Figure 1: Karez water system bird view

Turpan Karez Water System

A traditional water supply system agriculture in Turpan.

Xinyu He

Context.

Location:	Turpan, Xinjiang Province, China
Period:	Before 1845
Function:	Agriculture, drinking water source
Water Quality:	Fresh aquifer water
Length:	5000km
Components:	The Karez water system includes mother well, air shaft, main tunnel, surface canal, storage pond, settlement area and irrigated area
Status:	Partly in use

Karez system, which is quiet similar to the Qanat system, is widely constructed in Turpan Basin, Xinjiang province, China. The word *Karez* means "well" in local Uyghur language. Turpan Karez system could bring aquifer water from the mountain area to oases in lower part through tunnels.

Nowadays, this kind of low tech, autonomous run, energy free approach is gradually abandoned after the appearance of mechanical well. Then, only few Karez system could generate water because others laking of maintenance.

Figure 2
Country Scale

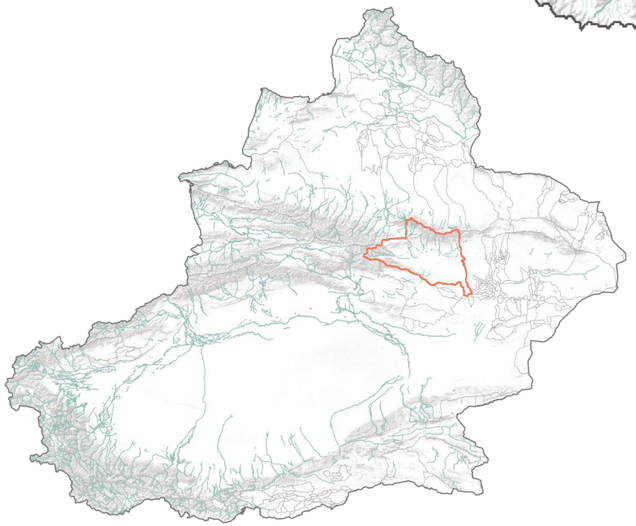


Figure 3
Provincial Scale

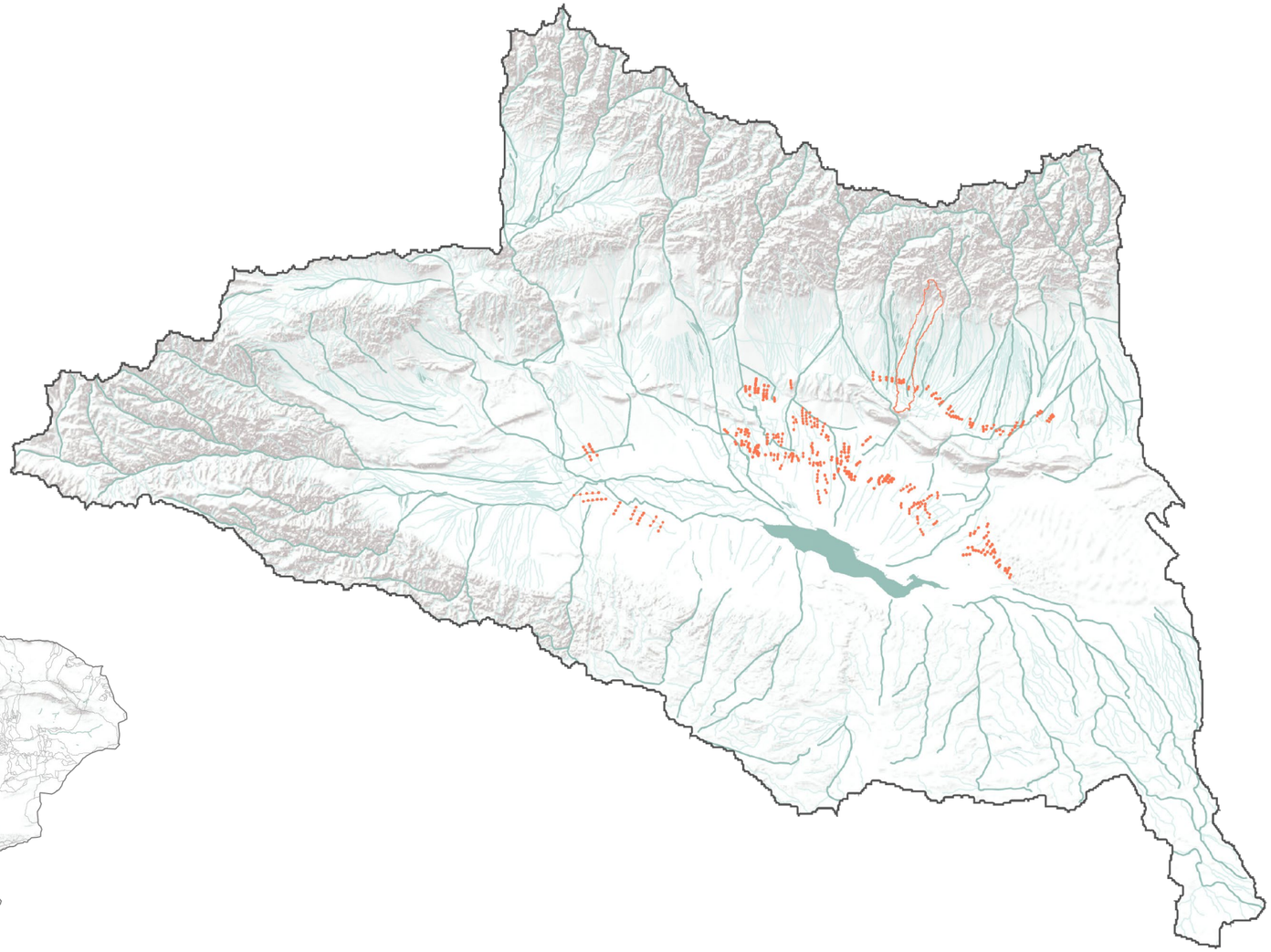
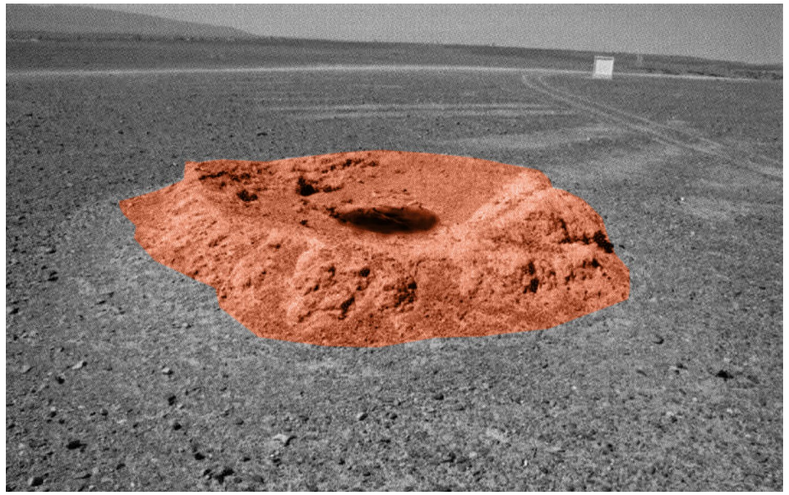


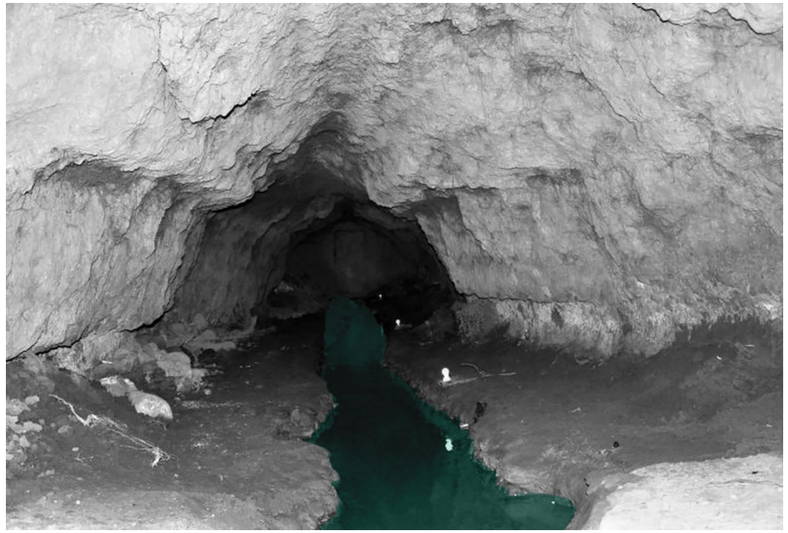
Figure 4
Watershed Scale

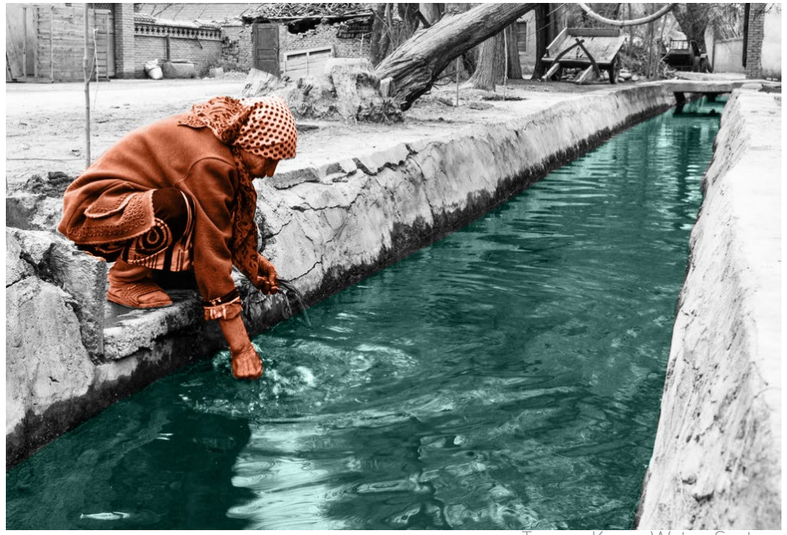
Water and it’s Journey

The water collected by the mother wells of Karez system will distribute to the oases through main tunnel, surface ditches and water retention pond.

Figure 5. top left - Aerial view of access shafts: the massive vertical access shafts is to make the construction and maintenance of underground tunnel easier.
Figure 6. top right - Perspective view of single access shaft
Figure 7. bottom left - ànqú (Underground Tunnel): a line of water system that collect and transport groundwater to land surface
Figure 8. bottom middle - Lāobà (Storage pond): An artificial water retention area built to collect clean water from Karez system the was normally in round and square shape.
Figure 9. bottom right - People taking water from Mínqú (surface ditches): Some ditches are built with rammed earth while other are built with hard rocks.







Climate

Climate zone: Continental desert climate
Sub-climate: Extreme continental desert climate with long, extremely hot summers and cold winters

Climate & Weather Averages

High t°:	40°C
Low t°:	-10°C
Mean t°:	16.2°C
Precipitation:	1.4mm
Humidity:	33%
Dew point:	-2°C
Wind:	5 km/h
Pressure:	1016 mbar
Visibility:	25 km
Hottest Month:	July (33°C avg)
Coldest Month:	January (-7°C avg)
Wettest Month:	June (3.3 mm avg)
Windiest Month:	June (6 km/h avg)
Annual Rainfall:	16.9 mm per year

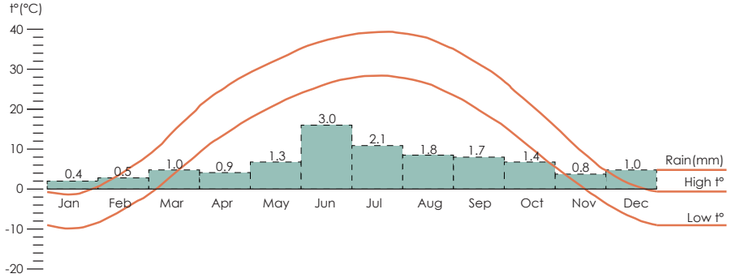


Figure 12
Climate of Turpan

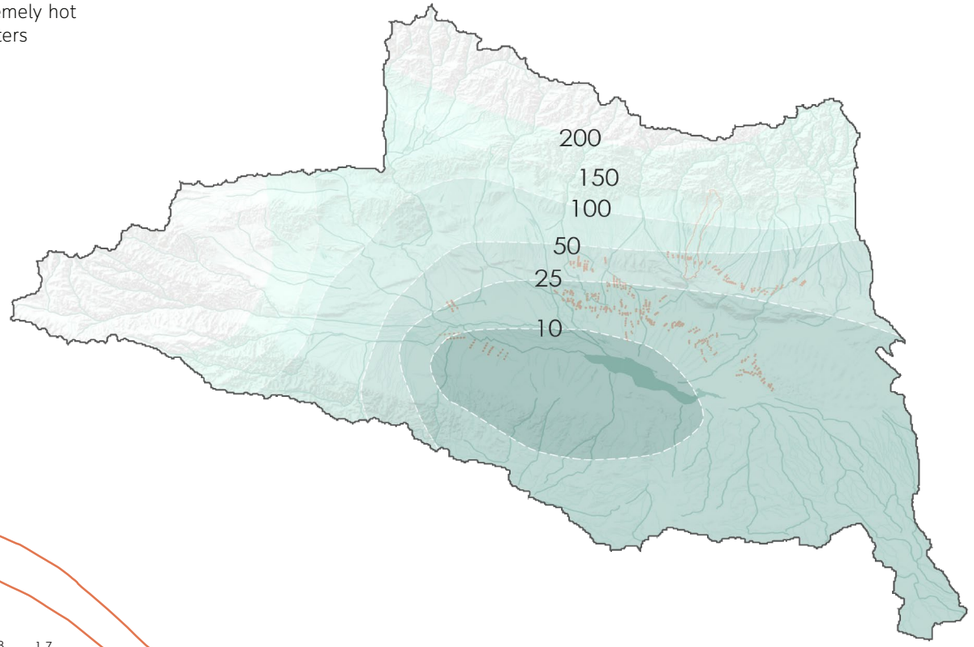


Figure 13
Average precipitation (MM/Year)

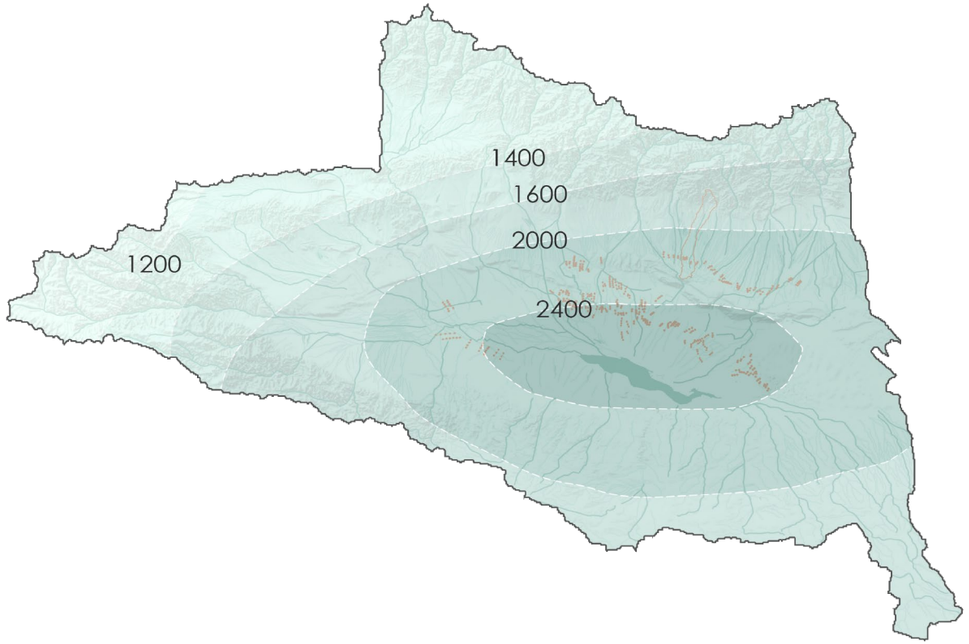


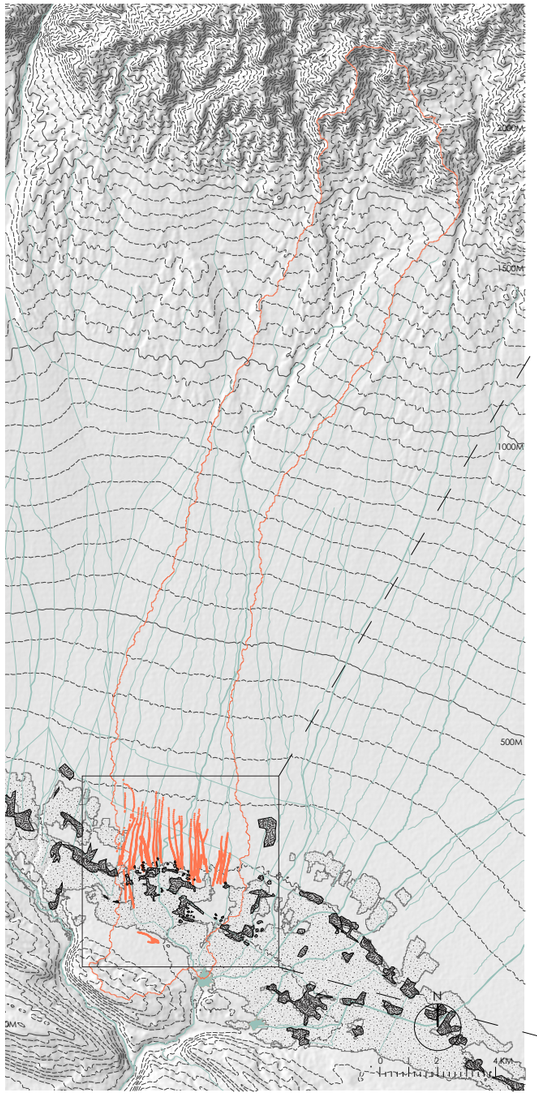
Figure 14
Average evaporation (MM/Year)

Catchment

Normally, the oases in Turpan were fed not only by Karez water system but also streams. Compared with streams, the water flow of Karez water system was more stable and had nearly no difference in different seasons. Because of that, farmers relied on Karez water system a lot for agriculture production and domestic water supply in the past.

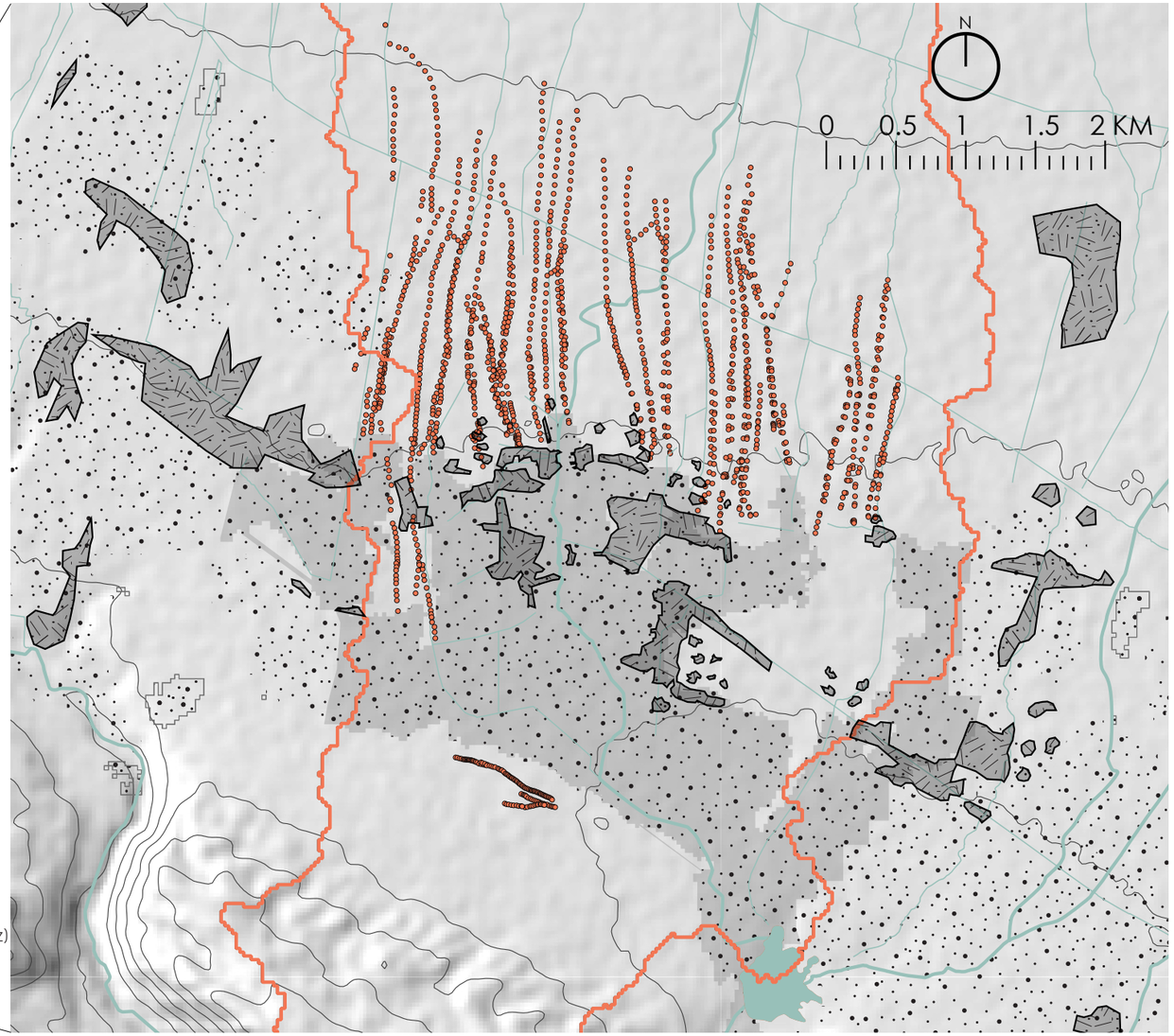
The first map(Figure 15) illustrates one main stream which flow to oases and its catchment. Within the stream catchment, multiple Karez water system were constructed to gain water as well.

The zoom-in map at the right(Figure 16) shows detailed structure of Karez water systems and farmland irrigated by them. Buildings were constructed mostly near the outlet of underground tunnels and then followed farmlands. Exceed water would finally flow into the reservoir at the foot of mountain.



Building area
Farmland
Karez well
Water bodies
Contour lines
Sub-catchment

Figure 15
Stream catchment

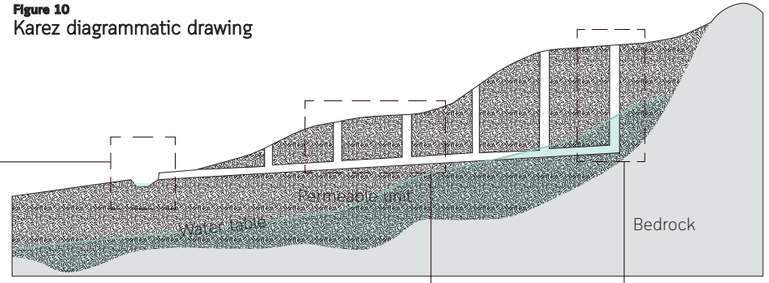


Building area
Farmland
Farmland(irrigated by Karez)
Karez well
Water bodies
Contour lines

Figure 16
Karez catchment

Construction Process

Figure 10
Karez diagrammatic drawing



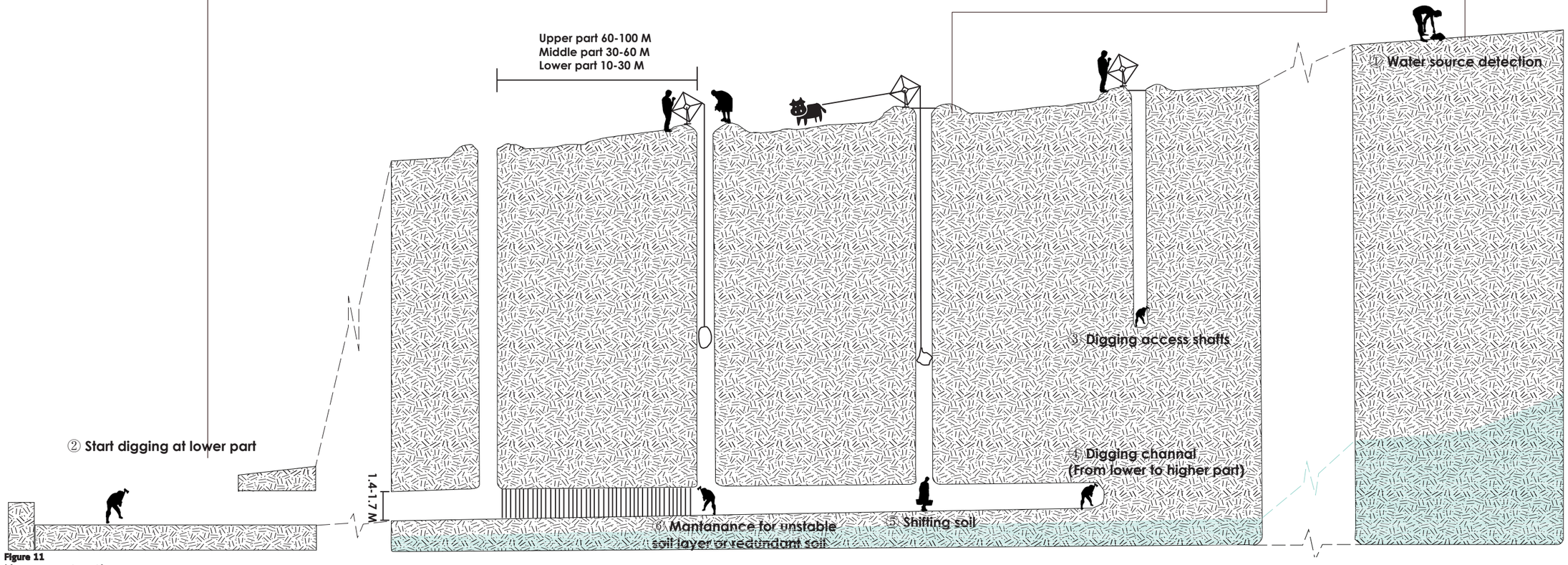


Figure 11
Karez construction process

Water system plan

The Turpan Karez water system includes not only water collection and transportation part but also the distribution part. This water system plan illustrates the water flows from the outlet of tunnels to the agriculture field. Together with stream, it fed citizens, farmers, plants along ditches, agriculture field, animals and also create cooling living environment.

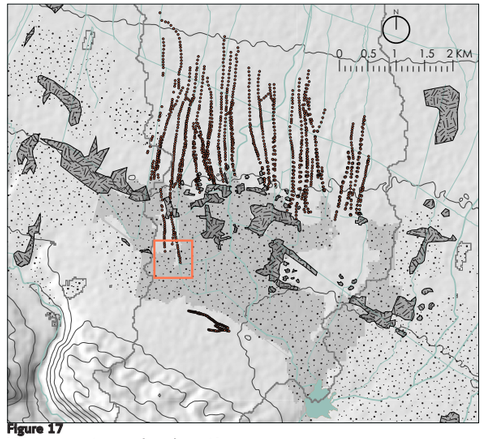
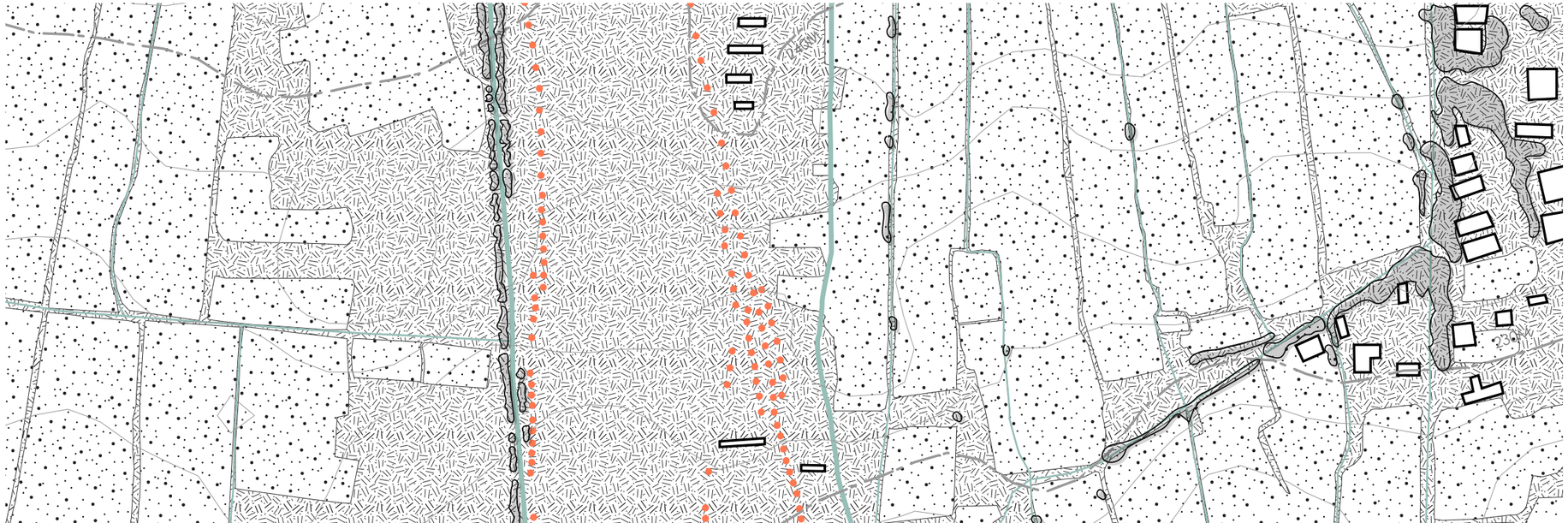


Figure 17
Water system plan location



Farmland

Sandy soil

Water retention

Trees

Canal

Karez access shaft

Karez outflow

N

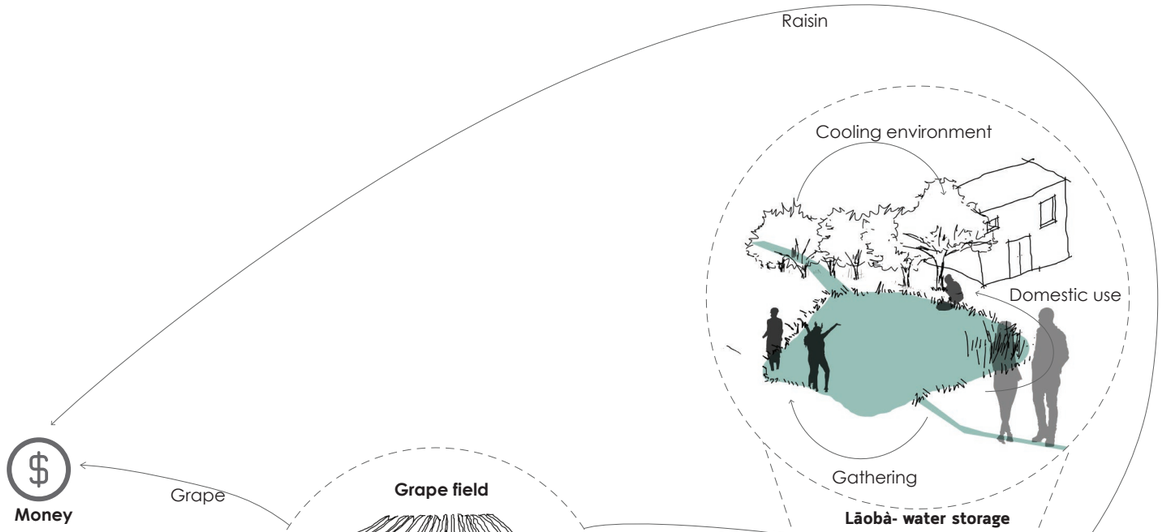
0 50 100 150 200M

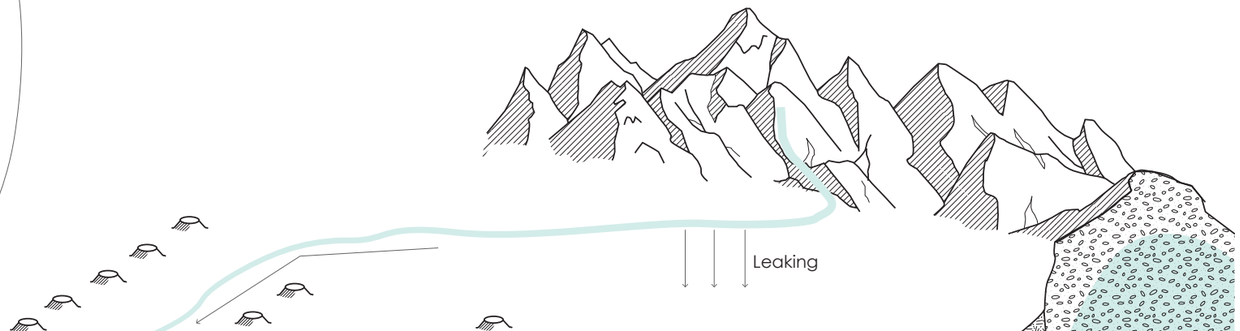
Figure 18
Karez water system plan

Water circularity

Turpan has an extremely high evaporation amount and little rainfall. Therefore, the appearance of the Karez water system helped a lot for people living here. The water collected from the mother wells flowed through the tunnel and then appeared on the ground. Generally, water on the ground would store in Lāobà for domestic use and irrigation use. Together with stream water from ice melting, water flowed through ditches than to agriculture field and ended in the reservoir.

In the process of water flowing, the structure of Karez water system creates a suitable living environment for both animals and humans. The shape of access shafts provides suitable habitats for cave animals and also could be used for birds to hide from the extreme wind and sun. And water in Lāobà creates the living environment for water plants, trees, and birds. For human aspects, Lāobà creates a cooling environment for living, gathering public aspects, and domestic water supply. And also, water flowed in the canal to feed the grape field for farmers making money, and some grapes dried in the grape drying room for further storage and money-making as well.





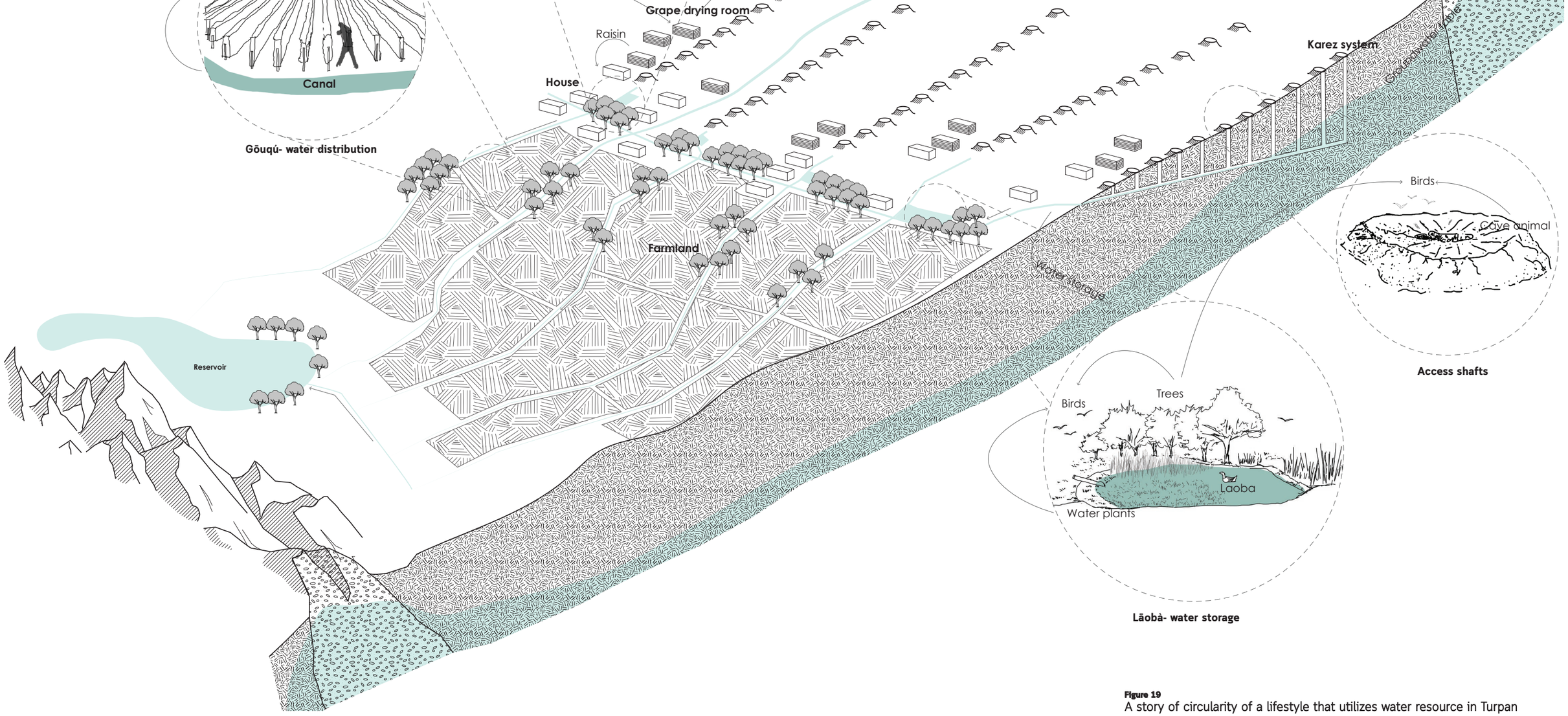


Figure 19
A story of circularity of a lifestyle that utilizes water resource in Turpan

Conclusion

Turpan karez water system shows how people in the past deal with extreme continent desert climate. Ancient people use wisdom and experience to collect, transport, and store water to improve agriculture production and living quality. Together with long-time and strong sunshine, Karez water system brings prosperous fruits dominated agriculture such as grapes and Hami melon. In conclusion, the system portrayed three special values included landscape values, strategic values, sustainable values, and ethnographic and identity values.

Landscape values - the whole system is created with the purpose of gathering water. By understanding the landscape form and soil condition, the construction of this system makes up the following oases landscape structure such as buildings, ponds, and agriculture fields in the lower reach. For the beginning part, the large number of mother well structures on the bare landscape is also unique scenery.

Strategic values - the location of Karez water system was based on the understanding of soil humidity, slope and soil condition etc. Taking advantage of those aspects, the water system work automatically, with low cost and high quality water output. Meanwhile, The buildings and farmlands in the oases also use the topography of the land and water system.

Sustainable and Circularity values - The system entirely use local materials and build carefully. Water has been used not only for human but also created vegetation communities and animal habitats.

Ethnographic and Identity values - This water system has strong relationship with local people in both physical and spiritual aspects. People here have a festival called Qingquan festival (Figure 20) to celebrate precious water from Karez water system.

Figure 20
Qingquan festival

Reference

Project X- Turpan Karez water system

Mächtle, Bertil, Stefan Hecht, Nicola Manke, Bernd Kromer, Susanne Lindauer, Cheng-Sen Li, Ying Li, Xiaofei Wang, and Olaf Bubenzer. 2019. 'The Age and Origin of Karez Systems of Silk Road Oases around Turpan, Xinjiang, PR of China'. Pp. 359-78 in Socio-Environmental Dynamics along the Historical Silk Road. Springer, Cham.

翟源静. 2017. 新疆坎儿井传统技艺研究与传承[Research and Inheritance of Xinjiang Karez Traditional Skills]. 合肥：安徽科学技术出版社
Retrieved from http://book.ucdrs.superlib.net/views/speciPc/2929/bookDetail.jsp?dxNumber=000016700901&d=3D386ED735E357E1561D1D0361DACAC0&fenlei=1706070802

尼鲁法尔·阿布力米提. 2015. '坎儿井系统及其对生态环境的影响研究'[Research on Karez System and Its Impact on Ecological Environment]. 新疆大学.
Retrieved from http://cdmd.cnki.com.cn/article/cdmd-10755-1015801122.htm

鲁靖康. 2017. '清代新疆农业研究'[Xinjiang Agricultural Research in Qing Dynasty]. 陕西师范大学.
Retrieved from http://cdmd.cnki.com.cn/Article/CDMD-10718-1017242192.htm

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Figure 1 Retrieved from https://card.weibo.com/article/m/show/id/2309404548862911053900?_wb_client_=1&object_id=1022%3A2309404548862911053900&extparam=lmid--4548862914594831&luicode=10000011&lfid=231522type%3D1%26t%3D10%26q%3D%23%E4%B8%AD%E5%9B%BD%E8%BF%91%E4%BB%A3%E5%8F%B2%23&featurecode=n. Edited by author

Figure 5 Retrieved from http://www.abovetopsecret.com/forum/thread1090894/pg1. Edited by author

Figure 6, 8 Retrieved from 新疆维吾尔自治区第三次全国文物普查成果集成：坎儿井. Edited by author.

Figure 7 Retrieved from https://so.sina.cn/palmnews/web-sinanews-app-download.d.html?from=wap. Edited by author.

Figure 9 Retrieved from http://pic.people.com.cn/BIG5/n/2015/0409/c1016-26818509-9.html. Edited by author.

Figure 10 Retrieved from https://www.researchgate.net/publication/327249688_A_Karez_System%27s_Dilemma_A_Cultural_Heritage_on_a_Shelf_or_Still_a_Viable_Technique_for_Water_Resiliency_in_Arid_Regions/figures?lo=1. Drawn by author.

Figure 11 Retrieved from 新疆坎儿井传统技艺研究与传承. Drawn by author.

Figure 12 Retrieved from https://en.climate-data.org/asia/china/xinjiang/turpan-2590/. Drawn by author.

Figure 13, 14 Retrieved from https://www.geog.uni-heidelberg.de/md/chemgeo/geog/geomorph/china_2009_reader.pdf Drawn by author.

Figure 20 Retrieved from http://travel.people.com.cn/n/2014/0610/c41570-25127170-3.html. Edit by author

Glossary

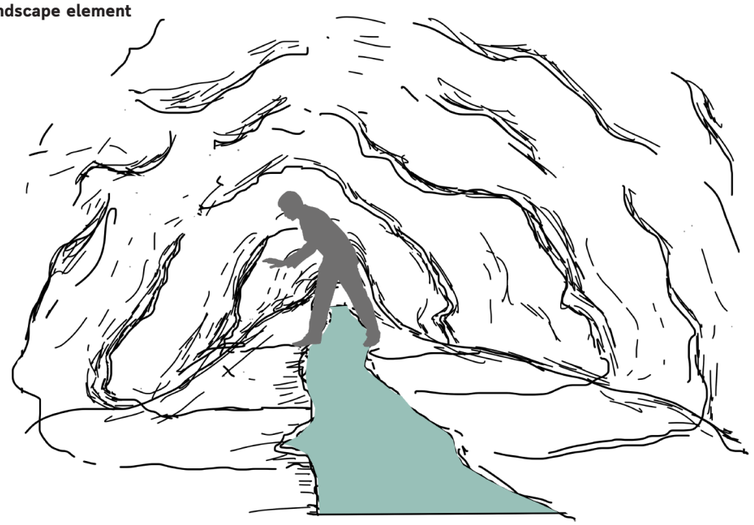
/water landscape element

Lāobà- 涝坝
water retention

An artificial water retention area built to collect clean water from Karez system in round and square shape. Those water retention ponds are for domestic and irrigation use and are usually not far from outlets of Karez system. And trees are planted to provide shadow.

Project: Turpan Karez water system, China
Climate: extreme continental desert climate with long, extremely hot summers and cold winters
Year: before 1845
Water type: groundwater
Landscape type: oasis landscape
Altitude: 210~240 m.a.s.l (meters above sea level)
Soil condition: brown calcic soil
Materials: excavated soil and rammed earth
Period: permanent
Form: round or square surface
Use or Function: domestic and irrigation use

/water landscape element



ànqú- 暗渠
Underground channel

An underground channel to transport groundwater to the surface, caved in the natural stone.

Project: Turpan Karez water system, China
Climate: extreme continental desert climate with long, extremely hot summers and cold winters
Year: before 1845
Water type: groundwater
Landscape type: oasis landscape
Altitude: 210~240 m.a.s.l (meters above sea level)
Soil condition: brown calcic soil
Materials: excavated soil and rammed earth
Period: permanent
Form: line
Use or Function: Water transportation

Glossary

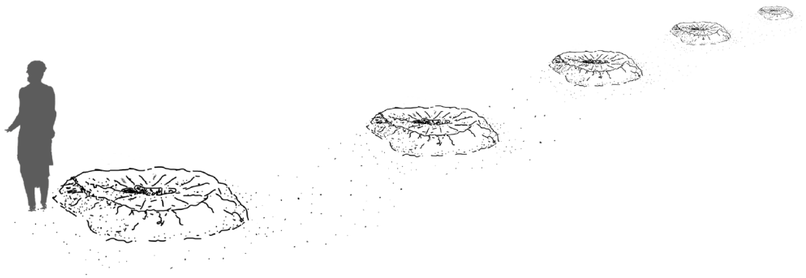
/water landscape element

Mínqú- 明渠
Irrigation ditch

Ground waterways that distributes clean water for irrigation use. Some ditches are built with rammed earth while other are built with hard rocks.

Project: Turpan Karez water system, China
Climate: extreme continental desert climate with long, extremely hot summers and cold winters
Year: before 1845
Water type: groundwater
Landscape type: oasis landscape
Altitude: 210~240 m.a.s.l (meters above sea level)
Soil condition: brown calcic soil
Materials: rammed earth or hard rocks
Period: permanent
Form: networks of lines
Use or Function: irrigation water transportation

/water landscape element



Shùjǐng- 竖井
Access shafts
People built access shafts when they constructed the tunnel of Karez water system. Those shafts help people to get in and keep underground air fresh.

Project: Turpan Karez water system, China
Climate: extreme continental desert climate with long, extremely hot summers and cold winters
Year: before 1845
Water type: groundwater
Landscape type: oasis landscape
Altitude: 210~240 m.a.s.l (meters above sea level)
Soil condition: brown calcic soil
Materials: rammed earth or hard rocks
Period: permanent
Form: networks of lines
Use or Function: Construction and ventilation

Glossary

/water stories

Táoqì- 陶器
Pottery for taking water

Some pottery was put at the edge of ditches for people to take water. The purpose was to let people not pollute water system while using water.

Project: Turpan Karez water system, China
Climate: extreme continental desert climate with long, extremely hot summers and cold winters
Year: before 1845
Water type: groundwater
Landscape type: oasis landscape
Meaning: Utilitarian
Water workers and users: Inhabitants/ Farmers
Materials: clay
Period: Daily
Use or Function: collect water