From survival to revival:

A new water management way for upper reaches of Tarim river integrated a sustainable livelihood design



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A new water management way for upper reaches of Tarim river integrated a sustainable livelihood design

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LANDSCAPE ARCHITECTURE

Acknowledgment

I am always exploring what is the limit of a landscape architect. This thesis is one of my explorations in an extreme location. It gives me a nice journey to get into a place I have never been to. The final results show the beauty of extreme, the limitation of extreme, and the possibility of extreme. It is also represented what I have learned in TU delft.

For the past year, I would like to give big thanks to my mentors, Inge Bobbink and Luiz Marcos de Carvalho Filho. Thank you for your patient, kind and clear touring. You gave me instruction when I am in chaos, gave me encouragement when I was lost, and gave me ideas when I was blank-minded. Thank you for your accompany in my exploration and bring me back when I was out of the boundary.

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I would like to thanks my indoor plants. Even though you just come to my room one month, but in this important month, you stopped me in the exploring path every now and then, which let me feel tired.

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Reference

Abstract

Water scarcity is a problem not only in the Tarim river but worldwide. Starting from water scarcity in the upper reaches of the Tarim River, this research focuses on exploring the possible solution for water scarcity and unsustainable livelihood for farmers in this region. By referring to similar cases and literature, principles of water-saving, afforestation, and new circularity were concluded to solve those problems. During the design process, the possibility of the upper reaches of the Tarim River was explored by the method of logical system and mapping. This project brings a new water system, farming method, and forest to this region and by those new elements could formulate a new solid circularity. In this design-based research, solutions for water scarcity and sustainable livelihood are explored, experimented , and achieved in the upper reaches of the Tarim River.

01. Fascination

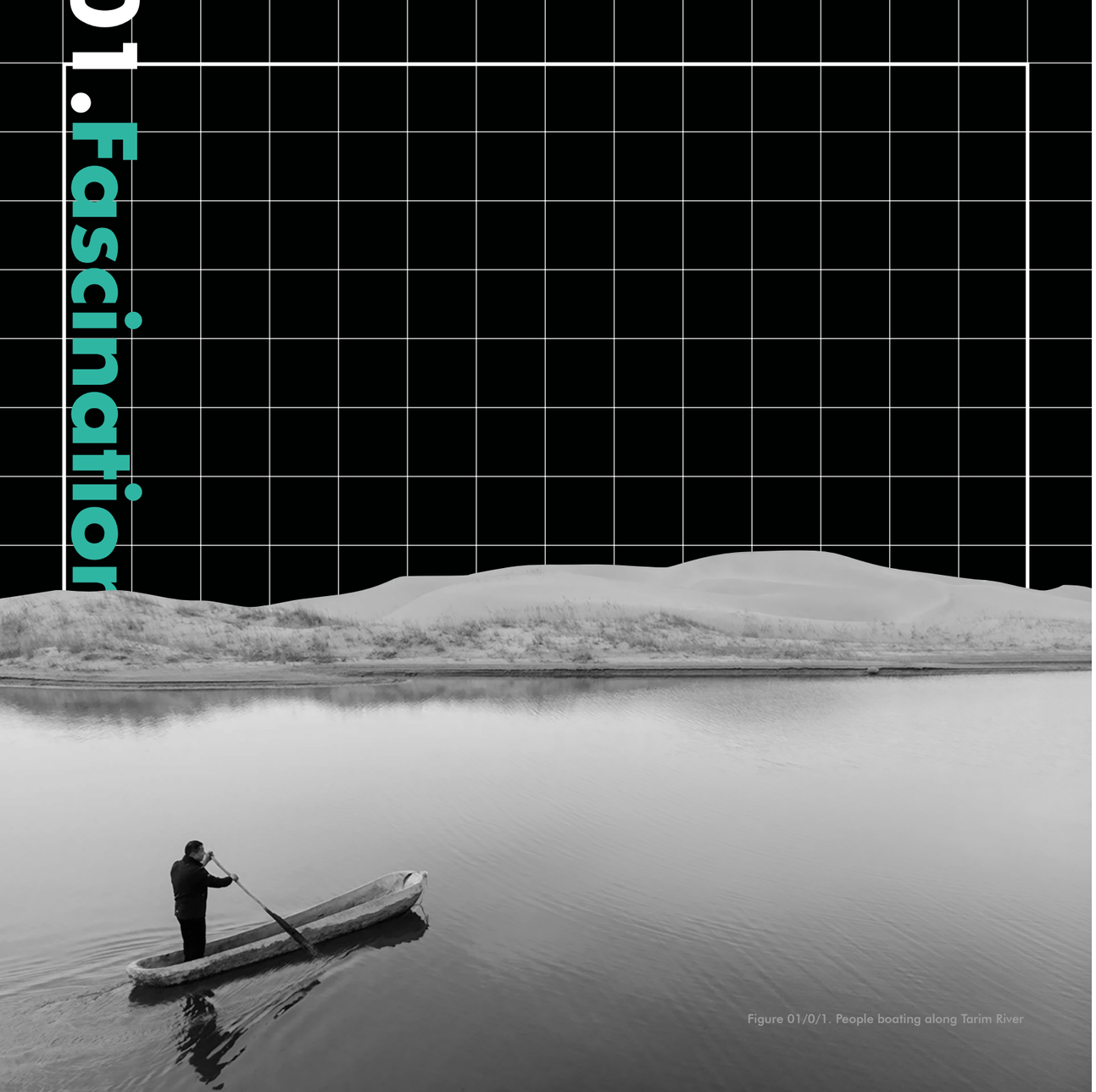
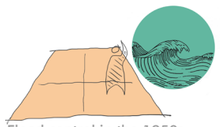


Figure 01/0/1. People boating along Tarim River

01.1 Huge change of living in Tarim River

My strong interest of this project arose from one widely spread word which described how people's life along Tarim river changed in the last 70 years. "Flood control in the 1950s, flood irrigation in the 1960s, water saving in the 1970s, drought resistance in the 1980s, and flow cut off in the 1990s. So what about 21st century? "said by a farmer lived in upper Tarim river.

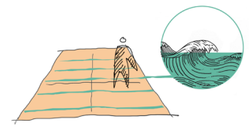
Those huge changes are mainly arose from human everlastingly utilizing water resources. As a consequence, human's lifestyle has changed a lot because of water issues.



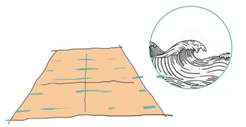
Flood control in the 1950s



Flood irrigation in the 1960s



Drought resistance in the 1980s



Flow cut off in the 1990s

Figure 01/1/1. People action changes during times

01.2 Amazing landscape, folk custom and people along Tarim River

Meanwhile, there are still other multiples aspects that attract me to give an insight to the Tarim River. As a person who used to live in the south part of China, many aspects along the Tarim River are different from where I live, which appeals to me a lot.

The river landscape and desert landscape are amazing for their dynamic, color, and dryness. As a river mainly relies on the snow melting and rainfall in the headstreams, Tarim river runoff change dramatically in different seasons. It could perform like a normal stream in the winter while could be hundreds of meters wide in the summer. The colors along the Tarim river also change a lot because of the different ingredients. The farmland, the riparian forest, and the desert all are the composition of this colorful landscape. And the most dominant characteristic of this landscape is its dryness. As one of the driest parts of china, it always attracts plenty of views from tourists and naturalists by its unique quality.

The unique folk custom in the Tarim river basin is one of the most strong impressions of people living in the south part of China. Most people here are still following their traditional living way. They are still farming, fishing, barbecuing, gathering, and dancing along the Tarim River. Moreover, they are still keeping their purity, hospitality, passion, and optimism.



Figure 01.2.1 Upper stream aerial view



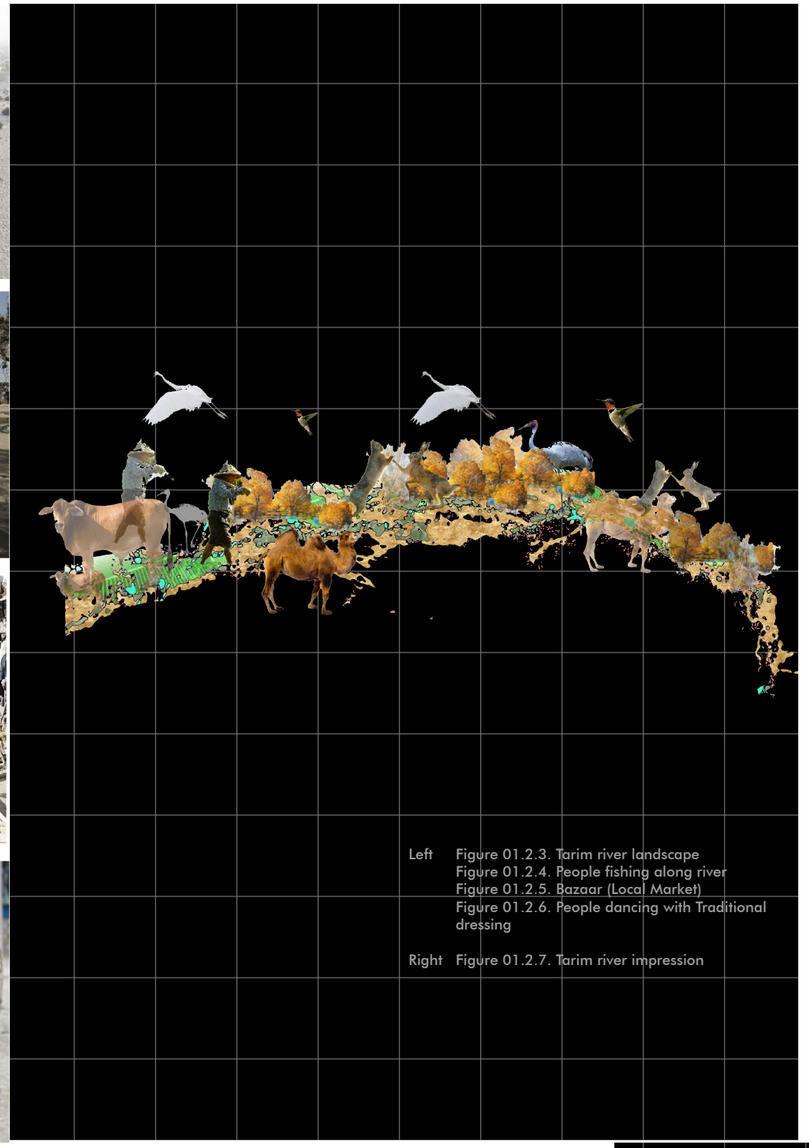
Figure 01.2.2. Lower stream aerial view











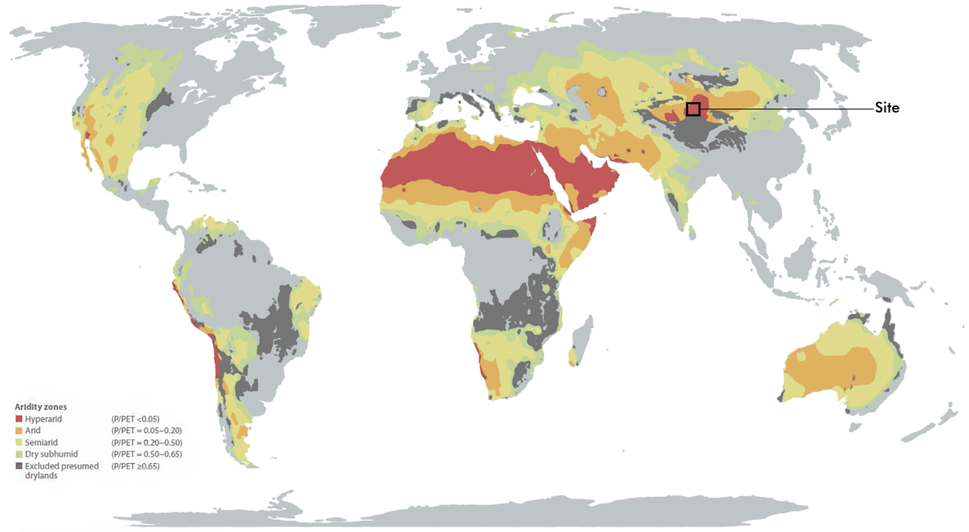
Left Figure 01.2.3. Tarim river landscape
Figure 01.2.4. People fishing along river
Figure 01.2.5. Bazaar (Local Market)
Figure 01.2.6. People dancing with Traditional dressing

Right Figure 01.2.7. Tarim river impression

01.3 Water scarcity worldwide

Besides characteristics of the Tarim river mentioned which fascinated me above, there is also another reason that I want to start this project. Water scarcity is getting worse under the circumstance ff climate change. Based on the UNESCO data, 1.42billion people are currently living in areas of high or extremely high water vulnerability. And in the future, it is estimated that about 4.8-5.7 billion people will suffer water scarcity at least one month a year. Thus, the issue of water scarcity could be one of the most important issues which people will encounter in the future.

The water scarcity problem within the Tarim river basin is complicated. It is not only because of the physical extreme condition but the methods of people deal with it. Thus, diving into in Tarim river basin could also be both challenge and a chance for me. It tests the possibility of a landscape architect and helps me to have the experience to experiment with the principles and toolboxes for water scarcity.



Note: P = precipitation and PET = potential evapotranspiration.
Source: UNEP-WCMC (2007)





Top Figure 01.3.1. Arid and semi-arid region in the world
Bottom left Figure 01.3.2. Running water shortage
Bottom Right Figure 01.3.3. Children taking water from a well

02: Context
Tarim River Basin

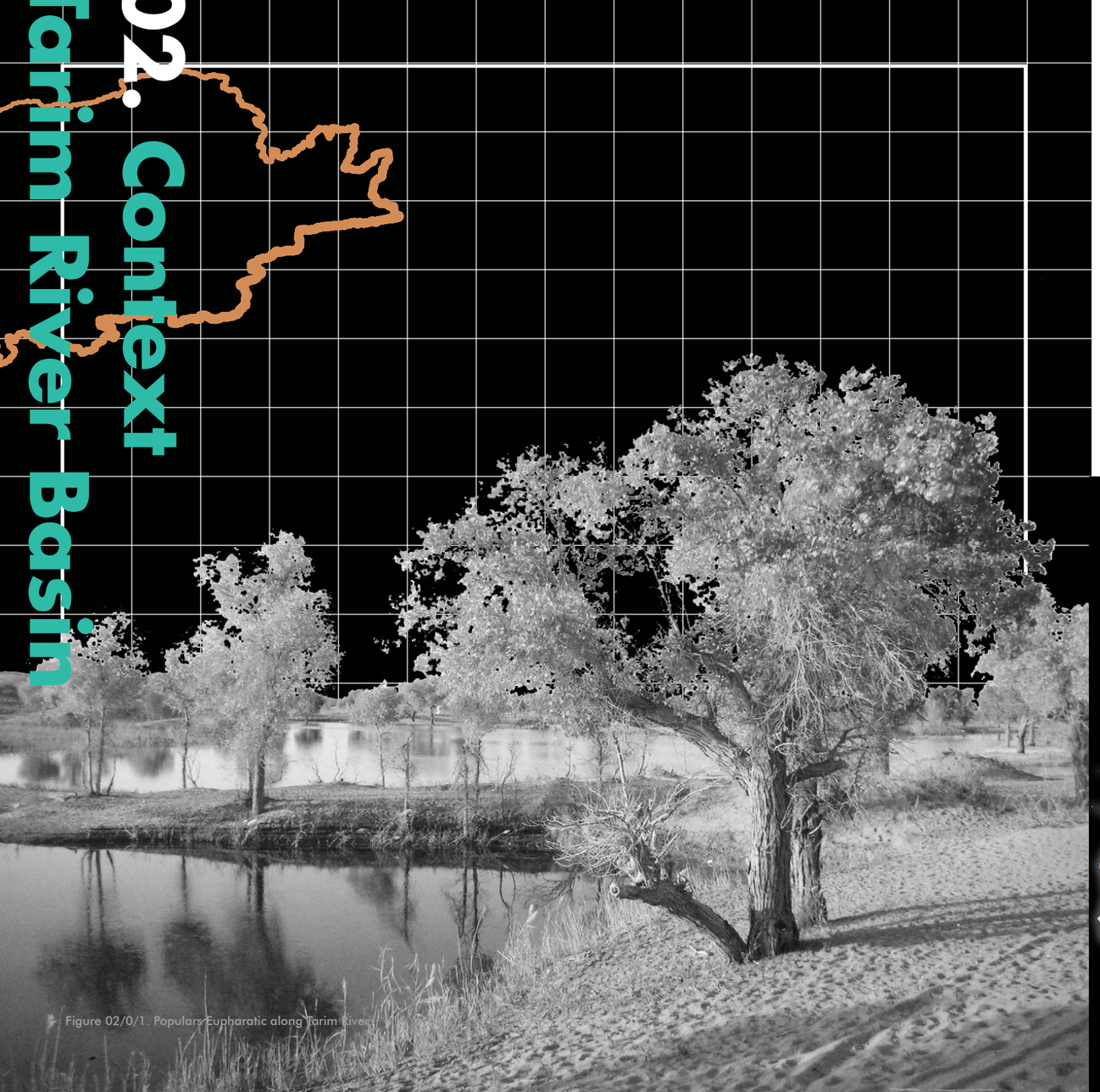


Figure 02/0/1. Populars Euphratic along Tarim River

02.1 General information

Tarim river basin, located in the southern part of Xinjiang Uygur Autonomous Region, is the largest endorheic basin in China. It contains the Tarim river and streams merged into the Tarim River. Because of the climate and long-distance to oceans, the center of the Tarim river basin is a huge desert named the Taklamakan. People living in this basin are mainly in the edge mountainous region and rely upon the water from the Tarim River and its headstreams.

Based on UNEP definition, most parts of the Tarim river basin area in the hyperarid and arid zone. Influenced by the landform and location in Eurasia, the climate type is a temperate continental climate. The yearly evaporation amount could be 2500mm to 3400mm while the yearly rainfall is less than 50-100mm. Thus, the Tarim river gets water from headstreams and only a little rainwater could join the river in the journey.

The name of Tarim means uncontrollable horses in the local language, and it describes the easily changeable watercourses of this river in this sandy environment. However, with the construction technology improvement and population growth, people start to control the watercourses and fully exploit the water sources of the Tarim River. This uncontrollable river is seriously nowadays controlled and affected by human activities, might not in a positive way.

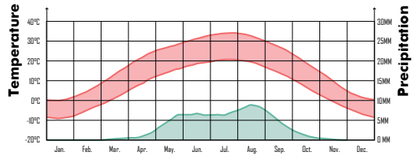


Figure 02.1.1. Temperature and precipitation in Upper Tarim river

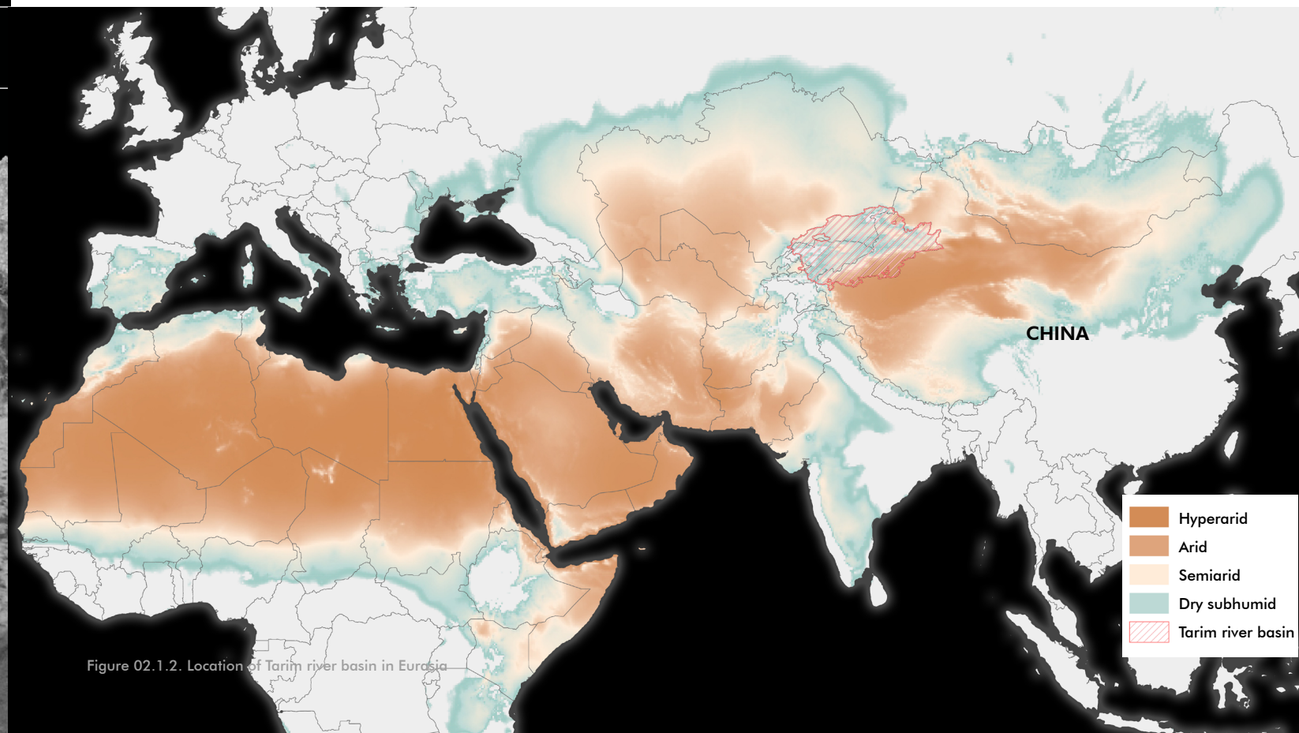


Figure 02.1.2. Location of Tarim river basin in Eurasia

02.2 Water system

Tarim River system contains 4 headstreams and one mainstream. Water from snow, rain, and ice gathered in high mountains at basin edges, carrying sand, flows to the basin center, then heads east. Due to high temperature and topography, the Tarim river ends up in lakes instead of oceans and sometimes would cut off because of lacking water in the dry year.

The water of the Tarim river is mainly from the Aksu river, and Kaidu-konqi river is controlled by humans and re-watering in the dry season to mitigate the water shortage in the lower Tarim River. The runoff of the Tarim River changes based on the record from 1956-2016, the dry year and water-rich year could have a huge amount of difference. For instance, the amount of water in 2009(Dry) is 1.41 billion cubic meters while it is 2.32 billion cubic meters in 2010 (Rich). Meanwhile, about 70-80% of the yearly runoff happens between June and October.

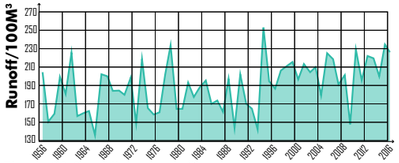


Figure 02.2.1. History runoff

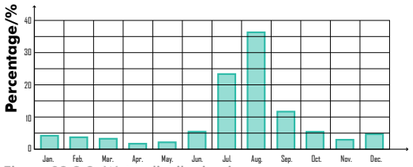
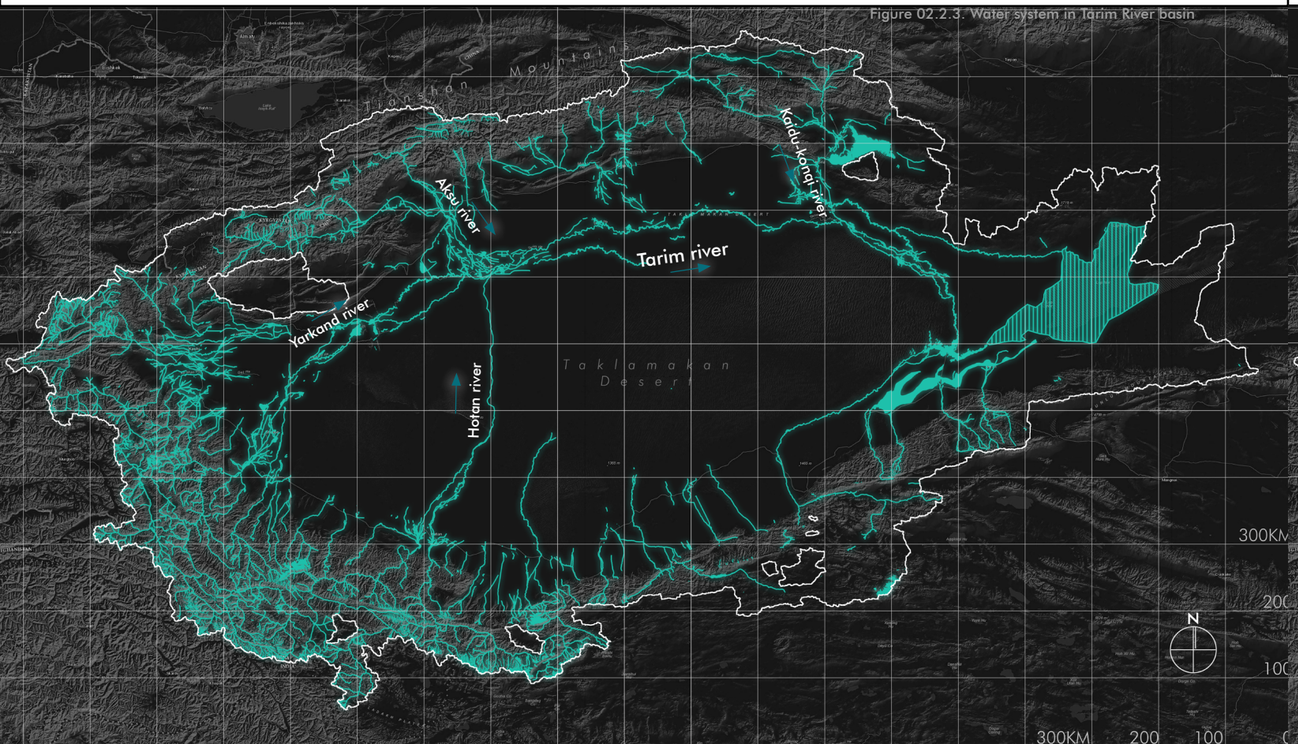


Figure 02.2.2. Water distribution in one year

Figure 02.2.3. Water system in Tarim River basin



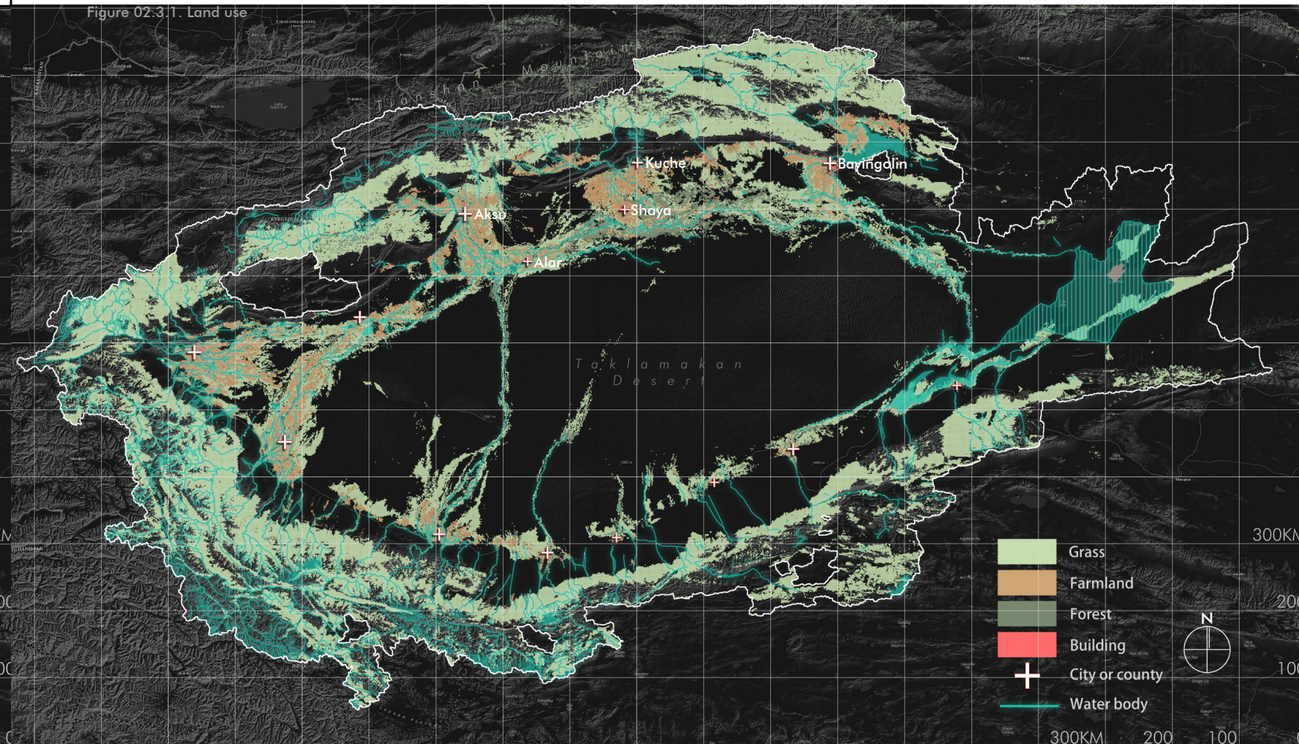
02.3 Human settlement

The total population of the Tarim River basin is approximately 11 million, and it is one of the biggest Uyghur ethnic group gathering regions in China. According to 2012 data, the urbanization rate of the Tarim River basin is 29.38%. Most people live in a suburban area and live in a traditional farming way.

To survive in this dry and sandy environment, human settlement and production activities mainly happen at the edge of the Tarim basin where is relatively more humid and water-rich comparing with the desert in the center. Meanwhile, the Tarim River provides another lifeline for people in the desert environment. People rely on the water and oases brought by the river to live and plant crops such as cotton and grape.

The farmland area is also highly connected with the river system, and it is more closed to the headstreams and, upper and middle parts of the Tarim River. Because of the unstable water supply in the lower Tarim River, agricultural activities are less active.

Figure 02.3.1. Land use



02.4 History change

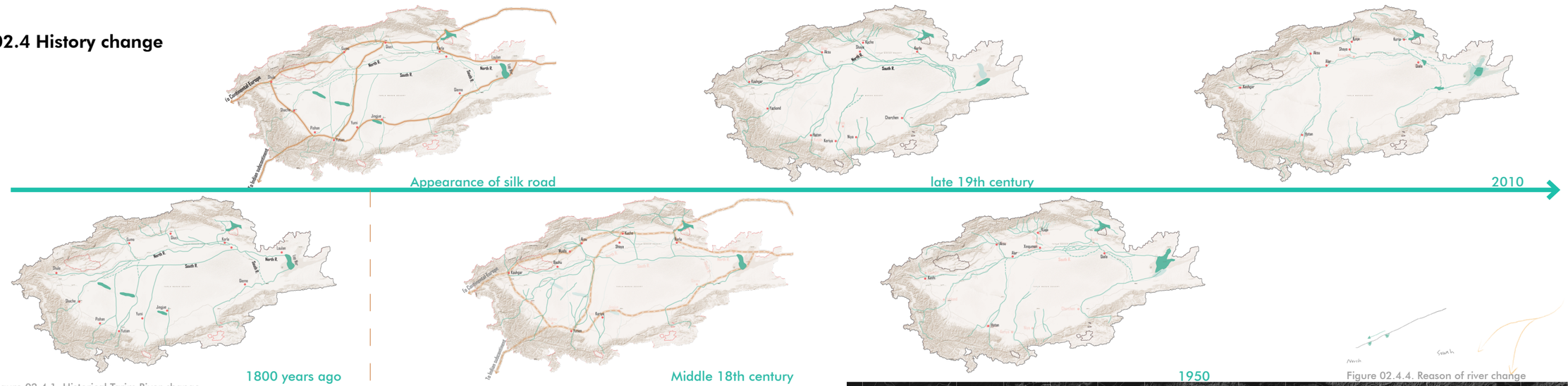


Figure 02.4.1. Historical Tarim River change

The appearance of silk road brought long time history of perspective for this region.



Figure 02.4.2/3. Old drawings about silk road

In the dynasties of Two Han and Northern Wei (1800 years ago), 9 headstreams could reach the Tarim river and vast amounts of water helped the Tarim river to reach Lop Nor, a big salt lake. During that time, there were Tarim North and Tarim South two parts heading east parallelly.

The existence of the Tarim river system provided the foundation of the appearance of the Silk road. The Silk Road, a trade network connecting east and west, was mainly happened on the edge of the Tarim river basin. The only part which connected the north and south part of the silk road from Qiuci and Yotian relied on the oases of the Tarim River.

During the middle 18th century, the silk road starting to disappear. The Tarim north river had disappeared and many tributaries still joined the Tarim river except the Keriya river.

In the late 19th century, the Kuche river in the north part lost its connection with the Tarim river while other tributaries also still contributed to the Tarim River. The mainstream of the Tarim river at this time was tortuous and with many branches.

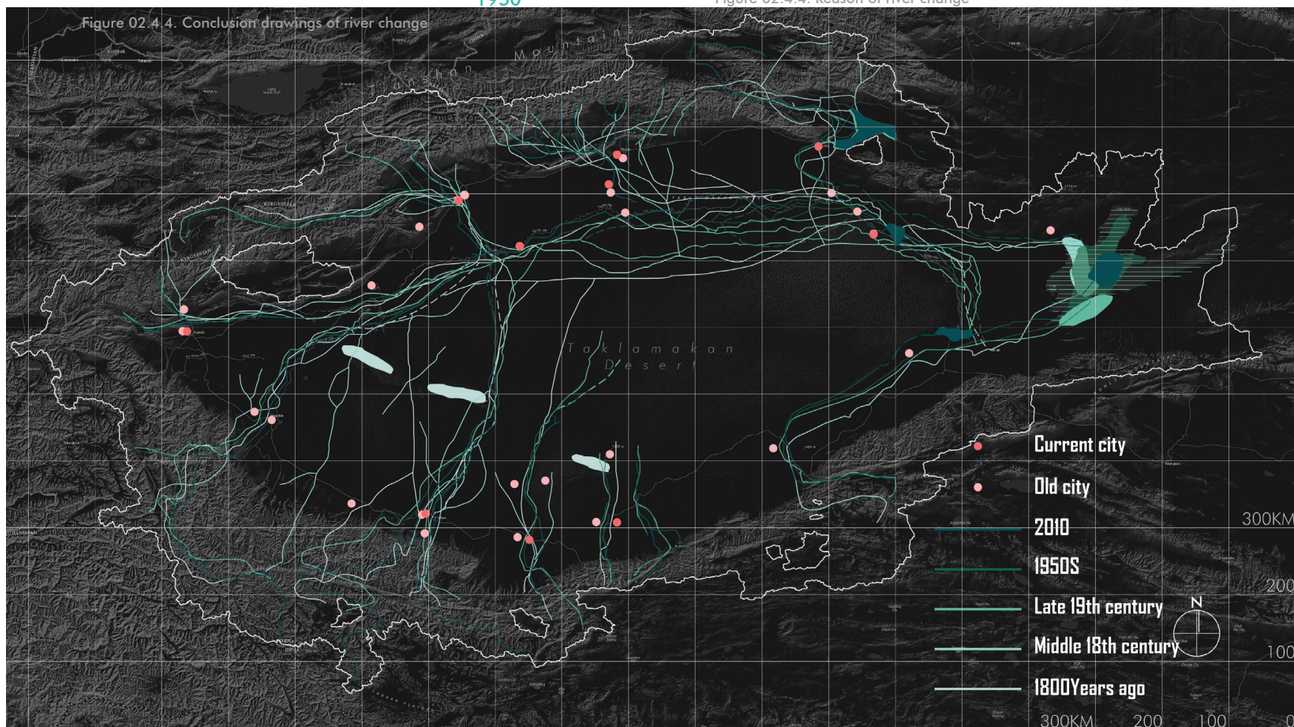
In the map of the late 1950s, many tributaries lost their connection with the Tarim river including the Weigan river in the north. Comparing with the Tarim river in 1800 years ago, the headstreams decreased from nine to four. And the lower part of the Tarim river cannot reach Lop Nor in the dry season.

And in the current situation, Tarim totally lost its connection with Lop Nor and gets shorter and shorter. Many old cities along the Tarim River including Jingjue and Keriya disappeared with the change of the Tarim River.

In conclusion, the Tarim river mainstream headed north a lot and lost many connections with its tributaries. The dramatic change of river has three main reasons including the basin topography with higher south part, sand movement by the northern east prevailing wind, and climate-hydrologic fluctuations.

Figure 02.4.4. Reason of river change

Figure 02.4.4. Conclusion drawings of river change



02.5 Silk road remains

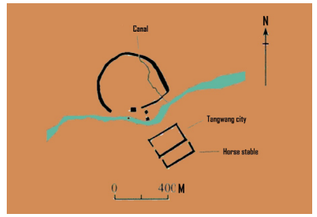








Figure 02.5.1. Map of Tangwang city
Figure 02.5.2. Outside image of Tangwang city
Figure 02.5.3. Inside image of Tangwang city
Figure 02.5.4. Image of Tangwang city wall

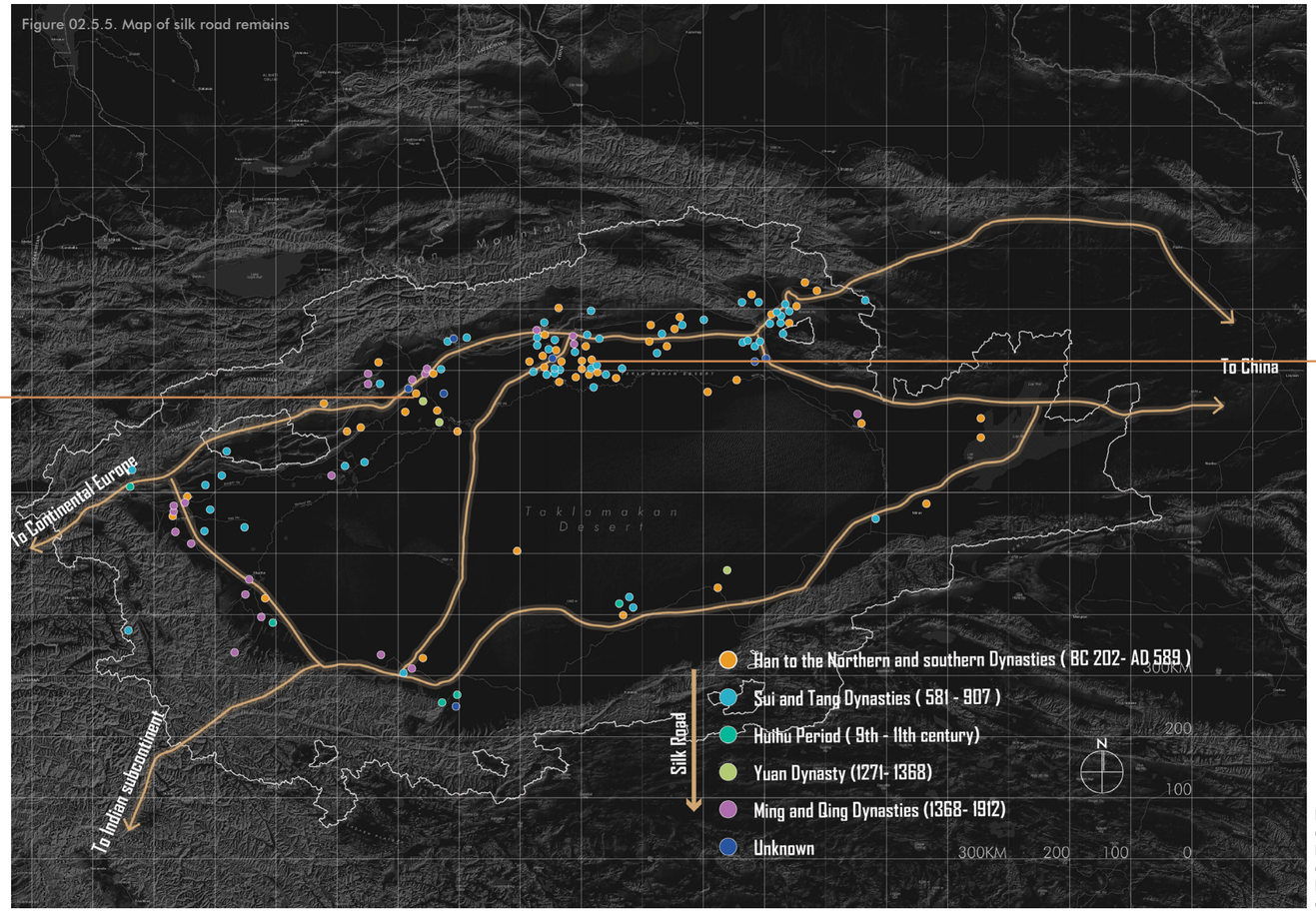
The appearance of the silk road for centuries left a lot of heritage in the Tarim river basin. Thanks to the dry and sandy environment, many silk road heritages could be conserved in good conditions.

The map below shows the location of recorded heritages in the Tarim river basin. And the great numbers of heritages from the Han to Tang dynasties (BC202- AD907) were founded. Compared with the south silk road, the north silk road has more dense and dynamic heritages.

The left one remains parts of Tangwang city, and it was a medium city close to the canal, built about 7-10 the centuries. Due to the environmental change especially the canal disappearing, the city disappeared. The remains are 5-7m height ramparts. The photos show the perspective outside and inside of ramparts.

On the right side are heritages closer to modern times. The first two images are about a Beacon tower and the third image is a copper smelting site.

Figure 02.5.5. Map of silk road remains



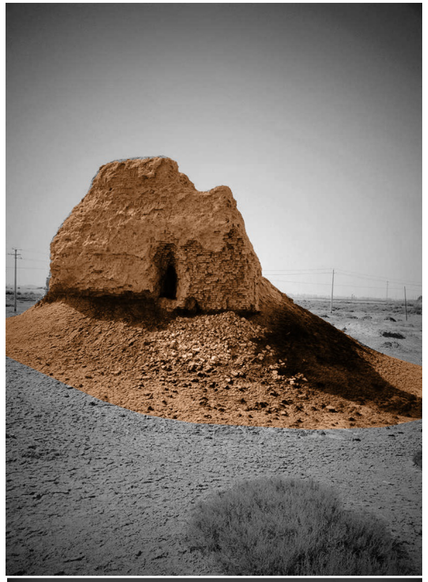






Figure 02.5.6. Image of Beacon tower
Figure 02.5.6. Image of Beacon tower
Figure 02.5.8. Image of copper smelting site

02.6 Agriculture and river distribution in Tarim River Basin

Based on the government statistics, people consumed more than 97% of water for agricultural activities while industrial water consumption and daily usage is less than 3%. The current type of irrigation method is still the traditional way, which uses a large amount of water to flood the fields. Only 28% of fields upgrade to the high efficient water-saving method like drip irrigation. The main crops within the basin are cotton, wheat, pears, grapes, and dears.

The Tarim river distribution strongly influences the agricultural land. With enough water supply, 3 headstreams have more agricultural land than the mainstream. In the mainstream of Tarim River, the upper stream has more agricultural land and reservoirs than the middle and lower part. In the upper stream, there are two big reservoirs and 4 small reservoirs. Based on those water infrastructures, the only city along the Tarim River was built. Alar city takes about 0.25*10^8 cubic meter water from the water system for daily and economic use.

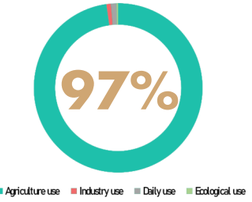


Figure 02.6.1. Water consumption type

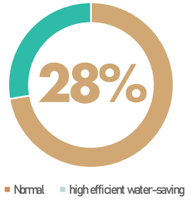


Figure 02.6.2. Water-saving farmland percentage

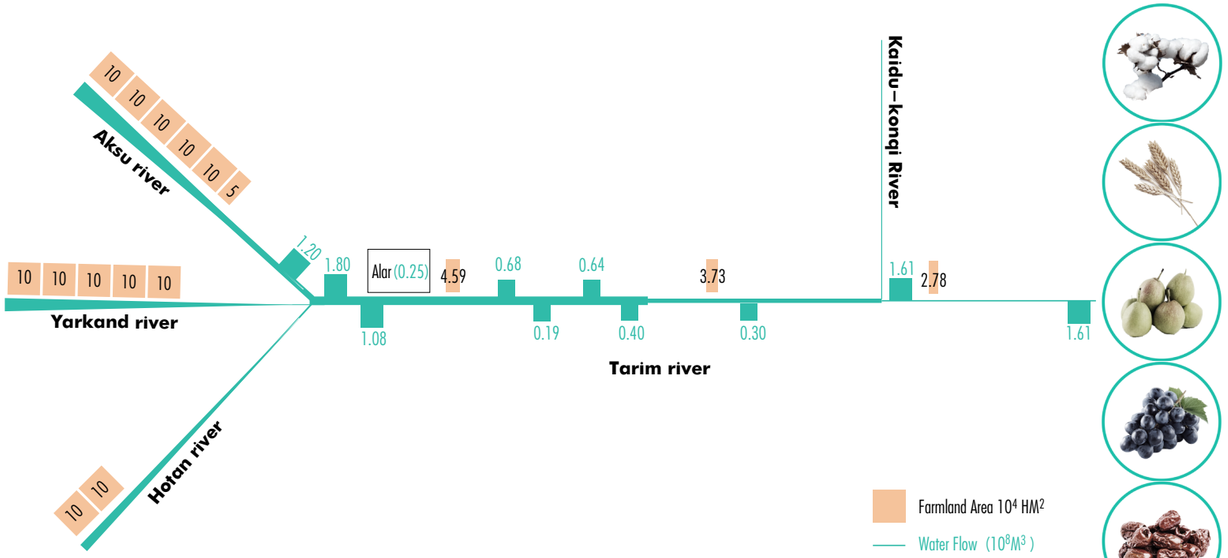


Figure 02.6.3. River distribution

Figure 02.6.4. Main crops

02.7 Government involvement



Figure 02.7.1. Policy 1: The surface water distribution of 4 Head stream and 1 main stream



Figure 02.7.2. Policy 2: Tarim river water resources management regulation

To ensure equal water accessibility for people in the whole basin and ensure constant flow for the lower stream, the government made two policies to control the water consumption by each part of the river. The surface water distribution of 4 Head streams and 1 mainstream was made in 2001 to clarify that the water amounts of water could be consumed by each headstream and the mainstream in different water frequency year1. While the Tarim river water resources management regulation was made in 2014 to regulate the use of water resources.

Based on two policies, the mainstream can get 3.174 to 6.762 billion cubic meters. For each water-consuming sector such as the farming sector, the water consumption is quite the same and the only different part is the remaining water for the ecology sector.

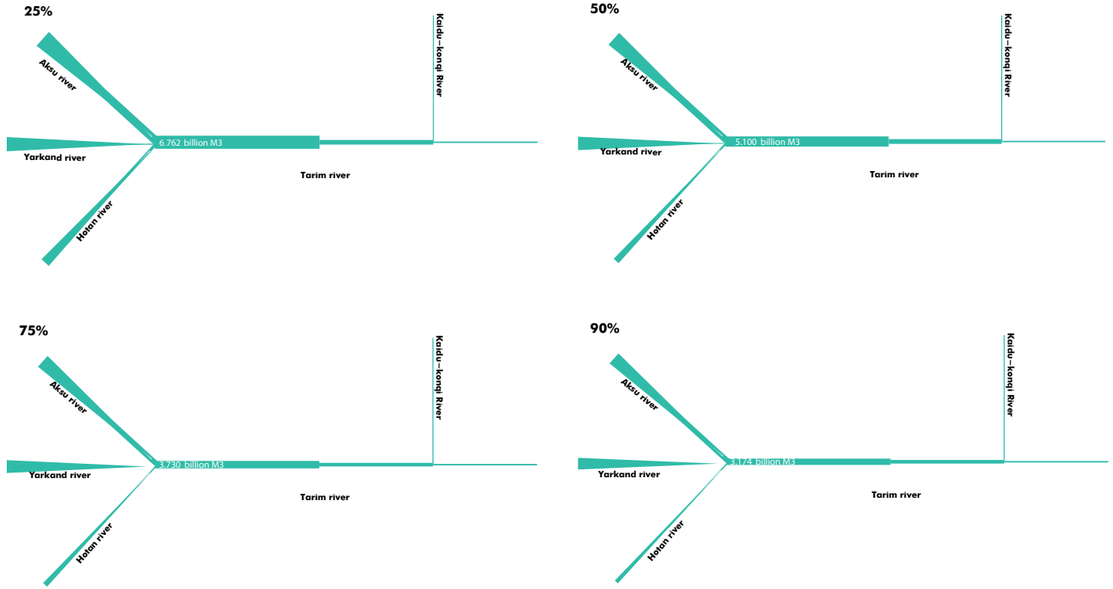
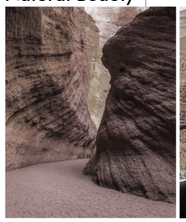


Figure 02.7.3. Water discharge plan in different water frequency year(1)

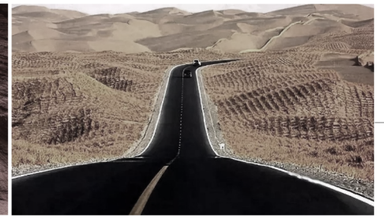
(1).Water frequency of year definition: it means how many years could reach this amount year in last 100 year. when it is 90%, it means 90 years could get this amount of water. It means that it is extremely dry.

02.8 Tourism

Natural Beauty



Gobi canyon



Road in desert



Tianshan Goddess Tree Garden



Euphrates euphratica forest in Luntai

Heritage



Kizil Caves



Silk road remains

Folk custom



Luobu Village



Uyghur festival

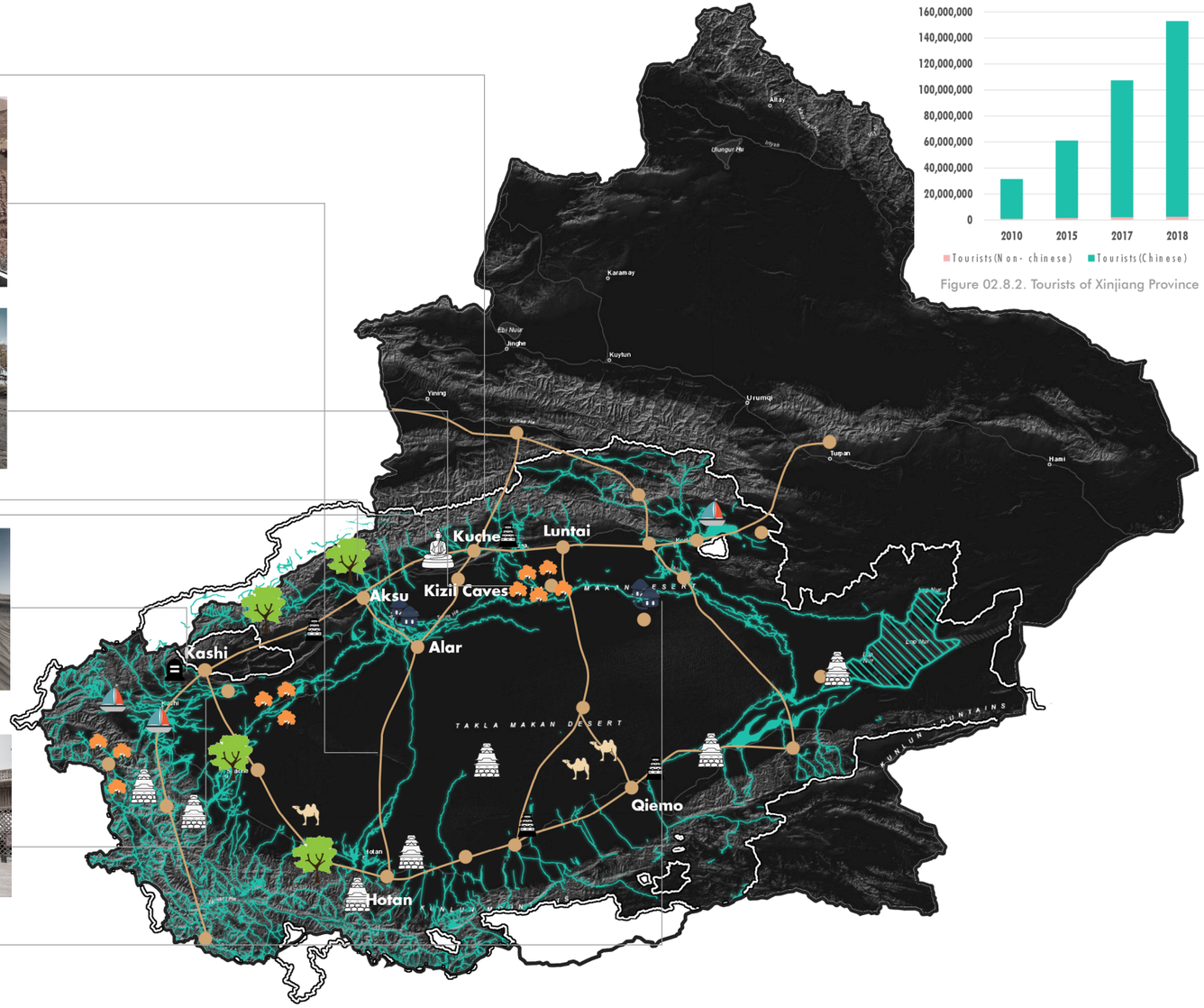


Figure 02.8.1. Tourism route and resources in Tarim basin

Figure 02.8.2. Tourists of Xinjiang Province



Figure 02.8.3. Tourists stay time of Xinjiang Province

Tarim river basin is famous in China for its rich tourism resources. It contains natural beauty, heritage, and folk customs.

Thanks to unique terrains, the Gobi landscape, and Wind-erosion landscape could be found at the edge of the Tarim river basin. And in the center of this basin, there is only the Taklimakan desert. Meantime, the Tarim river also creates a different type of forest landscape in oases.

The heritage is maintained quite well because of drought. Currently, the famous heritage is the Kizil caves and several silk road remains.

Folk custom is also a special attraction in the Tarim river basin, the Luobu Village and Uyghur ethnic groups have a more different traditional custom when compare to other parts of China.

Tourism is a fast-developing sector in Xinjiang province, whose south part is mainly the Tarim river basin. From 2010 to 2018, the number of tourists increased from 30 billion to 150 billion. The stay time for tourists is mainly between 3-7days. The fast grow tourists will also affect the water resources in some fields.



Figure 03.0.1. Farmland along Tarim river

03. Project Diagnosis

03.1 Problem Field 1- Water scarcity

03.1.1 Result- Getting shorter river

Water scarcity is a problem that always exist in the area. In the past, because of low population and farming technology, the exploitation of water resources was under natural capacity. But in modern context, water scarcity become more serious and influential.

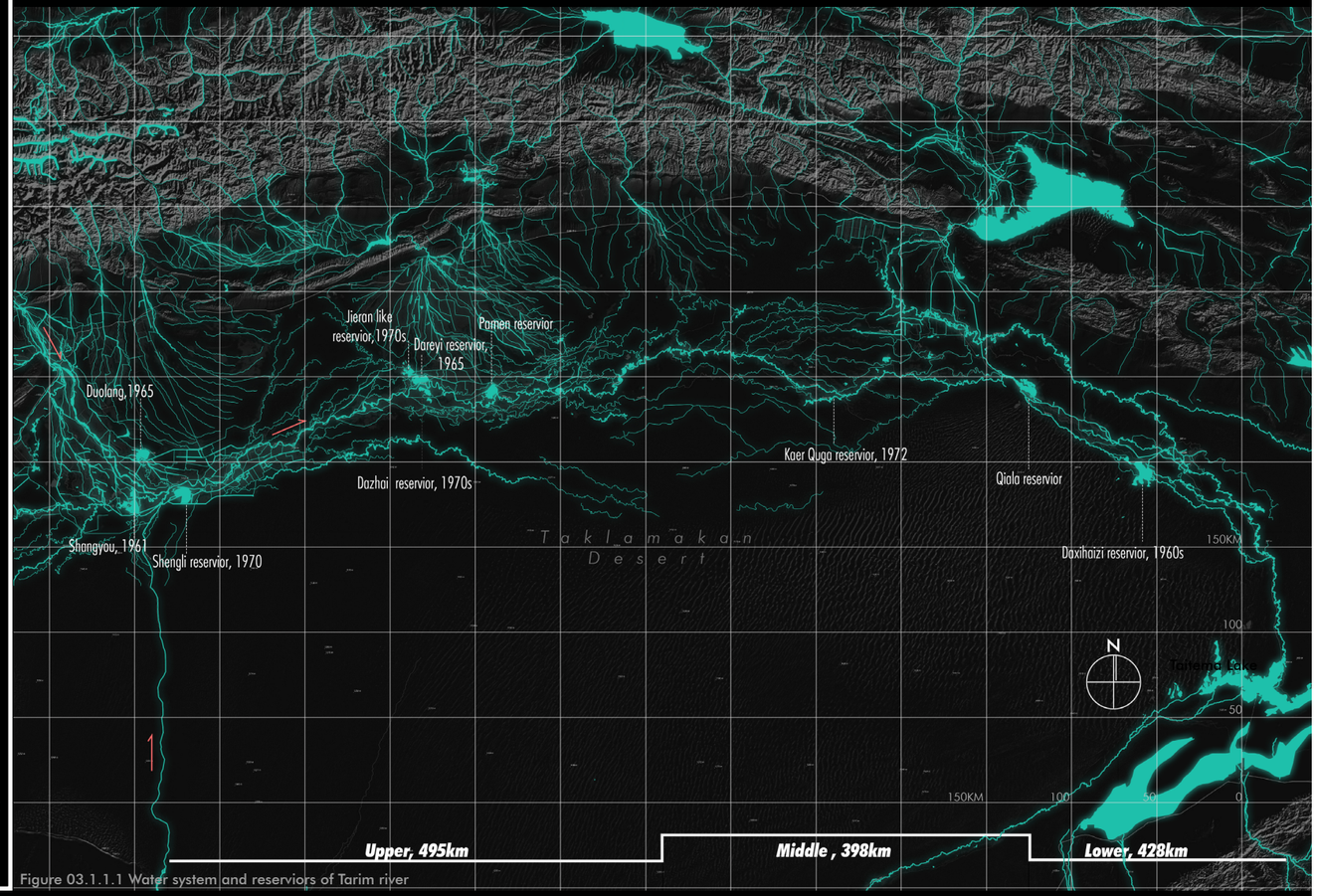


Figure 03.1.1.1 Water system and reserviors of Tarim river

The length of Tarim river mainstream is 1321km and it could reach literally Taitema lake. However, in last 60 years, the cut off length of Tarim river in dry season is getting larger and larger because of water scarcity.

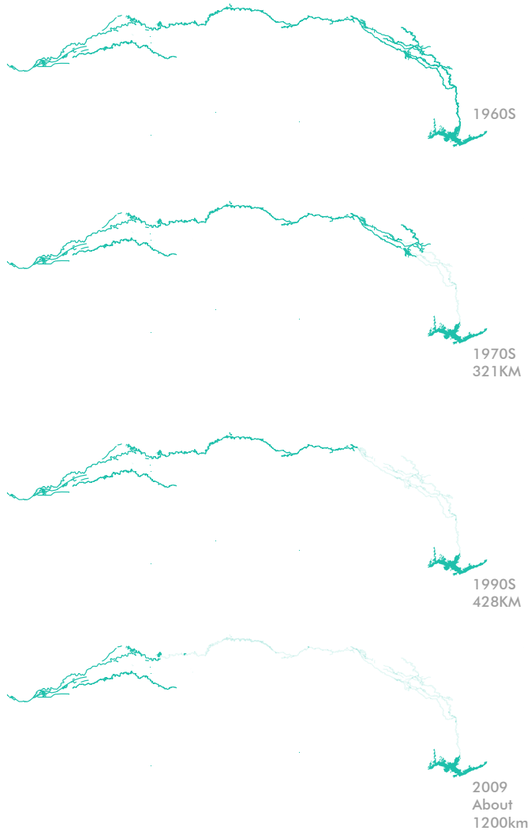


Figure 03.1.1.2. Cut off in dry season

03.1 Problem Field 1- Water scarcity
03.1.2 Result- Ecology decreasing

Another phenomenon indicated water scarcity in Tarim river is ecology decrease along river side. Between 1980-2010, about 9769.05KM^2 natural vegetation area disappeared or replaced by desert and farmland. Large part of disappeared vegetation area were mainly arose from water scarcity.

The ecology decrease happened seriously in Tarim river comparing with other river situation in the whole basin.

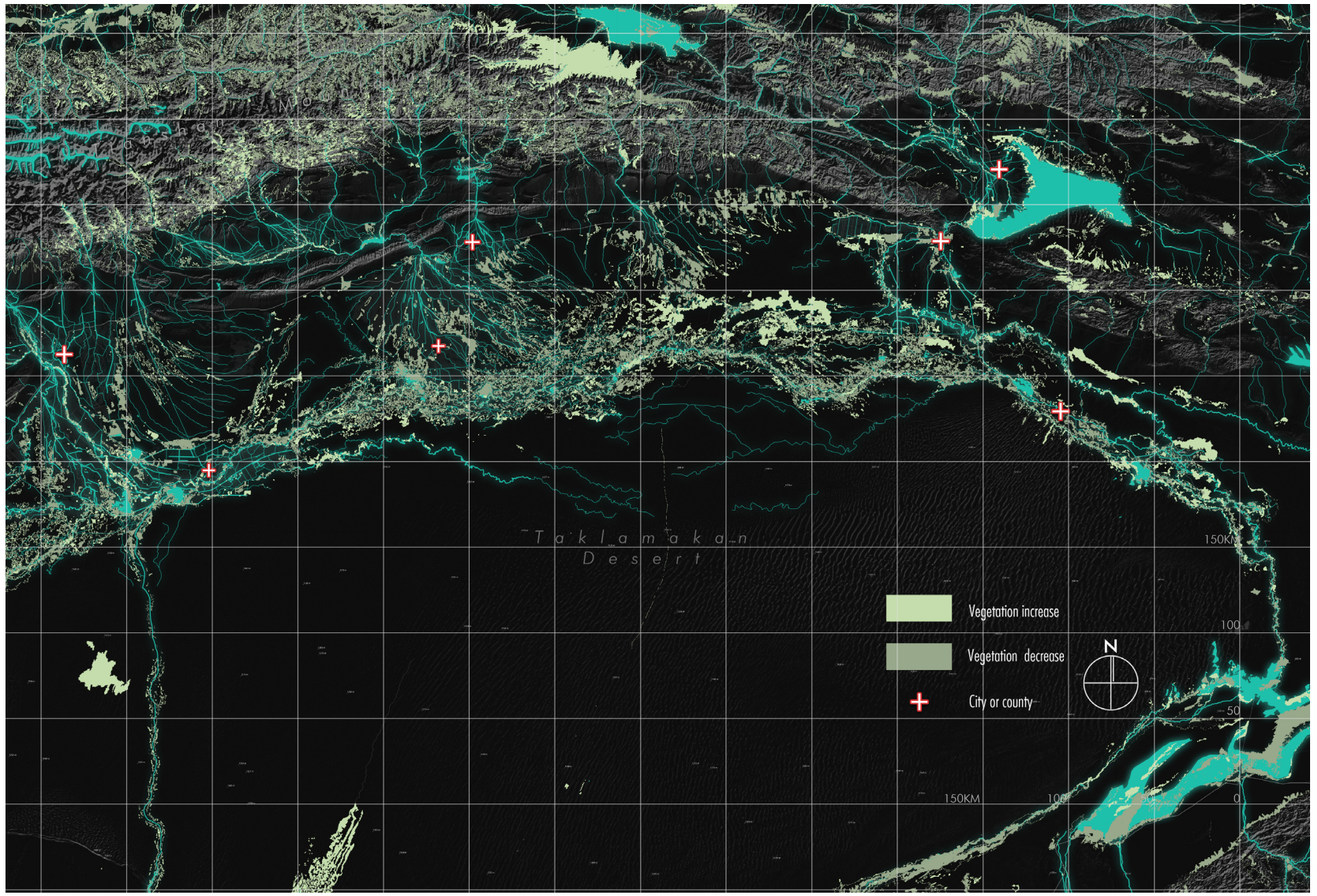


Figure 03.1.2.1. 1980s- 2010 Tarim river basin ecology decrease



Figure 03.1.2.2. Dead trees



Figure 03.1.2.3. Dry land

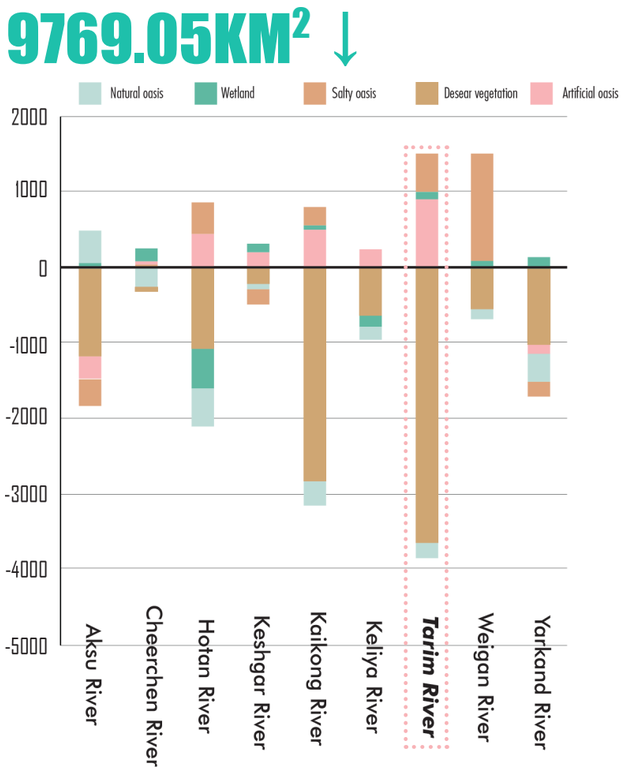


Figure 03.1.2.3. 1980s- 2010 Tarim river basin ecology decrease

03.1 Problem Field 1- Water scarcity

03.1.3 Reason and future trend- Farmland and population explosion

Reason- Farmland and population growth

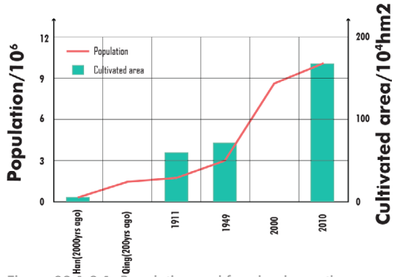


Figure 03.1.3.1. Population and farmland growth



Tripled in last 70 year

Figure 03.1.3.2. Overpopulation



Doubled in last 70 year

Figure 03.1.3.3. Farmland along Tarim river

The reason of the getting worse water scarcity phenomenon is because both farmland and population growth. After the establish of PRC, the population and farmland area increased in a extremely fast way. During last 70 years, the population tripled and the farmland area doubled. The water consumption of human increased enormously which caused getting shorter river and squeezing water for vegetation. The increasing water consumption were mainly in upper stream of Tarim river and leaved only little water flow to lower part.

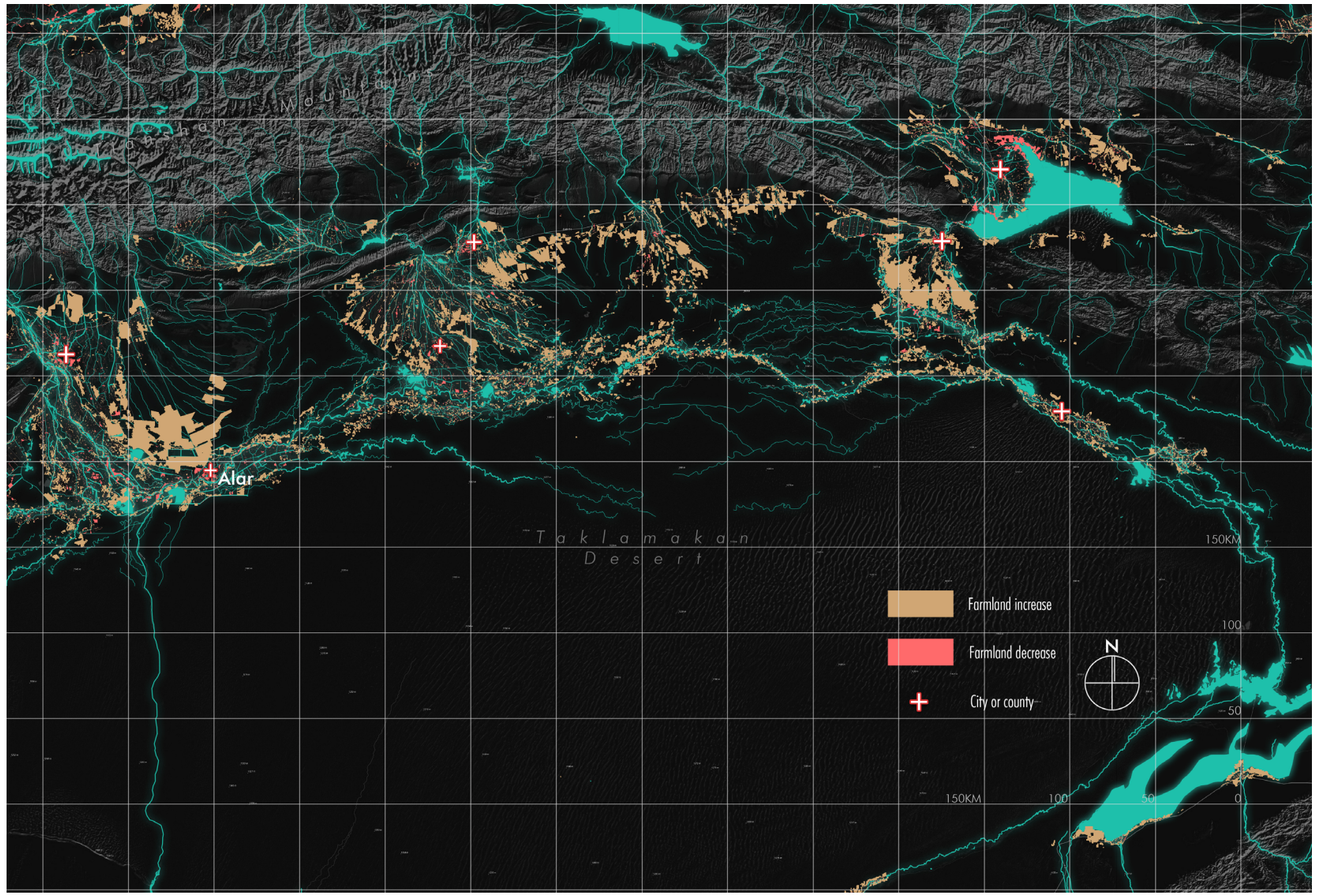


Figure 03.1.3.4. Farmland change in last 20 year

Future trend- planning and climate change

The future situation of the Tarim river is also not optimistic. Alar, the only city along the embankment of Tarim river, is one of youngest and fast development city in China. The population of Alar will reach 0.5million in 2030 and 1million in the further future, increasing water pressure.

Climate change would also increasing the water issue. Based on the research SUMARIO, rising temperature will increase the water consumption in agriculture sector, ecology sector and evaporation in reservoir. Under the increasing 2℃ scenario, the water consumption in Tarim river will increase about 2,400 million cubic meter.

Alar city planning

Objective: **Regional central city**
Industrial city and **transportation hub**
Leisure **tourism city** for aging population

Population: 409,000(2019) - **500,000**(2030)
– **1,000,000**(further)



Figure 03.1.3.5/6. Alar satellite image and city plan

Climate change- increasing temperature

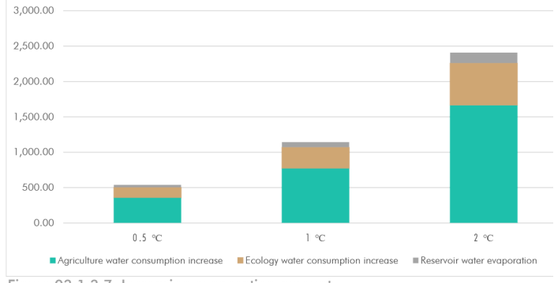


Figure 03.1.3.7. Increasing evaporation amount

The diagram shows the water flow in Tarim river basin in an average water flow year.

Water starts from snow melting and rainfall in the mountain edge. The four headstreams are Yarkand river, Hotan river, Aksu river and Kaidu-konqi river. The dark blue frame indicates the main stream of Tarim river water flow while the light blue frame shows the head stream water flow.

The Tarim river could be divided into upper, middle and low part by Alar Yingbaza and Qala hydrological stations. The water consumption in Tarim river could by divided in economical part including agricultural use, daily use and industrial use and other(ecological) part, which could be read at red flow part.

As a conclusion, the farmland explosion,temperature increasing, population growth and future city policy will all increase the water consumption, which leading the lack of ecological water..

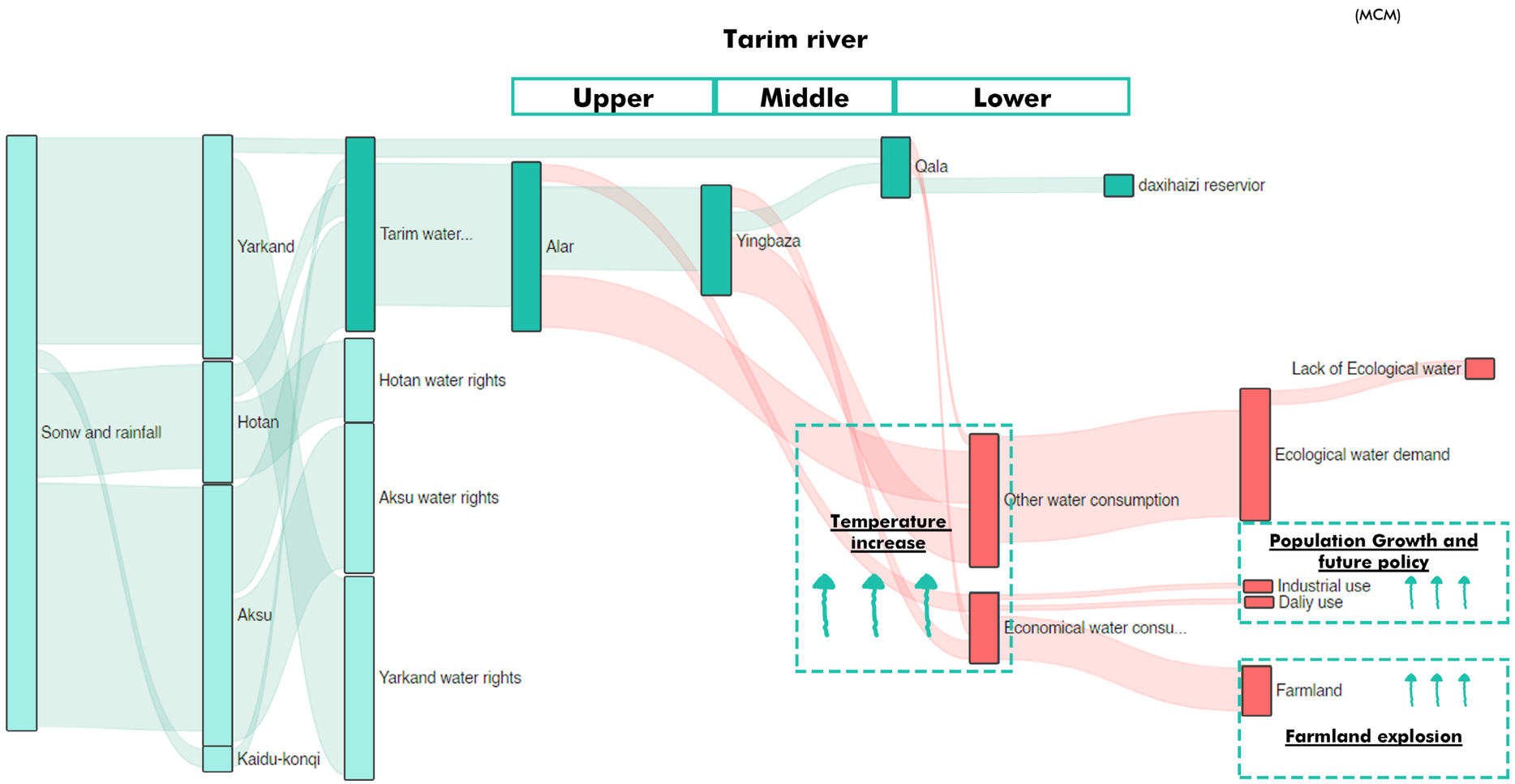
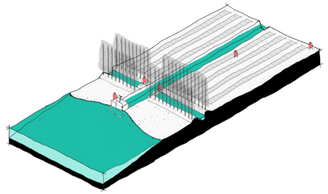


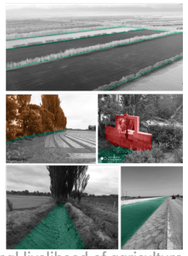
Figure 3.1.5.1. Water flow in 50% frequency year

03.2 Problem Field 2 - Unsustainable livelihood

03.2.1 Traditional livelihood





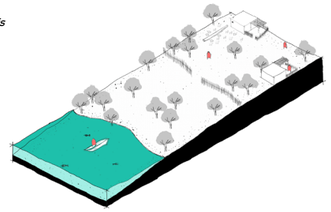


Agriculture

Agriculture is an essential tradition living way for people in Tarim river. People constructed canals to irrigated lands and the main production in the past is more about vegetables.

Figure 03.2.1.1 Traditional livelihood of agriculture





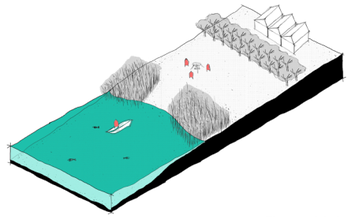


Livestock farming and fishing

Livestock farming and fishing used to be a way of living for people who lived in Tarim Rive. People raised sheep and camels by the existing forests and grasslands. And also, there is a lot of local fishes in the Tarim river when fishing. However, with growing agriculture water, and farmland, most of the forests, grasslands and fish disappeared. Making this way of living is disappearing.

Figure 03.2.1.2 Traditional livelihood of Livestock farming and fishing







Aquaculture

People used to do aquaculture in the remaining canals and water ponds. People did barbecues with local trees' branches when they got fish. With the shortage of water, this way of living is disappearing as well.

Figure 03.2.1.3 Traditional livelihood of Aquaculture

03.2.2 Traditional Local market- Bazaar

A bazaar or souk, is a permanently enclosed marketplace or street where goods and services are exchanged or sold.

As soon as Bazaar arrives (once a week, usually on Friday or Sunday; several adjacent bazaars can be staggered in time), people in a radius of tens of miles come to "catch the bazaar." Small merchants and hawkers also seized the opportunity to set up stalls on the bazaar and shouted. Some farmers also peddled small amounts of melons and fruits, eggs, poultry, sheep, and handmade products they produced on the bazaar.

It is an essential place for people living in different rural village to communicate and trade with others. Currently, since local farmers are nearly not producing the local vegetables and food, the bazaar is not that popular in Tarim oases.









Figure 03.2.2.1/2/3/4 People and products in Bazaar

03.2 Problem Field 2 - Unsustainable livelihood

03.2.3 Traditional circularity

The previous circularity of the region is a sustainable and complex. People have multiple production types including crops, fishes and livestocks to build up a prosperous local market (Bazaar). People exchange their products and information at the market, enhancing the local connection. Meantime, the silk road introduce international products and brought local products to international market. As a conclusion, the farmers in the past have multiple production and multiple markets to rely on.

However, in current situation, people only produce cotton here and only rely on external market to earn a living.

Before

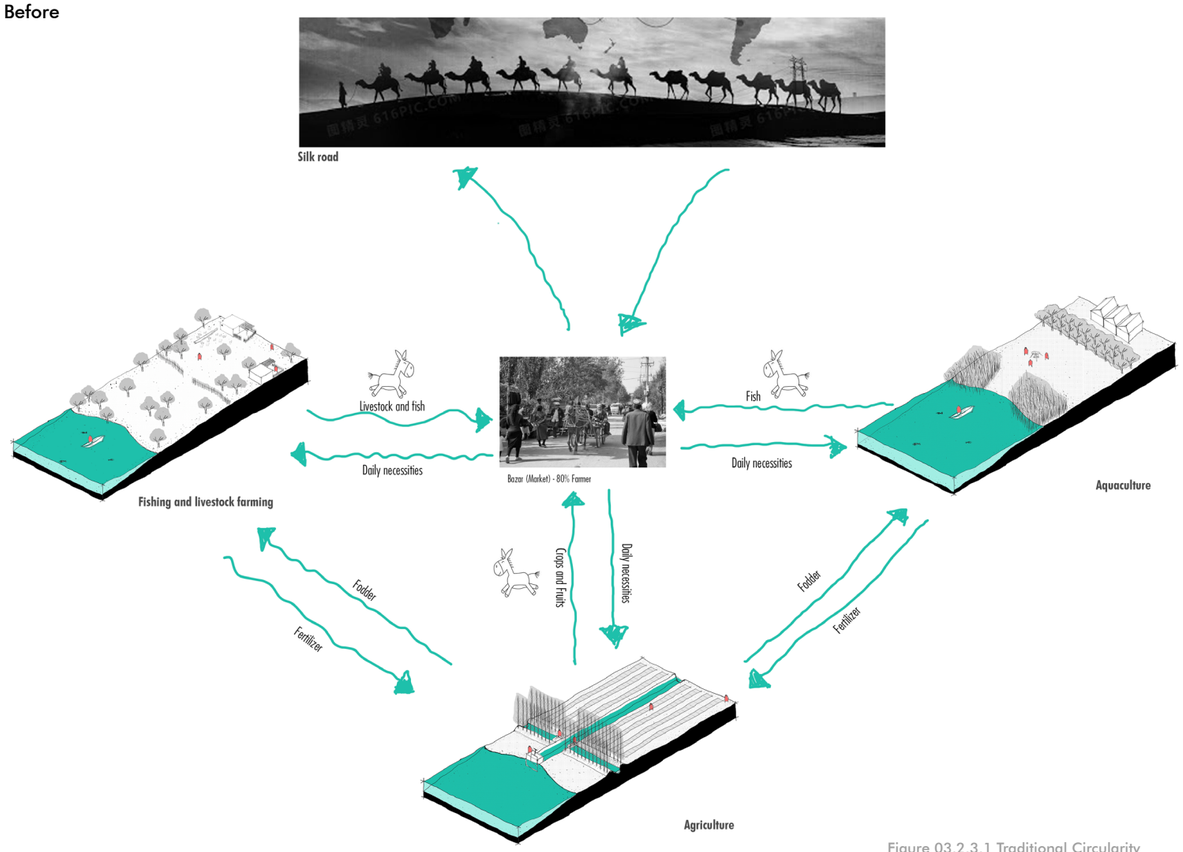


Figure 03.2.3.1 Traditional Circularity

03.2.4 Current vulnerable circularity

Currently, the silk road disappeared and the Bazaar is not popular without local food. the current farmers could only but simple circularity with the world by producing cotton. And farmland could only built little connection with the city

Now

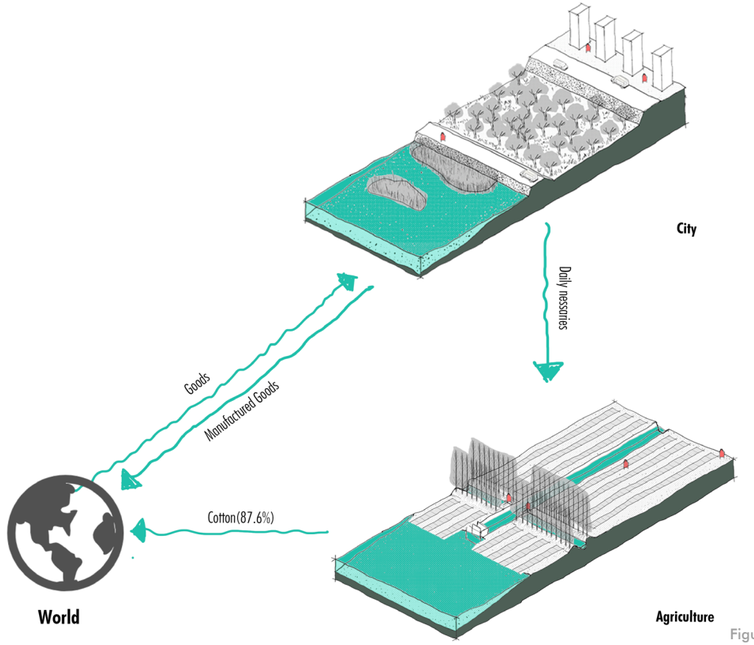


Figure 03.2.4.1 Traditional Circularity

03.2 Problem Field 2 - Unsustainable livelihood

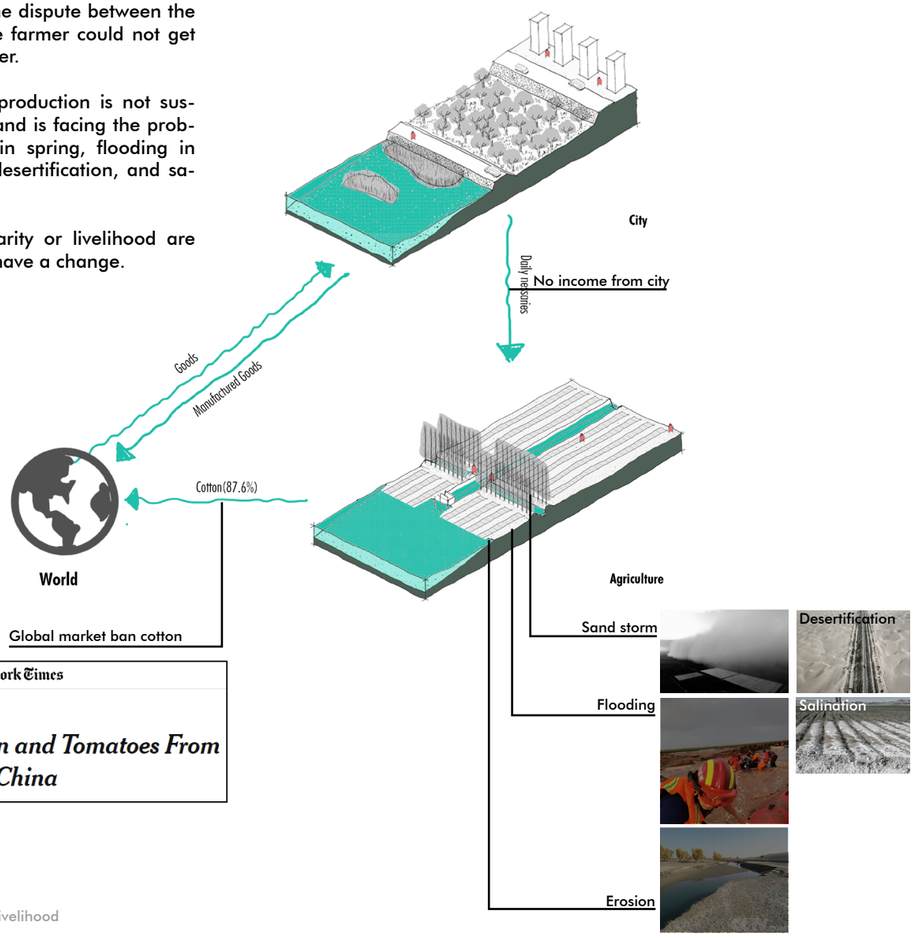
03.2.5 Problem of current vulnerable livelihood

The current simple circularity is facing a lot of problems.

Firstly, the main production of Tarim farmland, cotton, is been banned by the US and many other countries due to the dispute between the Us and China, while the farmer could not get money from the city, either.

Meanwhile, agriculture production is not sustainable now. The farmland is facing the problems of a sand storm in spring, flooding in summer, river erosion, desertification, and salination.

Thus, the current circularity or livelihood are vulnerable and need to have a change.

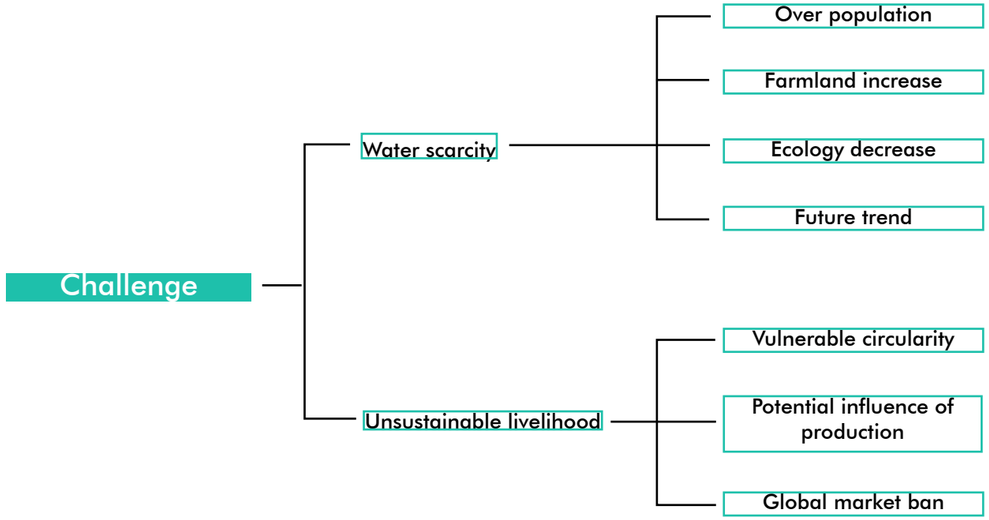


The New York Times

U.S. Bans All Cotton and Tomatoes From Xinjiang Region of China

Figure 03.2.5.1 Unsustainable livelihood

03.3 Challenge of Tarim river



03.4 Objective and Research Question

Objective

The objective of this project is to seek the possible water management outcomes for upper Tarim river to reach the sustainable living by analyzing, experiment, development and eventually implement. With a landscape architect perspective, the farmers in Upper Tarim River could finally reach the water balance and find a sustainable livelihood. As a huge project, it will also explore top-down government strategies and bottom-up farmers approaches' boundaries and possible integrating way. Meanwhile, The farmers and nature relation in this arid region is explored.

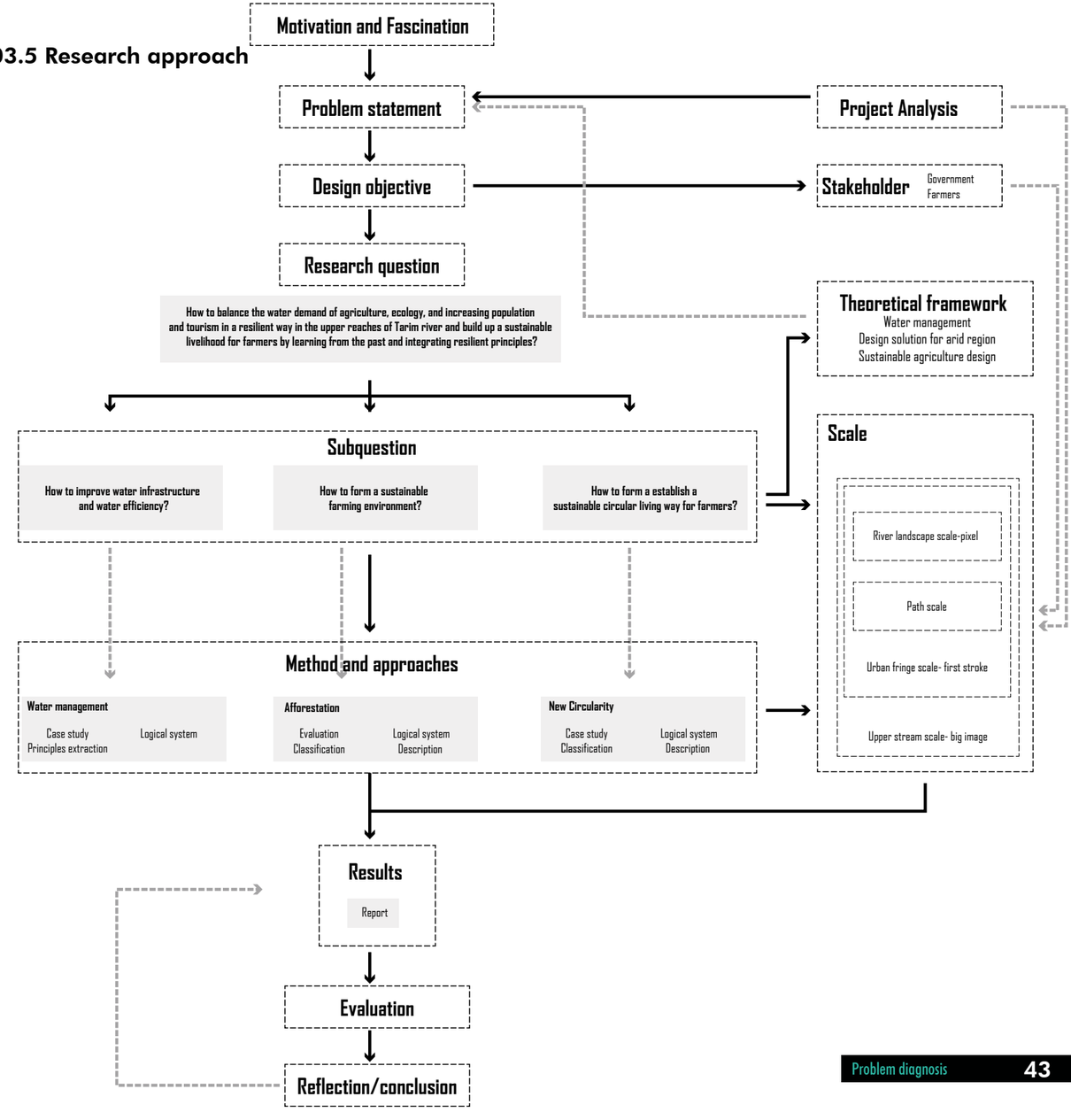
Research question

How to **balance the water demand** of agriculture, ecology, and increasing population and tourism in a resilient way in the upper reaches of Tarim river and build up a sustainable livelihood for farmers by **learning from the past** and integrating **resilient principles**?

Sub research question

How to improve **water infrastructure and water efficient**?
How to form a **sustainable farming environment**?
How to form a establish a **sustainable circular living** way for farmers?

03.5 Research approach



04. Methodology

04.1 Theoretical framework

Democratic water management

" Water is an essential resource that permeates beyond social and economic human welfare as well as Earth's ecological balance because water is key for its development. "

Water resources is valuable resources in 21st century. For people living in arid and semi-arid region, water is a crucial element which influence the economic development. It is estimated that 2.1 billion people are living in arid and semi-arid region, and this population will grow to half of global population until 2030.

Thus, the water distribution is important and directly connected with the economy sector. Unlike a hierarchical top-down government approach, a fair, demand-oriented, ecosystem-based and stakeholder-participating approach is more sustainable water management way.



Figure 04.0.1 Reservoir image along Tarim River

Design solution for arid region

" Arid regions have had no choice but to mandate, innovate, and fully integrate water conservation modalities. From city planning to investment in engineering and infrastructure, to the redesign of building facades, societies in arid climates are faster to embrace a retrofit of their entire operations."

Arid region design emphasizes on water conservation design, aiming to improve the water efficiency and design basing on the local climate. It often contains different topics such as water management, water conservation and the sustainable city. Base on the book out of water: design solutions for arid regions, the solution mainly come for three realm: domestic water use, agriculture water use and ecology services.

An insights in design solutions and strategies from existing projects in water scarcity region can get a new horizon to understand the water importance and future livable water-sensitive trend.

Sustainable agriculture design

" Farming systems must simultaneously address production goals, livelihoods, and environmental sustainability, in a constantly changing world. There is no defined set of practices that comprises sustainable farm design, because agroecosystem management takes place within this inherently dynamic context."

Sustainable agriculture theory mainly focus on getting profitable production needs, without the distributing of ecosystem services and degrade the land. To achieve the goal, farming process should innovated with consideration of environmental-friendly nutrients, land condition, water consumption, energy consumption, climate change and economic environment.

However, it is an obstacle that the outcome of strategies could not be seen by farmers in a short term. Thus, the long results eduction could be an essential part of sustainable agriculture design.

04.2 Research methodology

This project follows the Research by design strategy, by which the purposed of seeking water possibility and sustainability achieved. To achieve that, 3 scales will be researched in the whole project.

On the upper stream scale, logical system is used for describing and projecting the future water system, evaluation method is to evaluate the farming environment and ecosystem. Cases studies is to find the potential solution and principles for the project. On urban fringe scale, it is located around the Alar city and works as a start-up region of the whole project. Through the design experiment, it explore the water possibility for the region. On the urban-farmland-river path scale, it works as a exhibition path to show the importance and story of this project. By design this path, it shows to farmers the possible working way with the land, encouraging farmers to join this project.

Logical system: Extract water system

Considered the amounts of water related data and maps, the description of Tarim river water system should be in a simple way. Logical system is to proposed a water system which is considered to reflect the realistic situation. Based on this simplified water system, assumption and possible consequences could be explored. It works as a description model and exploration tool for the water possibility in this project.

Evaluation- Mapping by GIS to evaluate risk and potential

To understand the existing situation of the land, it is essential to find a way to record and measure the landscape. Mapping with GIS and other diagrams, the soil condition and farming environment could be evaluated. Based on that, the risk region and potential point could be marked out for further design.

Case study

Three cases study are researched in this projects. The three projects are about new irrigation method for saving water, a top-down approach for afforestation , and a bottom-up approach for afforestation and new circularity. Through those existing projects, principles and advantages are extracted.

04.3 Case studies

04.3.1 Israel water technology



Figure 04.3.1.1 Israel farmland in desert



Figure 04.3.1.2 Israel National Carrier

Due to the climate of the Mediterranean climate, Israel is facing lacking water. To survive in this land, Israeli scientists have developed a lot of methods to improve water accessibility.

The first main principle is to improve water use efficiency, a national water distribution system was built to connect 95% ends users population. This system contains a freshwater system, effluent water system, and brackish water system. By this structure, it can deliver a suitable quality of water to the end-users.

The second principle is to reduce the agricultural water demand. By drip irrigation, subsurface drip irrigation, and the calculation of transpiration rates, this responsive irrigation system could improve 85-92% water efficiency and this method doesn't damage the soil.

In the third principle, defining a chain of end-user improves water efficiency. For instance, Surplus water for normal agriculture could be used for saline tolerate water, finally into the forest.

04.3.2Three North Project

Top- down project

Three North Project

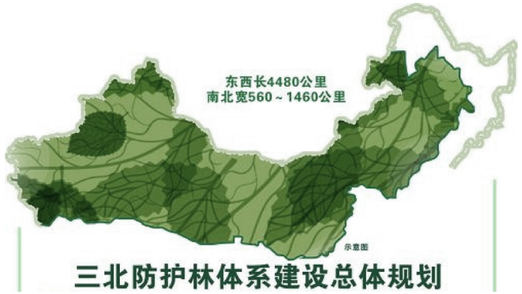


Figure 04.3.2.1 Three north project located province in China



Figure 04.3.2.2 Three north project outcome

Afforestation

Forest: Increase to 60,840,000 Ha

From 1978-2050
Phrase1 1978-2000
Phrase2 2001-2020
Phrase3 2021-2050

20 years as a period of construction time

Returning farmland to forest

Process:

Policy guidance + Voluntary participation → Evaluation size, quality + Negotiation → 1st period allowance + 2nd period allowance

16 Year Allowance paid by government

The three North projects are an afforestation project carried out by the Chinese government. This project is to create a forest in 3 northern provinces where facing desertification and sand storm.

The whole project currently has to increase 60millon ha of forest since 1978. The whole project could be divided into 3 phrases. The first phase is from 1978 to 2000, due to the low technology and scientific knowledge support, the trees from phase 1 dead a lot. the phrase 2 from 2001 to 2000 and the third on from 2021 -2050. Some experience could be learned from this process like planting dynamic species, considering the water demand of tress, etc.

One realistic thing in the process should be considered in the process of afforestation. That is how to return the farmland to the forest. The Chinese government has set up a process to guide people to participate and get feedback from the process.

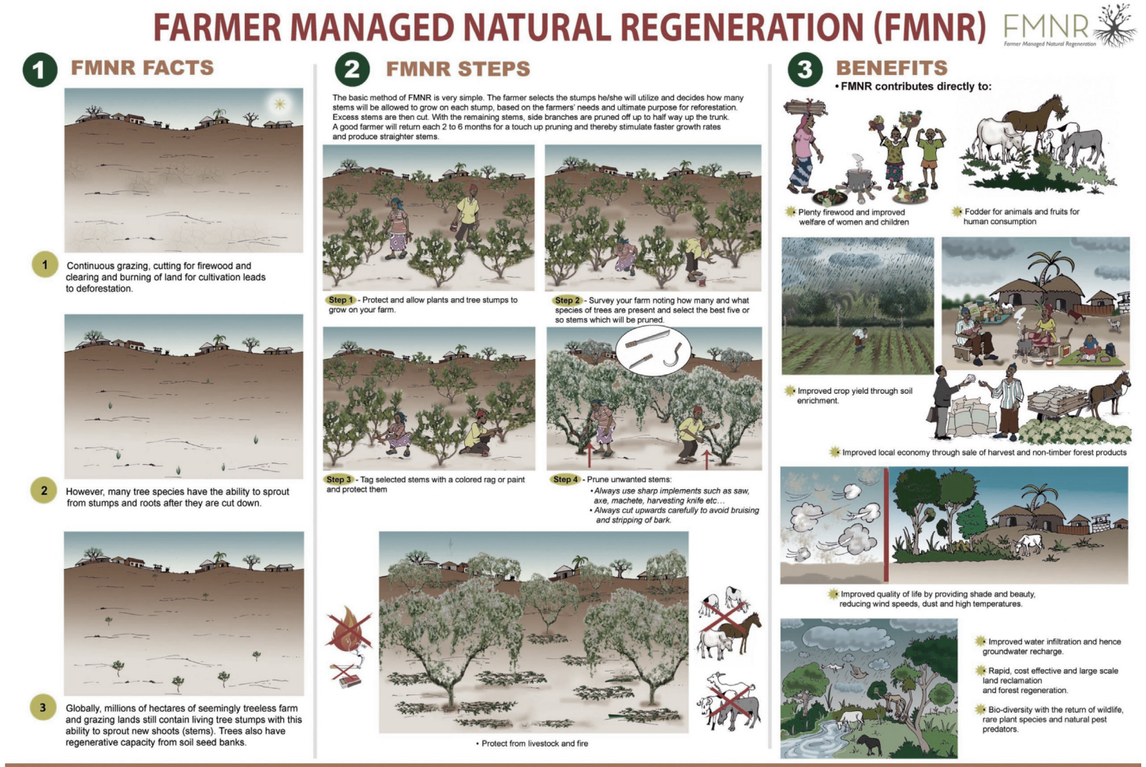
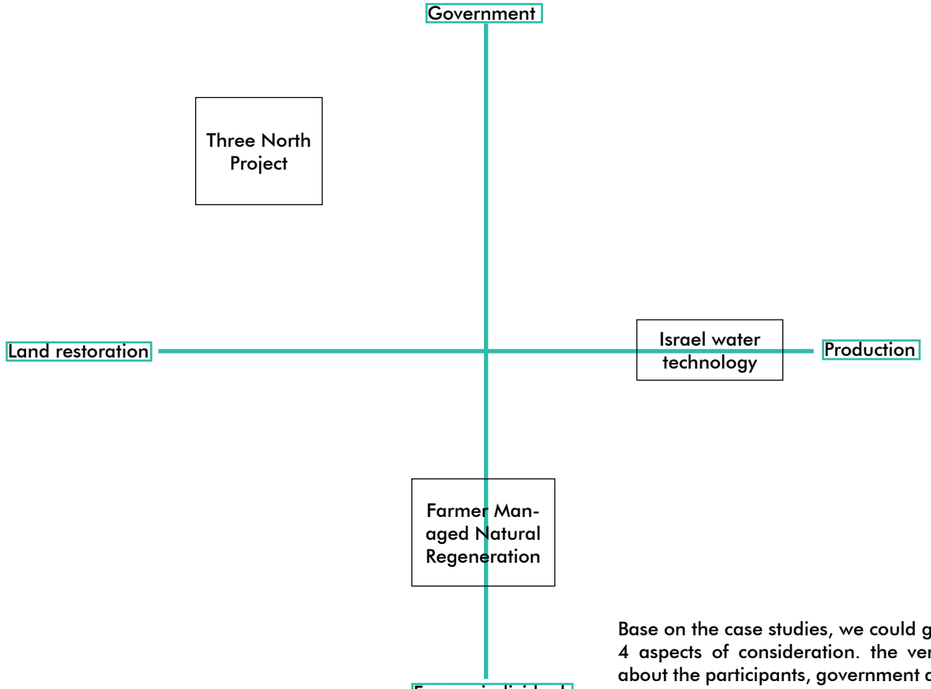


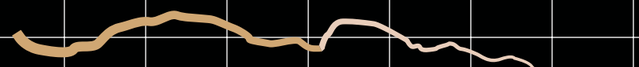
Figure 04.3.3.1 FNMA flayer

Farmer managed natural regeneration is a low-tech and sustainable project for afforestation in Africa, the main purpose of this project is to restore the forest to improve the microclimate and resilience of this land. This project starts from the low intervention of the land, then it let remain seeds and root in the land grow again. Farmers will choose the suitable trunk to let it grow to mature trees again. The things that can be learned from this project are not only to grow trees by natural forces but also the way they let people join. By workshops and NGOs participants, and also with easy-read instruction, farmers could learn the project easily and join easily



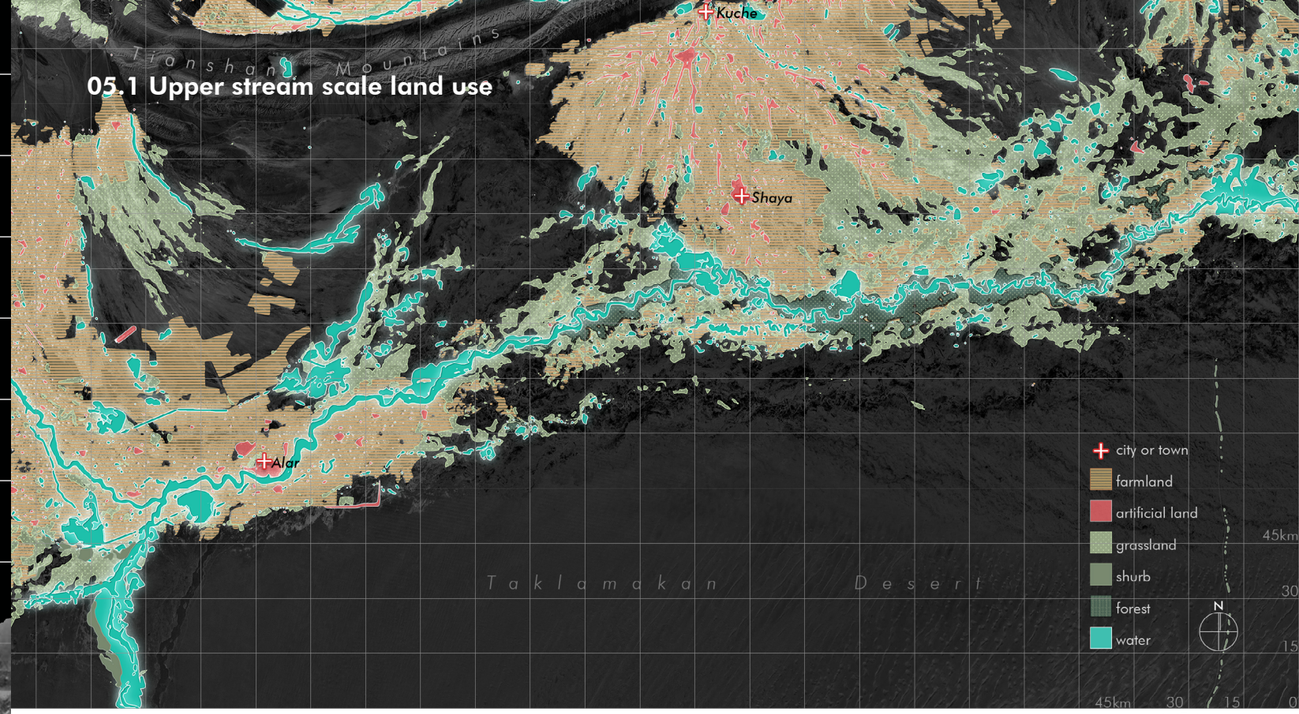
Base on the case studies, we could generally get 4 aspects of consideration. the vertical axis is about the participants, government and farmers. The horizontal axis is the purpose of this project, land restoration and production. For the Israel water technology, it considered government and farmers participant for production, while Farmer managed natural regeneration let farmers participate land restoration and production. For the Three north project, it has less consideration, and only let government join the land restoration process.

05. Analysis: upper stream



Upper scale of Tarim river was explored in this project as the human activities and water consumption were happening here.

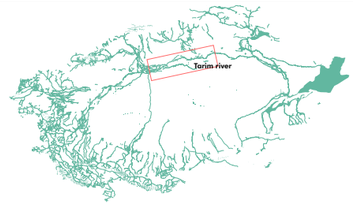
Four the better understanding of the upper Tarim river, **two topic** was explored in this chapter: 1) Water consumption 2)Farming environment

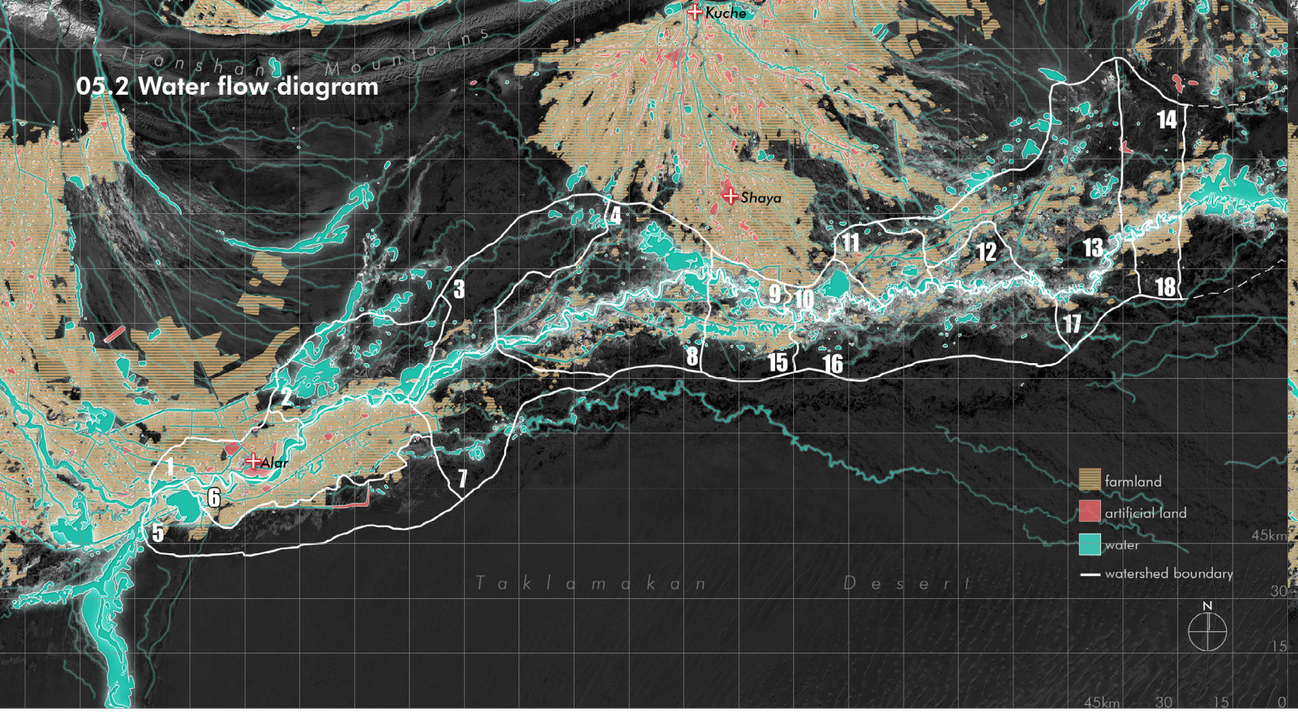


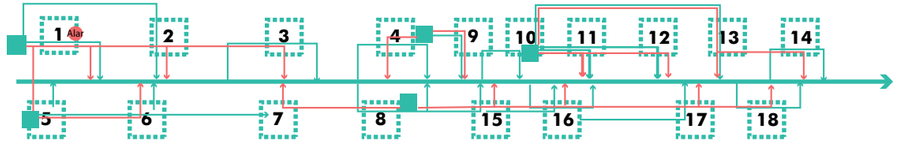
05.1 Upper stream scale land use

To have a better understanding and of the water issue of the Tarim river basin, the Upper stream scale could be a nice starting point. The upper stream part is filled with intensive farming actives as there is more continuous water flow. And also the only city, alar, is located in the beginning part of the upper stream.

The Upper scale of the Tarim river literally from the Alar hydrometric station to Yingbazha hydrometric station with a 495km length of Main courses. Based on the land use diagram, the main ingredients of the upper stream are farmland and desert. With the water conservancy facilities including canals and reservoirs, farmland nearly occupies every corner along the Tarim River. And other ingredients like grassland, forest, artificial land together with farmland are closely integrated along the Tarim River, forming the oases landscape.





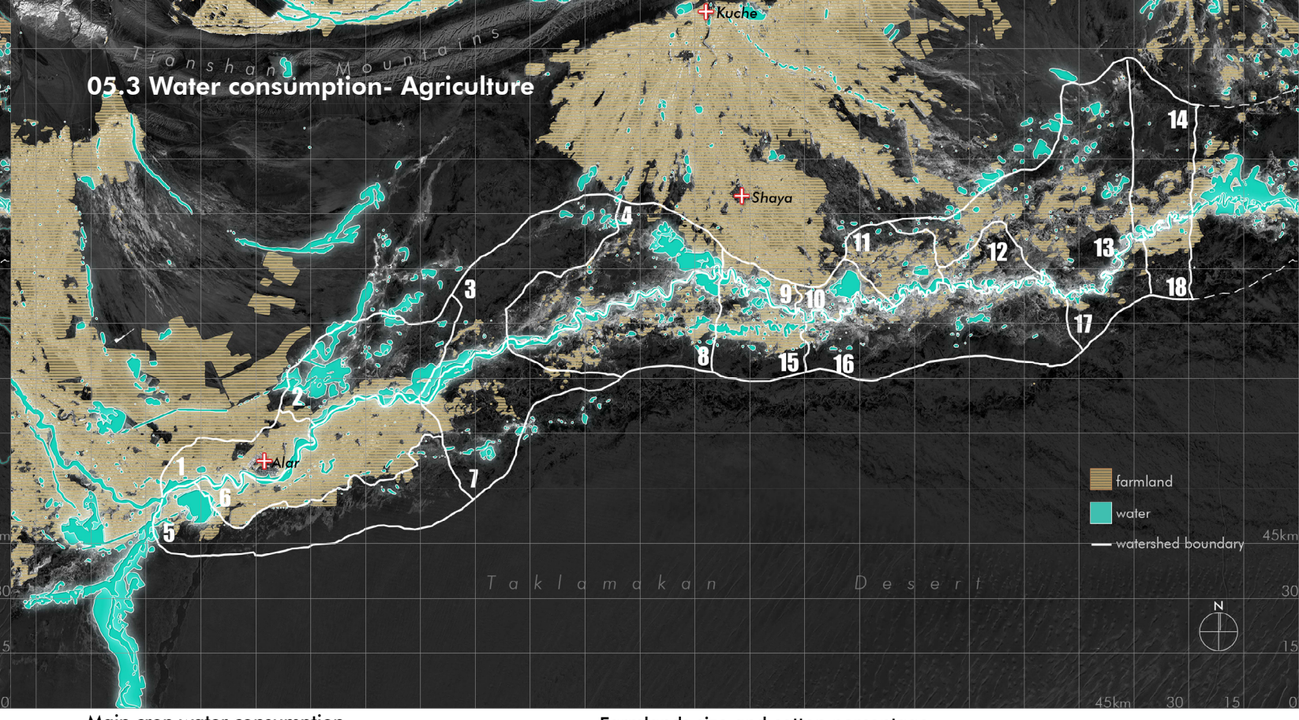


Agriculture water flow
Domestic water flow

The water system of the Tarim river is complicated, besides the river and branches themselves, farmers and government build Different levels of canals, ditches, and reservoirs for irrigation purposes. Meanwhile, the drinking water supply system and sewage water system which for the city alar and small villages surrounded by the farmlands make the whole water system hardly to clarify. Thus, a simplified water system method was used in this research.

Due to the long-distance of upper stream and complexity of the water system, the whole upper stream scale was divided into 18 small zones. The boundaries of those zones are based on the combination of the watershed and Tarim river embankments. For each zone, the inlet and outlet for agriculture and domestic water are clarified and marked. And the water sources for each zone are either the Tarim river or reservoir.

Based on the water system research, the 1-3 and 5-6 zones are more relied on the Tarim river and two reservoirs at the beginning of the upper scale, while 4 and 8-18 zone relied on another 3 reservoirs and river itself. Meanwhile, the excess water of agriculture and wastewater from the city are directly discharged at the river.



Main crop water consumption

Cotton 12,500 m3/hm2

Wheat 12,750 m3/hm2

Pear 18,000 m3/hm2

Grape 12,000 m3/hm2

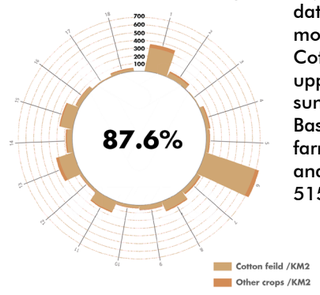
Date 10,250 m3/hm2

Water consumption is an essential fact for the research of upper stream water issue. In the water consumption research of this part, agriculture, tourism, daily water usage, and ecology water are the four main sectors for water consumption. Agriculture activities consumed the most water in these four sectors.

The agriculture activities in the Upper Tarim river are mainly farming. The farmland here starts from the river bank and expands toward the outside until the desert region where there is little water accessibility. The water for agriculture is mainly from the reservoir and little directly from the Tarim River.

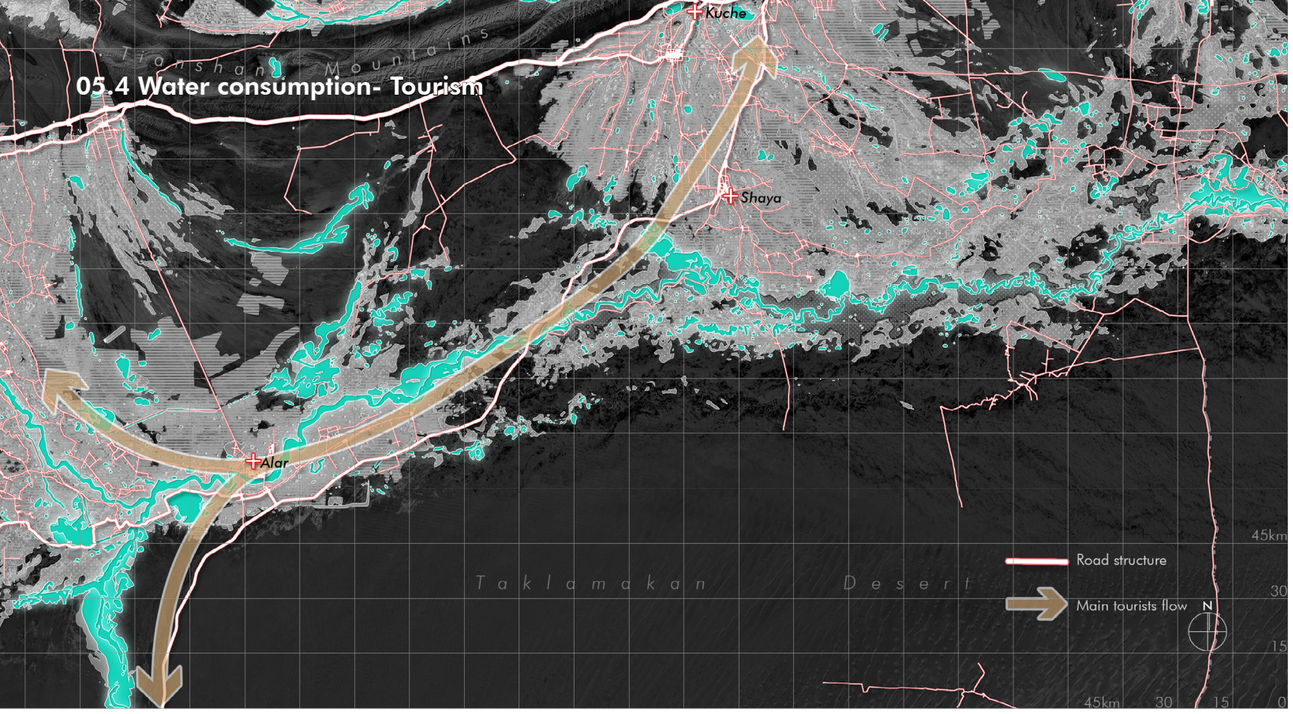
The main crops in the upper stream are cotton, wheat, pear, grape, and date. And all those crops consumed more than 10,000 m3 water per hm2. Cotton is the most popular crop in the upper stream due to the long time sunshine and suitable temperature. Based on recent research, 87.6% of farmland planted cotton in this region, and all the farmland consumed about 515 MCM water.

Farmlands size and cotton percentage

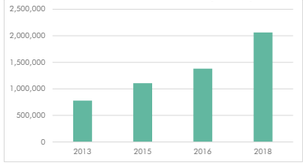


Farmland water inlet

Agriculture Water inlet (2018)= 515 MCM



Yearly tourists increase (Alar)



Tourism water consumption

Tourists type	Percentage	Daily water consumption
Not stay-over	66.13%	0.025 M^3/ Day
Stay-over	33.87%	2 M^3/ Day

Average water consumption per person = 0.694 M^3/ Day * 1.3Day =0.90 M^3

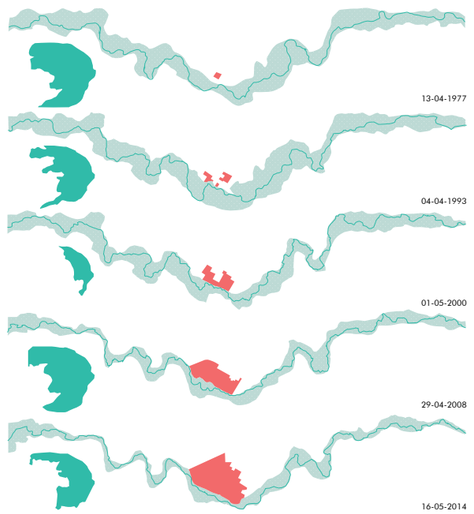
2018 tourism consumption = 0.90 M^3 * 2,062,500=1,856,250 M^3= 1.86 MCM

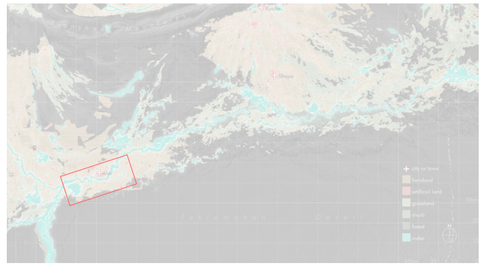
Tourism is a fast-developed sector in the city Alar. Located along the edge of the upper Tarim river, people who are traveling in the Tarim river basin will probably pass city Alar, which could be seen in the main tourists' flow. People who visit this city might visit the city surroundings, Tarim river, take a meal or stay over.

The number of tourists grew fast in the past few years. From 2013-2018, it nearly tripled and reach more than 2 million people in Alar. According to research, about 33.87% of people will not stay over in the city and consumed about 2 M3 per Day. Thus, the average water consumption per person could be counted as 0.90 M3 per Day. So the water consumption for tourists in Alar in 2018 will be 1.86MCM

05.5 Water consumption- Daily usage

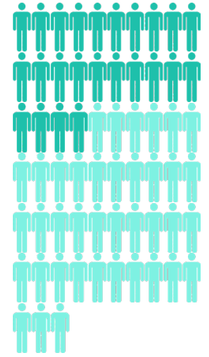
Fast Urban Development in upper stream





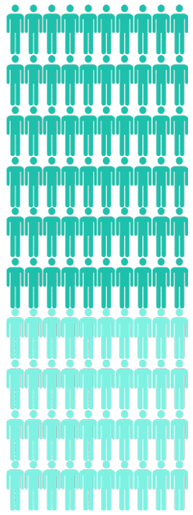
The urbanization along the Tarim River is extremely fast. During the last 40 years, Alar expanded more than ten times and has about 240,000 citizens now. The quick urbanization occupied the farmland surrounded and exploited both water and the space of the river. For the aspect of water consumption, the daily use of people occupied most water usage of the whole city.

Current population



Upper stream
population= 673,800
City residents= 242468
Village residents= 431332

Population forecast in 2050



Upper stream
population= 1,000,000
City residents= 600,000
Village residents=400,000

Water consumption

City residents*220L/day*365=
19,470,180.4 M3

Village residents*89L/day*365=
14,011,820.02 M3

Total Water consumption=
33,482,000.42 M3 = 33.48 MCM

The population of the upper stream is about 673,800 and will increase to 1,000,000 in 2050 and the urbanization rate will increase to 60%.

The water consumption of villagers and city residents is different. For the city citizens, the daily use of water is about 220L/day while the number of villagers is about 89L/day. Based on the current population, the total water consumption will be 33.48MCM.

05.6 Current Fresh Water consumption

=1MCM=1 million cubic meter

Agriculture 515 MCM

Tourism 1.86MCM

Daily use 33.48 MCM

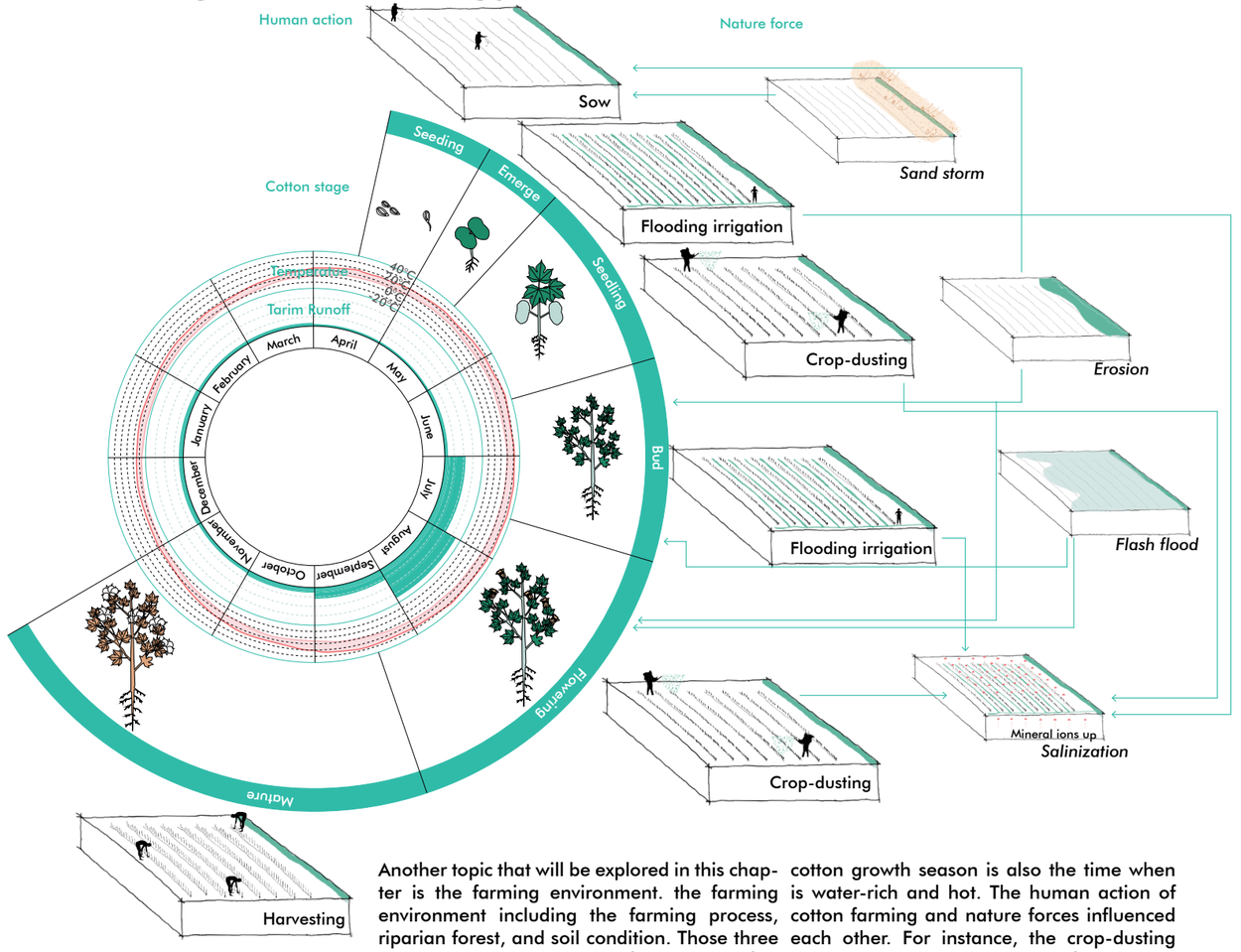
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Planed by government
Economic Total 406 MCM

In conclusion, the freshwater consumption in the upper Tarim river basin is about 550.34 million cubic meters on average. This data is quite bigger than the number the government planned for economic use. Based on the regulation of *The surface water distribution of 4 Head streams and 1 mainstream*, which is also mentioned in the introduction chapter, in a water average year, the upper stream is suggested to use about 406 million cubic meters for economic use. And other water will be used to recharge groundwater and support the ecology function.

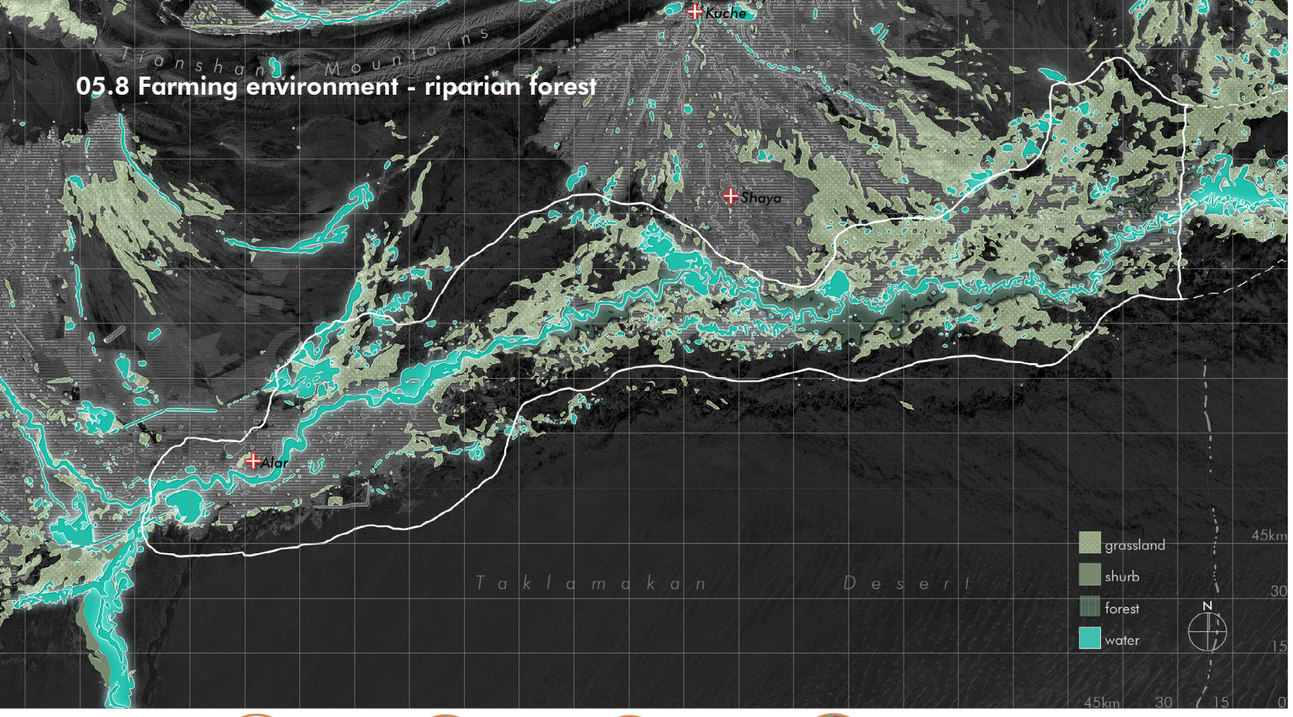
However, current economic water consumption now is larger than it should be, and agriculture consumed most water, which is squeezing quite a lot ecology water.

05.7 Farming environment - farming process

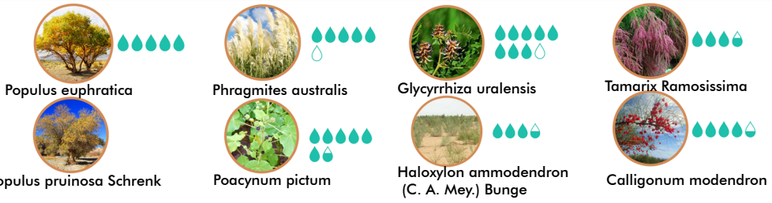


Another topic that will be explored in this chapter is the farming environment. the farming environment including the farming process, riparian forest, and soil condition. Those three aspects are all related to the farmer's benefits.

The diagram shows the relationship of Tarim river runoff, temperature, cottage stage, human action, and nature forces. In a yearly circle, the runoff peak, temperature, and cotton stage are highly related to each other. The cotton growth season is also the time when is water-rich and hot. The human action of cotton farming and nature forces influenced each other. For instance, the crop-dusting would accelerate the process of salination, and sand storms will remove seeds in the ground. In general, the four nature forces mentioned here will decrease production.



05.8 Farming environment - riparian forest



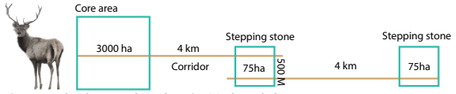
The riparian forest is a unique landscape along the Tarim River. In a natural condition, the riparian forest is on two sides of the Tarim River basin and could be several kilometers in width. working as a natural riverbank, it not only prevents the erosion of the river and also slows down the flash flood in some extreme conditions. Meanwhile, it prevents the expansion of the desert and salination.

However, as it shows in the riparian forest map, there is only part of the riparian forest remains in the upper Tarim river. Farmland takes place the forest's position, consuming more water and having little ecology function.

Unlike communities in a more humid environment, the riparian forest community is dominated by one or two single-type trees. The main tree species is Populus eurpharatic, which could tolerate extreme dry and salty conditions. In some locations, Tamaris chinensis and Populus eupharatic mixed forest could also be found. The shrubs in the riparian forest are Phragmites australis,llaloxylonam modendron and Poacynum pictum, etc. All of those could use little water to survive.

05.9 Farming environment - riparian forest community

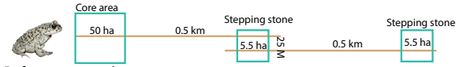
Species habitats requirement



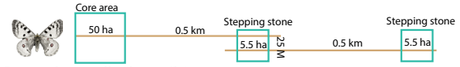
Cervus elaphus yarkandensis (Yarkand dear)



Polistes antennalis Perez



Bufotes pewzowi



Parnassius apollo (butterfly)



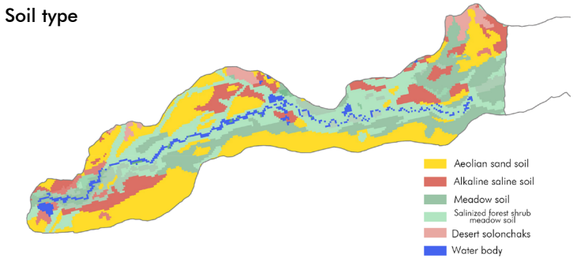
Ciconia nigra

The riparian forest community is fragile and dominate by Populus euphratica. The section at the bottom shows the species of trees, shrubs, and water plants and their relationships to the water in a natural condition. And the endangered animals including Yarkand dear and butterfly have their habitats in a different part of the riparian forest. The Yarkand dear lives inside the forest part while the butterfly lives in the boundary of the shrub area.

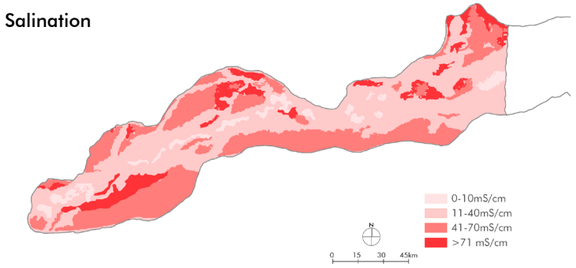
For different target species, they have their habitats requirement. For the five target species in this research, the Yarkand dear has more special requirements as it needs a bigger size core area and stepping core about 3000 ha and 75 ha respectively. And also wider corridor is required about 500m for this endangered dear. Those requirements are the minimum standard for those animals to move and survive.

05.10 Farming environment - soil condition

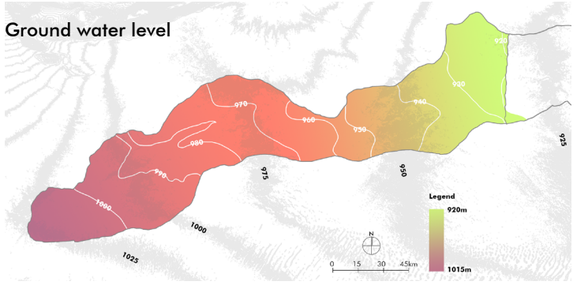
Soil type



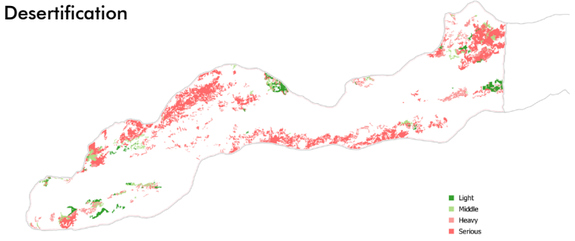
Salination



Ground water level



Desertification



4 type of mappings are made for the basic understanding of upper stream soil conditions including soil type, salination, groundwater level and desertification.

The soil type along the upper Tarim river is mainly meadow soil and salinized meadow soil. But in the font part of the Upper stream is more narrow and alkaline saline soil is also a lot in that part. This is might because the high dense of farming activity in that part has made the soil turn into bad saline condition.

This pheromone could be more obvious in the map of salination. The salination of soil is server and closer to the river bed in the beginning part of the upper stream. And also, some other parts of the upper stream are suffering from the salination problem even it is close to the Tarim River.

The water table here is not high and is generally about 10 meters on the edge of the Tarim River. When it is closer to the river, the groundwater table is higher about 2-5 meters.

Desertification is also a problem this region faces. Generally, it is happening at the edge of the oases and heavier when closer to the Taklamakan Desert. But also, this is some part of land facing this problem even it is very close to the water.

05.11 Farming environment evaluation



Based on the analysis of the farming environment, a conclusion map could be made. This map shows the high degeneration rate and corridor lacking places in the Upper Reaches of the Tarim River.

The high degeneration rate area is the place where are facing soil conditions degenerated including salination and desertification. The corridor lacking an area where the riparian forest is lacking because of farmland occupation and other reasons. Those places are also facing the problem like erosion and flash flood since those farmland are reclaimed from the river and riparian forest. Those marked areas should be considered placed need more urgent intervention.

06. Design Exploration



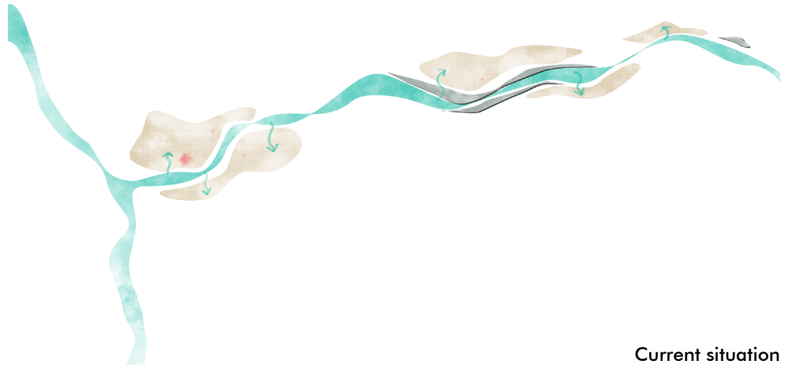
Based on the previous impression, clarification, and analysis of the Tarim River, the design exploration in the whole project is to find a better way to improve water efficiency and also provide a better environment for people living there. By achieving those two goals, people in the upper Tarim river could have the possibility to build up sustainable livelihood with a new circularity.

06.1 Design concept

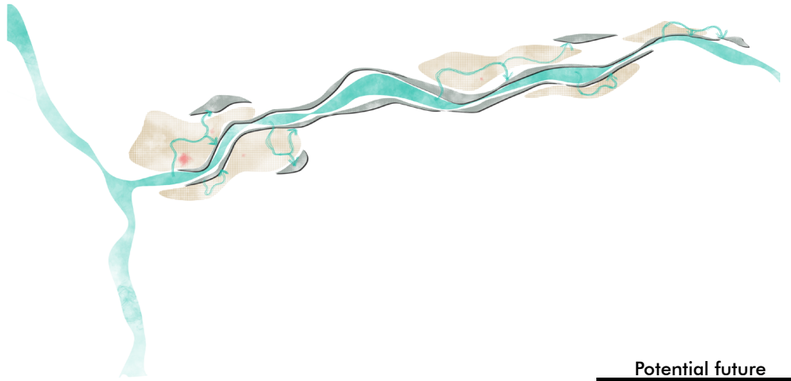
Research by design

So how to improve water efficiency and provide a better environment for people? In the research project, a design will be made to explore the potential answer. The whole concept of this design is improving the water efficiency of every drop by reorganizing water flow and improving farming methods and also built new forests to creating a better environment for farmers and citizens.

In the past, farmers and citizens take water to form the river without limitation and farmland expands every corner of the river bank. In the future, new water flow could be organized and riparian forests could be rebuilt. Meanwhile, a new protection forest could be built to protect the environment. those forests could be used as a wind barrier, a natural bank, and a production forest.



Current situation



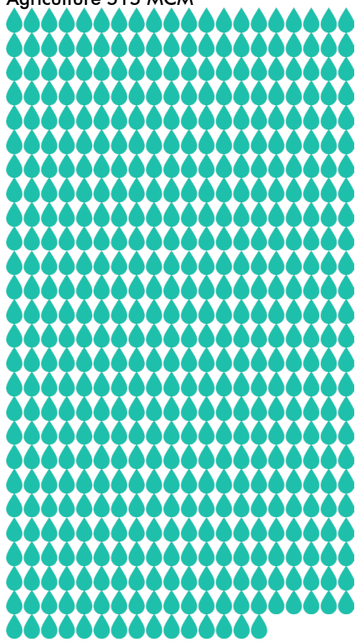
Potential future

06.2 Scenarios

06.2.1 Current water consumption and flow

=1MCM=1 million cubic meter

Agriculture 515 MCM



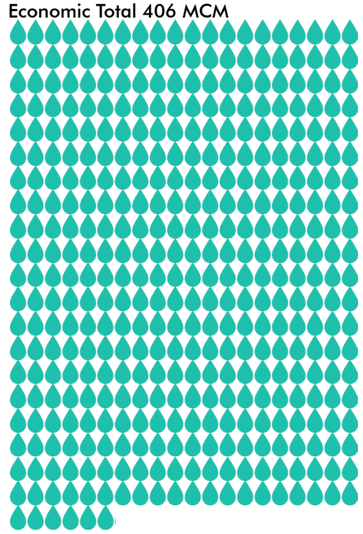
Tourism 1.86MCM



Daily use 33.48 MCM



Planed by government
Economic Total 406 MCM



Ecology water 1,602.66 MCM

>

<

Ecology water needed 1,747 MCM

To achieve the concept for sustainable living mentioned before, working on the water facts is essential. The water data and flows are the most basic aspects of the farming and living conditions. Based on the water consumption analysis and water flow analysis, the economic water is larger than the government planed, which caused about 144 million cubic meters of ecology water efficiency. Currently, the Tarim river could support about 45,900 ha, 2million tourists, and 673 thousand citizens.

Support

Agriculture 45,900 Ha

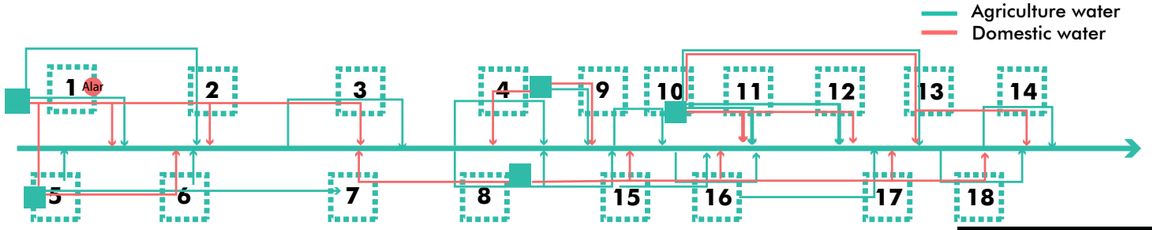


Tourists 2,062,500



Citizens 673,800





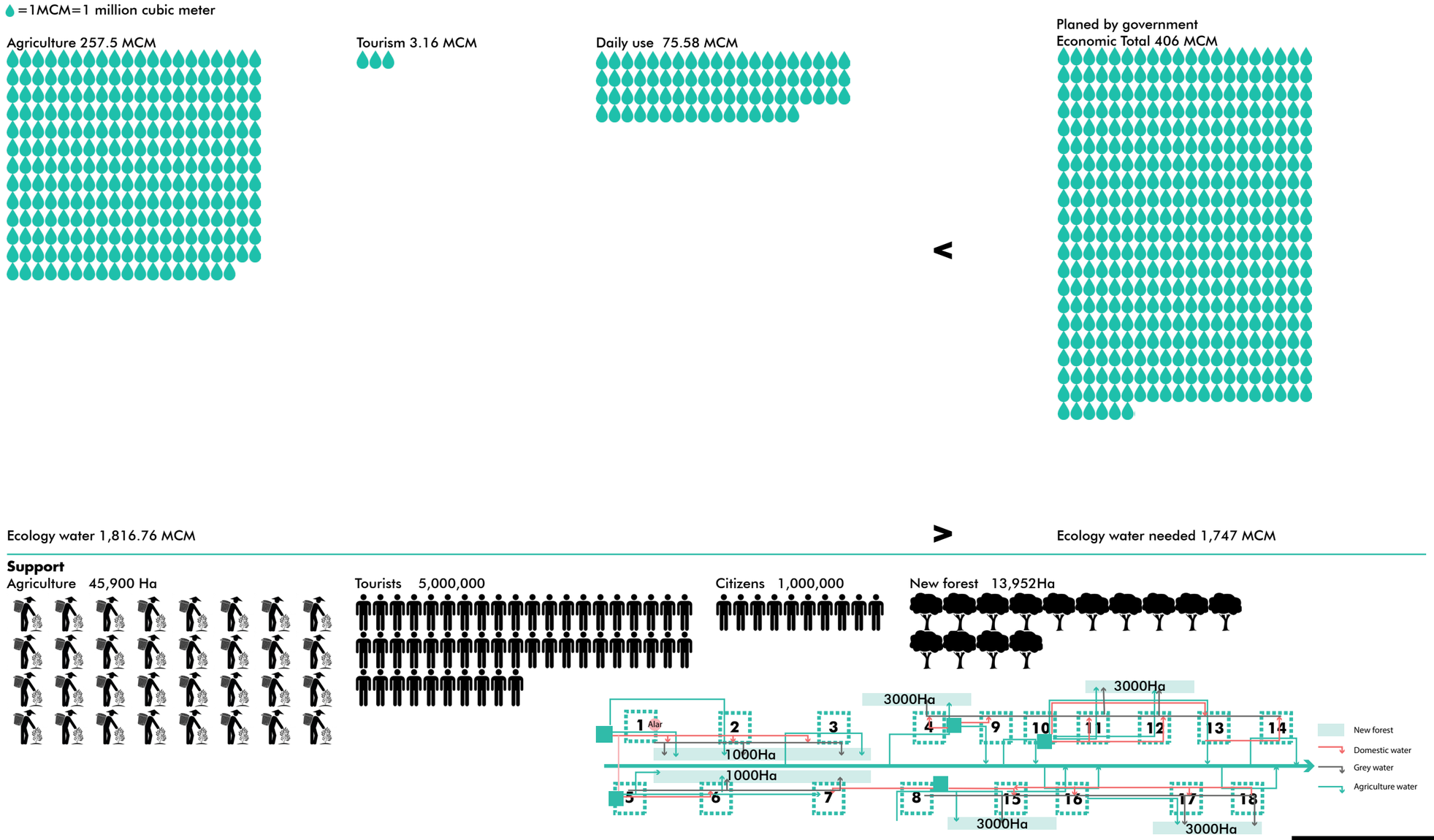
06.2 Scenarios

06.2.2 Water consumption and flow in 2050

The scenario of this concept is starting from reducing agricultural water consumption. By the research in some kind of project and cases, improving the farming method and new water flow including greywater structure could reduce more than 50% water consumption of agriculture. Thus, in this design scenario, the designer hypothesized the agriculture will reduce about 50% water consumption.

Meanwhile, the tourists are predicted to grow to 5 million and consume 3.16 million cubic meters of water, while the citizens will increase to 11 million and consumed about75.58 million cubic meters of water. In sum, the total economic water consumption will be less than the data planned by the government. The left water for ecology will be 69.76 million cubic meters.

Under this hypothesis, the saved water for ecology could supply about 14,000 hector size new forests. Thus, 1000 ha riparian forest could be built on each side of the river respectively, and four 3000 ha size protection forests could be built at the edge of the oases.



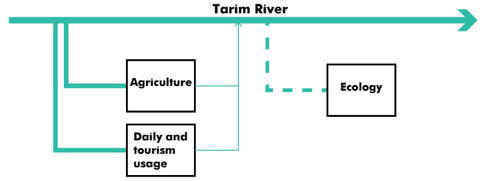
06.3 Principles
06.3.1 Water saving design

Based on the literature and case studies, water-saving design principles are extracted to mitigate the problems mentioned before. The water-saving design principles could be divided into two parts.

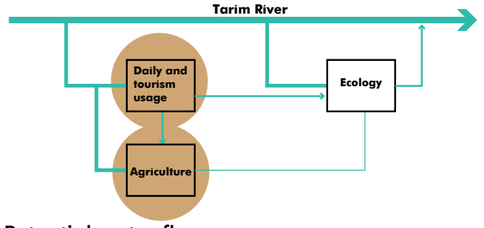
The first part is about re-organizing the water flow and improve water efficiency. The current water flow of the Tarim river is agriculture and city consumption is separate and left little water for ecology. By reorganizing water, the daily use and tourism use will be the first, and the grey water and black will be treated separately, then those "waste" water could be flow into agriculture and ecology part without the potential of damaging the land. For the agriculture water in a detailed flow, the cotton field will be changed into less water-consumed water, and then exceed agriculture water will be reused to other fields and forests.

The second part of water-saving principles will be a toolbox on a small scale. The toolbox could be divided into three categories, collect, transport, and collect. Those toolboxes could be used for farmers to improve water efficiency.

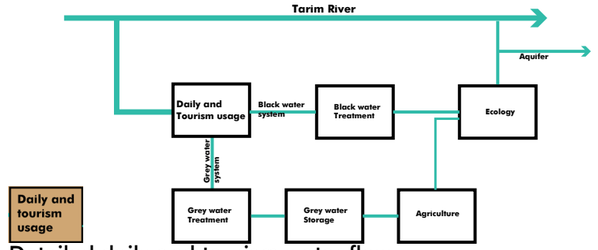
Flow principle



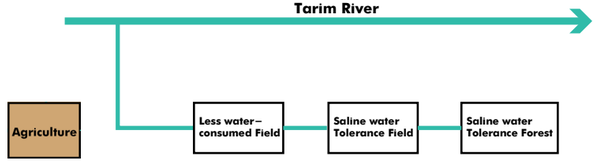
Current situation



Potential water flow



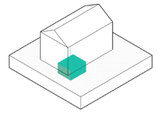
Detailed daily and tourism water flow

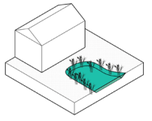


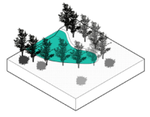
Detailed agriculture water flow

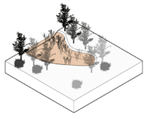
Tool box

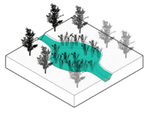
Collect


Grey water collector

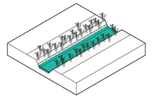

Housing Water pond

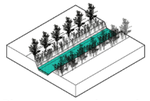

Water retention pond

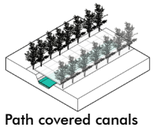

Waster water pond


Water Purification

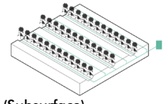
Transport

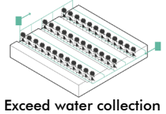

Semi-hardened canals

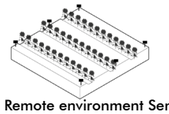

Plants covered canals

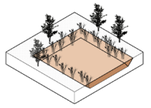

Path covered canals

Use


(Subsurface) drip irrigation

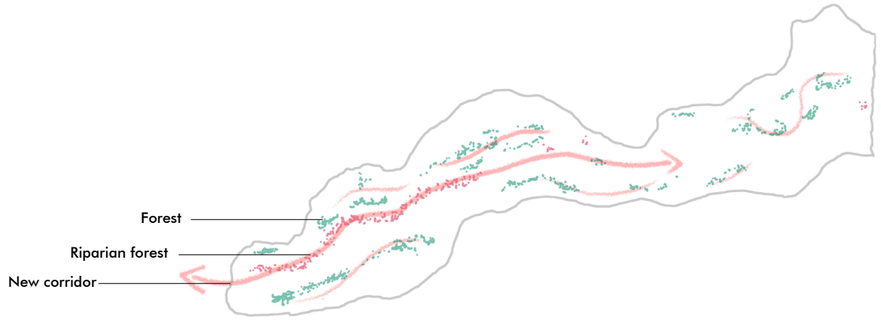

Exceed water collection


Remote environment Sensor


Ecological fish farm

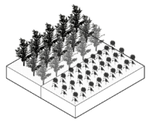
06.3 Principles
06.3.2 Afforestation

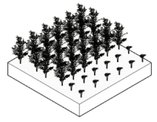
Potential planting

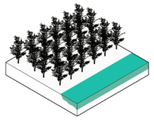


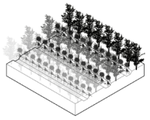
Planting Toolbox

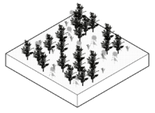
Choice

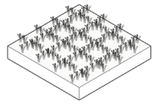

Protection forest

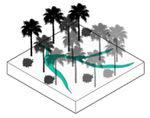

Wood production forest


Riparian forest

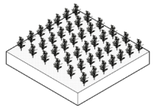

Agroforestry

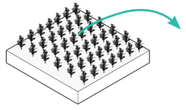

Food forest

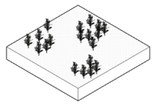

Grass grid

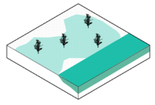

Saline tolerate forest

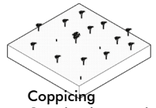
Method


Dense planting


Transport planting


Cluster planting


Growing by flood in soft bank


Coppicing
Growing by remain roots


Planting with Groasis Waterboxx

The potential planting principle is mainly based on the analysis before, the potential planting location is where has a higher potential of land degenerate and lacking corridor. the new forest and riparian forest could be built in those locations.

The planting toolbox has two categories one is the type of forests that could be chosen for the farmers and the other one is the method that could be used for planting a forest.

06.3 Principles
06.3.3 New circularity

New crops


Onion


Bak choy


Potato


Pepper


Date


A. venetum L.


Sunflower


Soy bean


Garlic


Tomato


Apple


Kidney bean


Melon


Hops


Almond


Walnut


Corn

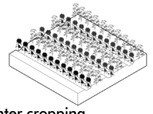

Pumpkin

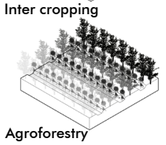

Peanut


Pea


Wheat

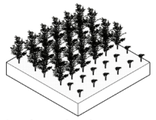
Potential Inter-copping/ Agroforestry

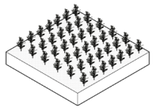

Inter cropping


Agroforestry



Other possible income


Wood production

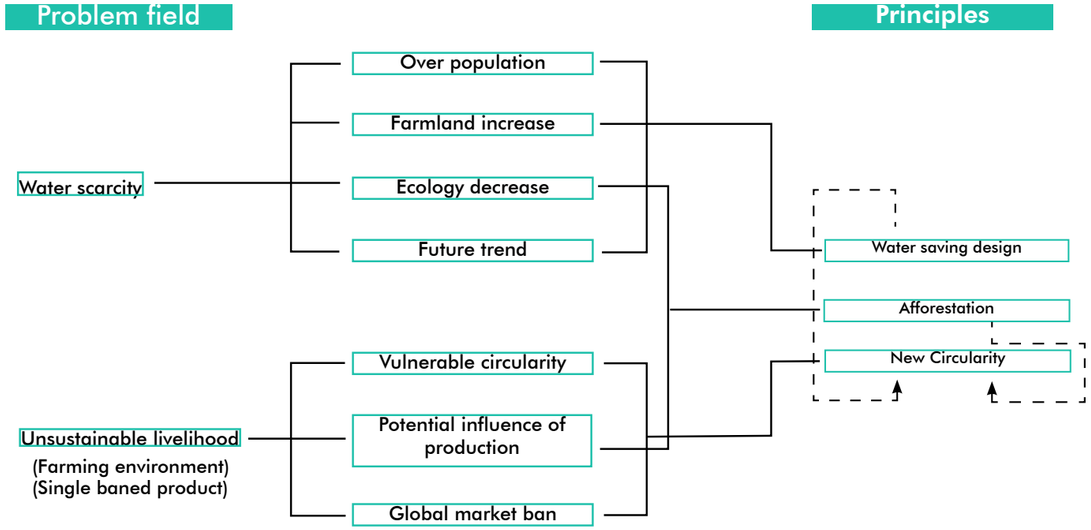

Planting

Rural tourism

Bazar (Market)

For the establishing of the new circularity, it is essential to find more ways of income and more connected to the city or government. The first principle is to select new crops. By defining the water consumption and climate needed, 21 types of crops have been selected for this region. After choosing those crops, a new planting method of intercropping and agroforestry could give diversity to the system and also boost production. Here are some potential combinations of different crops as a second principle. The third one is to have other possible incomes for farmers. The farmers also could choose to plant wood production forest, join the government's planting plan, rural tourism construction, and local market Bazar construction.

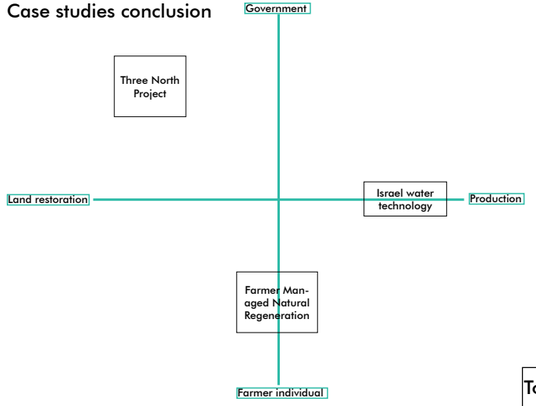
06.4 Design flow

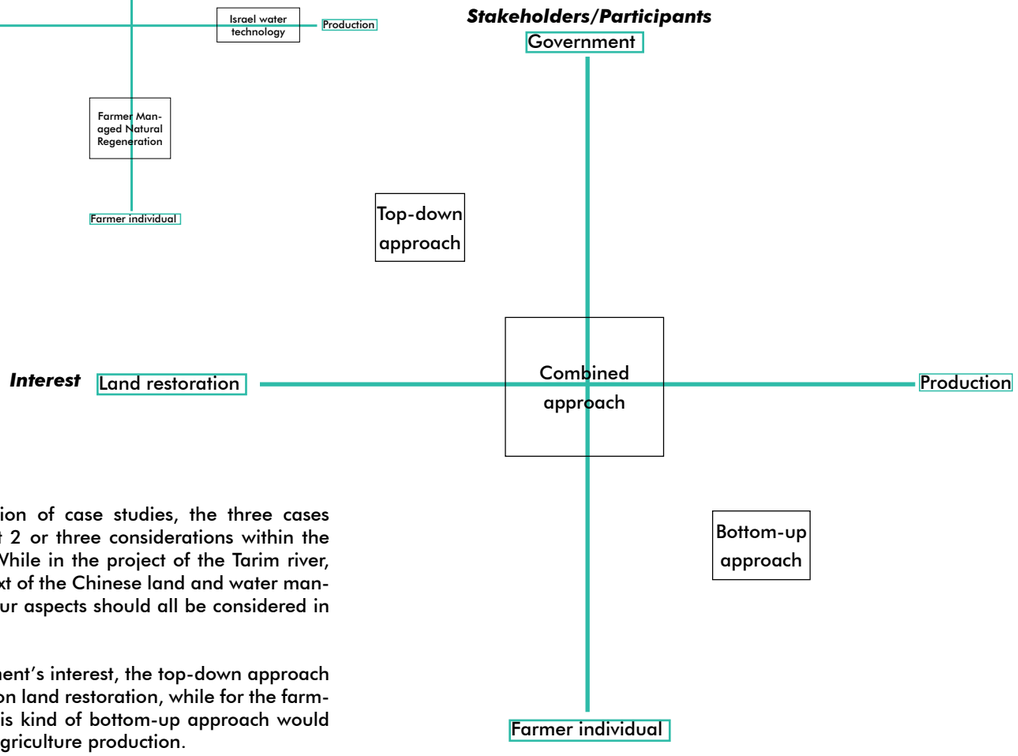


Based on the previous analysis of problem fields and upper reaches scale analysis, the water scarcity and unsustainable livelihood problems are the most crucial problem of the upper reaches of the Tarim River. To explore the solutions, principles were concluded in 3 parts. And for each principle, it could be solutions for those small problems. For instance, the water-saving design could mitigate the farmland increase, overpopulation, and future trend. While afforestation could solve ecology decrease and potential nature influence of production. Meanwhile, based on the water-saving design and afforestation, the new circularity could be achieved easily.

06.5 Design approach

Case studies conclusion



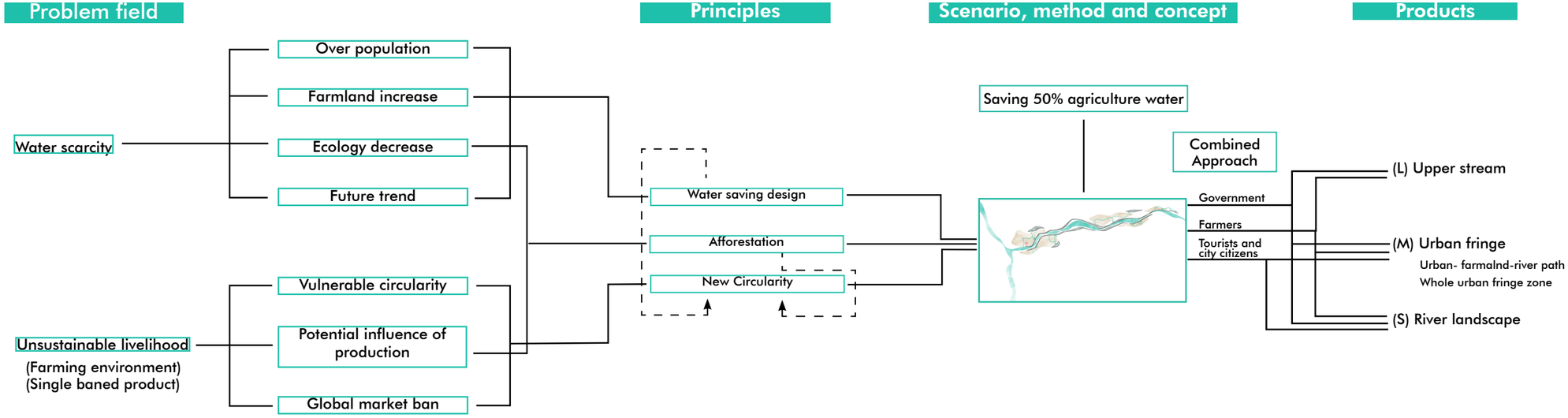


On the conclusion of case studies, the three cases could only meet 2 or three considerations within the whole project. While in the project of the Tarim river, within the context of the Chinese land and water management, the four aspects should all be considered in the projects.

For the government's interest, the top-down approach will more focus on land restoration, while for the farmers' interests, this kind of bottom-up approach would more focus on agriculture production.

Based on the two points above, in this design exploration, a COMBINED APPROACH would be tested and concluded. this kind of approach will combine the interests of land restoration and agriculture production, let the government and farmers all contributing to this project.

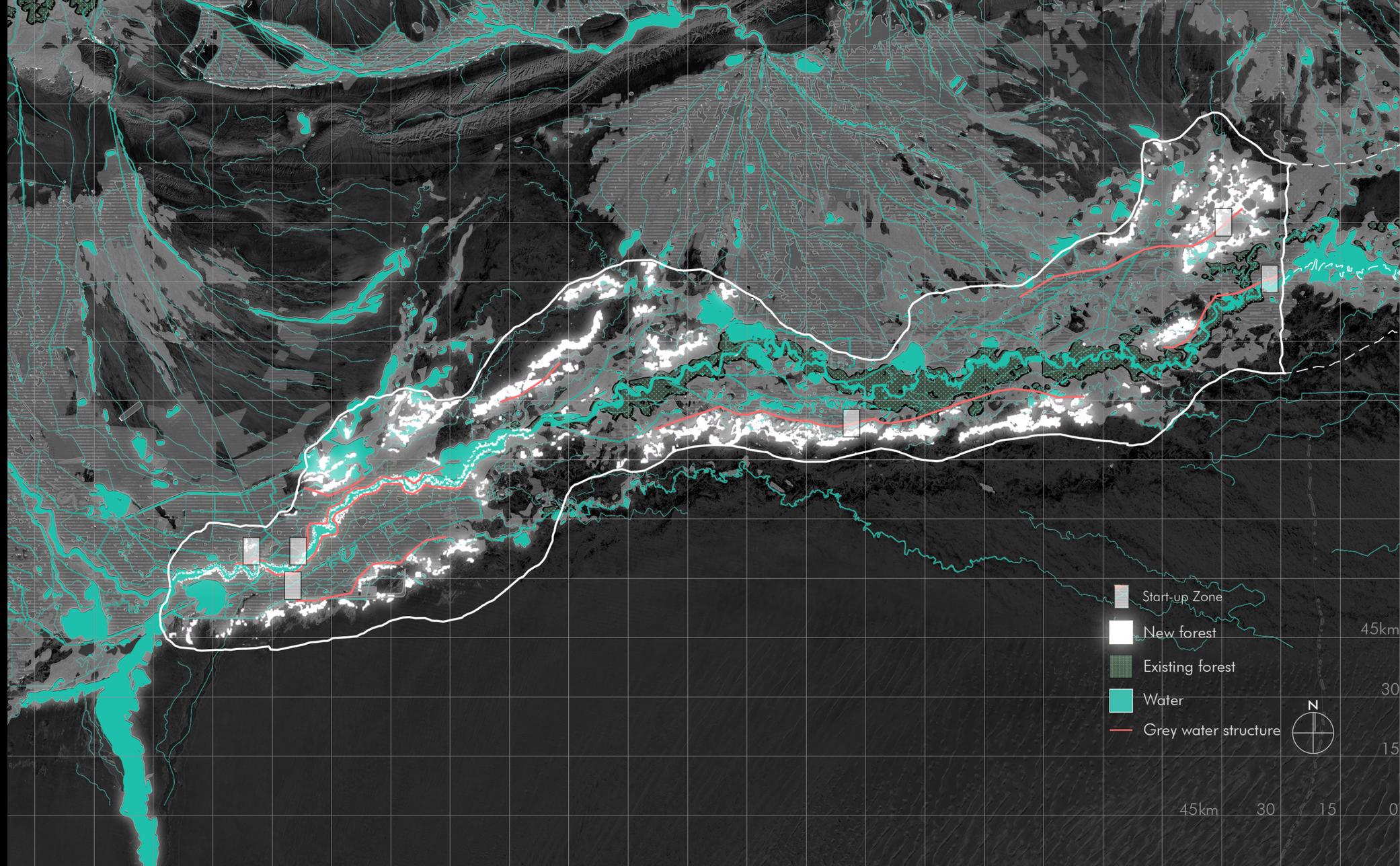
06.6 Design through scales



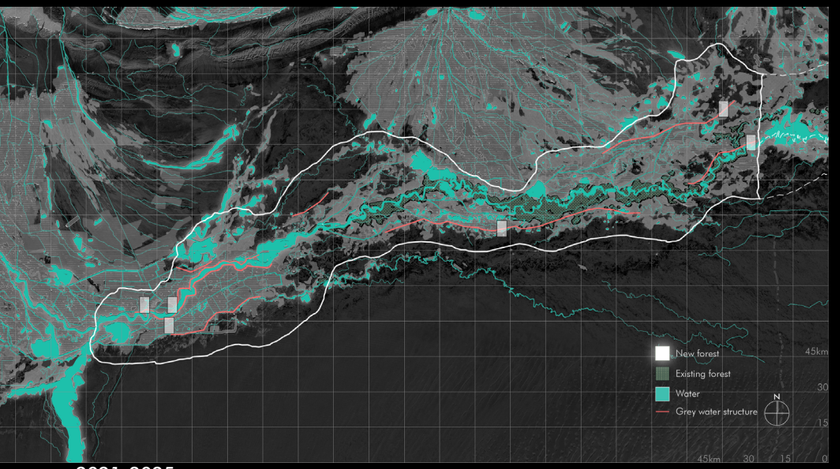
06.7 Upper scale design

06.7.1 Proposed plan in 2050

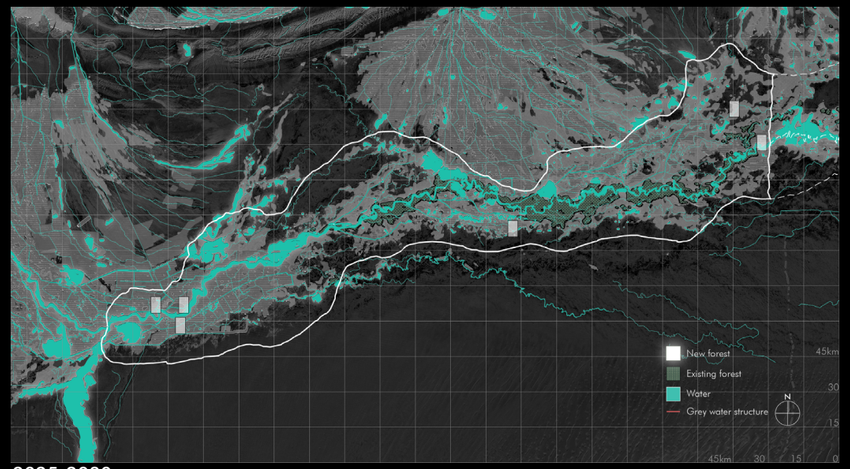
This map shows the potential planting forest in 2050. In this plan, the new forest will be planted at the edge of farmland and also in the beginning part of the river bank at the upper reaches of the Tarim River. Those forest locations are based on the analysis of potential land degeneration maps and the lacking connection in riparian forests. To plant those new forests, several greywater systems are built to collect the greywater from cities and villages. Those greywater systems are mainly underground to reduce leaking and evaporation. It also could work as a forest irrigation system by connecting with canals when the greywater is not sufficient. And six places are selected as start-up zones for this whole plan. The reason for choosing those places is the more close locations to city and towns. By doing projects in start-up zones first, they could show the possibility to participants and also work as Tree Nursery Centers for the whole region.



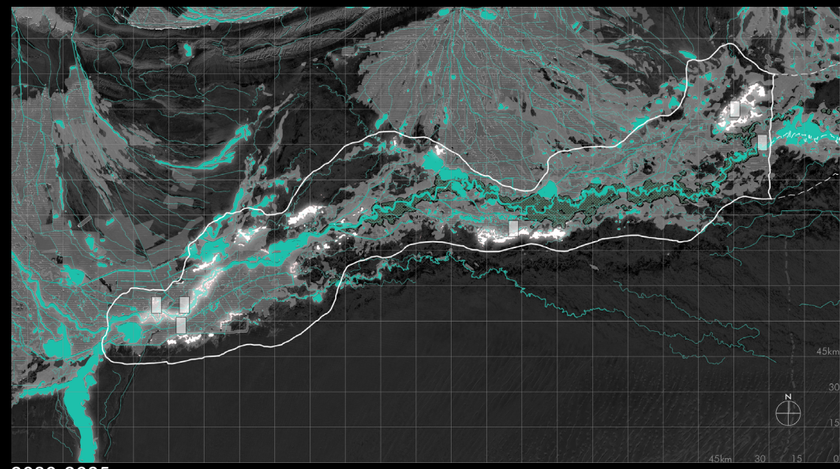
06.7 Upper scale design
06.7.2 Construction process



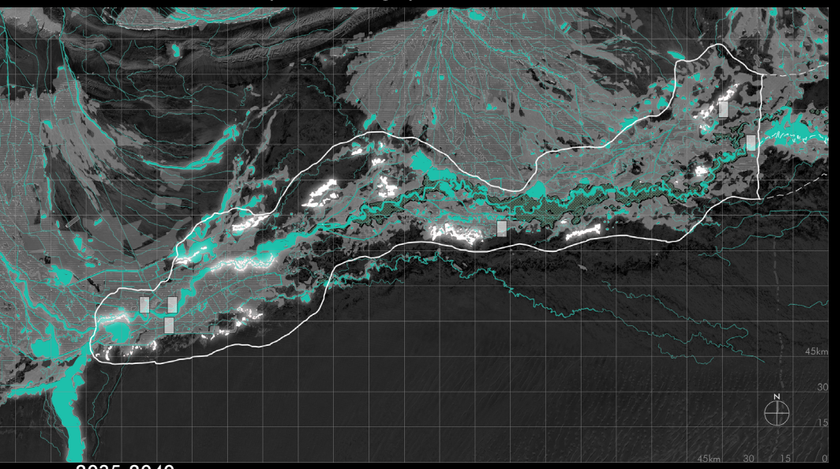
2021-2025
Construction of start-up zones and grey water structure



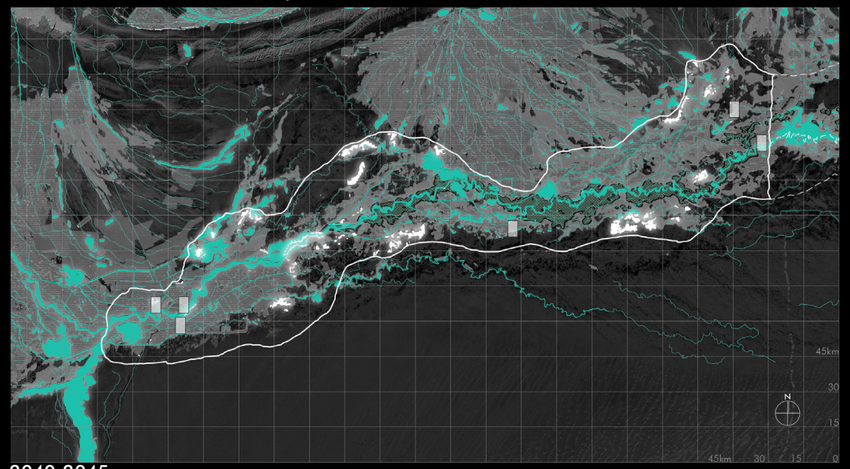
2025-2030
Continue construction of start up zones



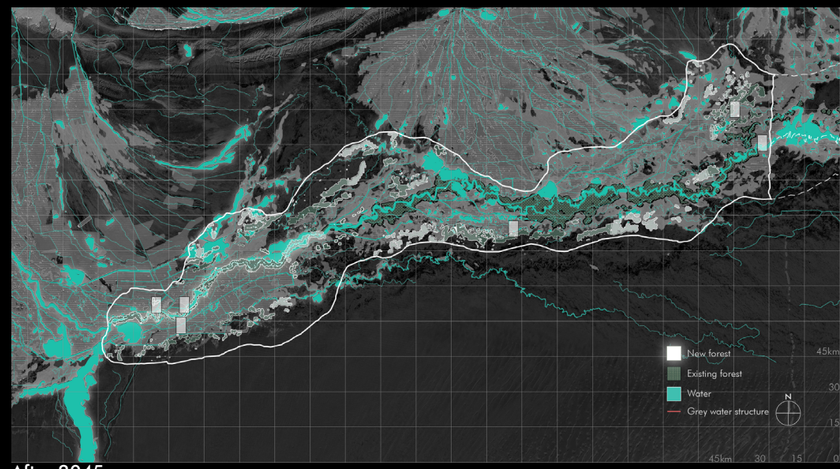
2030-2035
Zone A Forest construction



2035-2040
Zone B Forest construction



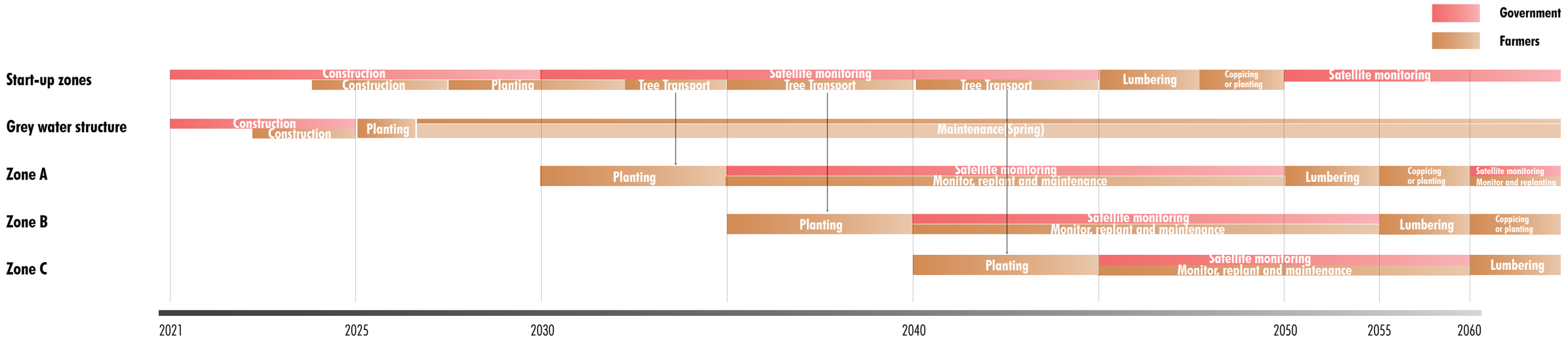
2040-2045
Zone C Forest construction



After 2045
Shift timbering in Zone A,B,C every five years

This sequence of mapping illustrates the Transformation of the whole plan from 2020-2050. This step-by-step strategy is mainly based on the characteristic of popular eupharatic and 15 years are enough for it grows mature and gets timber. During the whole process, the greywater structure is constructed first then start planting in start-up zones. After 10 years, the trees could be transported to a different part of the zones.

06.7 Upper scale design
06.7.3 Timetable

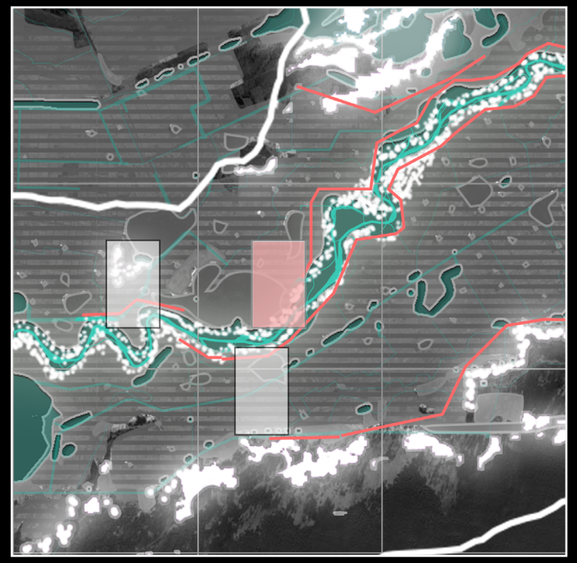


This timetable explained the whole landscape is constructed by the farmers and government. The startup zone will be first constructed. It could work as a tree nursery center for this whole region. the baby Populus eupharatic trees will be planted and transported to different zones. The government will participant in the construction in the beginning, and then invest money and provide support for the tree growing by satellite monitor, etc.

Baes on the characrestics of Populus eupharatic. The trees could grow to mature in 15-20 years according to the water facts. Thus, in the start-up zone, where is water-rich, the trees could be cut 15years after plantings. While for other parts, Trees will be cut for wood in 20 years. After then, The trees could grow the method of coppicing. If some trees don't grow, the replanting will happen by the farmers.

06.8 Upper Fringe impression

06.8.1 Zoom in startup zone



The start-up zone that will be zoomed-in is close to the city, Alar. In this more detailed design, it will introduce how this design is started and transformed more clearly. Moreover, it is close to the city, the land transformation and human relations including citizens and tourists could also be an interesting point for the whole transformation plan. Since this is a huge transformation plan in the upper reaches of the Tarim river, so this start-up zone plan could work as a test site for the whole plan. And how this plan will change the landscape in human perception will be explored as well.

06.8.2 landscape impression

Summer


Canal


Cotton feild


Small canal


Canal


Farmland


Vegetation


Tarim river


Tarim river


Tarim river

Winter


Pond




Forest


Tarim river


Canal


Road

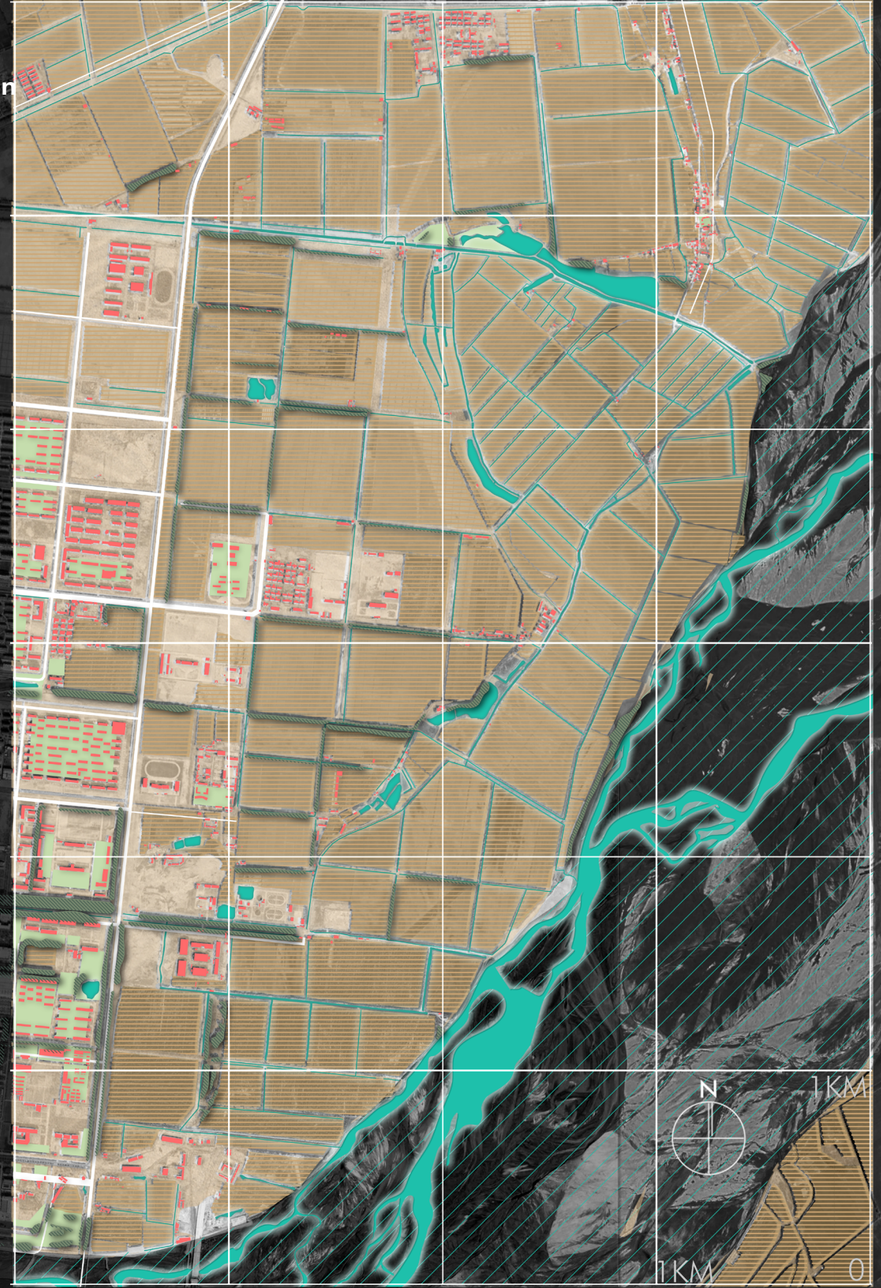

Traditional housing


Current housing

The landscape itself is quite different in the summer and winter in the start-up zone. In the summer, when water is rich, the whole zone is more humid and partly covered with green vegetation. The vegetation will get denser when people are more close to the Tarim River. In the winter, the land is totally dry and becomes lifeless. The river will get frozen and the river gets extremely narrow.

06.8 Upper Fringe impression

06.8.3 Landuse and layers

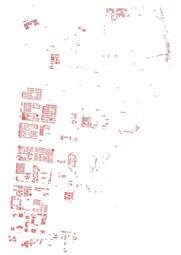




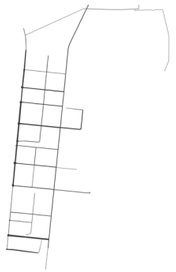
Forest



Water system



Housing



Road



Farmland



River boundary and dike

Grassland

This graph shows the different layers of the current startup zone. Located in the urban fringe, the start-up zone is a space between the city and the river. The boundary between city and farmland is quite clear. As we can see in the layer maps, the grassland, road structure, and trees are denser in the urban area and little in the farmland area. While in the boundary of river and land, the farmland occupied the space of the forest, making the boundary more in straight artificial line. In the farmland area, the dense water systems are irrigation canals and water retention ponds.

Overall speaking, this urban fringe area is full of farmland and there are strong boundaries between farmland and surroundings.

06.8 Upper Fringe impression

06.8.4 structures



The current road structure is one distinctive structure of the whole start-up zone. Because of 15 meters width, it became an obstruct between farmland and city. The current road structure didn't reach the farmland area, so in the farmland part, it is still unpaved road, making the difference even bigger.

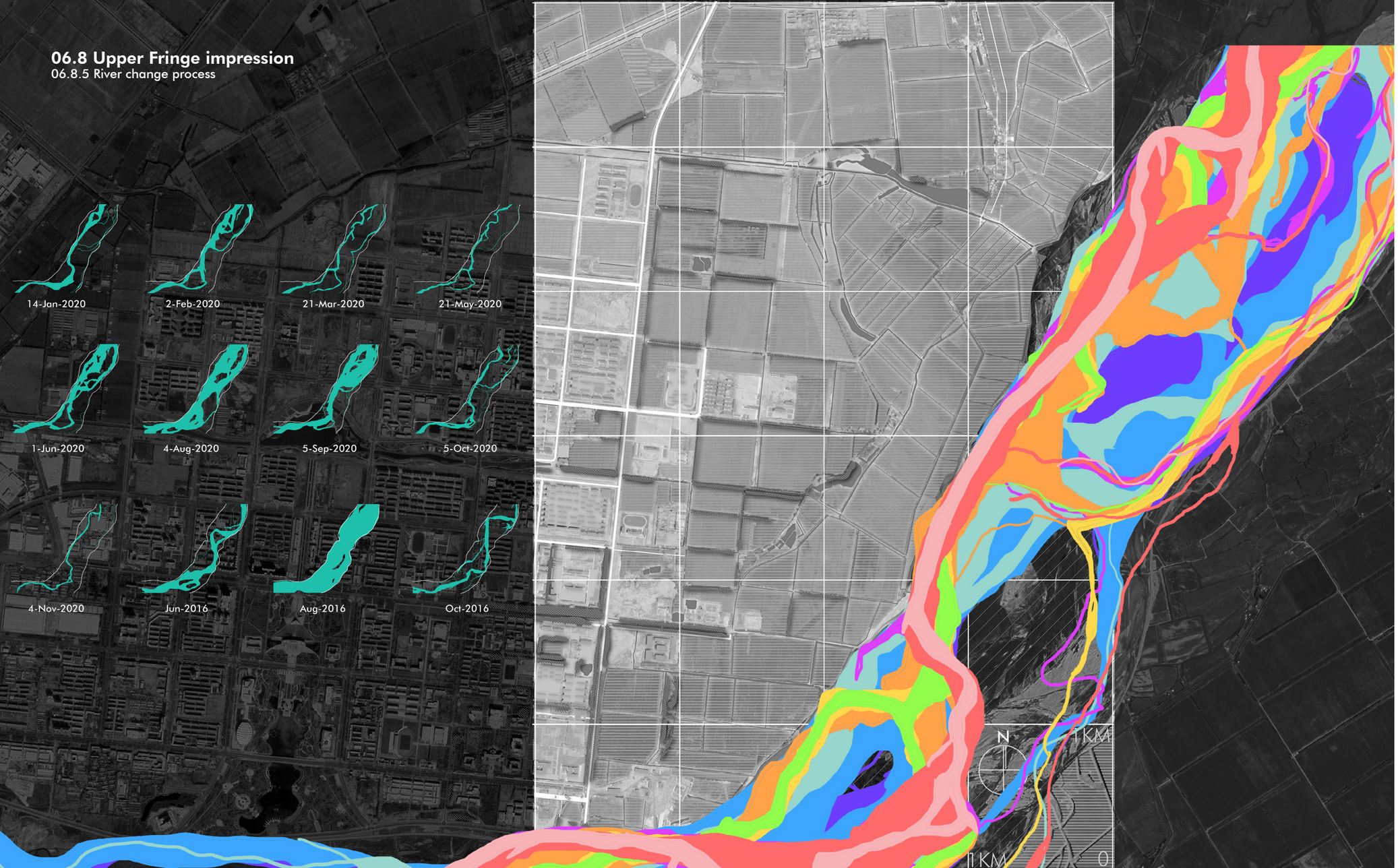
The second structure is more invisible and it is the old river palimpsest. Due to the reclamation of farmers, the old river place is disappearing. In the past, the east side of this structure is a river course and then it becomes farmland. Only the different hatch between two side farmland making this history visible now.

The third structure is the boundary between land and the current watercourses. Due to the current land is filled with farmland, the current boundary is hard and exclusive for each other.

The fourth interesting structure of this area is the transition within the city, farmland, and river. In this unmanaged situation, the transition feeling is strong and the experience is different. These three area are more like individual areas to each other and can not exist in a harmony.

06.8 Upper Fringe impression

06.8.5 River change process



The Tarim river runoff and flows changed a lot within one year. Based on the monitor of the satellite image, yearly changes could be mapped. During the last year, the river runoff is rich from June to September and is poor especially in Spring. And last summer, the runoff is not at a high level because the river courses is not full during the flood season, while it can be seen in the flood season of 2016.

By overlapping different months' runoffs, someplace could be flooded in some water-rich months while some places could never be flooded last year.

06.8 Upper Fringe impression

06.8.6 Seasons process



Four seasons is an instinctive process when people experience the Urban fringe landscape. As mentioned in the landscape photos, the seasonal change is quite strong during one year.

Thus, a model was built to stimulation the landscape change in four seasons in the farmland and future forest area. In the spring, the land is still dry feeling and some green vegetable starts growing. While in the summer, due to the water become rich, the trees and crops grow fast and with full canopy, and the land grows again. Then in the fall, the most beautiful season, the land turned totally yellow. The forest of Populus eupharitic will become orange and become a tourists attraction. Finally, in the winter, the landscape turns into dead land again, everything is grey and dusty.

06.9 Upper Fringe design

06.9.1 Urban fringe master plan

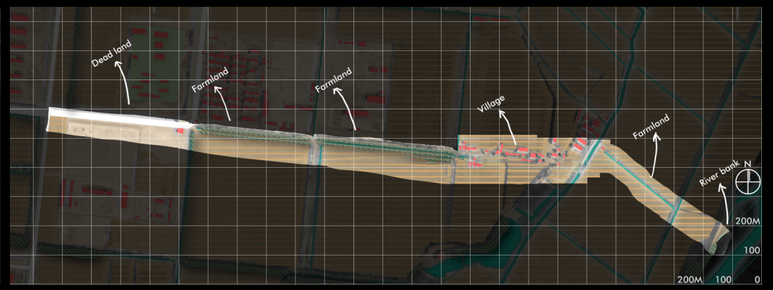
This master plan shows the landscape after the construction of startup zones. Build with the three types of principles and applied those principles into those design structures, this design forms a riparian forest system, a grey-water structure, and a new connection between urban area, farmland, villages, and Tarim river. By creating those structures, continuous water flows and a sustainable farming way could be achieved. Thus, farmers, citizens, and tourists could have a wonderful experience in this urban fringe.



06.9 Upper Fringe design

06.9.2 Starting path- Design plan

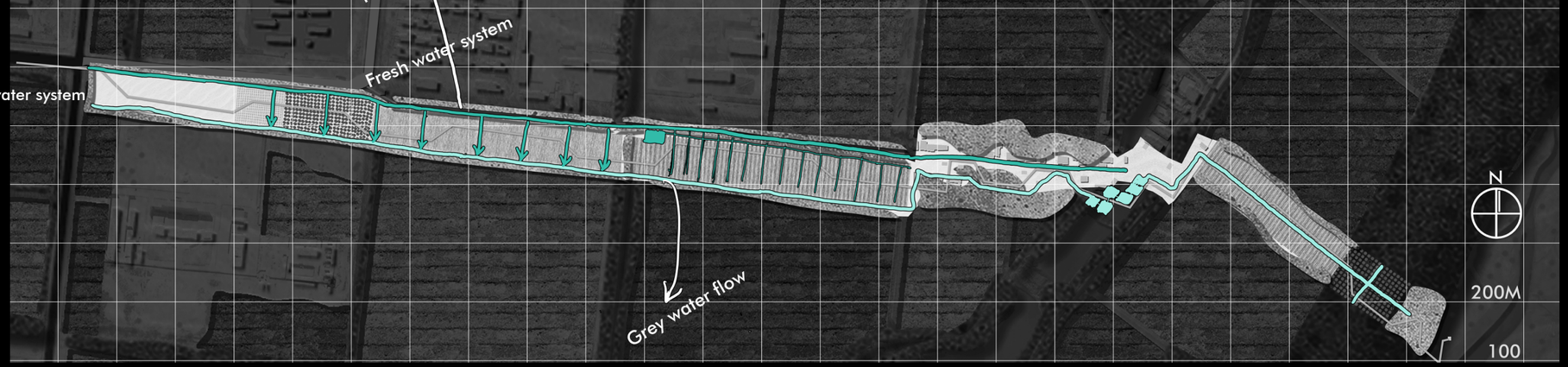


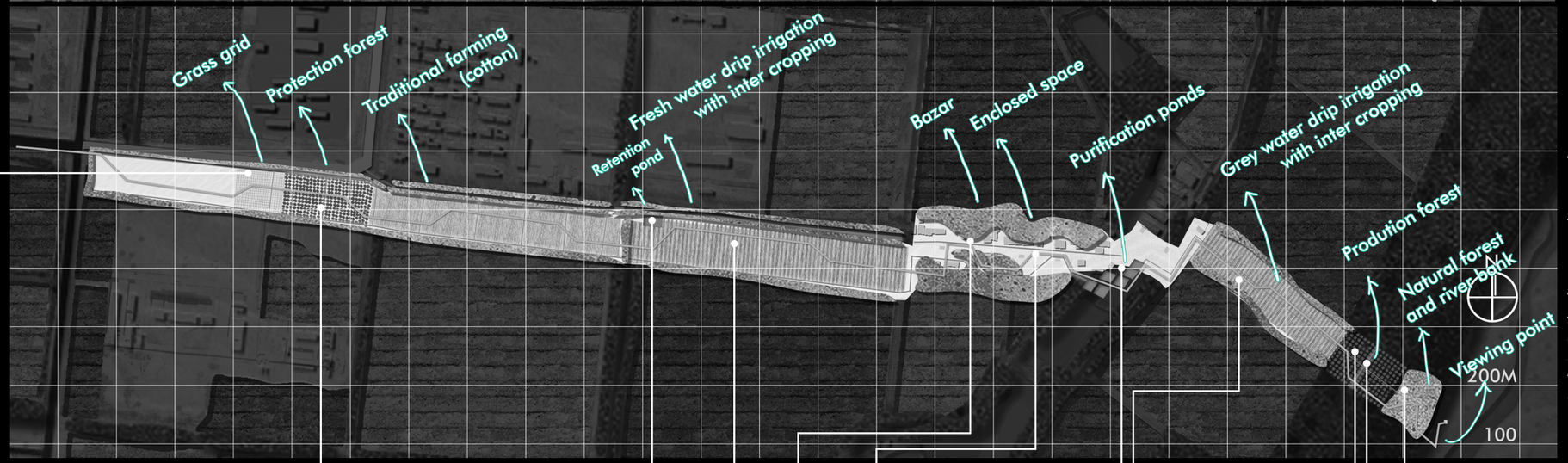


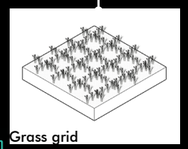
The purpose of path design is to introduce the whole project to the potential participants and making connections between different separate parts. The current path has few dynamics and the landscape is not attractive for visitors. The current land use from city to river could be city- dead land- farmland-village- farmland- river bank. So in the design exploration, it will show the potential principles to deal with the land and let people see the benefits of those principles. By designing those aspects in a small path, people might willing to join in this project.

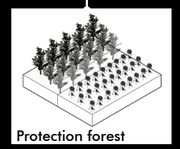
The principles used in the path from left to right are grass grid, protection forest afforestation, traditional farming method, freshwater irrigation with intercropping, Bazar, purification ponds, greywater irrigation, production forest, and riparian forest.

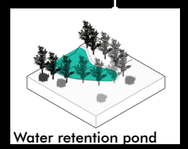
In the design, one new grey structure is built. Combining it with the existing freshwater system, people could understand what kind of water is used for irrigation and how the greywater is purified and then in the farmland.

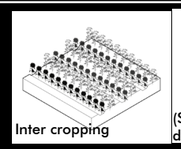


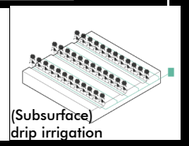


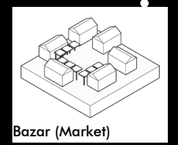




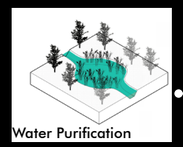


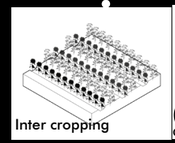


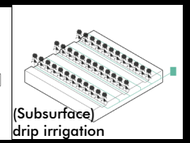




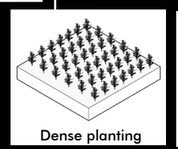


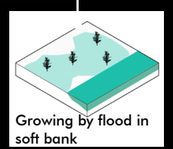










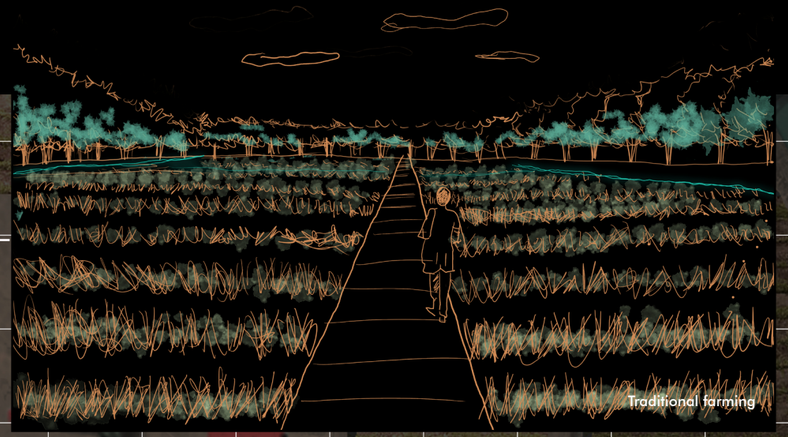


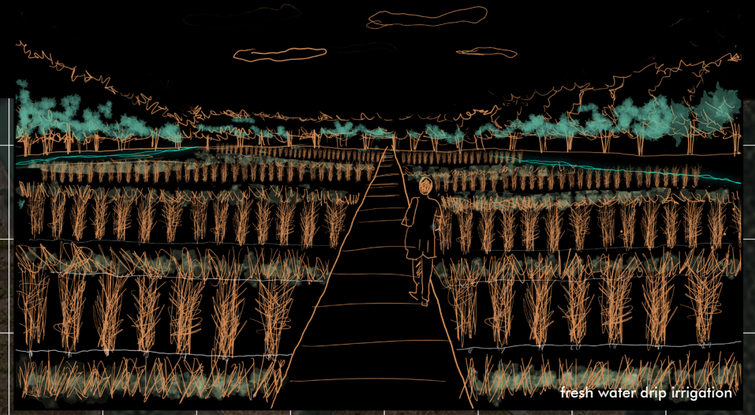
This map shows a budget of principles used in the Path. From west to the east, the different types of principles are used based on the current situation of the land.

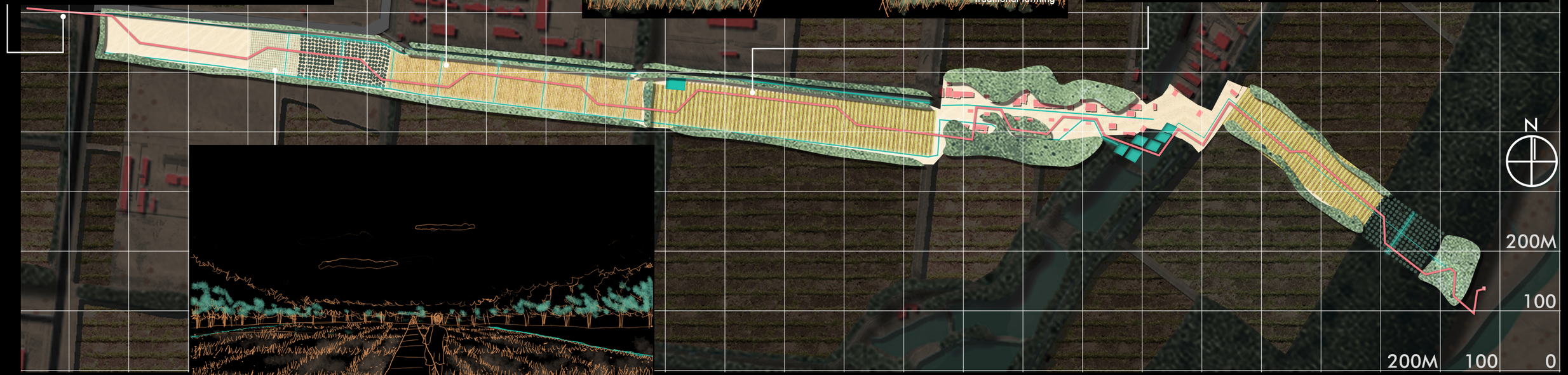
The water system indicates different water used for this path, and also show the idea that not only freshwater but the greywater will be used for the irrigation and afforestation.

06.9 Upper Fringe design
06.9.3 Starting path - experience

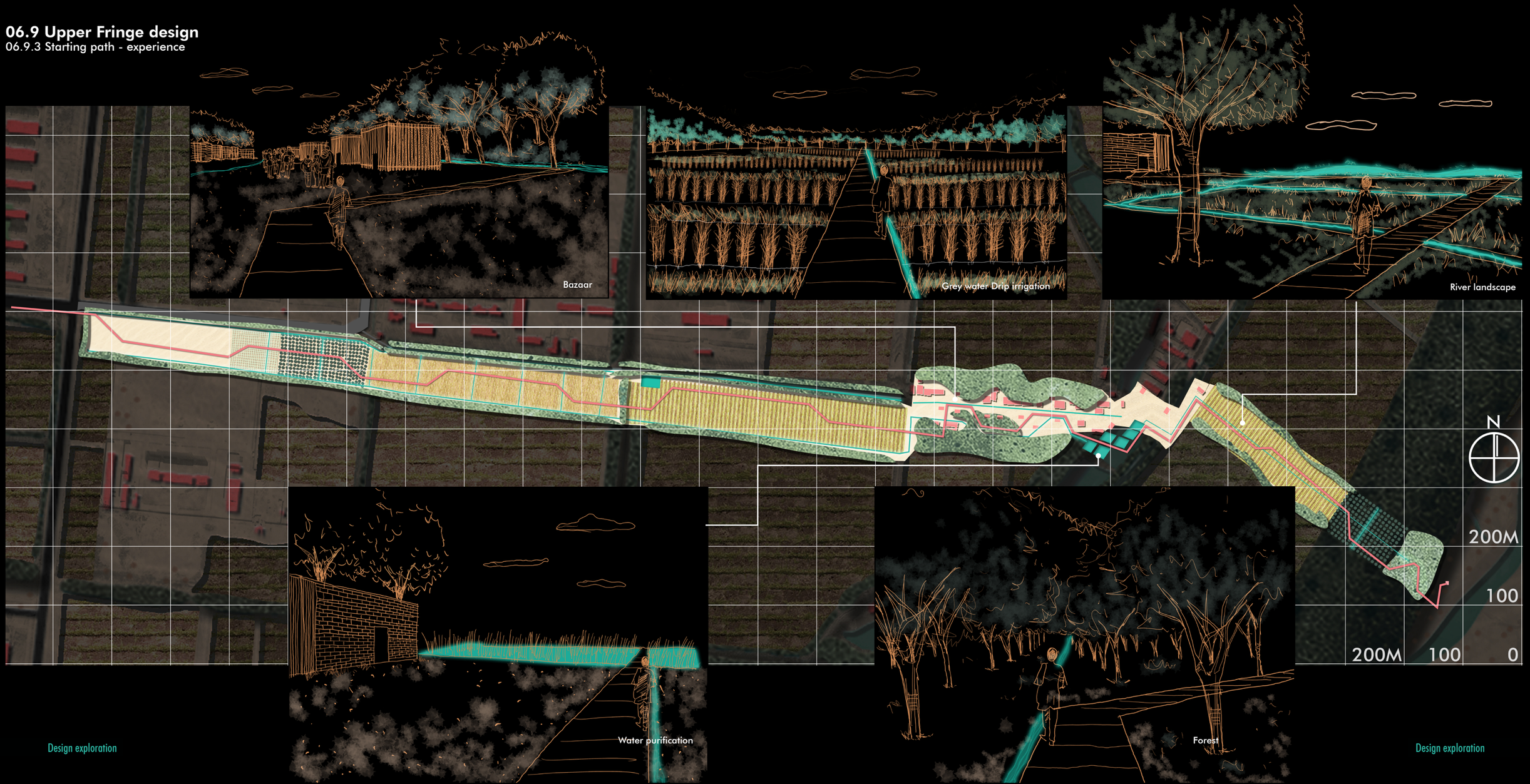








06.9 Upper Fringe design
06.9.3 Starting path - experience



06.9 Upper Fringe design
06.9.5.Startup zone - Construction process



This master plan shows the landscape in 2030, after the construction of the startup zone. The construction process could be divided into 4 phases, the first phase is to construct one urban- farm-land- river path. During this path, people could have a brief understanding of the whole project by introducing different principles in this path. In 2026, the purification part of the greywater system could be built along the old river palimpsest. One year later, trees will be planted along those ponds to reduce evaporation and creating a better microclimate. Then in 2027, tree planting starts in the riparian side and could be transported after 3 years.



2021-2023
Construction of starting path



2023- 2026
Construction of grey water system

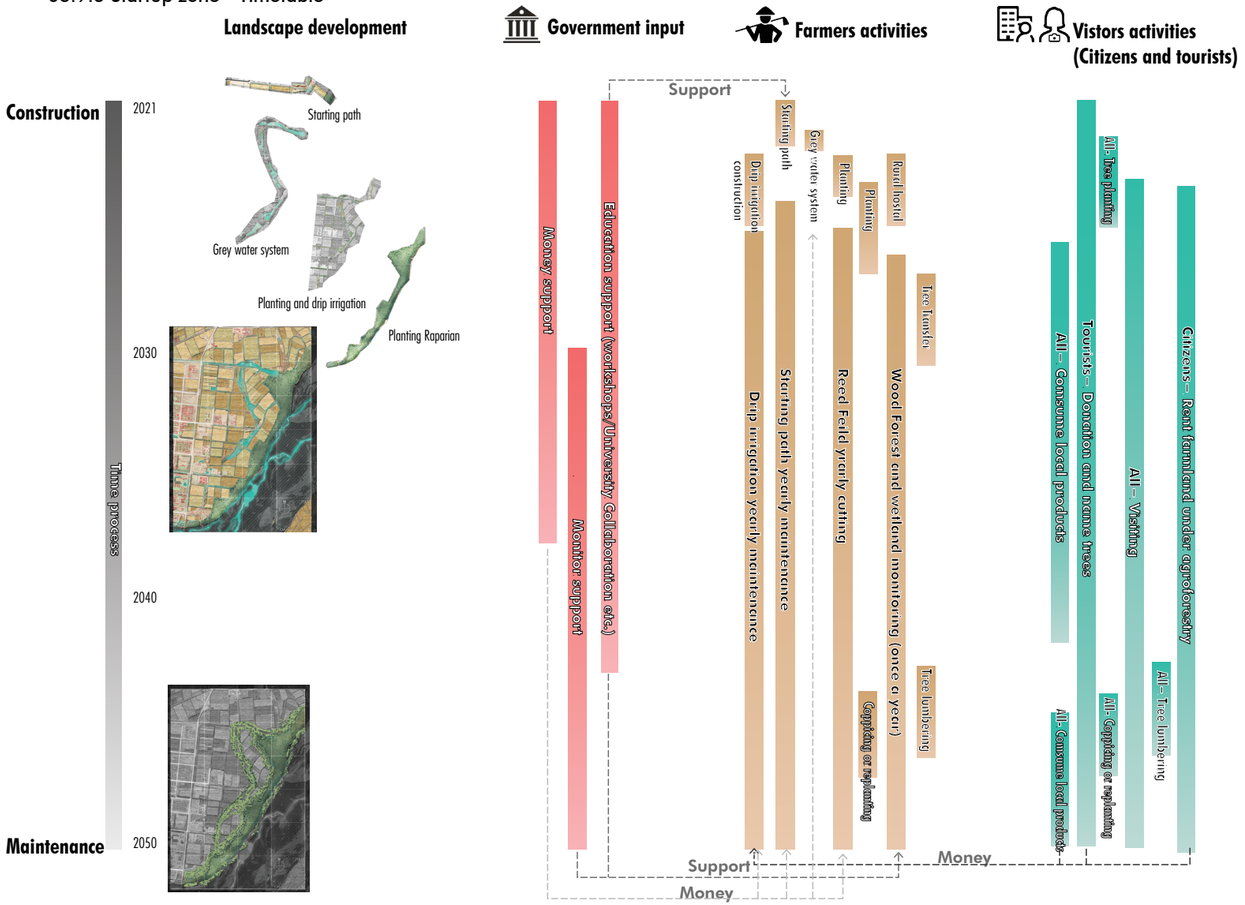


2026- 2027
Planting along grey water system and irrigation transformation



2027-2030
Planting the raparian forest

06.9 Upper Fringe design
06.9.6 Startup zone - Timetable



This timetable could explain the construction and development of the master plan. Generally, the government will invest money for the first twenty years, the visitors and local production will provide money for the maintenance of this project. The farmer will be the main supporter of this construction and maintenance plan while the visitors are the volunteers of this project.

06.9 Upper Fringe design
06.9.7 Startup zone - Nature process



Potential forest map in 2050



Flood season after 2050



Dry season after 2050

The master plan on the previous page is just after construction in 2030. 20 years later, the forest could expand by the natural growth and also the willingness of farmers' participants. The riparian forest system will expand towards the Tarim Riverside and the soft riverbank will form with the force of nature and human intervention. For inside forest, it will expand as well. And some parts might emerge with riparian forest. The old river trace will be more distinctive.

In the food season after 2050, the riparian forest could slow down the flash flood and prevent farmland damaged to some extent.

While in the dry season after 2050, the grey water system could discharge water to the riverside.

06.9 Upper Fringe design

06.9.8 Water saving design- Grey water system agriculture

5 separate small greywater system is introduced in the urban fringe area. Besides the purification area, other parts of greywater transportation are mainly underground. The old river trace is used as the purification water ponds. The greywater will flow through several reed field ponds and then those water could be either collected or used for agriculture. Thus, in the process of purification, the greywater from the city could be used in the urban fringe and other parts of farmland.

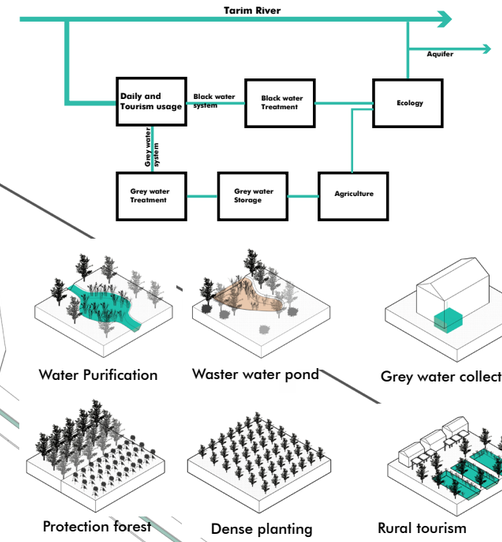


06.9 Upper Fringe design

06.9.9 Grey water structure - Purification ponds



Principles used

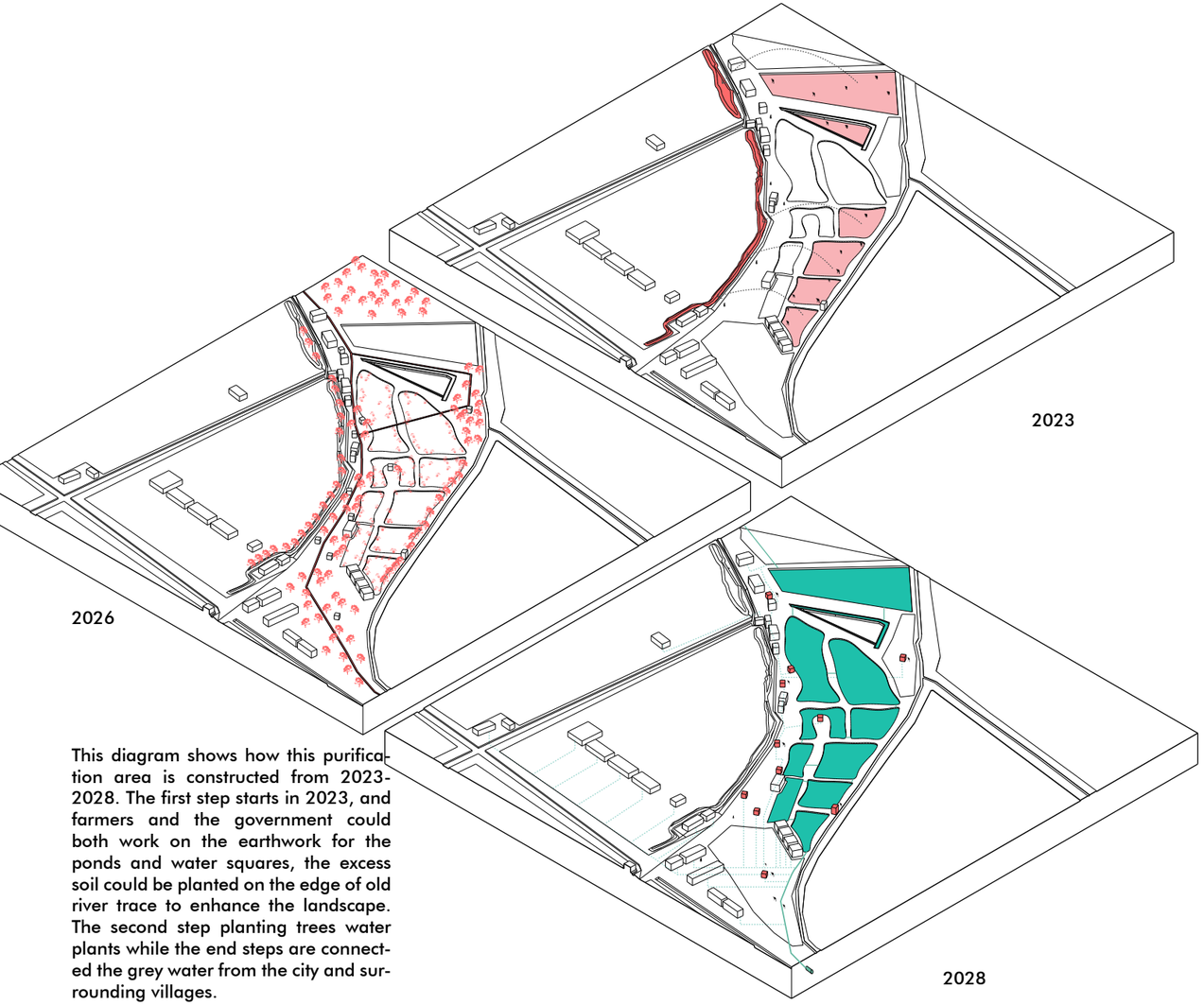


For an insight into the grey water structure, a series of drawings are made to explain the purification system of urban fringe areas. This drawing shows how those small reed fields are made and connected. Several different principles are tested in this small area including reuse grey water, purification, waster water collection pond, rural tourism.

The grey water from the city transport to the reed fields and be purified step by step. Finally, those water should be used in a water square, fish farm, and farmlands. Dense trees are planted to grow reduce the water evaporation and create a micro climate here.

06.9 Upper Fringe design

06.9.10 Grey water structure -construction process



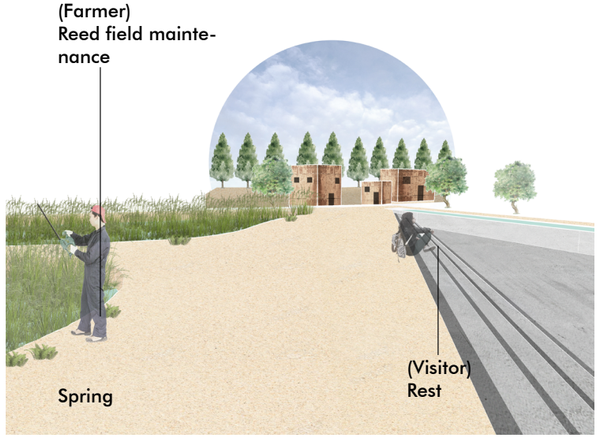
This diagram shows how this purification area is constructed from 2023-2028. The first step starts in 2023, and farmers and the government could both work on the earthwork for the ponds and water squares, the excess soil could be planted on the edge of old river trace to enhance the landscape. The second step planting trees water plants while the end steps are connected the grey water from the city and surrounding villages.

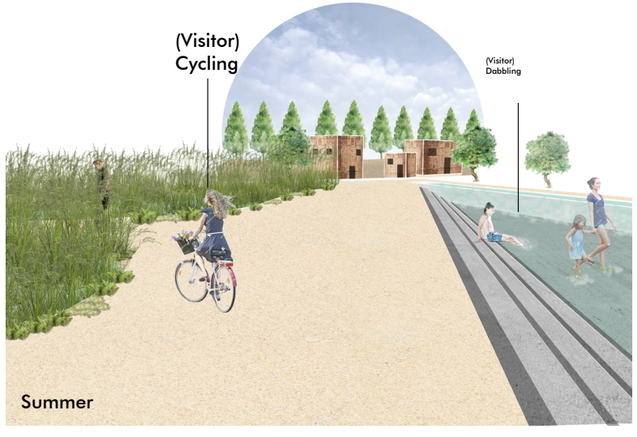
06.9 Upper Fringe design

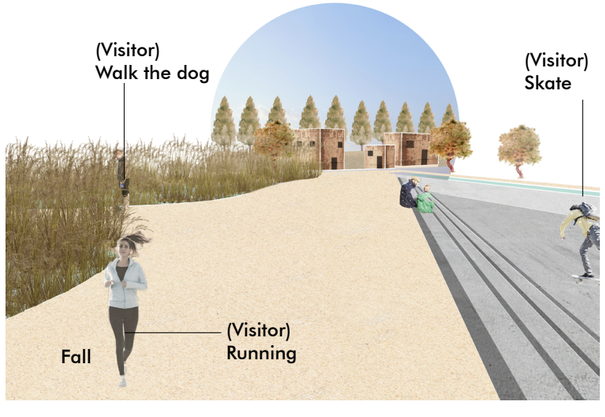
06.9.11 Grey water system - Atmosphere after activities

The series of diagrams show the atmosphere change in this purification system. And also, it shows the different people's activities in the landscape.

In the spring, the reed field will be cut by the farmers and people starting to visit this site. In the summer, the number of visitors from the city became more. since the construction of the water square, people could play with purified water in the water square, boosting the activities of this region. Then in the fall, the yellow nature landscape will attractive go or pass by this region, the water square could be used for skating. While in the winter, some water could flow into the water square for ice skating, which created some activities for the dead winter landscape.





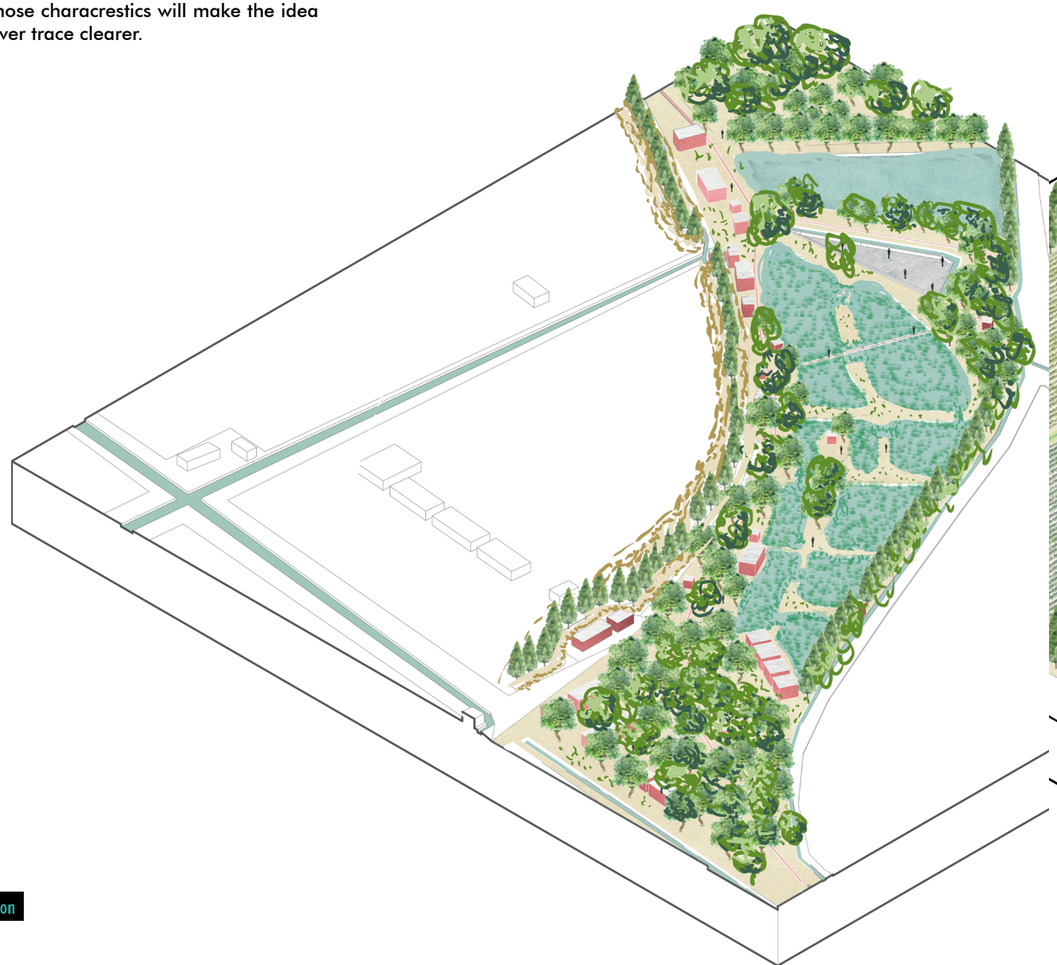




06.9 Upper Fringe design

06.9.12 Grey water structure- Maintenance and possible future

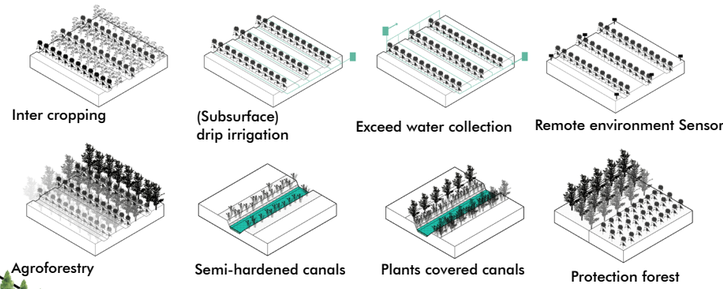
So in the possible future, due to the sandy soil texture, the water pond shapes will be more dynamics and some parts of different ponds could be connected. Those connected ponds will address the feeling of old river trace. The growing trees will form a nice boundary and roof for this thin area. Surrounded by the forests, the human perspective will be nicer. Meanwhile, the soil mound and trees on the mound will accumulation sand from the air and sand storm. Those characrestics will make the idea of reshowing old river trace clearer.

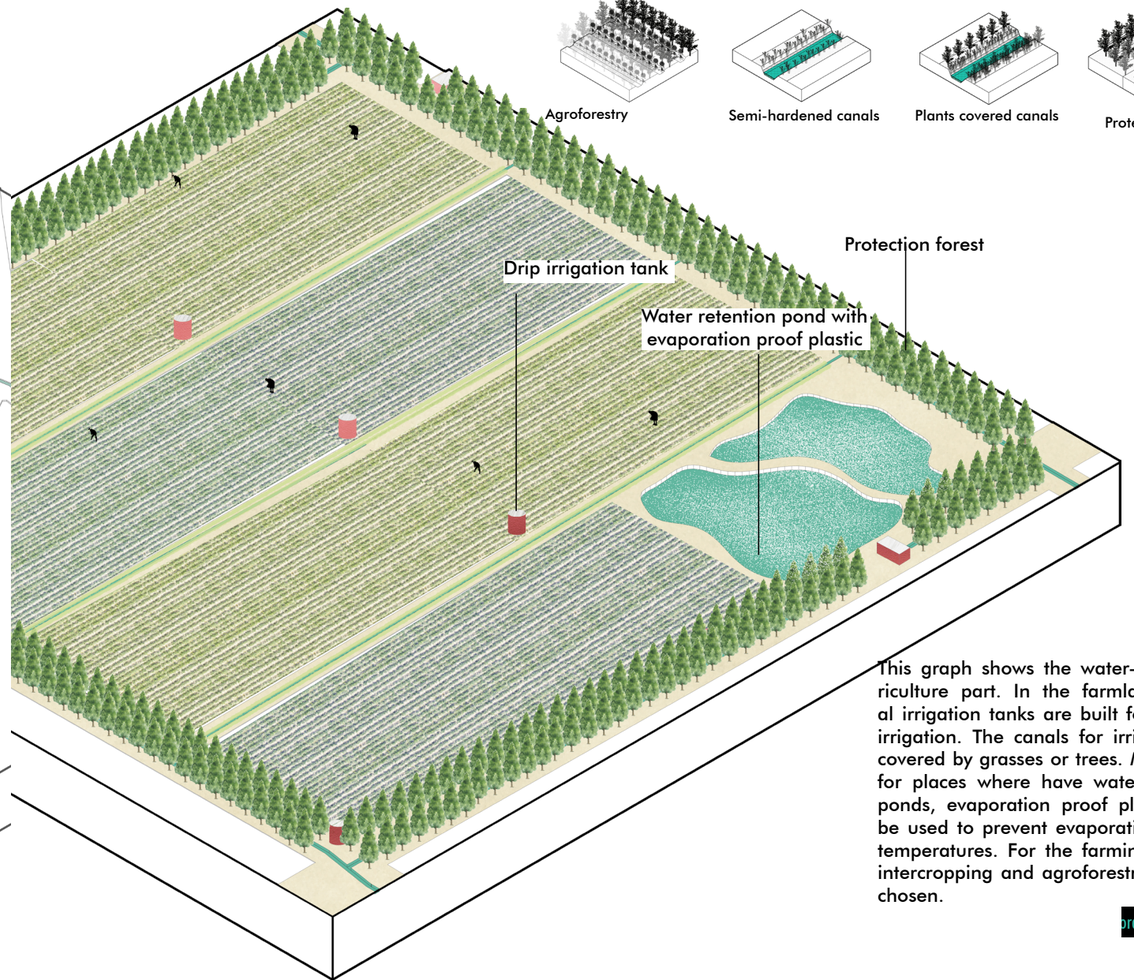


06.9 Upper Fringe design

06.9.13 Water saving design- Agriculture

Principles used

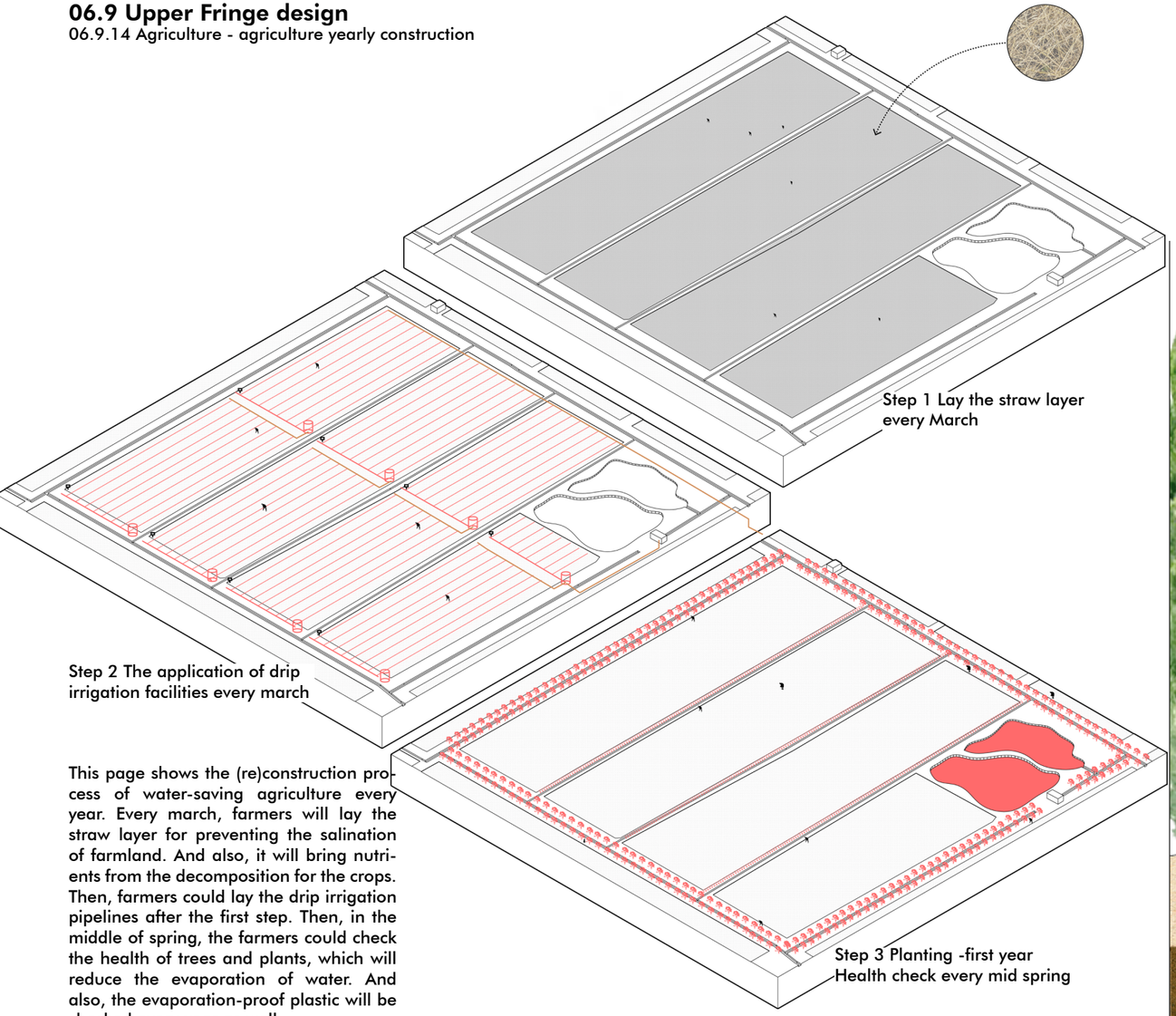




This graph shows the water-saving agriculture part. In the farmland, several irrigation tanks are built for dripping irrigation. The canals for irrigation are covered by grasses or trees. Meanwhile, for places where have water retention ponds, evaporation proof plastic could be used to prevent evaporation in high temperatures. For the farming method, intercropping and agroforestry could be chosen.

06.9 Upper Fringe design

06.9.14 Agriculture - agriculture yearly construction



This page shows the (re)construction process of water-saving agriculture every year. Every march, farmers will lay the straw layer for preventing the salination of farmland. And also, it will bring nutrients from the decomposition for the crops. Then, farmers could lay the drip irrigation pipelines after the first step. Then, in the middle of spring, the farmers could check the health of trees and plants, which will reduce the evaporation of water. And also, the evaporation-proof plastic will be checked every year as well.

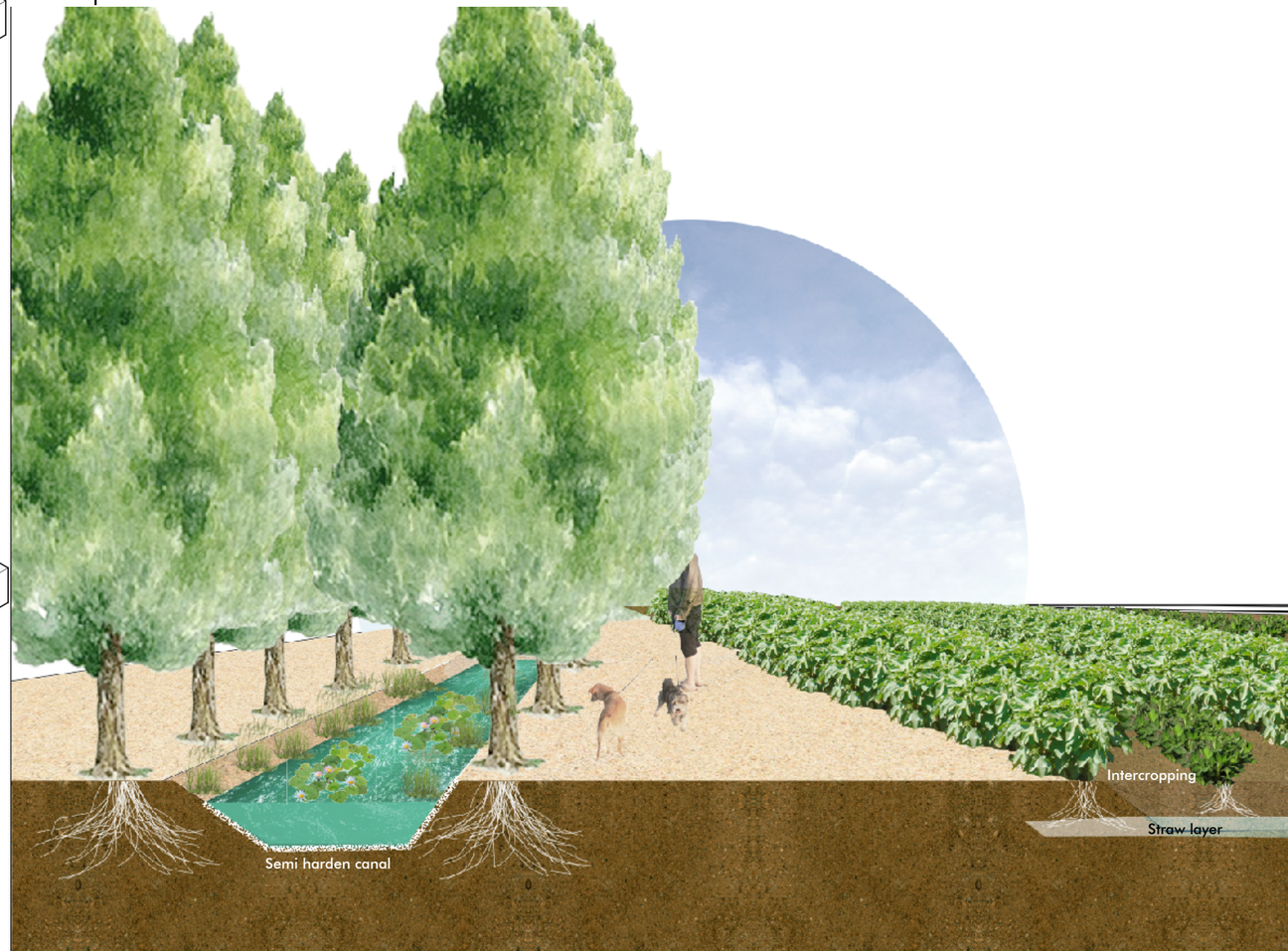
06.9 Upper Fringe design

06.9.15 Agriculture- Water saving agriculture perspective



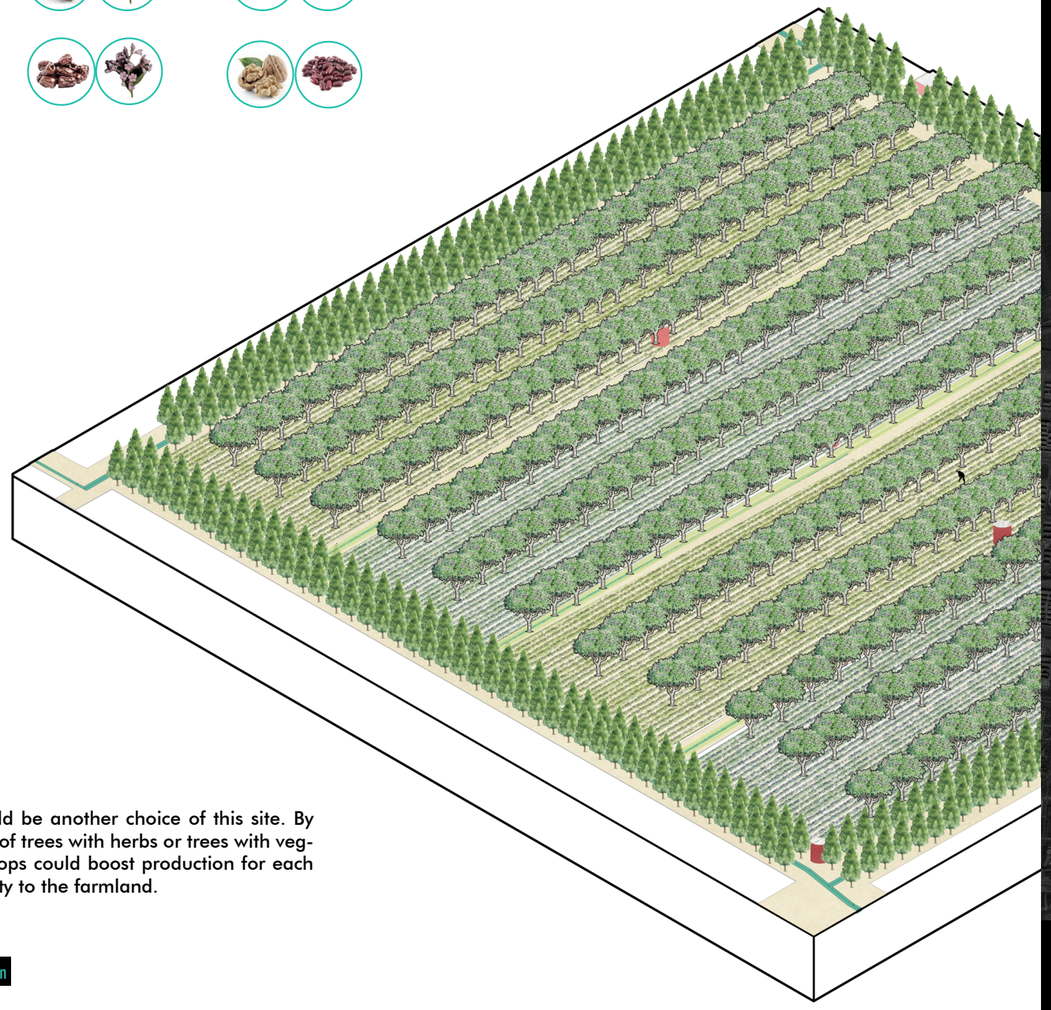
Populus alba var. pyramidalis Bge

The farmland and canal boundary are shown in the perspective. The intercropping and semi harden canal are explained and the spatial feeling is explored.



06.9 Upper Fringe design
06.9.16 Agriculture - agroforestry





Agroforestry could be another choice of this site. By the combination of trees with herbs or trees with vegetables, those crops could boost production for each and bring diversity to the farmland.

06.9 Upper Fringe design
06.9.17 Afforestation-forest structure

The design of the forest structure is based on both humans and ecology. The first map shows the forest structure of human view. the wood production forest should be more than 200 meters width and it could save as the function of the natural embankment. While other forest could work as wood production, farmland protection forest, or agroforestry.

The second forest map shows the view from animals. three types of stepping stones are built as animal habitats based on the previous analysis. Meanwhile, the whole riparian forest could work as corridors for animals movement.

Forest in human views



Forest in animals views

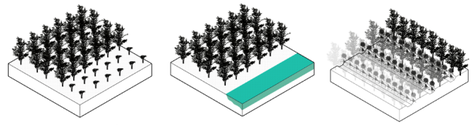


06.10 Upper Fringe design

06.11.3 Afforestation - Stepping stone

This diagram shows the landscape of the biggest stepping stone for the animals. The structure of the landscape is the soft riverbank, production forest, and agroforestry. The soft riverbank will be shaped by the River water and, the plantation will be less. In the production forest is dense and works as the animal moving the main path, some small bridges will be built to making animal corridors. The human path is built at the edge of the core for the less distribution for the forest.

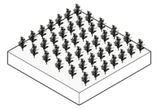
Principles used



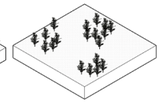
Wood production forest

Riparian forest

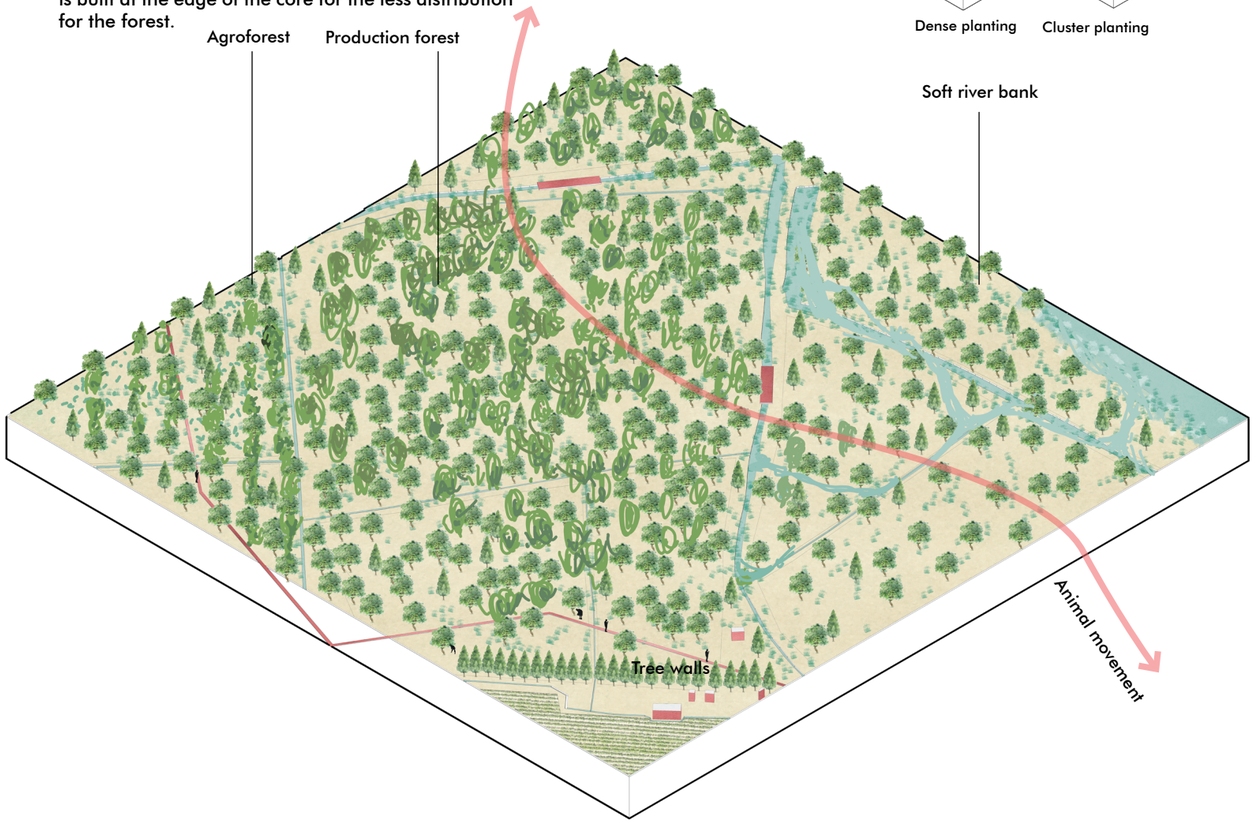
Agroforestry



Dense planting

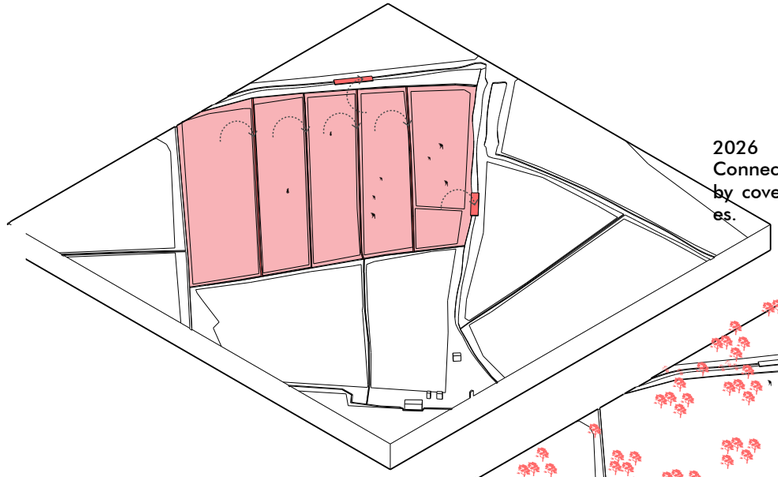


Cluster planting



06.10 Upper Fringe design

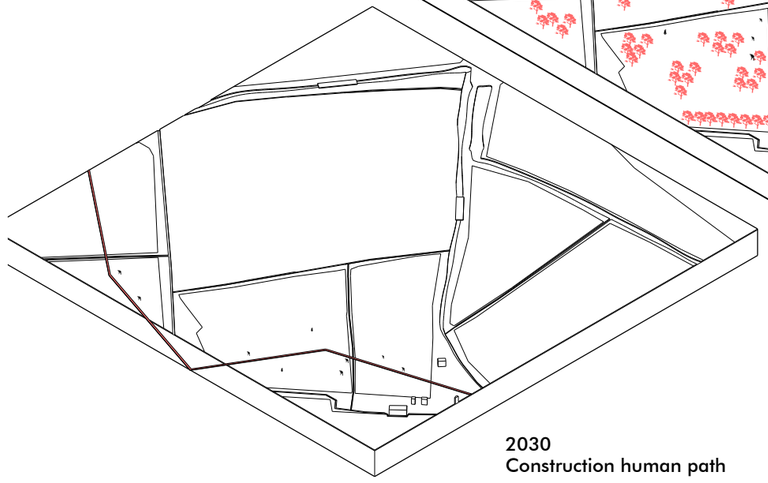
06.11.3 Afforestation - Stepping stone construction



2026
Connect different land by covering the ditches.



2027
Planting



2030
Construction human path

The construction of the stepping stone has 3 steps, and it brings connection from previous separate farmland and then plants in 2027. Finally, construction the human path at the edge in 2030

06.10 River landscape detailed design

06.10.1 Design site

A detailed design is made for exploring the river landscape, the forest landscape, and the detailed construction of forest and landscape.

The zoomed-in place is one stepping stone of the riparian forest.



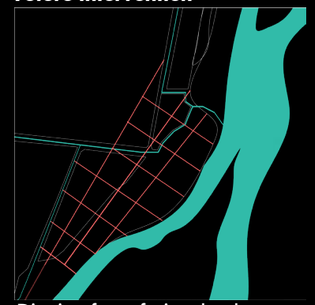
Current situation



This figure illustrates the current situation of the selected area, the landscape here is quite similar to other places in the upper reaches of the Tarim River. Thus, this design exploration is like a pixel of this whole area and could be applied to other places.

The current ingredient of this area are farmlands, Tarim River, few trees, and bare land. The blue hatch area is the watercourses of the Tarim River. And the river could not reach the bare land even in water-rich seasons.

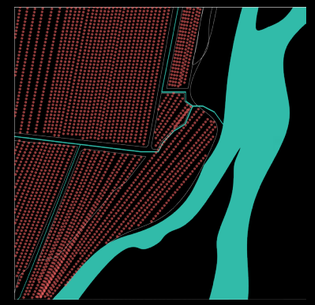
Future intervention



Digging for soft river bank

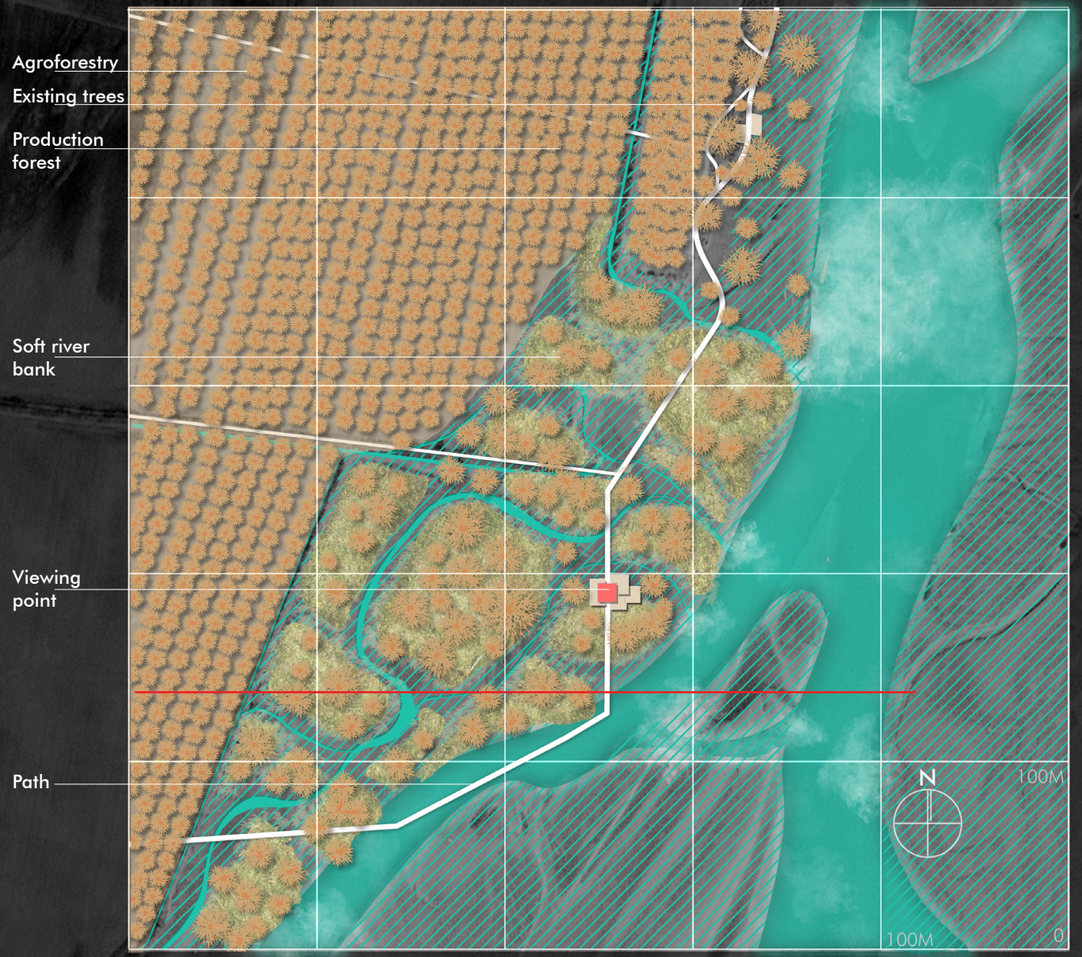


Path construction

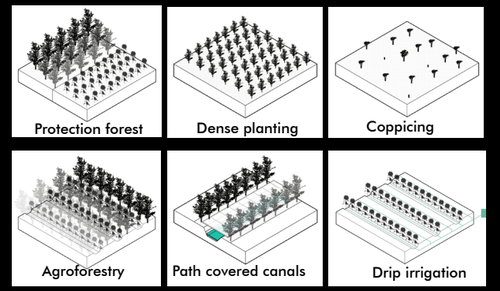


Planting

06.10 River landscape
06.10.2 Potential Master plan in 2050



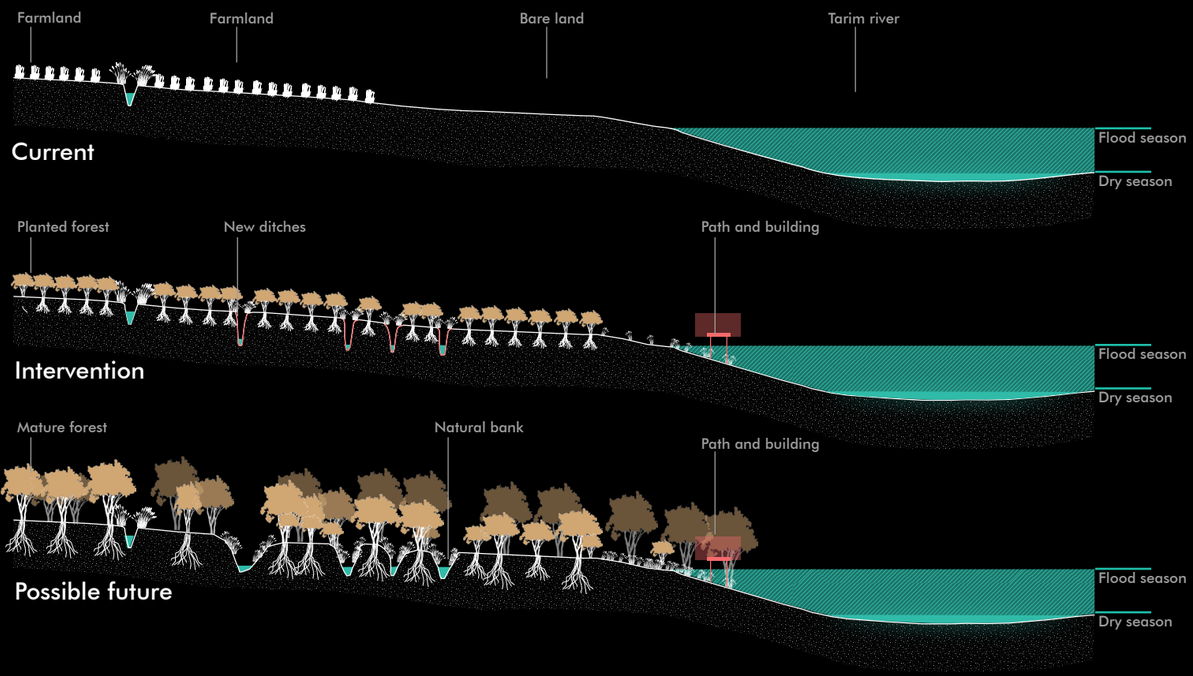
Principle applied



This master map shows the possible riverlandscape in 2050. After the 3 interventions of this pixel, the river landscape will developed by the natural forces. By the river erosion in flooded season, the river ditches digged will become natural form and unpredited. The river bank will get into the natural form agagi. The prodution forest will grow with full canopy in very straght lines while it is more flexible in the soft bank area . New viewing point is introducd in this area for vistors to experience the river landscape.

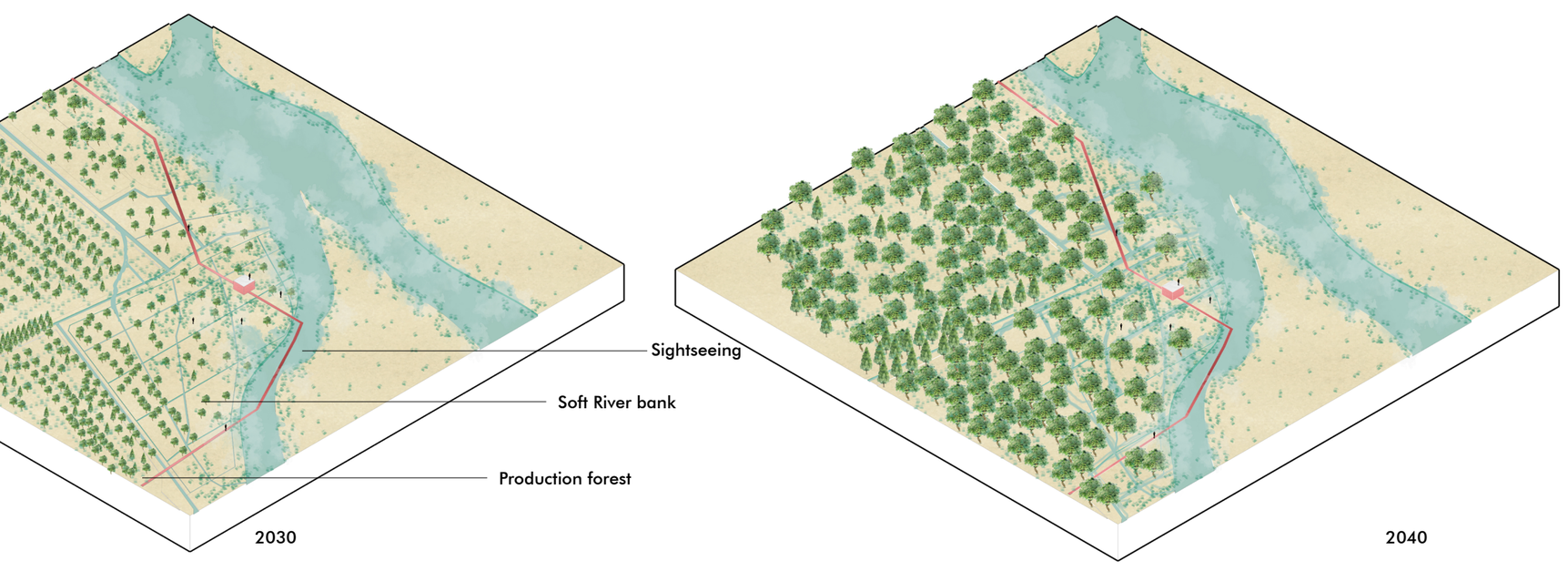
The section explained the landscape change when intervention and after nature forces. In the current situation, the landscape is only farmland and bare land. Aftter the intervention of digging, planting and paving, the river bank will be more natural. The river adn forest could grow towards each direction

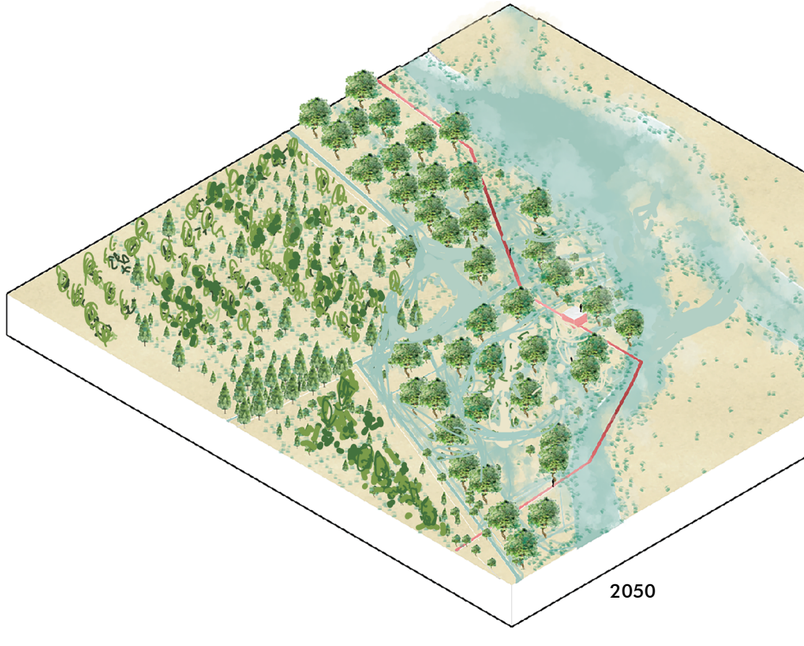
Development section



06.10 River landscape

06.10.3 Development of river landscape

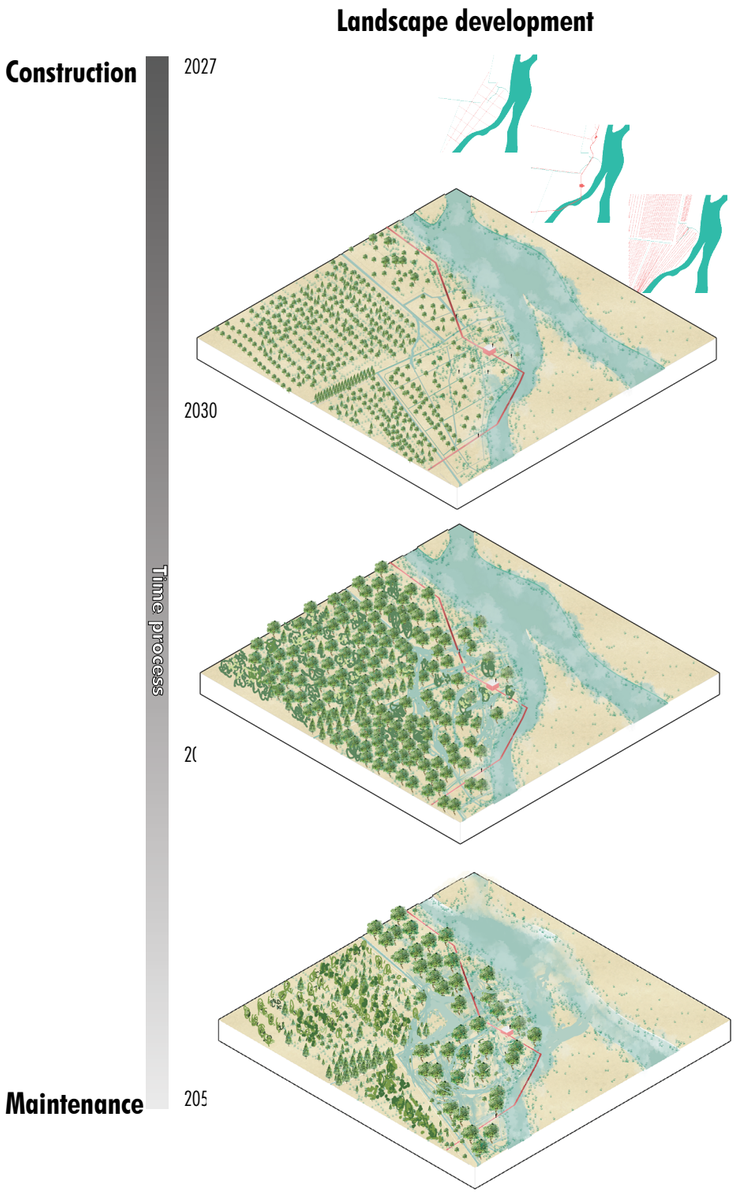


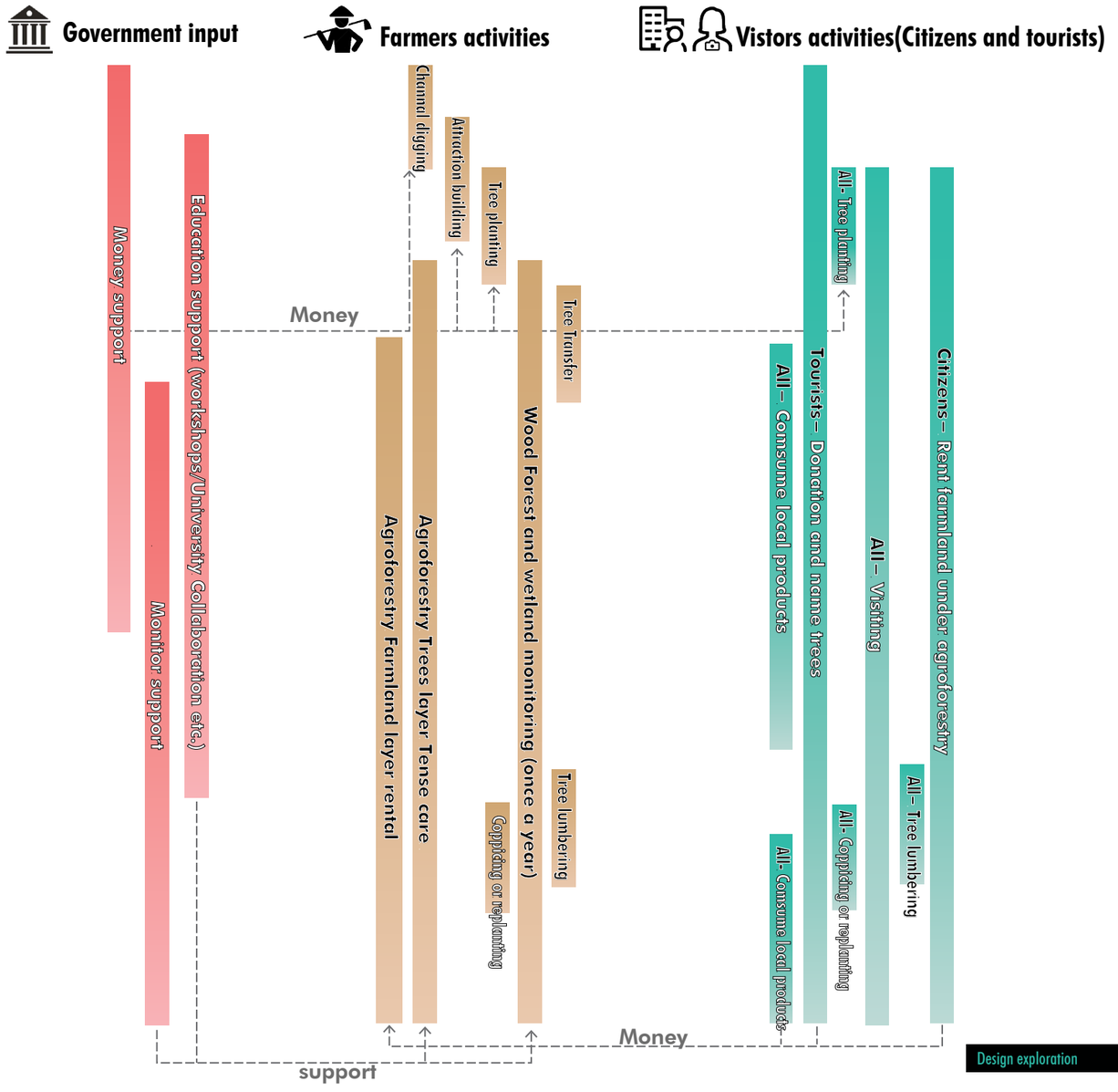


This figure shows the landscape change after construction. The construction of the river landscape would be finished in 2030, the river banks are still straight lines, and trees are very dense and small after planting. Few citizens will be attracted to this area. After 10 years, the river will flood those ditches, after the erosion of water, those ditches start to become like natural river courses. Trees grow and some parts could be cut down or transport to other places. In 2050, the riverside becomes natural appearance and people could be attracted to the riverside, some part of trees could be cut down and grow again.

This natural process is not only important in this pixel design but also essential for other river-side planting schemas. By digging ditches and letting those flooded, the current straight farmland boundary could be formed into a natural form, boosting the ecological function and natural beauty.

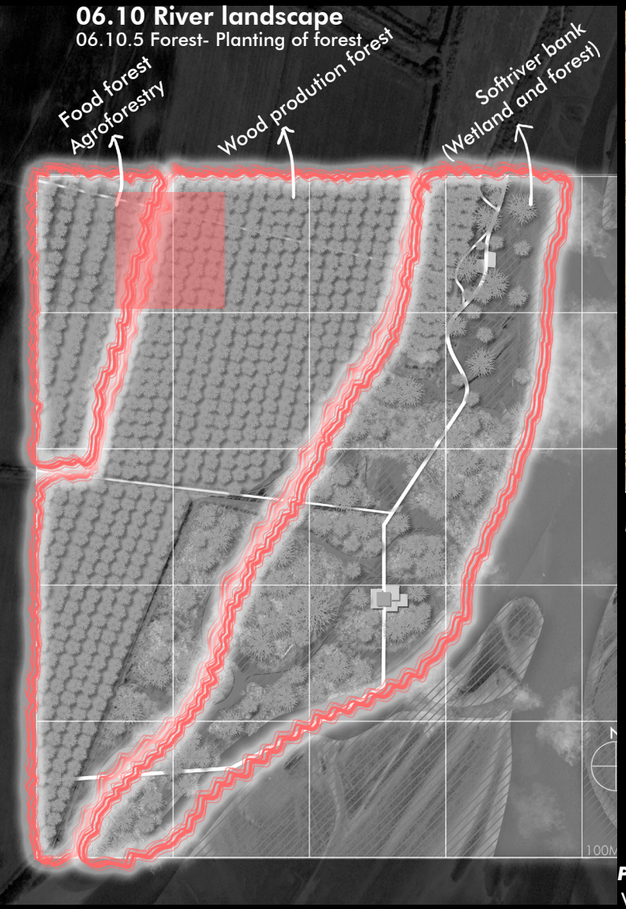
This timetable shows the construction and development of the river landscape and the human action or interventions during the construction and development. In the Construction pharse2027-2030, the government invests money, scientific support for the farmers, and city volunteers to build the river landscape. After construction, farmers could do monitor and maintenance jobs and also rent out agroforestry farmland to citizens for money. Visitors could visit and consume local products hereafter construction. For tourists, could donate to this project and name some trees if they want, while citizens could rent farmland to grow their own food.

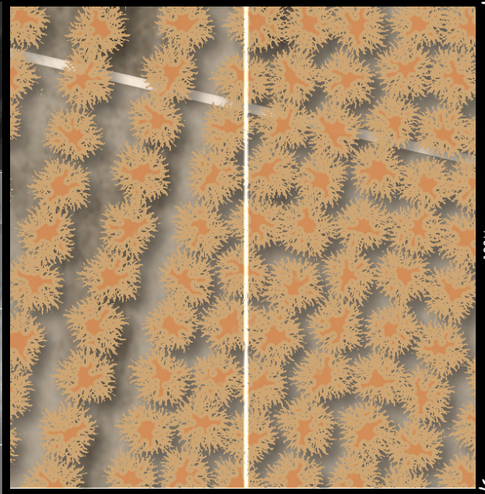




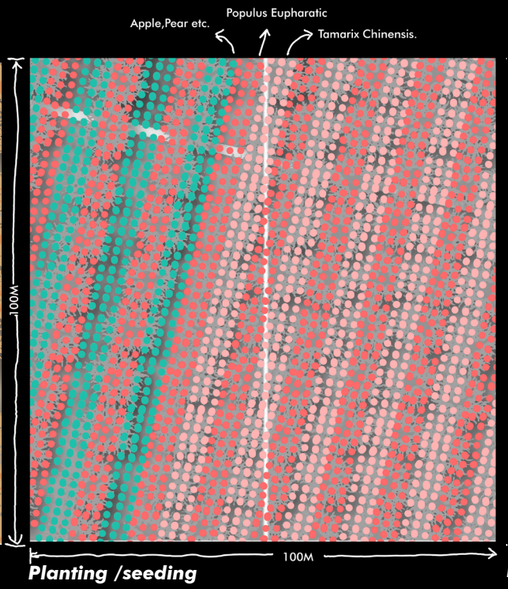
06.10 River landscape

06.10.5 Forest- Planting of forest

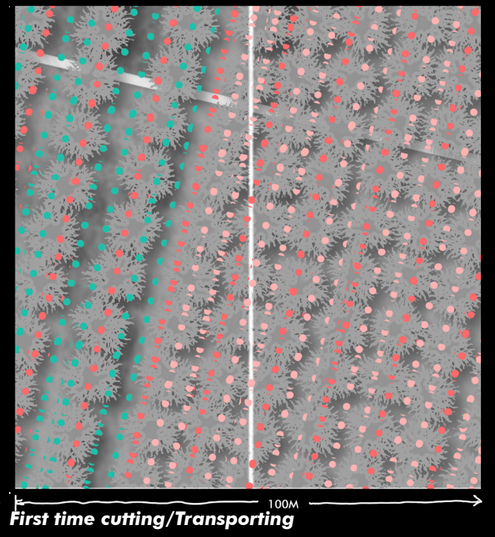




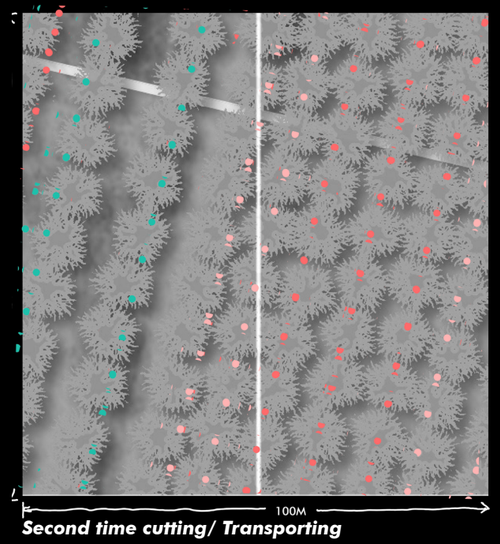
Final plan



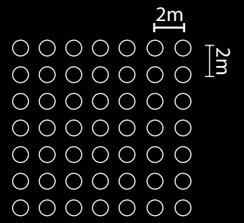
Planting /seeding

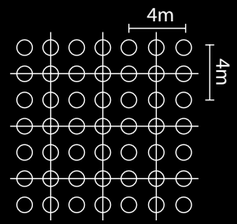


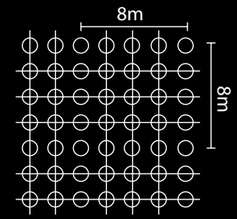
First time cutting/Transporting



Second time cutting/ Transporting







Production

Wood production forest



Timbe for construction and paper making

Agroforestry



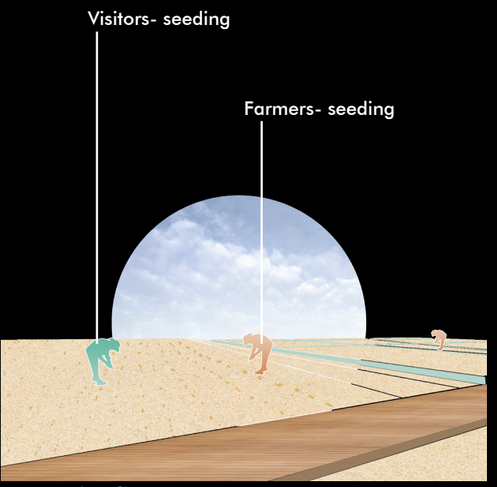
Food

One spot is to choose to understand how the agroforest and wood production forest is planted and grow. The size of this area is 100m*100m, in this design proposal, there will be 10 trees left in a line. This is based on the size of grow stage of Populus Eupharatica and Tamarix Chinensis.

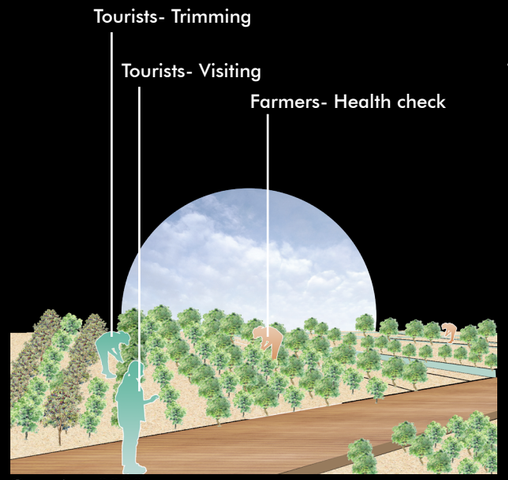
In the starting, the trees are planted in very dense size by the seeds, about 2*2meters. After 1 year of growing, the forest should start cutting and transporting by rows. By continuously cutting, the landscape will be looked like the same size now.

06.10 River landscape

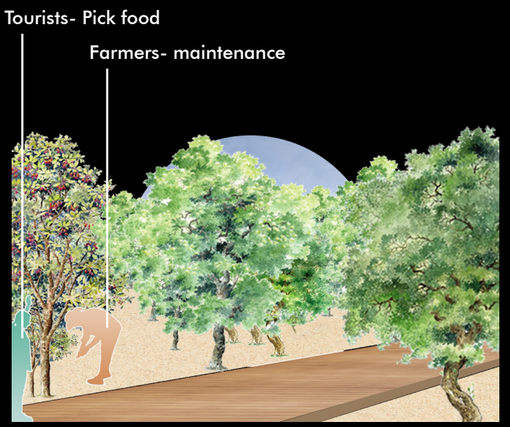
06.10.6 Forest - Atmosphere change during planting and cutting



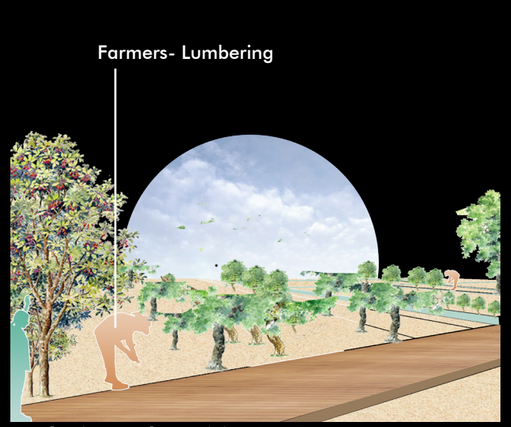
Seeding 2028



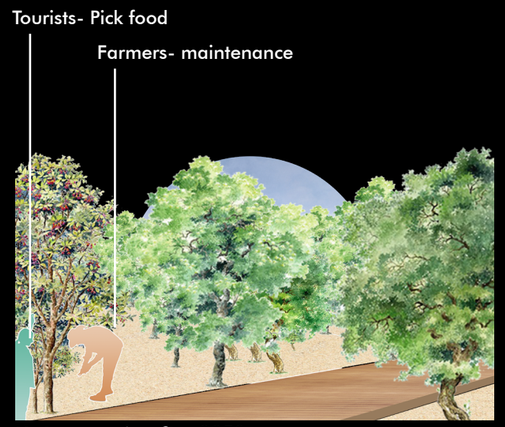
Growing 2030



Mature 2043



Lumbering and coppicing 2045

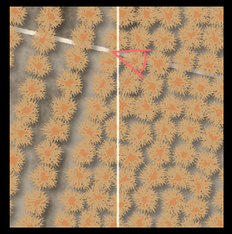


Mature again after 2050

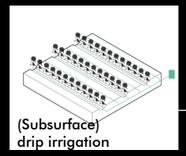
This series of drawings shows the landscape change and human activities during the planting can cutting process. Seeding from the bare land, it will grow a dense cluster of trees after few years. Then by the maintenance of visitors and farmers, the trees will grow to mature about 2043. Then, people could start lumbering the wood and left root and some trunk. After few years, trees will become mature again.

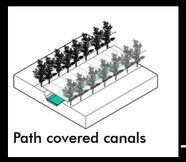
06.10 River landscape

06.10.7 Forest- Production forest Perspective



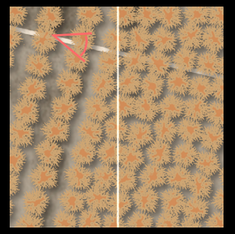
This perspective shows the landscape from the forest towards the river side. It show the rows populus eupharatic, drip irrigation and the human perception.





06.10 River landscape

06.10.7 Forest- Agroforest Perspective



This image show the agroforest landscape. the trees are not denser than production one. The farmland under the forest could be rent to citizens for farming.

06.10 River landscape

06.10.8 Riverside- master plan





The zoomed-in site is the riverside where is built to experience the river landscape. This red square is where the building is and the surrounding are different height levels of the platform. This building and platforms will have different height differences with the water in different months. So visitors could have a nice spot to water Tarim river and play with Tarim river.

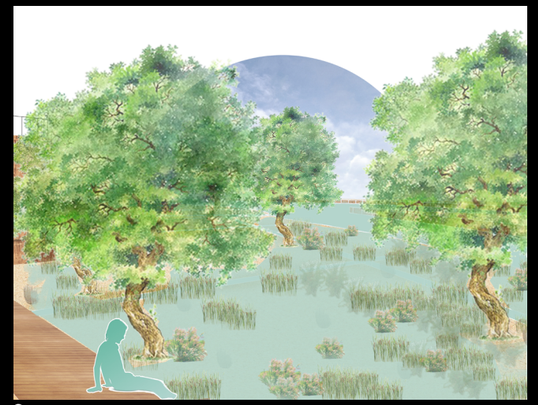
06.10 River landscape

06.10.9 Riverside - atmosphere and human activities

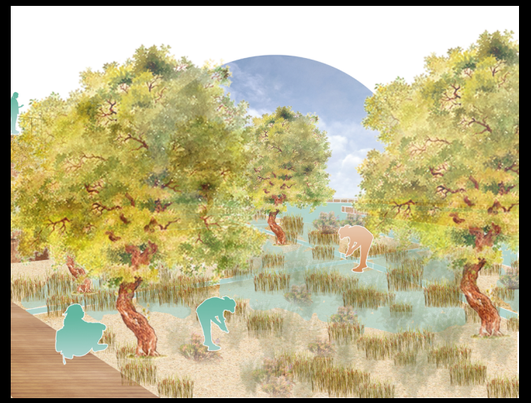
In this series of landscape atmospheres, the river change and people's activities of different seasons will be explained. In the spring, farmers could start to check the health of the trees and wetland plants, and visitors start to visit the place. When in the summer, the tree turns green and many lands are flooded. Visitors could play with water in this place. Then in the fall, the landscape turned yellow and many visitors will come to this place and farmers will come to check and cut some parts to the wetland for better growing. When in the winter, the water table is low and tree is bare few people will join except when the water becomes ice.



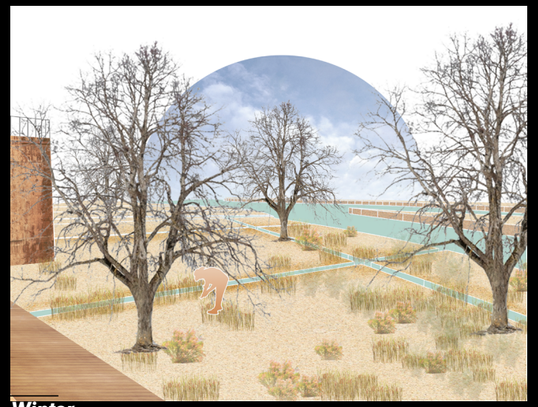
Spring



Summer



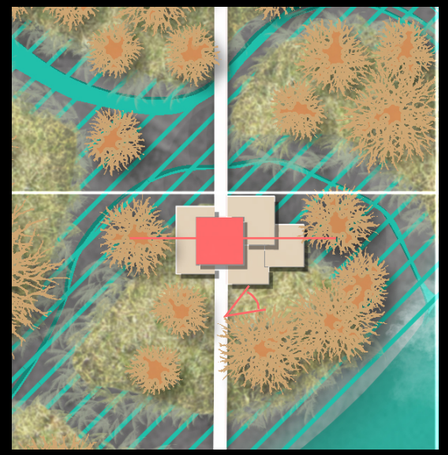
Fall



Winter

06.10 River landscape

06.10.10 Riverside- perspective

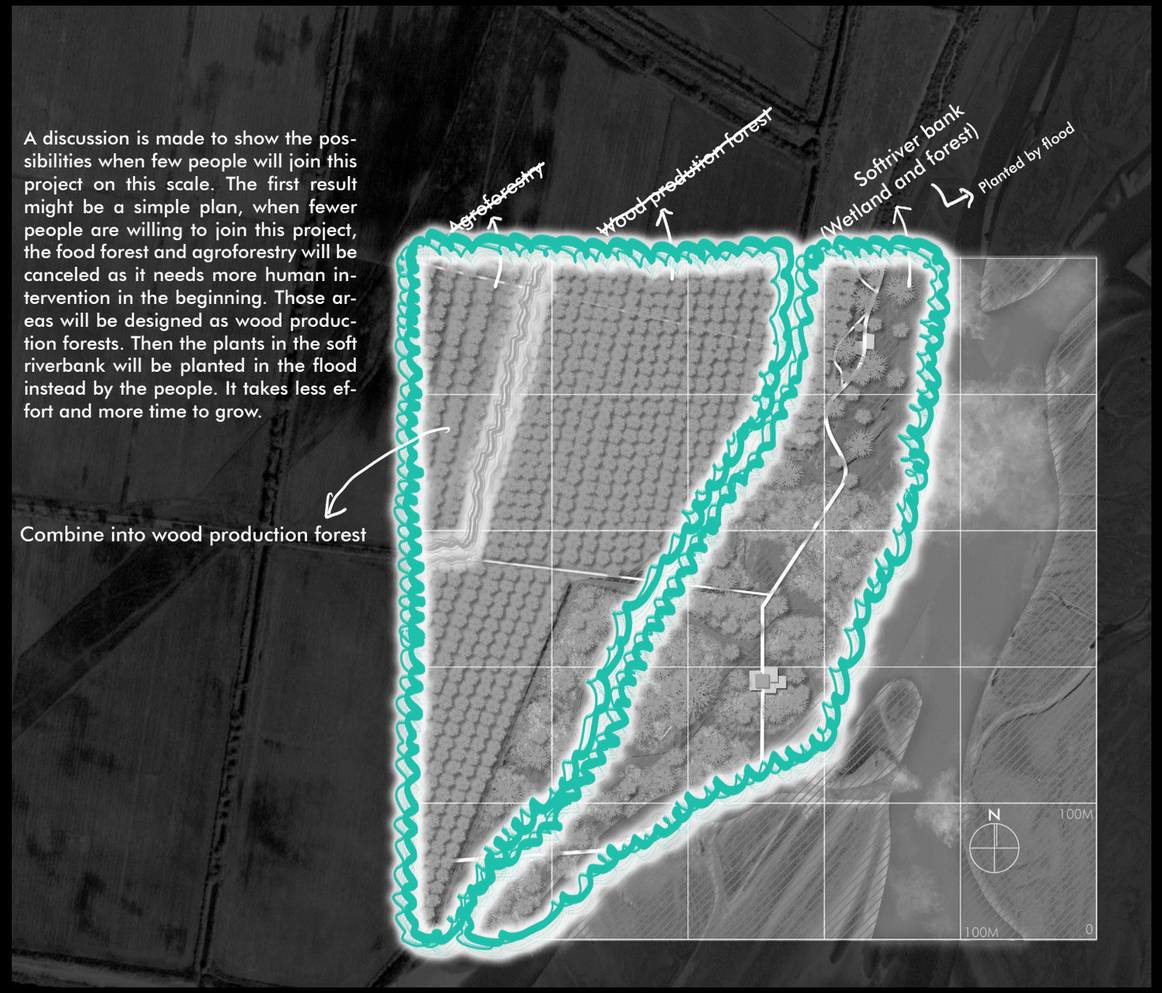


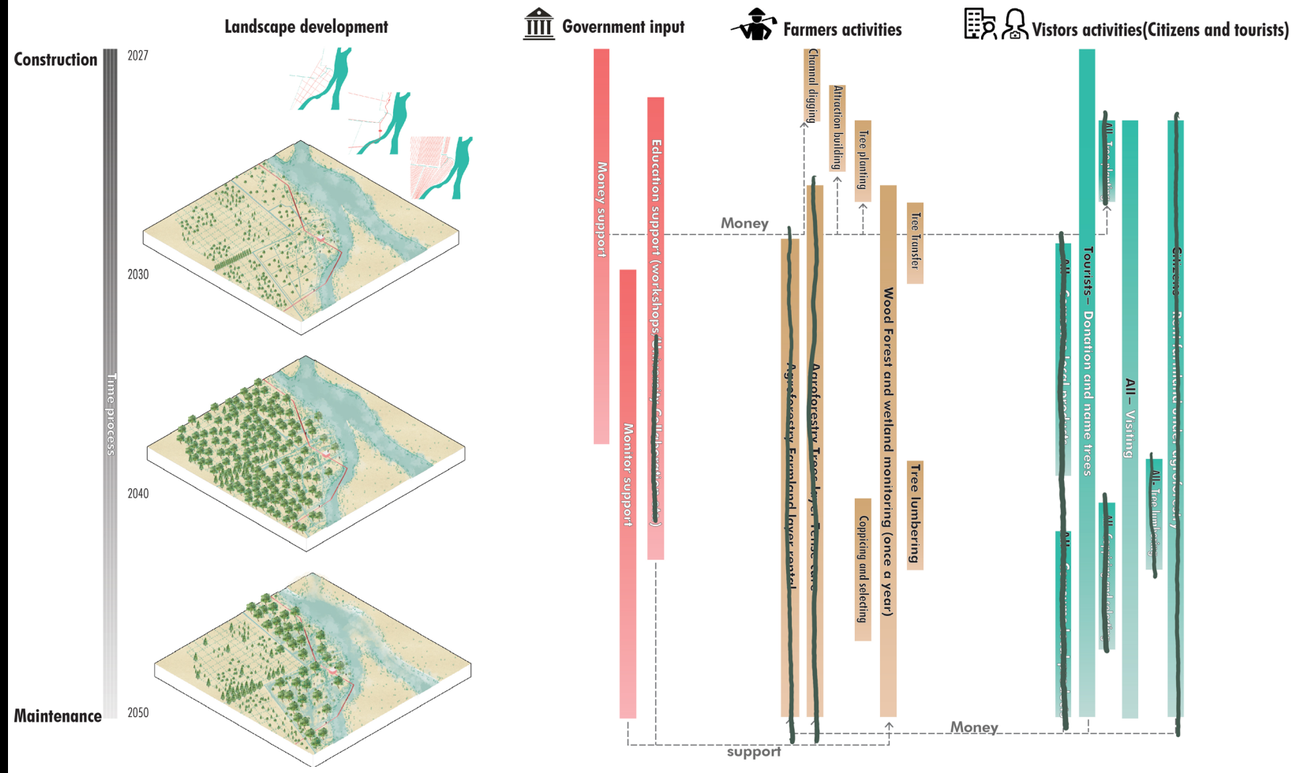
The perspective shows the river landscape in 2050 autumn. The small wood building is made by the local timber and could integrate with the background. Those platform could help visitors have a closer distance to the river and landscape.

Section of the platform



A discussion is made to show the possibilities when few people will join this project on this scale. The first result might be a simple plan, when fewer people are willing to join this project, the food forest and agroforestry will be canceled as it needs more human intervention in the beginning. Those areas will be designed as wood production forests. Then the plants in the soft riverbank will be planted in the flood instead by the people. It takes less effort and more time to grow.





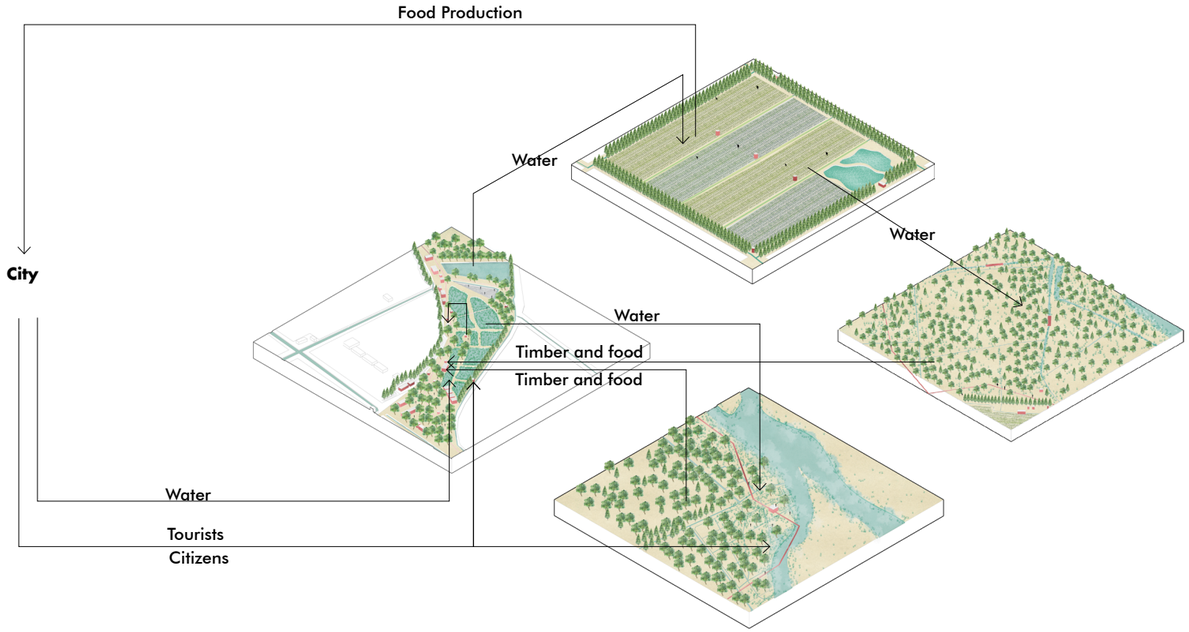
Then, an easy maintenance plan is needed. In this timetable, fewer visitors will join the project and the farmers' jobs will be reduced a lot as there will be no need for agroforest. Thus, farmers do not need to do highly intense agroforestry. Due to the fewer participants in this timetable, the forest will go in a wild and more natural direction.

07 · Conclusion and reflection

07.1 Conclusion

07.1.1 Design conclusion- new circularity

After design exploration, a new circularity could be set up. Unlike the fragile circularity before, the new circularity connects the city alar with farmland, village, new forest, and river. The city discharges grey water to the farmland, and also people in the city guide to exploring the suburb. While the urban fringe area could bring fresh and local products like vegetables and timber to the city, and also bring nice gathering space and landscape to the potential tourists.



During the research process, three subquestion has been answered.

How to improve water infrastructure and water efficiency?

In the upper reaches of the Tarim River, the current water infrastructure is poor and simple. So in the design process, a new water system was introduced in this area when considering on a big scale. By adding a grey water system, it brings a new irrigation water supply and improves water efficiency. When zoomed in a more detailed scale, water-saving principles is also applied to different places. In farmland areas, drip irrigation was used to save agricultural water, the semi-harden canal was applied to reduce the water loss. Moreover, a new purification water place not only improves the water reuse percentage but also give adaptivity to the water system.

How to form a sustainable farming environment?

In this research thesis, the sustainable farming environment is more focusing on soil health, natural disasters, sustainable water supply, and climate change adaptivity. In the current situation, a single type of cotton production, and flooding irrigation method, and natural disasters are making farming in this whole sustainable. By the design exploration, multiple farming products, new farming systems, and new forests could give answers to possible problems and creating a sustainable farming environment.

How to form a establish a sustainable circular living way for farmers?

As mentioned in the problem field, the current system is fragile because of its simple circularity. People only rely on one simple agriculture production and only build-up related to the outside world. In the design discussion. A new circular living way is built for farmers. Farmers will farm for not only cotton but also other products, which could sell to the local community or outside world. And also wood production could be another choice for farmers. Meanwhile, by creating nice public space, Bazar and river landscape, it creates more connection and communication with tourists and city citizens.

07.2 Reflection

The relationship between research and design

Research and design are two important aspects of this thesis. In this graduation thesis,it is a more relatively design-based research. The main purpose of the research is to discuss the water possibility of the upper Tarim River and find a sustainable livelihood for farmers in this region. The design process is an approach to test the principles and achieve this research objective.

By understanding and reviewing the complex context of the water facts and the farming environment, a new farming process with this arid land was proposed. Meanwhile, in the process of this research, the design solution works like a testing site for the whole project, elaborating and adjusting the research solution. During the design stage, it combines the design framework and site characteristics. By testing, designing, and adjusting, the outcome product feedback to the research framework.

Limitation of the project

The project is based on a lot of other research, especially for the part of water-saving agriculture. The whole scenario of future water data is based on others' research and the agriculture water that will be saved is not easy to be calculated since the climate, crop choice and new strategies will all influence the result. But in a word, saving 50% water is not a correct but a relatively achievable amount.

And also, except the introducing the new water system in the upper stream scale, all other principles for the agricultural land are on small scale, and slightly influence the human perspective. So the design exploration draws more attention to the land transformation part while providing only some toolboxes and planting schema for the farmers.

Meanwhile, the results of this project are more like an initiative for the landscape, it might not be an adoptive project for the government because it is not coherent with the government's economic policy.

During the whole working process, it is difficult also to get the water flow data and other related data. Thus, some data might be out of date or incorrect.

The Ethical issues and dilemmas encountered in doing the project

"Nature and human relations"
The relationship between nature and farmers especifically nature restoration and increasing farmers' demand is complex. For the farmers' interests, they are interested in production and a stable lifestyle. It generally is the opposite of nature restoration. Thus, during the research process, how to balance the two sides and also pursued farmers to join the initiatives are the main dilemma to consider.

"Urbanization, farmland or more space to the river"
Alar is a relatively new city which is built in less than 30 years. However, the urbanization of this city is quite fast and it is toward to river direction a lot. And now to have a better connection with the town in the opposite of the river, the city is still expanding toward to riverside with an economic consideration. Just the year during my research the city has occupied some space of the riverside and farmland.

For farmers, they are willing to turn every good land into farmland. So it is easy to see farmland at the edge of the river, Even if the farmland is eroded a lot every year.

So how to define a land position in the whole project is a complex problem. While in the plan, the view is more on a planner's view, not the stakeholder's.

"People' willing to join and designers' proposal"
In this research thesis, how to let people is a big question to consider. Even if there are a lot of strategies is used to show and explain the whole project to the stakeholders. But it is still hard to clarify the willingness of people. So what is a designer could propose and what are stakeholders interested need more exploration by on-site activities including workshop, questionnaire .etc

Reflection through the relationship to the Flowscapes studio

This project is part of Flowscapes studio. By understanding the design solution. By understanding the research tools and methods provided in the studio, this project conducts approaches including landscape as infrastructure, green and blue structure research and design with process, etc. Based on those approaches, circular flows are established between the land, water, and farmers.

Relation of project outcome and research question

The research question of this project is about water demand and sustainable livelihood. Based on the research on cased and theory. This project establishes design principles and strategies, which will guide the following design production. By testing those design solutions on a different scale, the research question will be addressed and answered in the design process.

To answer this research question, the participants of farmers is one of a key element in the construction process. Designing with the stakeholder farmers, the results of projects contain not only the possible answers but also the construction process to achieve the answers.

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