
Warhead	< 19 kg (TNT) <2.1 kg
Max. firing range	27 km

122 mm MRLS (BM-21 'GRAD')

Fig.82

Barrels	40 rockets
Warhead	18.4 kg (max-24kg)
Muzzle velocity	690 m/s
Max. firing range	52 km

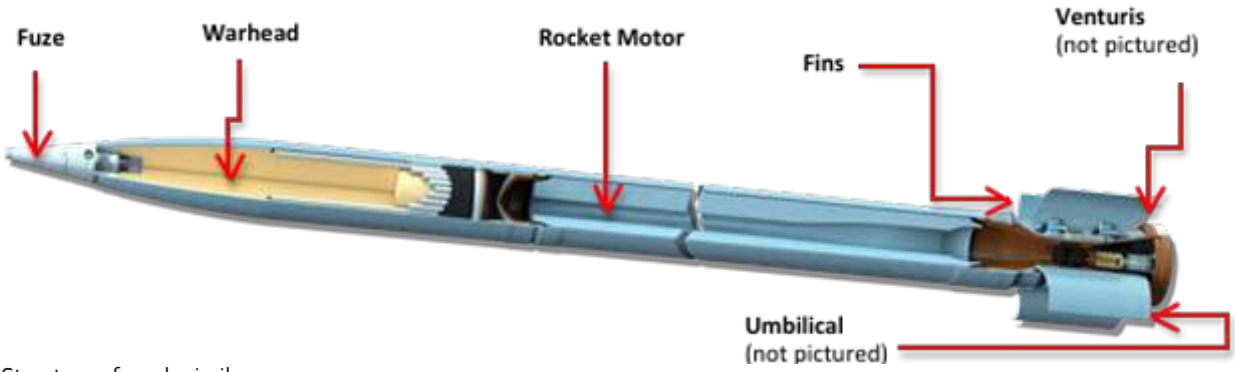


Fig.83 Structure of gard missile

Fig.84 Gard missile

Calibre	122	mm
Weight	66.0	kg
Warhead weight	18.4	kg
Net explosive quantity	8.32	kg
Length	2870	mm
Number of fragments	1640 – 2280	
Range of fire	20.4	km

Grads are notoriously inaccurate. Accuracy refers to the ability of a weapon to hit a desired target and, as a wide-area system intended to blanket a large area on an open battlefield, Grads are not designed to hit pinpoint targets, but rather provide area coverage.

Source: USSR Ministry of Defence, 1971.

Unlike mortars, which typically land at an angle close to 90° to the ground, rockets impact at a much flatter trajectory. As a result, the majority of fragmentation flies in front of the point of impact, rather than around it. Due to the size and weight of Grad rockets' fragmentation (each fragment is less than 3g), shrapnel is unlikely to cause serious damage to permanent structures made from brick or concrete. Buildings usually don't suffer serious structural damage from Grad rockets unless they sustain a direct hit. Even then, the explosive quantity contained in a single rocket is unlikely to cause building collapse. An attack would likely not raze a single building to the ground, as might be the case with a precision airstrike utilising a far greater explosive quantity. The large amount of heat given off at the initial point of detonation may also cause fires in areas with an abundance of flammable material.

The biggest risk considered in this project is **not** nuclear weapons or missiles, which can be detected and intercepted, but N.Korea's coastal artillery, namely conventional weapons that can be fired suddenly and without warning.

N.Korea's main weapon, the 122mm artillery, has a warhead of 20 kg, and the new 240mm artillery, introduced in 2021, has a warhead of 90 kg.

The thickness of the main structure of the shelter is based on the structure of a U-boot bunker that withstood a bomb weighing 5 tons. (Roof 3.5 m, exterior wall 2.5 m, interior wall 1.5 m)

This thickness can withstand past N.Korea's provocations and the largest conventional weapons North Korea currently has.

Fig.85 Grad missile

Fig.86 North Korea multiple rocket launcher

04 Goals

UNDRR defines disaster as a serious disruption in the functioning of a community or society, regardless of scale, due to a hazardous event.

This study aims to solve the problem of the disruption of community functioning in Yeonpyeong Island due to the risk factors mentioned above through a new shelter model.

A shelter where residents inevitably have to stay for a long time should be complemented by a public space that is attractive and accessible to residents through various program operations.

Through the combination of shelters, aquaponics, and cultural spaces, the daily needs of residents such as work, life, and leisure are met in the shelter. Thus, the daily lives of the residents, who have been disadvantaged in their livelihoods and studies during each exercise or emergency, will continue uninterrupted.

Utilizing the slopes of the interior of the island for the shelter will take the villagers away from the coast, which is their main place of work.
The project must be easy to evacuate for both villagers and workers on the coastal mudflats.

In addition, the shelter units should be spatially adaptable, expanding and contracting flexibly to meet different needs, such as capacity and evacuation period.

05 Methodology

North Korea's attack direction axis

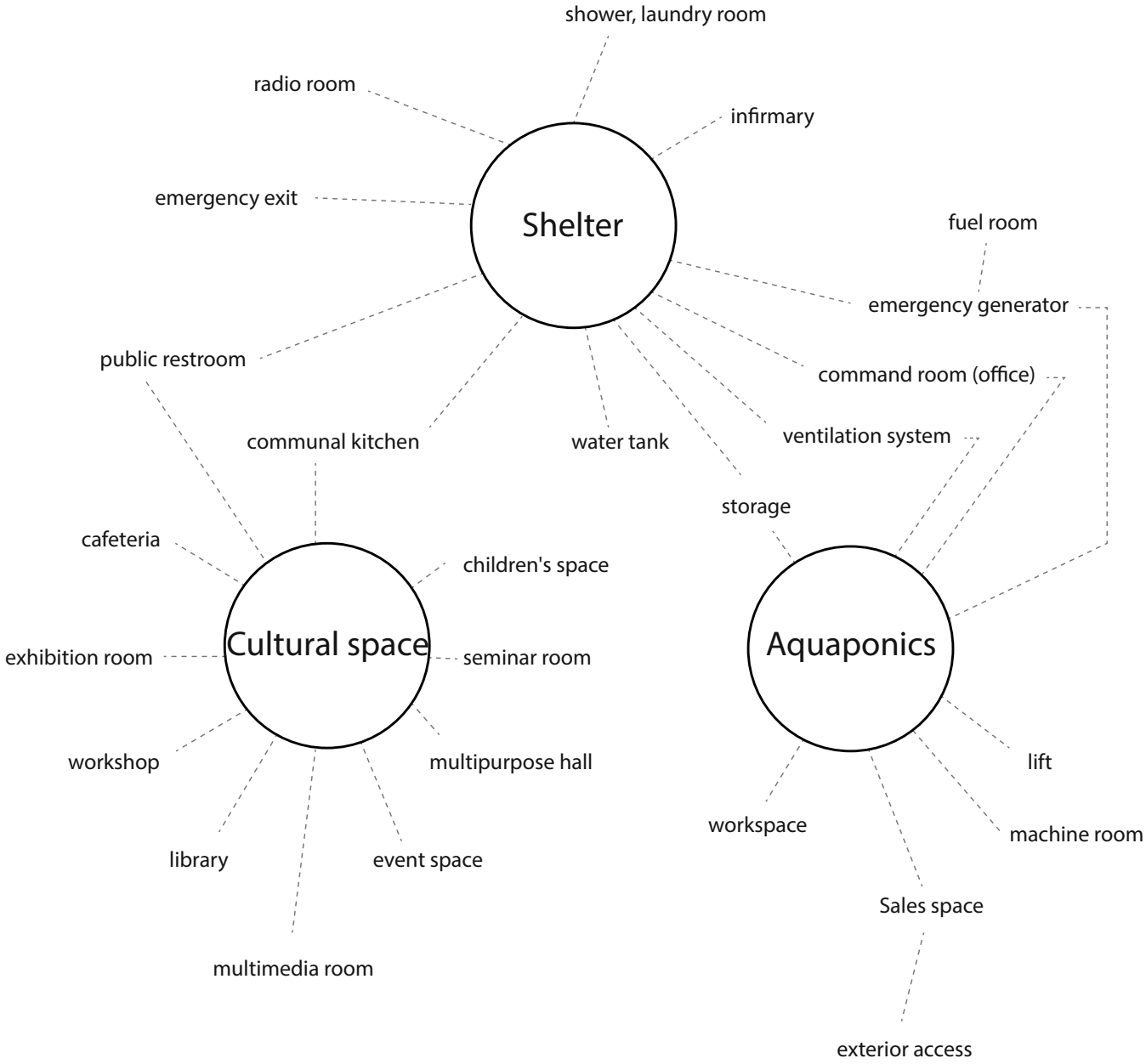
5.1

Space program

The uses of the space program are broadly divided into three categories. Aquaponics is operated without interference in an independent space, and in times of peace, the shelter space is used as a cultural space for residents.

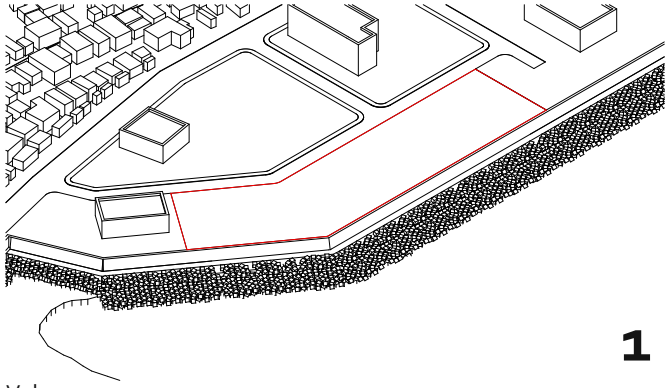
Shelters and aquaponics require similar facilities. Facilities such as machine rooms and emergency power generation rooms are located underground because any problem can affect the entire facility. The shelter + cultural space unit is also located underground, but can utilize natural light by taking advantage of the coastal level difference, because the south is safe from North Korean artillery fire.

The first floor level, which is mainly accessed by villagers, is where offices and sales facilities are located, and residents can enter the basement level through each lounge on the first floor.



Space program

1.
The building site is located on the coast close to the village, so it has the geographical advantage of being able to accommodate both people in the village and those working in the mudflats in case of an emergency. Most of the damage suffered from North Korea's artillery fire was caused by fire. Sites located slightly away from residential areas are safe from nearby fires.
2.
Increase the safety of facilities that need to be protected with underground spaces created by level differences.
3.
The machine room, warehouse, power generation room, etc. are located underground for protection and located on the north side to ensure smooth supply of materials.
4.
With the exception of Aquaponics, each unit has one evacuation space and one community space. In peacetime, cultural programs are offered, but depending on the situation, the functions of each unit are shared and can be expanded for shelter purposes.
5.
Each box used as an entrance serves as a buffer space before entering the units. Each unit has at least two emergency exits.
6.
The service and sales areas are located on the ground floor level, accessible to the villagers. Someday, when the war is over, the north wall will be removed to allow for commercial space and tourist facilities.



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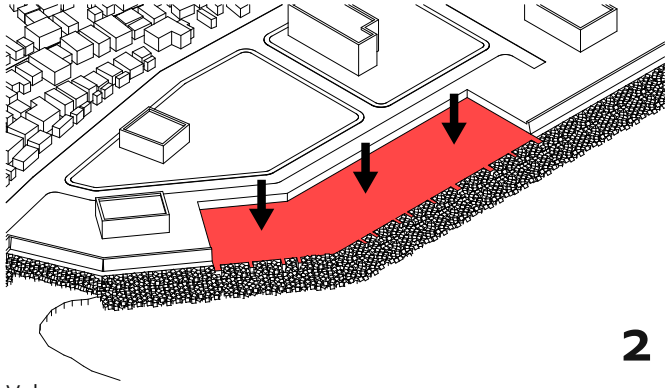

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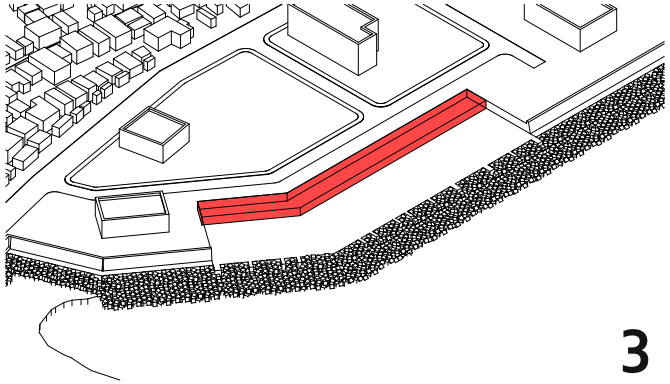

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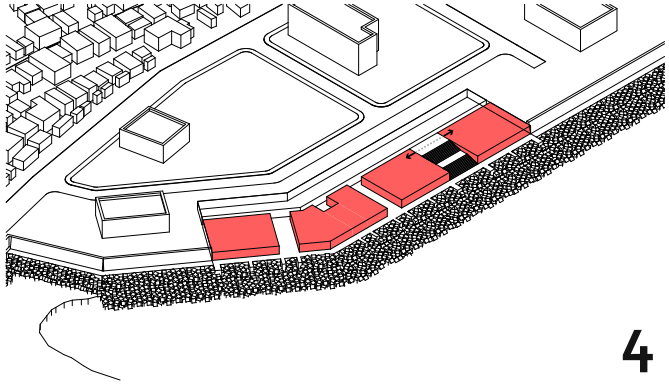

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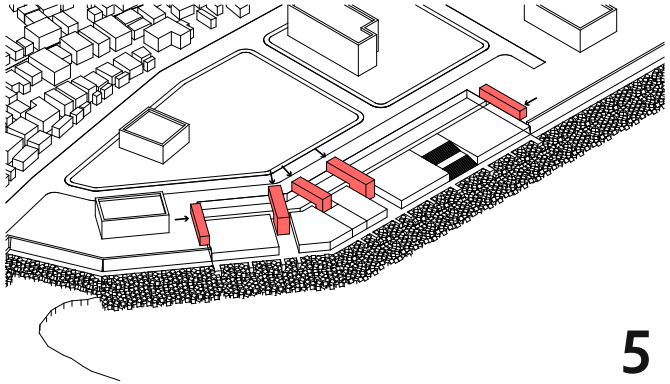

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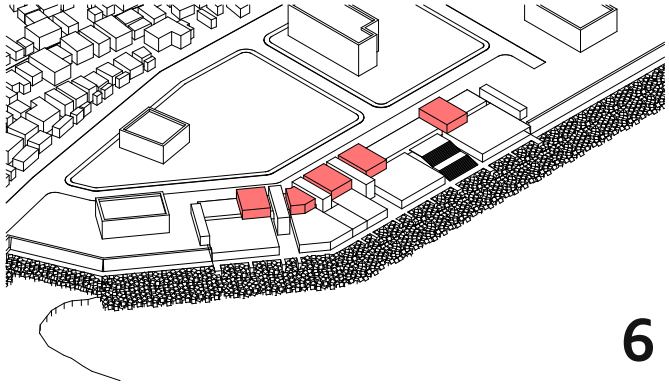

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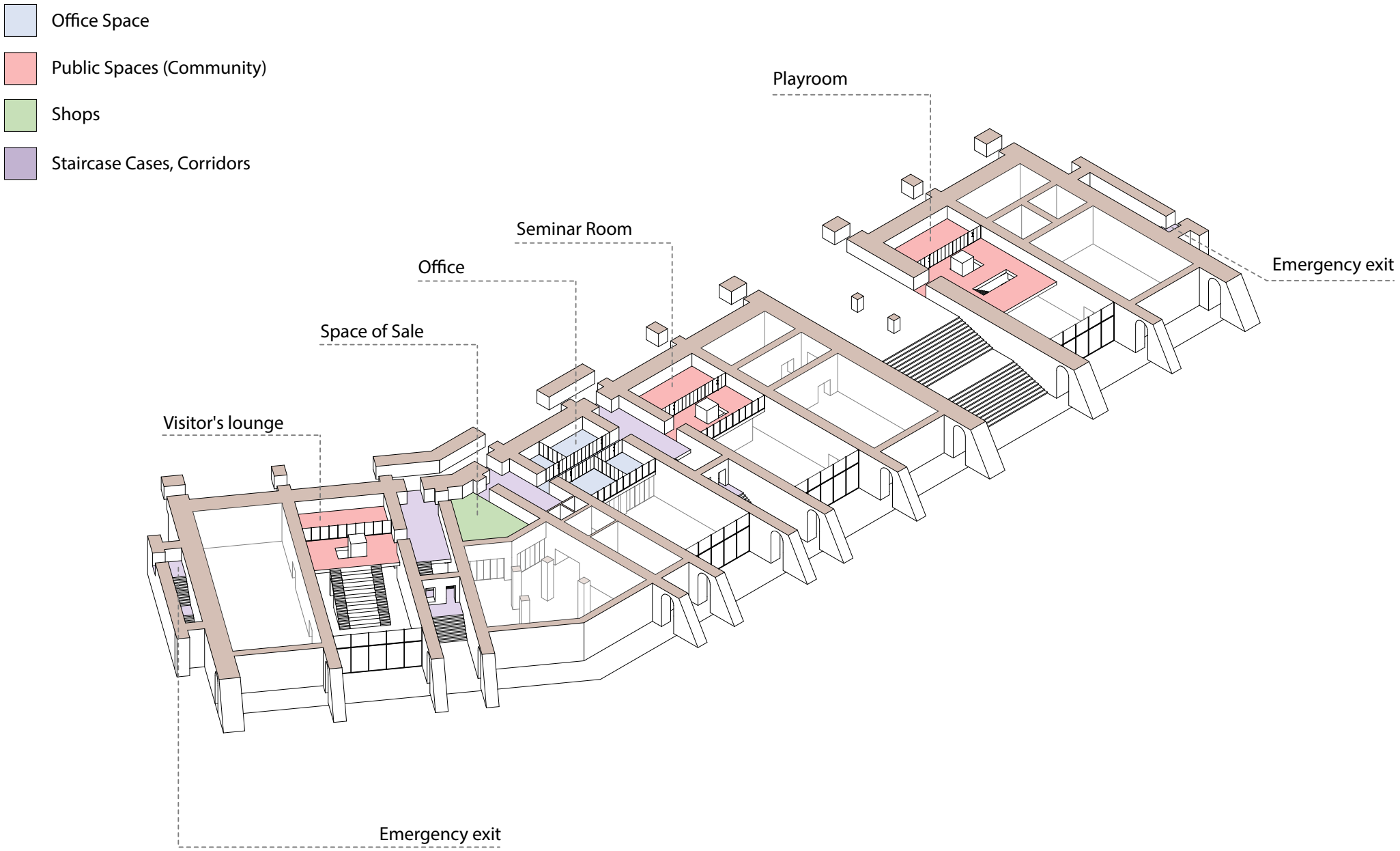
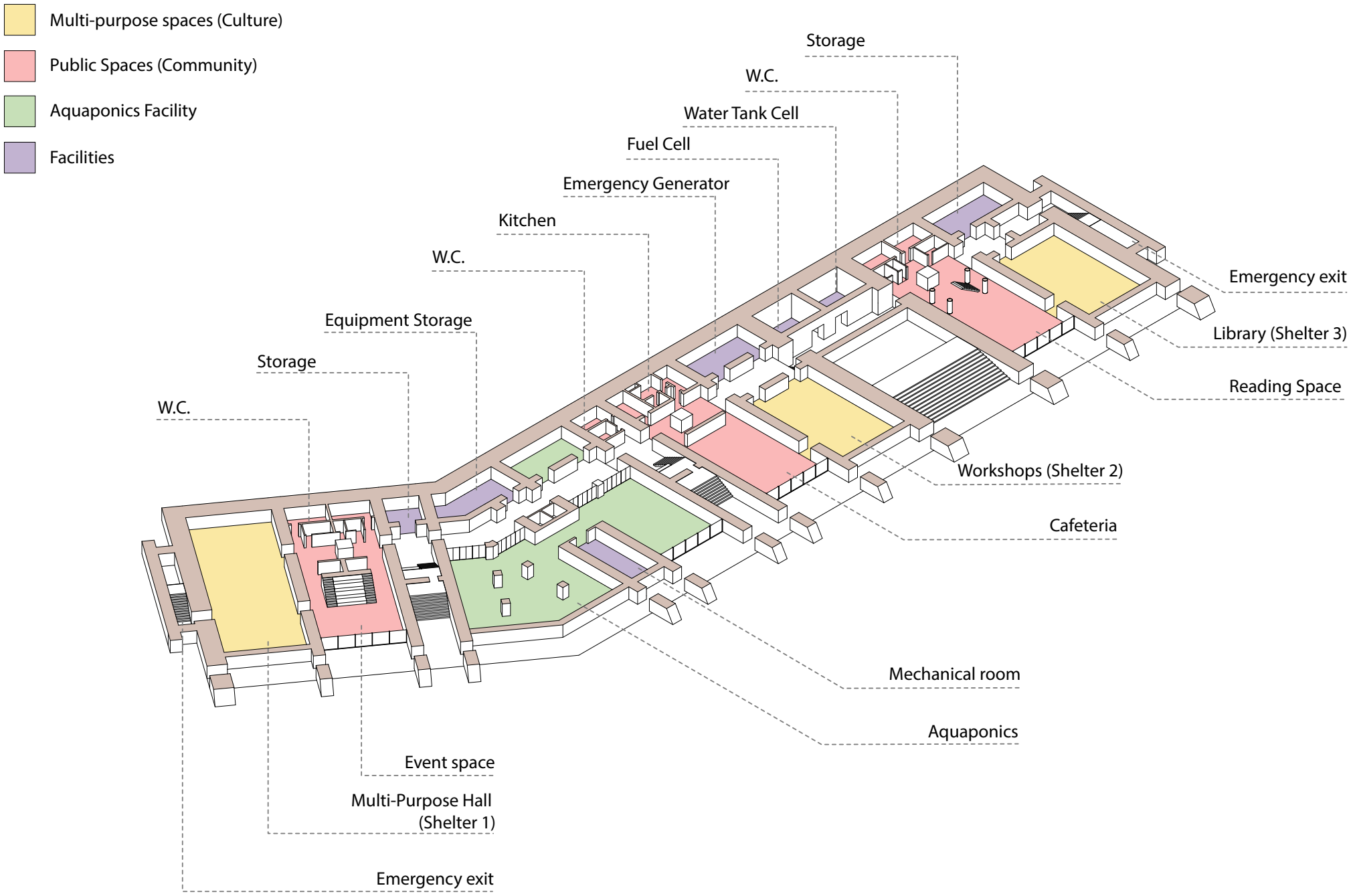


Ground floor zoning



Basement space zoning

5.2
Situational response

Article 14 of the Enforcement Rules of the Civil Defense Act of the Republic of Korea states, "All evacuation facilities may be used for other purposes during normal times, but must be managed so that they can be used as evacuation facilities immediately.

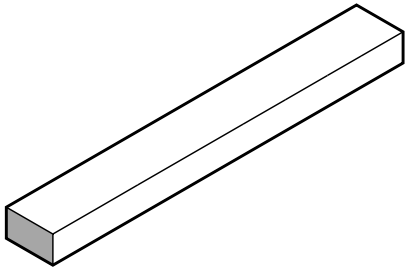
In this project, the volumes that normally provide cultural programs will immediately function as expanded shelters, depending on the seriousness of the situation, and is expandable in three levels.

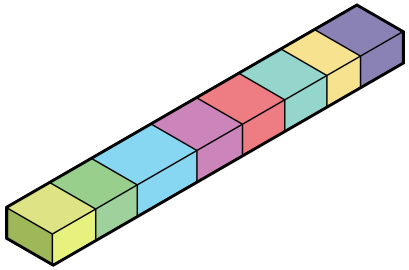
The longer an individual stays in a shelter, the more space they need. Under current regulations, the square footage per person is 1.43m² in government-funded shelters and 0.825m² in public shelters.

Level 1
considers a stay of no more than one day and is intended for temporary evacuation due to a scheduled drill.

Level 2
considers a residence (evacuation) period of one to two days and is intended for evacuation due to sudden air and artillery strikes. (1.43m²/pp)

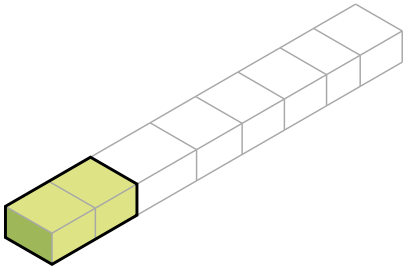
Level 3
considers a residence (evacuation) period of 3 to 60 days, and is intended to accommodate displaced people until the village is rebuilt from shelling. (3.3m²/pp)

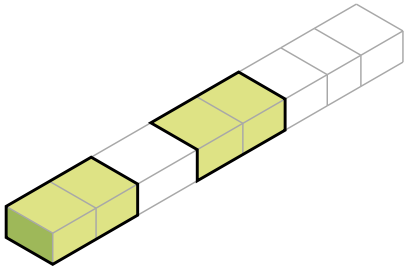


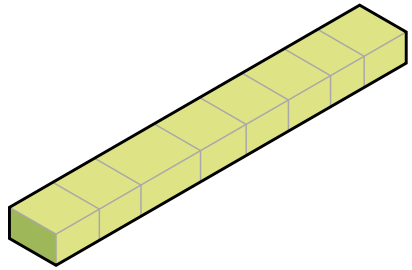


TOTAL VOLUME

USUAL PROGRAMS







Lv.1 Shelter Expansion

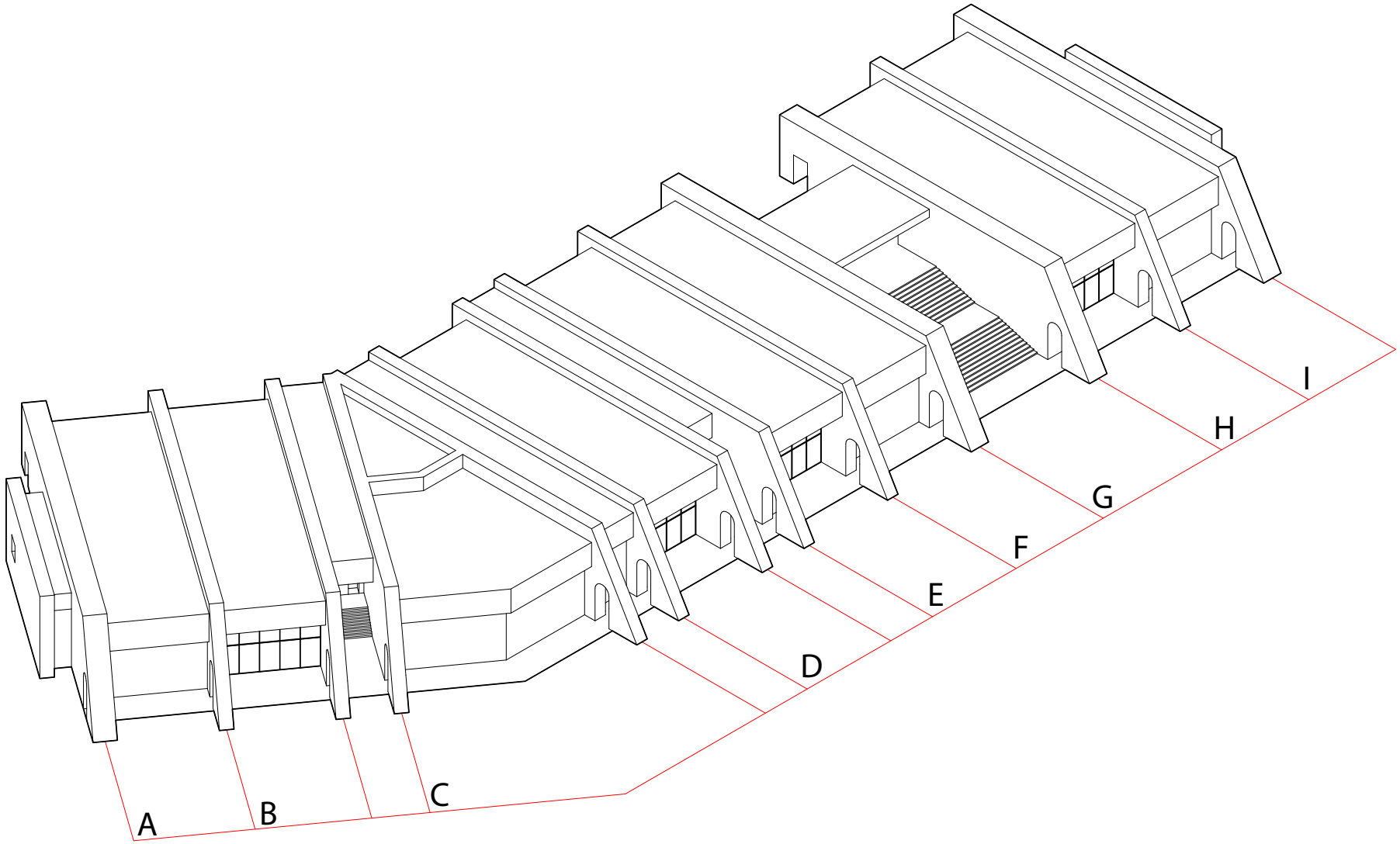
Lv.2 Shelter Expansion

Lv.3 Shelter Expansion

Expansion system

5.2.1

Use in peacetime & Evacuation training



shelter units

Specialized areas for groups

Normally, all units are open to villagers. However, to ensure daily routine during evacuation training, certain units are given priority to certain groups.

1. Kids group (H)

Unit-H, which has a children's playroom on the ground floor, is given priority to children's groups and teachers.

2. Student group (F, H, I)

There are a total of 43 students in Yeonpyeong Island. Students can first use the library, reading room, and multimedia room for education, and a seminar room is also provided if additional space is needed.

3. Office labor group (D, E)

Office space and conference rooms in Unit-D,E are provided to workers for urgent work.

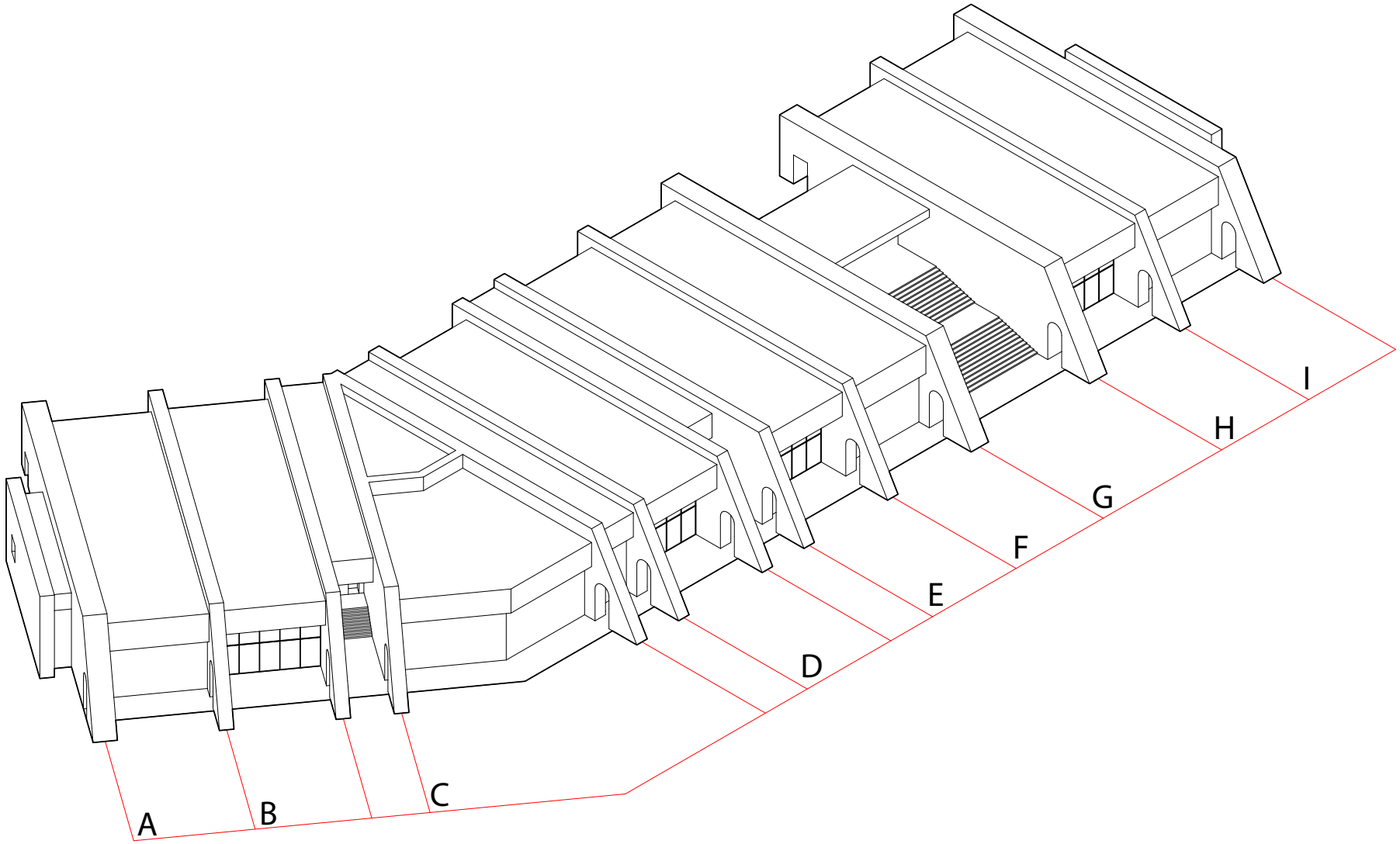
4. General group (A, B)

Units A and B accommodate more people compared to other units. A monitor room, communication space, and visitor lounge are provided for general residents.

Use of the unit in general evacuation training		**Available area**
A	: Multipurpose hall	299.2 m²
B	: Event space + Visitor's lounge	163.8 m² + 115.5 m²
C	: Aquaponics (LED)	282.6 m²
D	: Aquaponics	163.8 m² + 52.5 m²
E	: Cafeteria / Communication space	163.8 m² + 115.5 m²
F	: Workshop / Seminar room	163.8 m²
G	: Underground tunnel (Connect F and H)	72.5 m²
H	: Reading zone / Kids playroom	163.8 m² + 115.5 m²
I	: Library / Multimedia room	163.8 m²

5.2.2

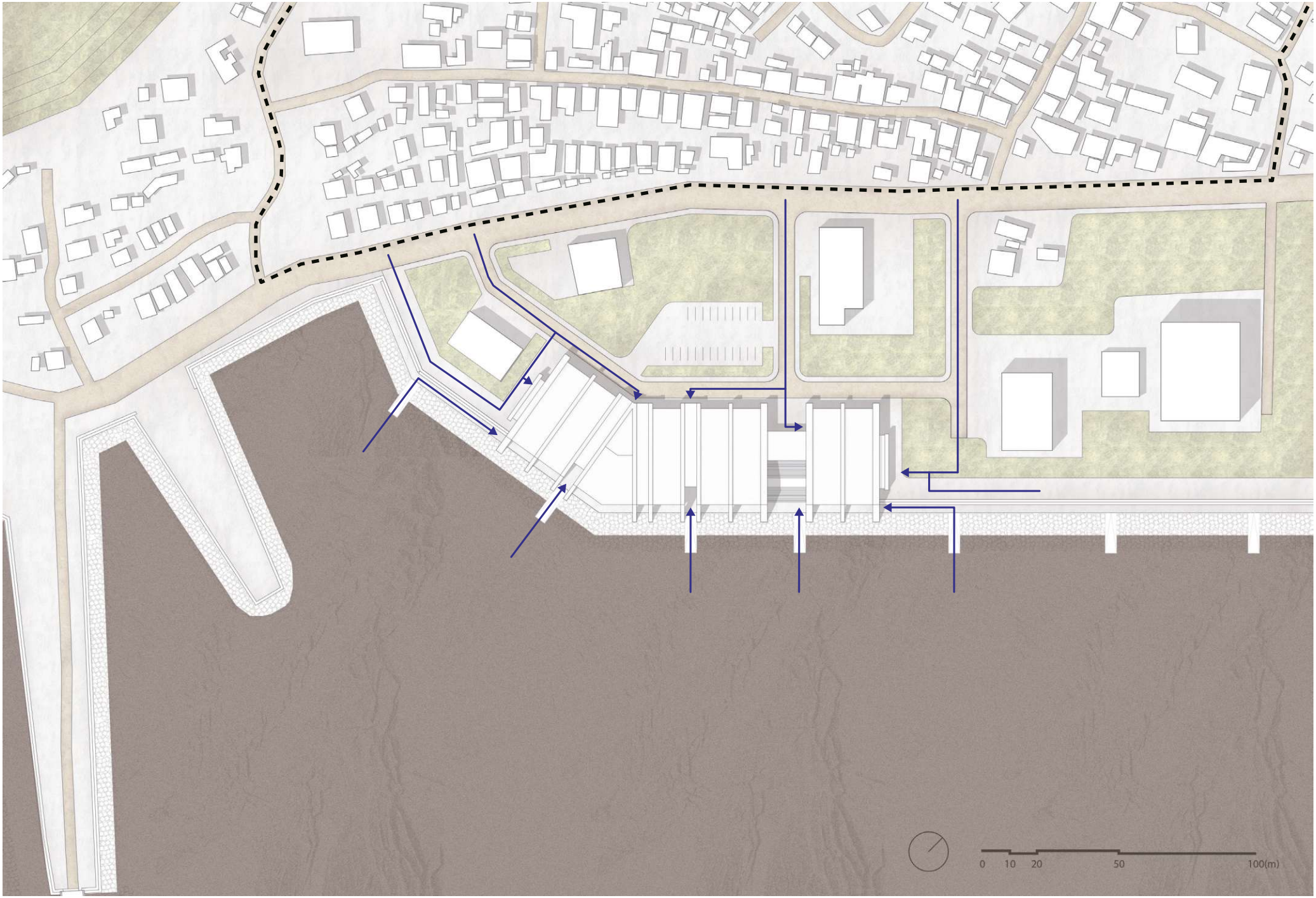
Use in emergency situations



shelter units

Situation level (refuge period)	Use of the unit in case of disaster	Available area
Level 1 (1-24 hours) A+B (1 Shelter + 1 Common space)		
	A : Solid facade / Shelter space	299.2 m²
	B : Open facade / Common space	163.8 m² + 115.5 m²
	C : Solid facade / Aquaponics (LED)	282.6 m²
	D : Open facade / Aquaponics	163.8 m² + 52.5 m²
	E : Open facade / Common space (Kitchen)	163.8 m² + 115.5 m²
	F : Solid facade / Shelter space	163.8 m²
	G : Underground tunnel (Connect F and H)	72.5 m²
	H : Open facade / Common space	163.8 m² + 115.5 m²
	I : Solid facade / Shelter space	163.8 m²
Level 2 (1-2 days) A+B+E+F (2 Shelters + 2 Common spaces) + Communal Kitchen + Additional Toilet		
Level 3 (3-60 days) A+B+C+D+E+F+G+H+I (3 Shelters + 3 Common spaces) + Communal Kitchen + Additional Toilet / Washroom + Self-sufficiency through Aquaponics (500 m² of Aquapinics produces 33 tons per year)		
Max. Capacity - 780-800 (per)		

5·3
Evacuation route



Evacuation route

06 Result

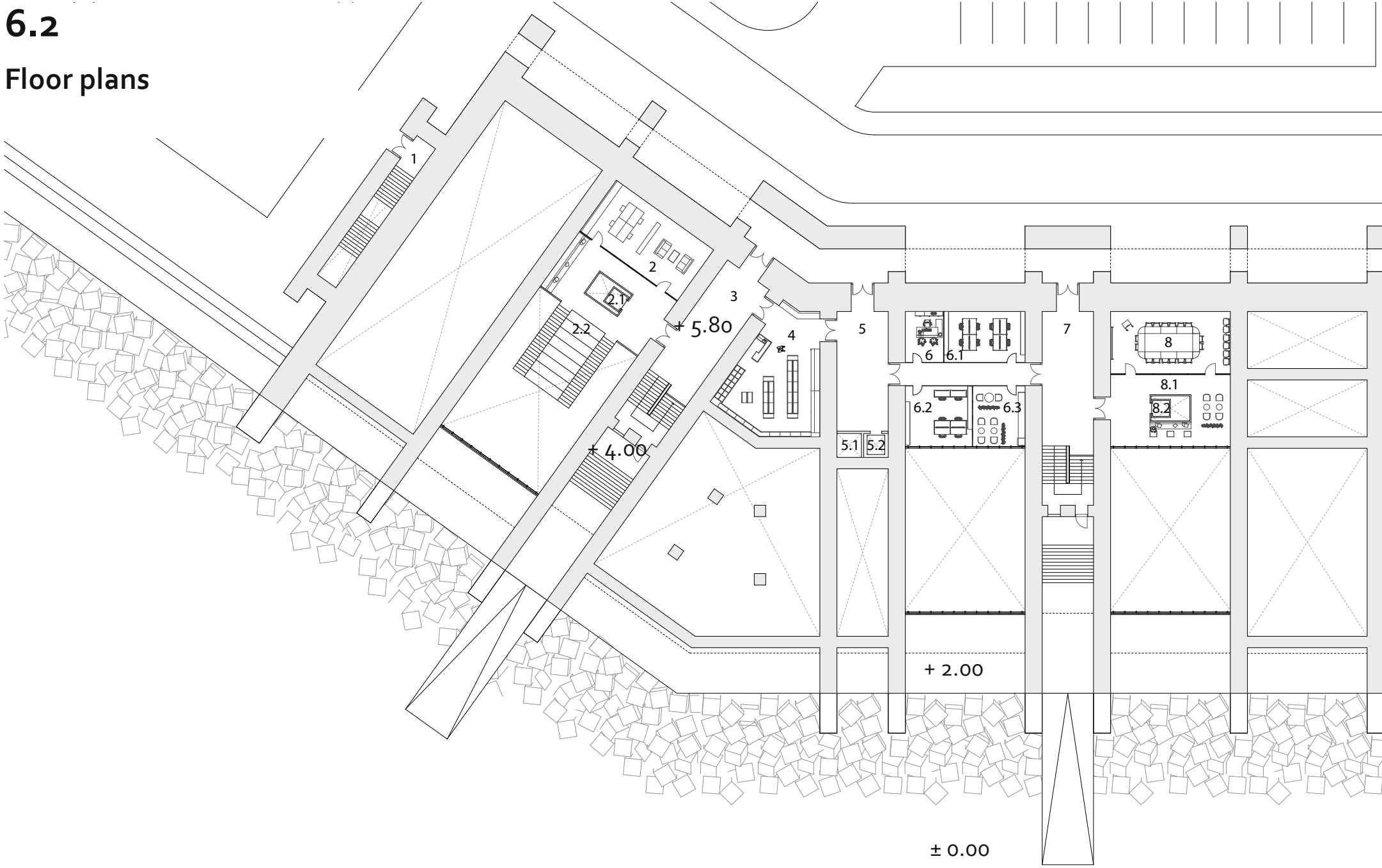
6.1

Site plan

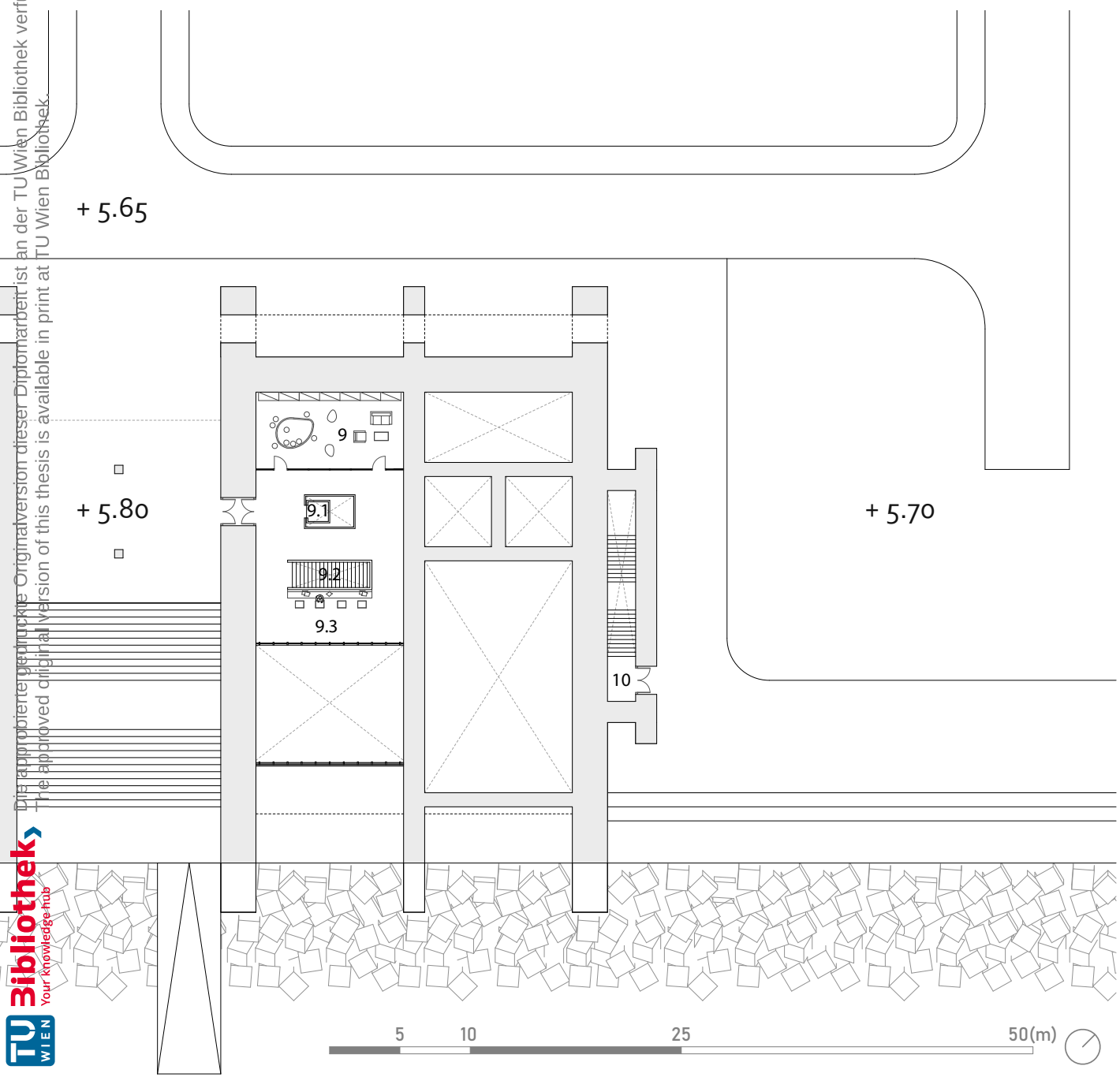
Site plan

6.2

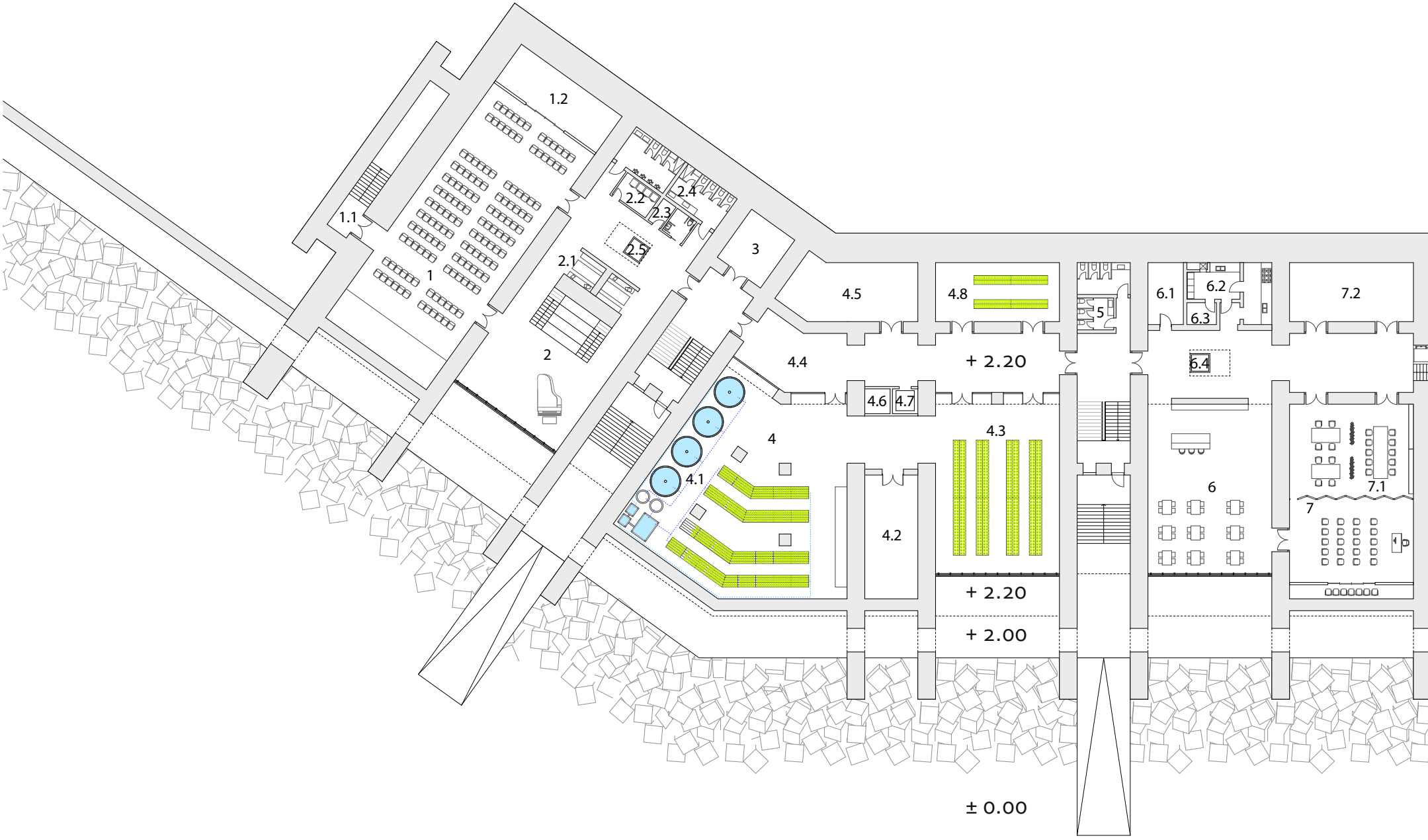
Floor plans



Ground floor plan



1.0	Emergency Exit	
2.0	Visitor's lounge	58.1 m²
2.1	Elevator	2.7 m²
2.2	Gallery stairs	
3.0	Main entrance_1, Stairwell_1	52.8 m²
4.0	Space of Sale	77.8 m²
5.0	Main entrance_2	10.5 m²
5.1	D.A	5.1 m²
5.2	Elevator (for freight)	5.1 m²
6.0	Office_1	15.2 m²
6.1	Office_2	32.0 m²
6.2	Office_3	32.5 m²
6.3	Staff lounge	25.2 m²
7.0	Main entrance_3, Stairwell_2	52.8 m²
8.0	Seminar Room	58.1 m²
8.1	Visitor's lounge	64.6 m²
8.2	Elevator	2.7 m²
9.0	Kids room	58.1 m²
9.1	Elevator	2.7 m²
9.2	Stairs	12.6 m²
9.3	Visitor's lounge	118.4 m²
10.0	Emergency Exit	

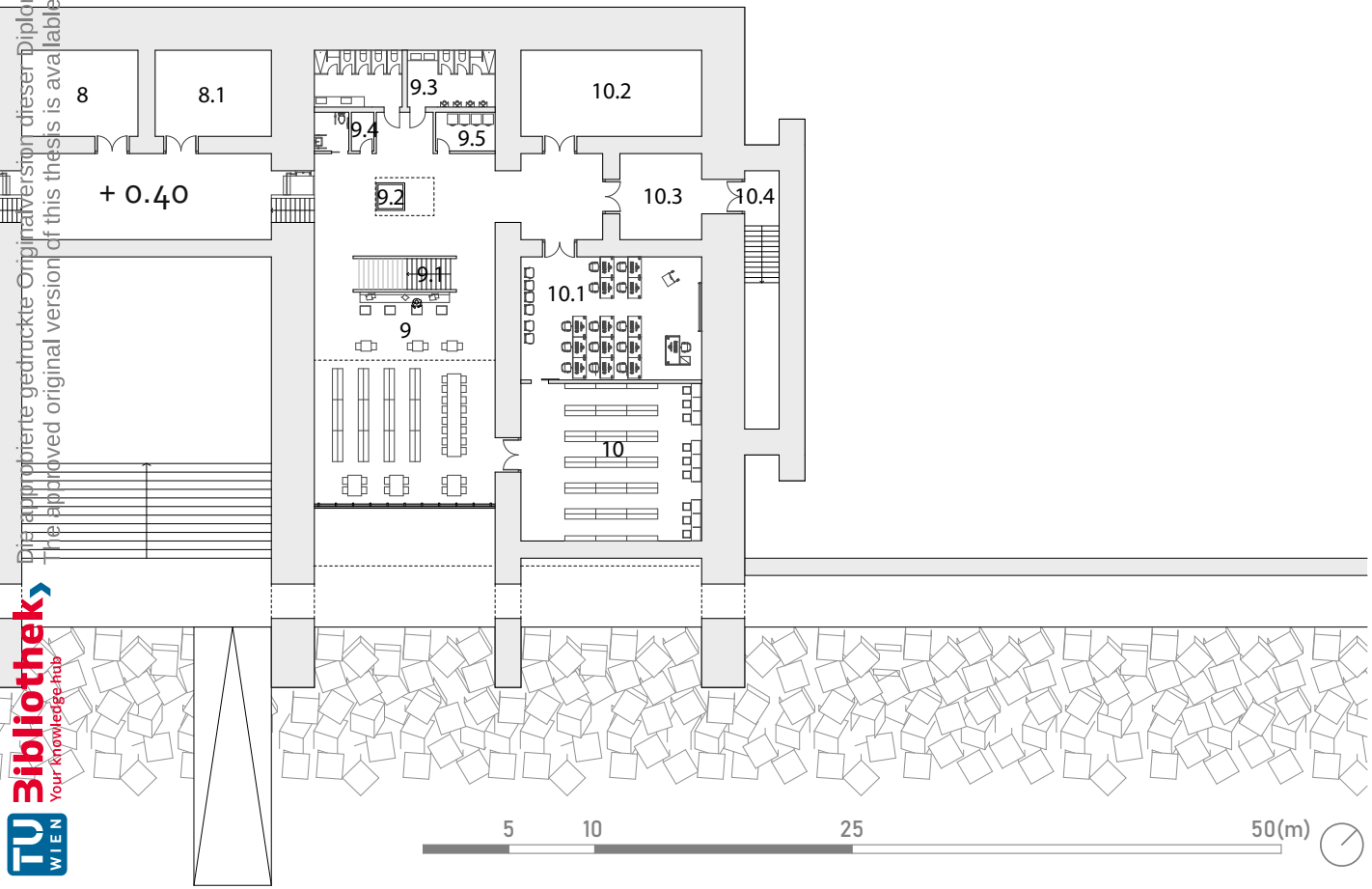


Basement floor plan

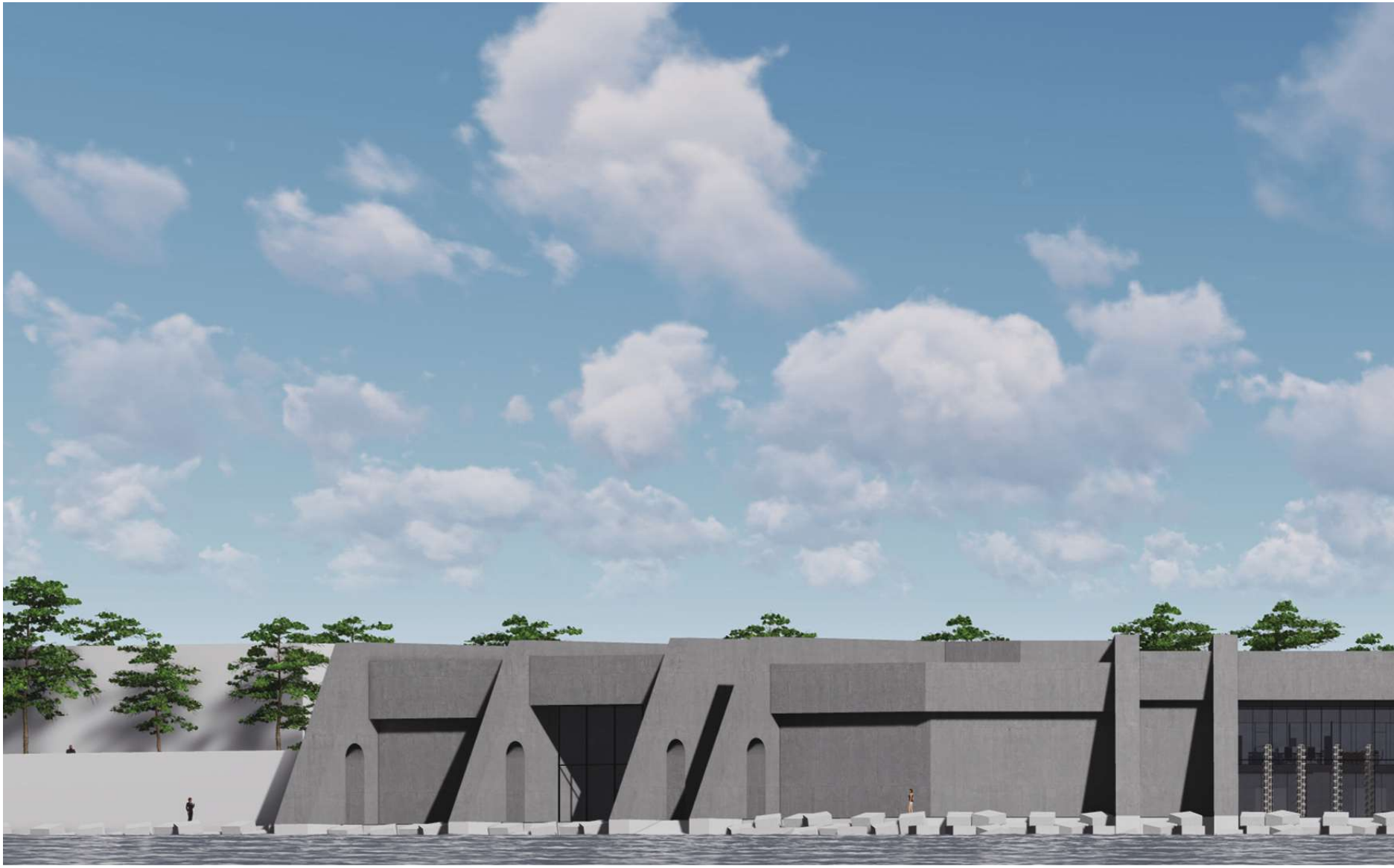
1.0	Multi-Purpose Hall (Shelter 1)	259.0 m²
1.1	Emergency Exit	
1.2	Storage	41.0 m²
2.0	Event space	163.8 m²
2.1	Talkbox booth	6.5 m²
2.2	Laundry room	7.8 m²
2.3	Cleaning tools Storage	3.0 m²
2.4	WC	33.7 m²
2.5	Elevator	2.7 m²

3.0	Storage	22.5 m²
4.0	Aquaponics (LED light)	282.6 m²
4.1	Fish farm, Water tank	
4.2	Mechanical room	48.3 m²
4.3	Aquaponics (Natural light +LDE)	163.8 m²
4.4	Visitor's lounge	45.1 m²
4.5	Storage / Prep room	55.8 m²
4.6	D.A	5.1 m²
4.7	Elevator	5.1 m²
4.8	Seed germination room	52.5 m²

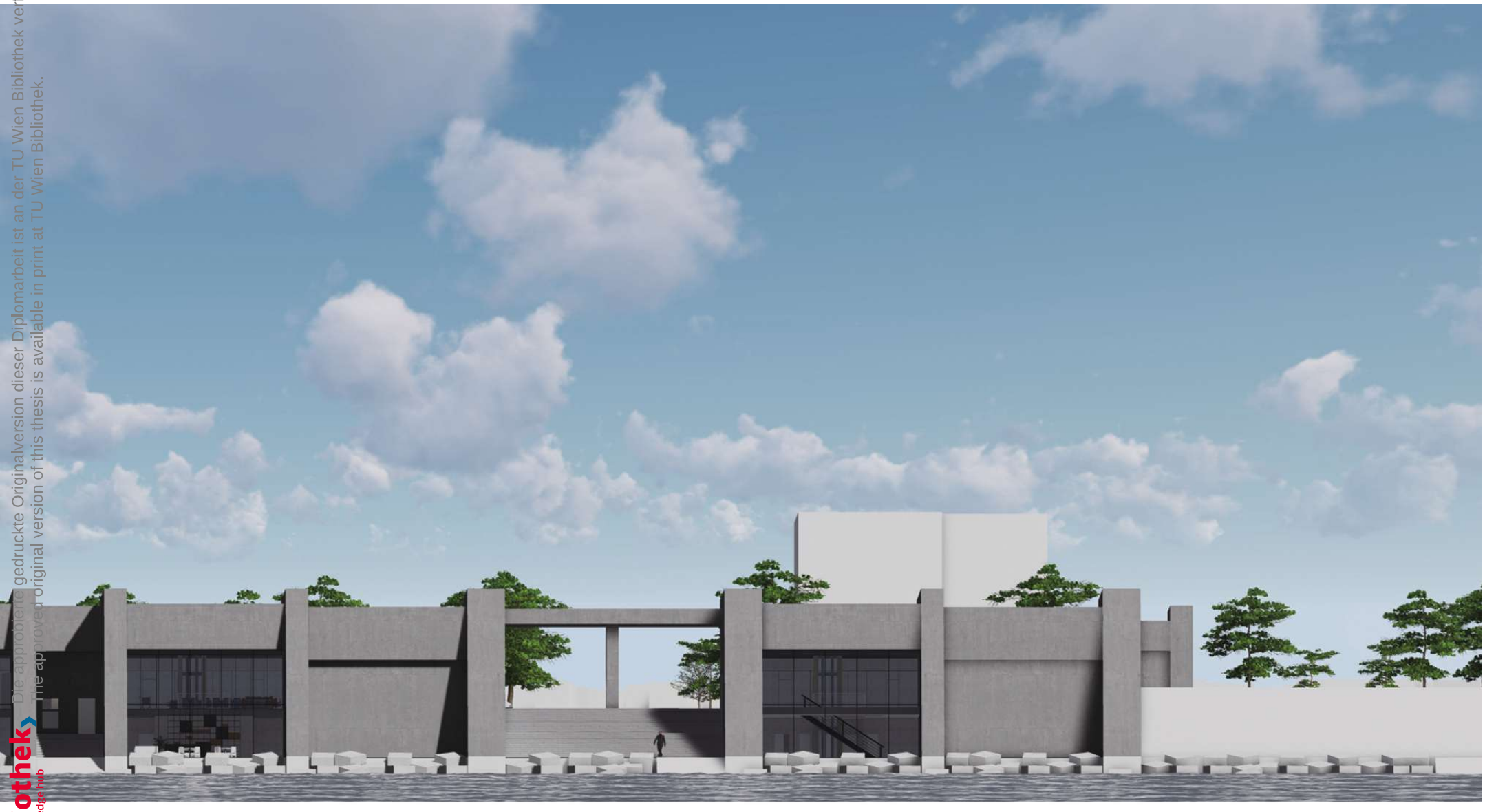
5.0	WC	23.5 m²
6.0	Cafeteria / Cafe	163.8 m²
6.1	Storage	15.8 m²
6.2	Kitchen	27.6 m²
6.3	Cold storage	4.8 m²
6.4	Elevator	2.7 m²
7.0	Workshop_1 (Shelter 2)	88.3 m²
7.1	Workshop_2 (Shelter 2)	85.0 m²
7.2	Emergency generator room	52.5 m²
8.0	Fuel Cell	33.8 m²
8.1	Water Tank Cell	33.8 m²
9.0	Reading Space	163.8 m²
9.1	Stairs	12.6 m²
9.2	Elevator	2.7 m²
9.3	WC	33.7 m²
9.4	Cleaning tools Storage	3.0 m²
9.5	Laundry room	7.8 m²
10.0	Library (Shelter 3)	96.1 m²
10.1	Multimedia room (Shelter 3)	77.2 m²
10.2	Storage / Machine Room	52.5 m²
10.3	Vestibule	23.8 m²
10.4	Emergency Exit	58.1 m²

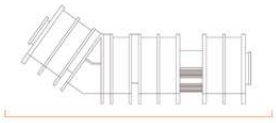


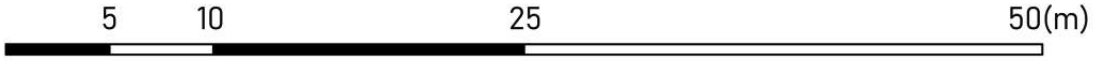
6.3
Elevations



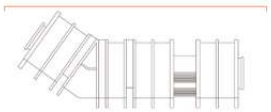
South side Elevation

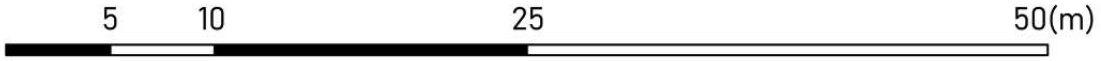


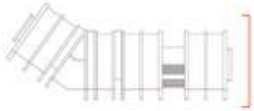




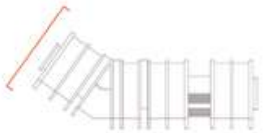
North side Elevation







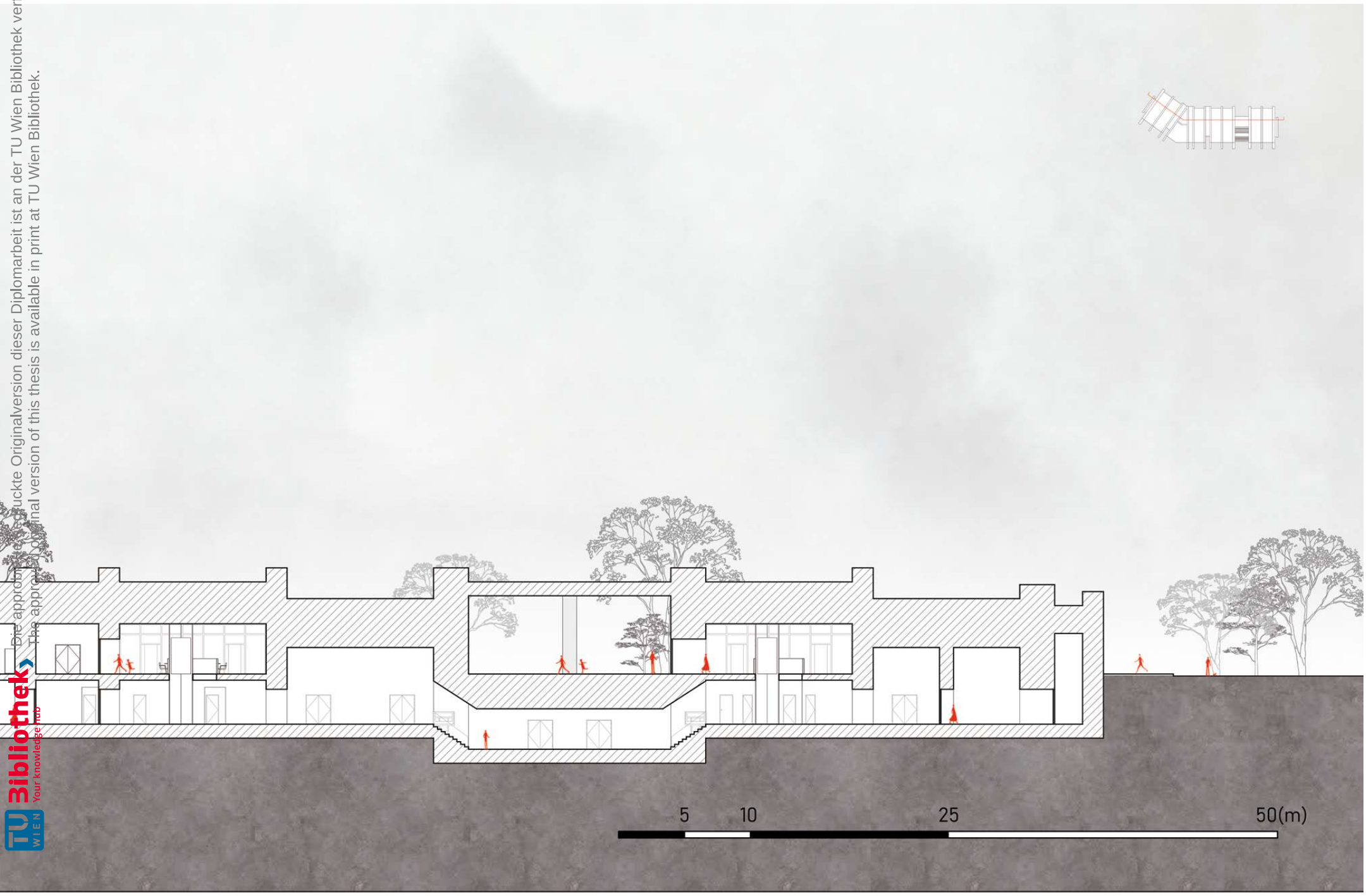
East side Elevation



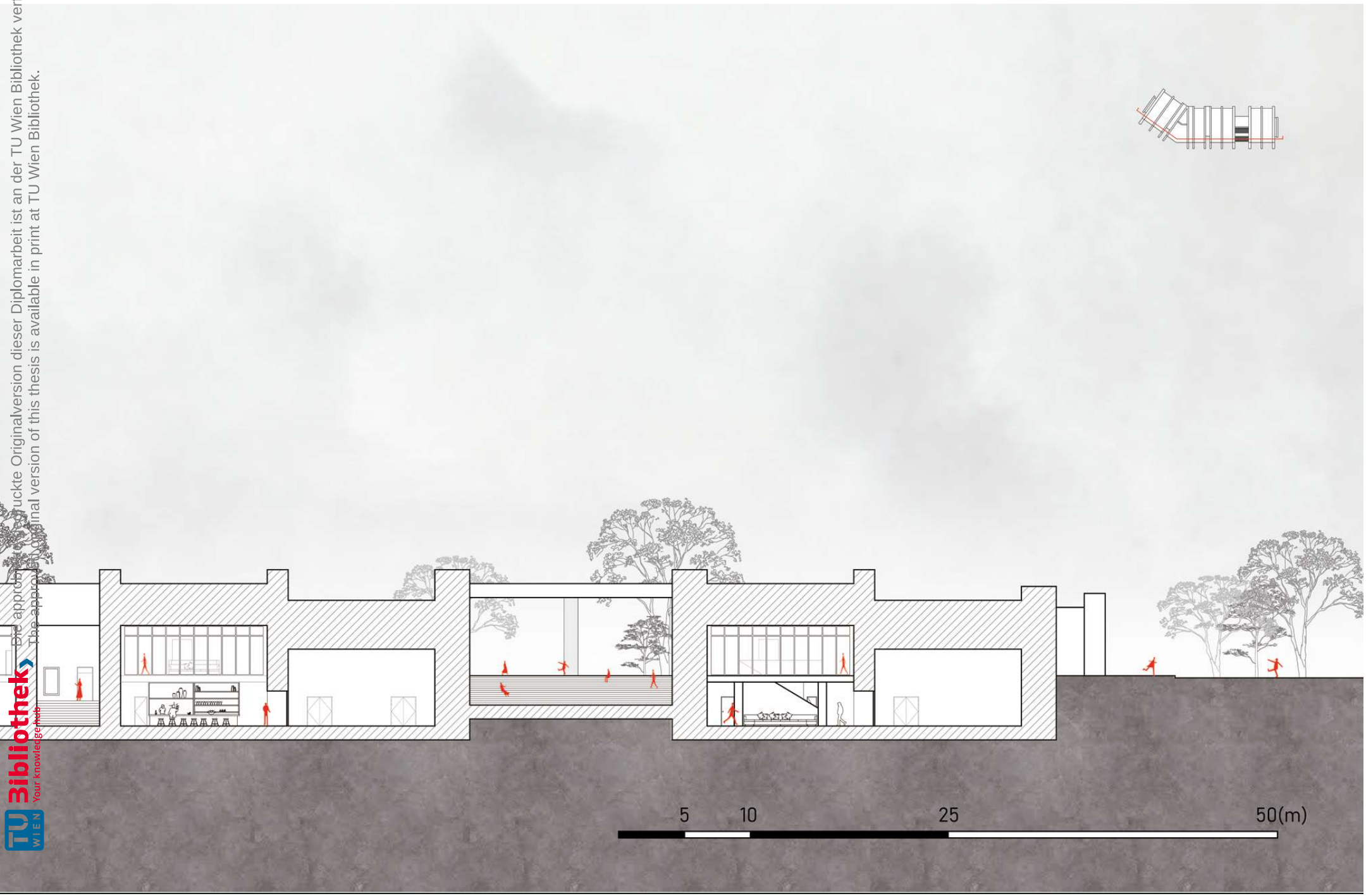
West side Elevation

6.4
Sections

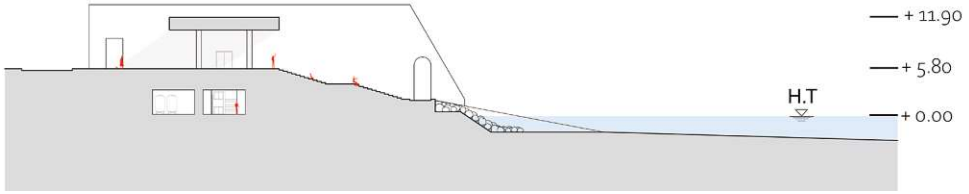
Long section view_1 (corridor)



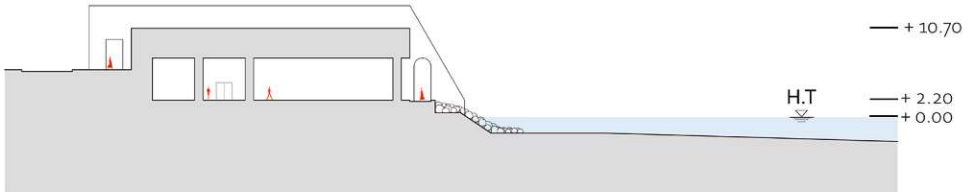
Long section view_1

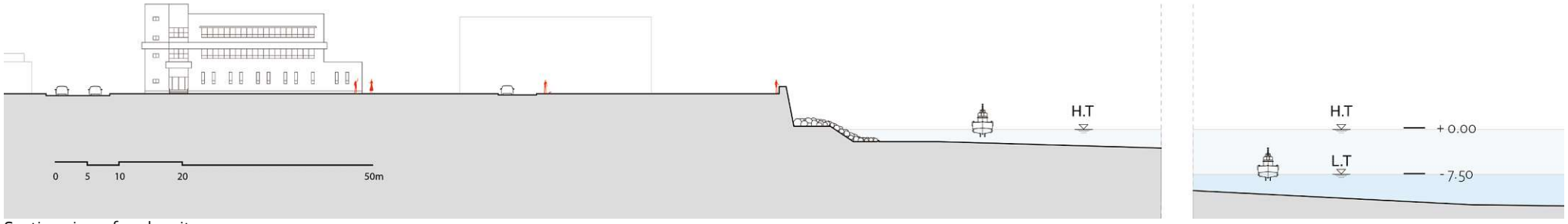


Type - A



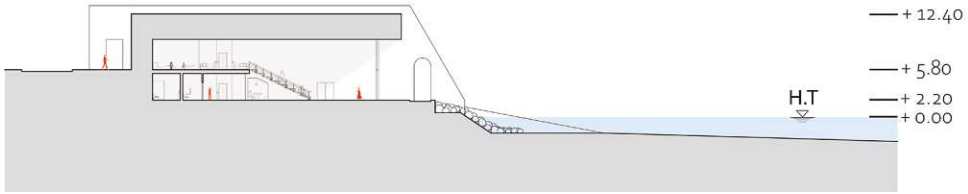
Type - B



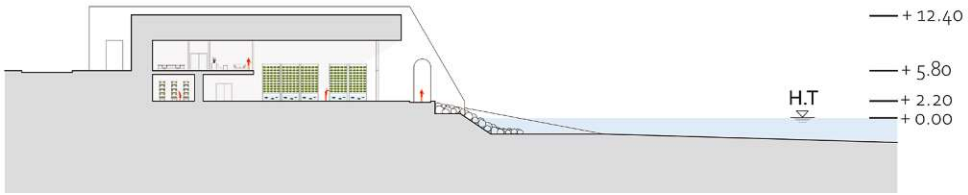


Section view of each unit

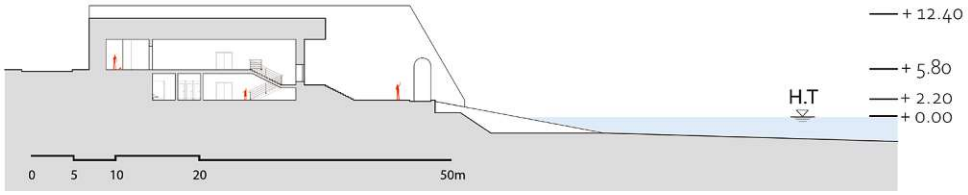
Type - C



Type - D



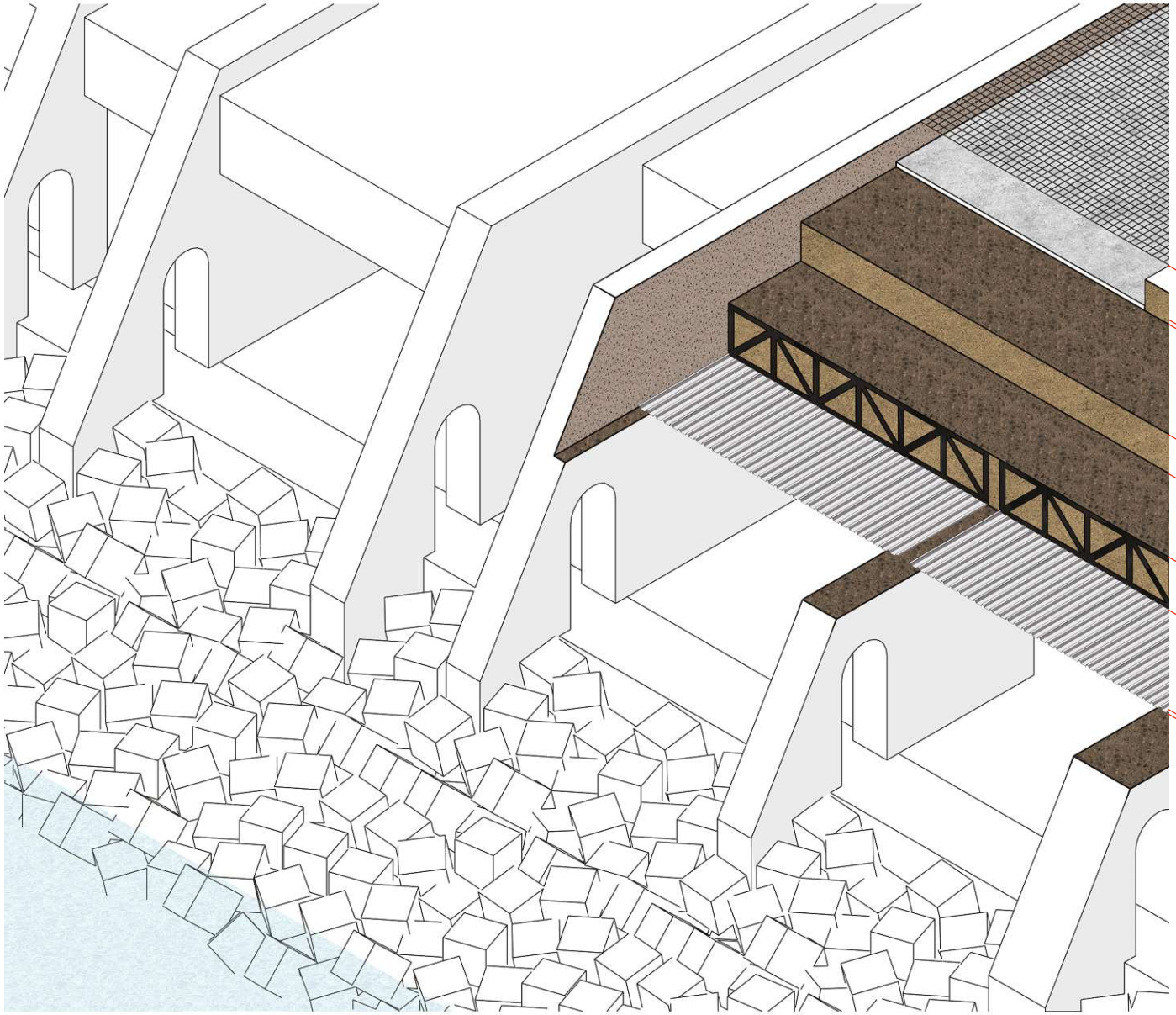
Type - E



Section view of each unit

6.5

Structure & Facade section



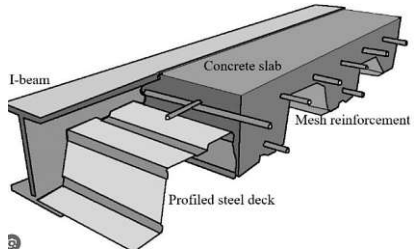
Pre-Detonation Screen

Concrete + Granite (0.3m)

Reinforced concrete (1.2m)

Embedded steel beams
in concrete (2m)

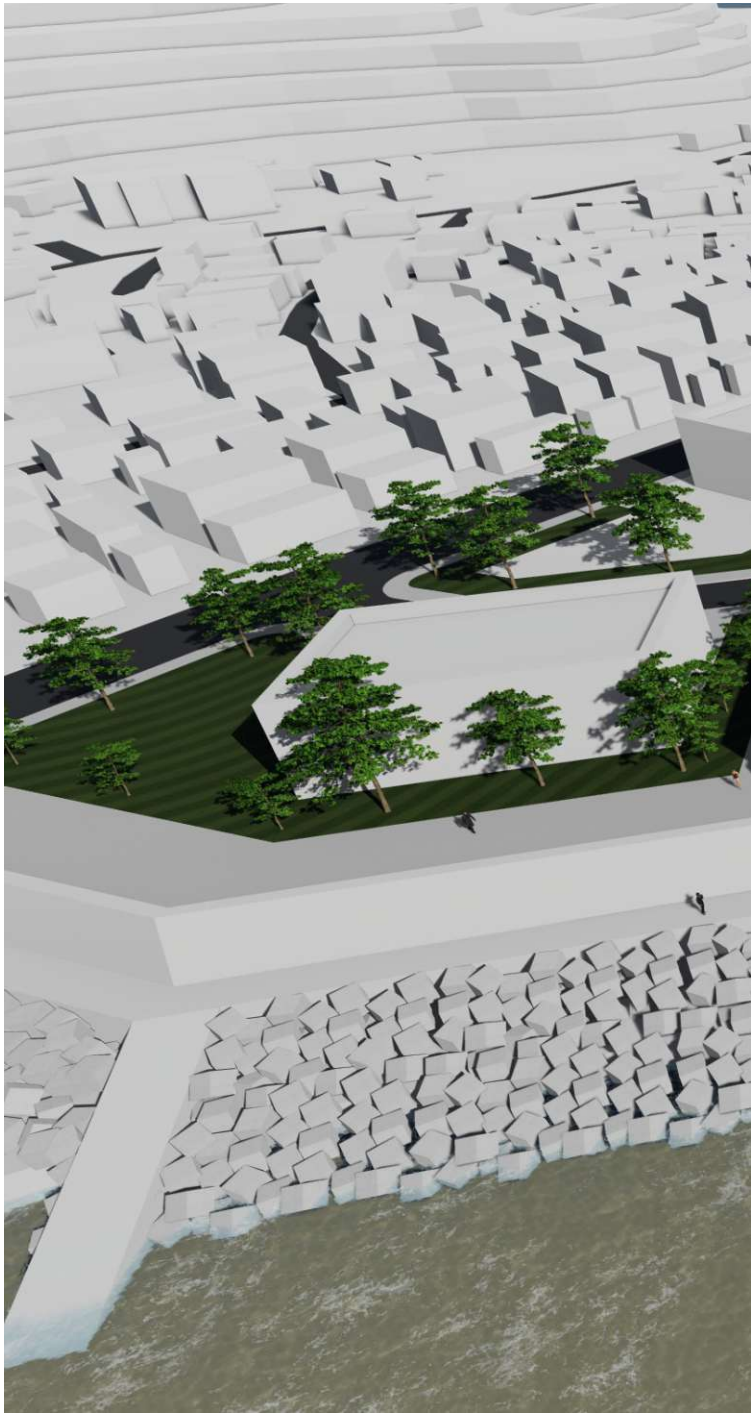
Corrugated steel plate



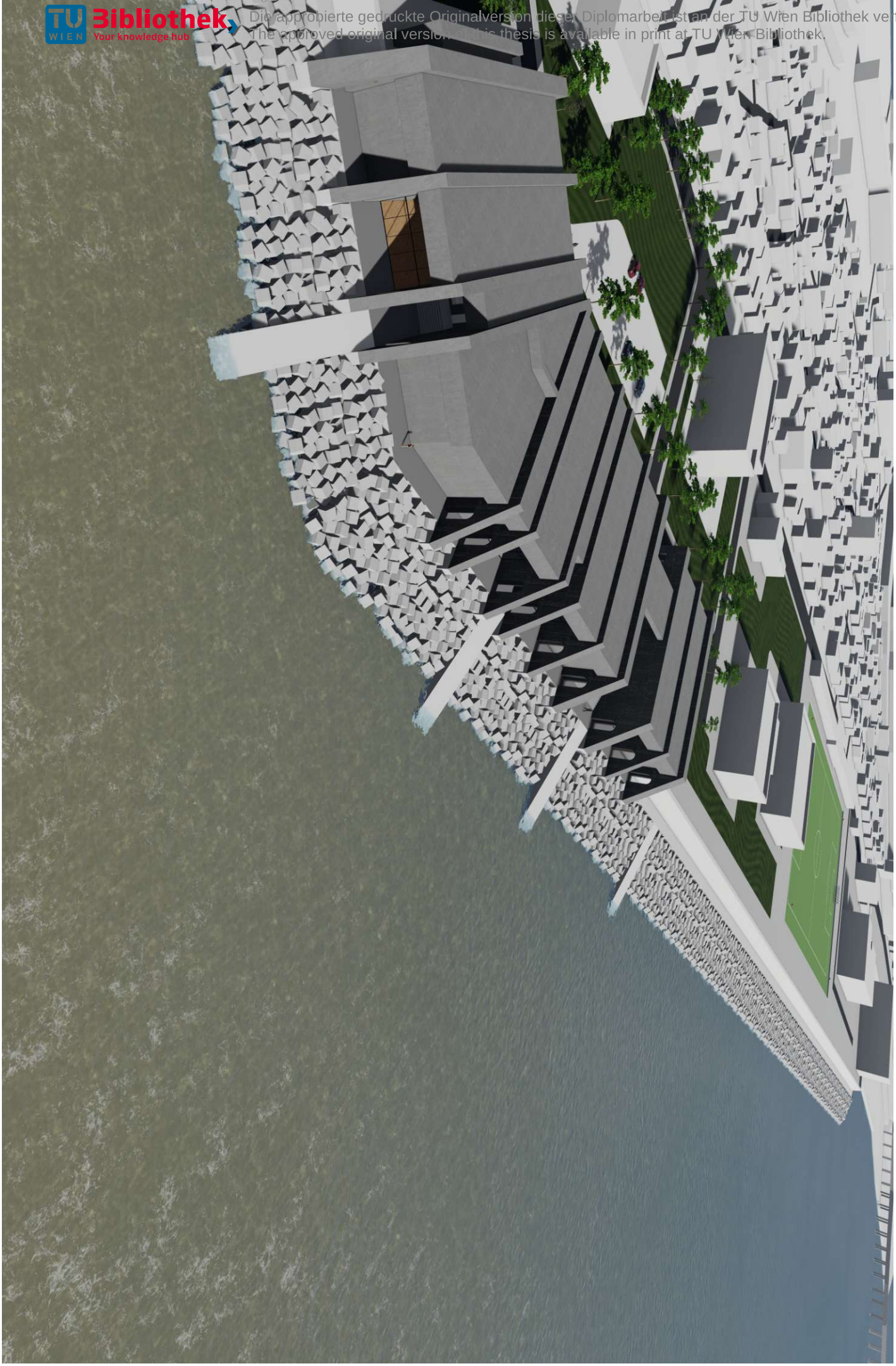
Construction design axonometry

6.6

Visualizations

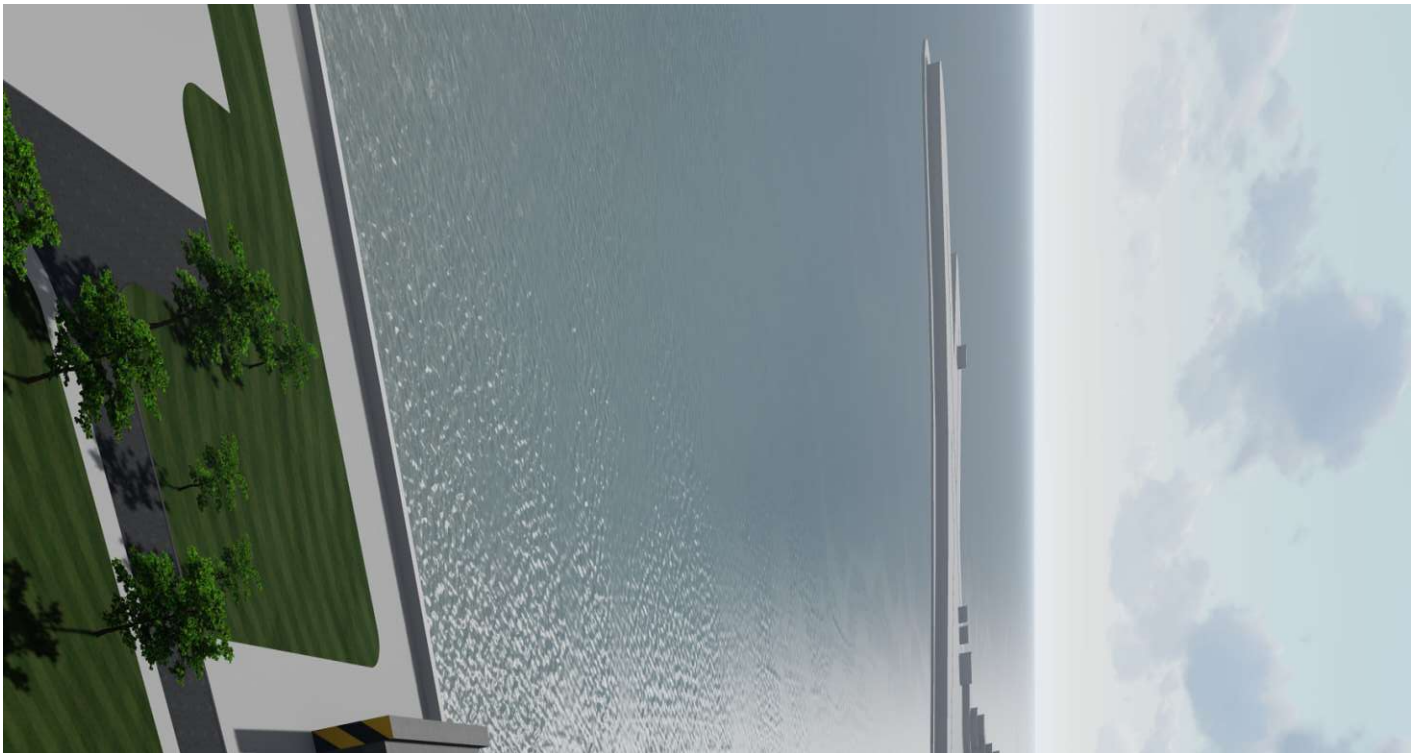


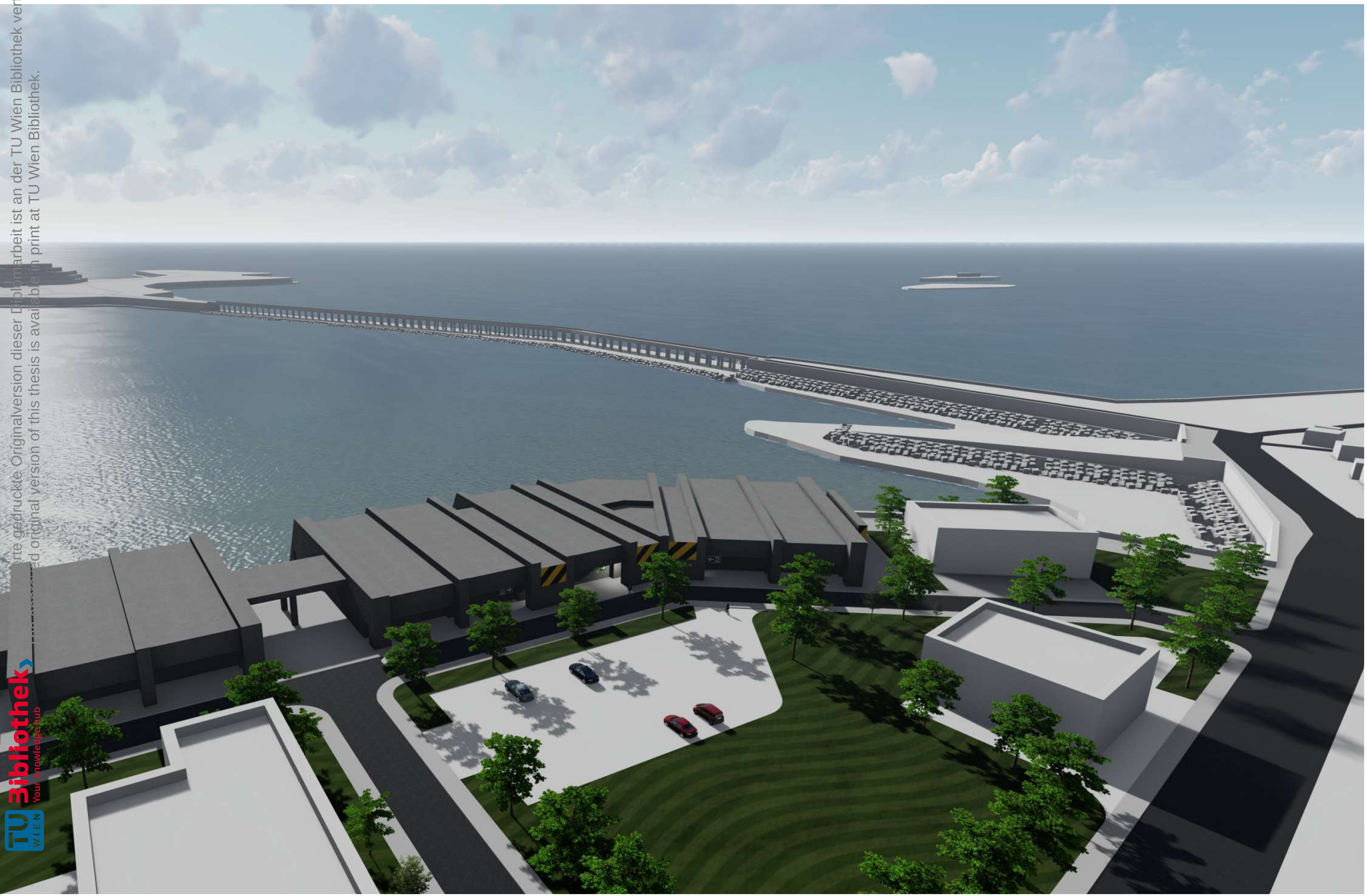
South side



Entrance / North side

North side





Event space / Interior perspective

Office / Vertical farm / Interior perspective

6.7 Animation Clips

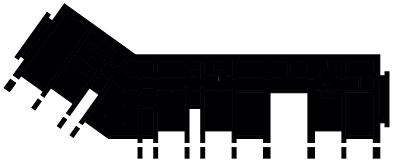
07 Evaluation

Bruttogrundfläche

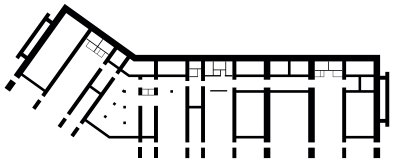
Konstruktionfläche

Nettoraumfläche

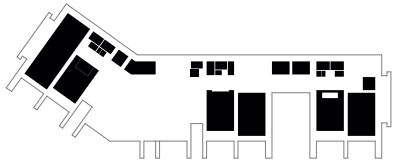
KG



BGF : 4,176.15 m²
100%

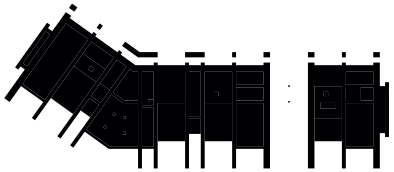


KGF : 1,366.87 m²
32.73%

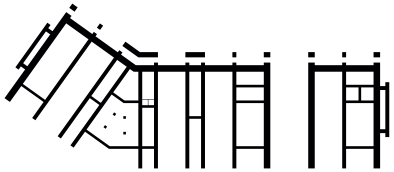


NRF : 1,455.93 m²
34.86%

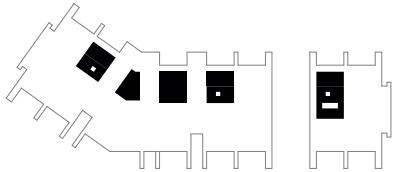
EG



BGF : 4,464.62 m²
100%

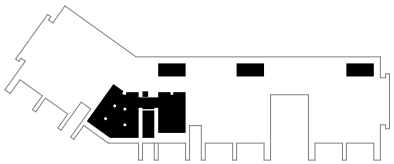


KGF : 1,417.42 m²
31.74%

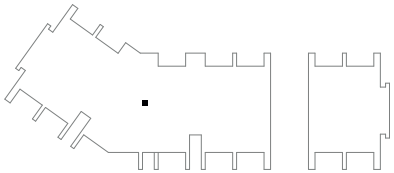


NRF : 619.06 m²
13.86%

Technikfläche

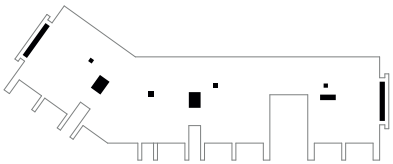


TF : 682.97 m²
16.35%

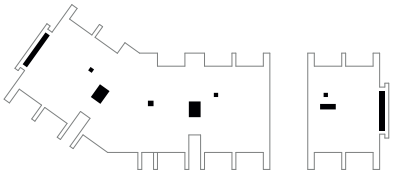


TF : 4.52 m²
0.1%

Verkehrsfläche

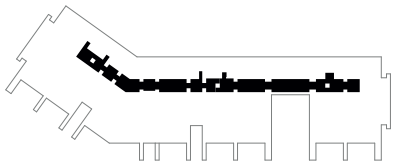


VF : 139.04 m²
3.32%

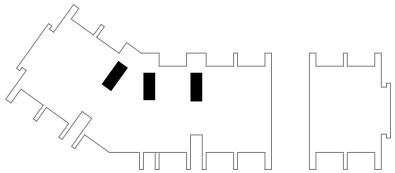


VF : 139.04 m²
3.11%

Verkehrsfläche / Korridore



Korridore Fäche : 531.34 m²
12.72%



Korridore Fäche : 146.25 m²
3.28%

08 Attachment

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List of Figures

Fig.40
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Fig.41
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The author DOKYUN JUNG drew all other pictures, plans, illustrations, and visualizations.