Building as a Pedagogy,

Rural School on Ridge of Loess Plateau

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Abstract

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New schools in rural China often-time are driven by blind pursuit of modernity and executed by methods that diminish human dignity, erode human well-being, disconnect human with nature, local community and cultural tradition. Those sub-standard learning environments are neither climate nor culturally responsive. Buildings, particularly learning environments, should be a pedagogy that acts as educational tools for imagination, sense of place, ecological awareness, cultural sensitivity... A healthy learning environment should facilitate comfort, productivity and humanity. This thesis takes a pre-established model, an existing multi-story school on ridge of Loess Plateau in Dongxiang, Gansu province of China, as the site of the project, re-evaluating the significance of ecological and vernacular aspects in architecture.

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BUILDING AS A PEDAGOGY

RURAL SCHOOL ON RIDGE OF LOESS PLATEAU

Xiaoxi Jiao
Committee: Rob Peña, David Strauss

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Chapter 1:

Statement

BUILDING AS A PEDAGOGY

New schools in rural China often-time are driven by blind pursuit of modernity and executed by methods that diminish human dignity, erode human well-being, disconnect human with nature, local community and cultural tradition. Those sub-standard learning environments are neither climate nor culturally responsive.

This thesis takes a pre-established model, an existing multi-story school on ridge of Loess Plateau in Dongxiang Autonomous County, Gansu province of China, as a failure model of rural school. It addresses these problems through the design of a high-performance learning environment in rural China that is organized around two themes:

i) Ecological and Vernacular Design

ii) Building as Pedagogy

By emphasizing the significance in ecological and vernacular aspects in architecture, this thesis re-proposes the rural school that fits its place, climate and local community by using the principles of high performance building design. The "high performance" goals for this school are:

i) Resources:

Values of ecological design include conservation and stewardship of resources; closing as many resource loops as possible.

ii) Social/Cultural:

Engagement from surroundings and be responsible for passing down the culture value to the next generation.

iii) Economical (Low Cost):

Considering the economy condition of the rural site, keep cost as low as possible by using local material and low techniques for construction.

Buildings, particularly learning environments, should facilitate comfort, productivity and humanity, which is particularly meaningful for the left behind children who are living in the rural area without sufficient care given from their parents. The idea of building as a pedagogy is that buildings have their own hidden curriculums that teach as effectively as any course taught in them. Learning takes place in buildings and also occurs as a result of how the buildings are designed, constructed and from what materials, how they fit their location, and how they are operated.

Buildings can be designed to recycle organic wastes and rainwater through ecosystems which can be studied and maintained by the children. Buildings can be designed to heat and cool themselves by using solar energy and natural air flow. They can be designed to inform occupants of energy and resource use. They can be landscaped to provide shade, break winter winds, produce food locally, and restore bits of vanished ecosystems. Buildings and landscapes can extend ecological imagination. They can invite children's participation into its operation... All of those make building as an pedagogy that help children acquire knowledge and establish healthy social relationships, act as educational tools for imagination, sense of place, ecological awareness, cultural sensitivity...

Chapter 2:

Place

LOCATION

GEOGRAPHY/GEOLOGY

CLIMATE

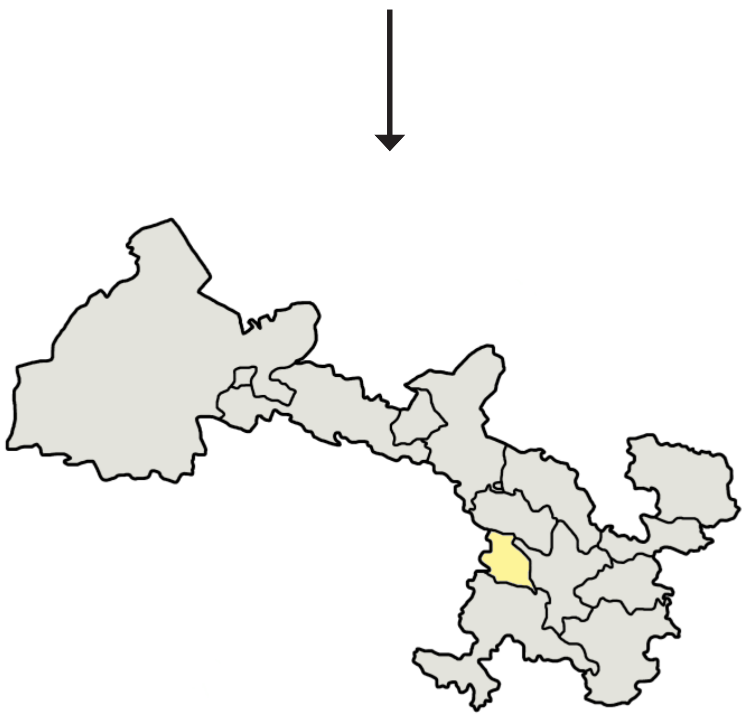
LOCATION

Dongxiang Autonomous County, Linxia Hui Autonomous Prefecture, Gansu, China

Linxia Hui Autonomous Prefecture is located in southwestern of Gansu province. It is south to Lanzhou, the capital and largest city of Gansu Province in Northwest China, and borders Qinghai Province in the west, Gannan Tibetan Autonomous Prefecture in the south, and the Dingxi prefecture-level city in the east. Linxia Hui Autonomous Prefecture is an autonomous prefecture for the Muslim Hui people, a large Chinese ethnic group. The prefecture is subdivided into eight county-level divisions: one county-level city, five counties and two autonomous counties for Muslim groups, namely Dongxiang, Salar and Bonan.

The study area called Dongxiang Autonomous County (Coordinates: 35°36′N 103°12′E) which is an autonomous county in the Linxia Hui Autonomous Prefecture, province of Gansu of the People's Republic of China. With area of 583 mi^2, more than half of the total population of Dongxiang ethnic minority are living in Dongxiang Autonomous County. It is located in eastern of Linxia Hui Autonomous Prefecture, borders Yongjing County in the north, Linxia County in the west, Hezheng County and Guanghe County in the south and the Dingxi prefecture-level city in the east.

Light grey shows the location of Gansu province of China.



Yellow shows the location of Linxia Hui Autonomous Prefecture in Gansu province.

https://en.wikipedia.org/wiki/Linxia_Hui_Autonomous_Prefecture

Linxia Hui Autonomous Prefecture is subdivided into eight county-level divisions: one county-level city, five counties and two autonomous counties. The one with red outline is Dongxiang Autonomous County.

Below: map of the Dongxiang Aotonomous County.

GEOGRAPHY AND GEOLOGY

Loess Plateau

The elevation of Dongxiang Autonomous County averages 2000 meters above sea-level. The Loess Plateau covers almost all of the area of Dongxiang Autonomous County with loess mountains and ravines. The Loess Plateau was highly fertile and easy to farm in ancient times, which contributed to the development of early Chinese civilization around the that area. But after centuries of deforestation and over-grazing, exacerbated by Chinese population increase, have resulted in degenerated ecosystems, desertification, and poor local economies. Land degradation results in canyons that cuts the loess plateau in Linxia Hui Autonomous County. Reduced moisture suction due to a degraded vegetation layer forms creeks flowing into the major rivers. The Loess Plateau's eroded silt is responsible for the great fertility of the North China Plain, along with the massively and repeated destructive floods of the Yellow River. Its soil has been called "most highly erodible... on earth".[1]

The Yellow River, the second biggest river of China, gets its muddy yellow color from the loess, runs through the northwestern part of the Dongxiang Autonomous County. It takes a sharp turn and runs to the west from where the 147 meters high Liujiaxia Dam is. The Taohe River runs the eastern of the county, forms the border between Dingxi and Dongxiang Autonomous County. These two rivers confluence at north to this county. The Liujiaxia Dam is a hydroelectric dam constructed from 1955 to 1969, a few years after the establishment of the People's Republic of China. The Liujiaxia Reservoir was created in narrow, but fertile valleys of the Yellow River and its tributaries displaced a large number of local farmers who were living in the northwestern part of the county.

Due to the land erosion, plus located in Alpine-Himalayan seismic zone, the loess plateau has witnessed the deadliest landslide ever recorded, which usually triggered by earthquake, accounting for million people killed in those event.

永靖县
Yellow River
LIUJIAXIAZHEN
刘家峡镇
Liujiaxia Dam
HONGQUANZHEN
红泉镇
WANGTAIZHEN
王台镇
SANYUANZHEN
三塬镇
YANGTAXIANG
杨塔乡
KAOLEXIANG
考勒乡
Liujiaxia Reservoir
刘家峡水库
Yellow River
LIANHUAZHEN
莲花镇
ANJIXIANG
安集乡
HETANZHEN
河滩镇
NANYUANXIANG
南塬乡
HEXIXIANG
河西乡
LIUSHUXIANG
柳树乡
Daxia River
QIAOSIXIANG
桥寺乡
ANJIAPOXIANG
安家坡
东乡族乡
Dongxiang
YINCHUAN
银川乡
TUQIAOZHEN
土桥镇
POTOUXIANG
坡头乡
DONGYUANXIANG
东塬乡
BEIYUANXIANG
北塬乡
PUCHUANXIANG
铺川乡
Linxia
临夏回族
自治州
LINXIA
临夏市
JINGGOUDONGXIANG
井沟东乡族乡
NANLONGZHEN
南龙镇
HONGTAIXIANG
红台乡
BAOHANZHEN
枹罕镇
LUPANXIANG
路盘乡
BAIHEXIANG
百和乡
MINZHUXIANG
民主乡
GUANBUXIANG
关卜乡
XINJIZHEN
新集镇
S2
S2
CHENJIAJIXIANG
陈家集乡
梁家寺
东乡族乡
YINJIZHEN
尹集镇
MAJIAPUZHEN
马家堡镇
SANHEZHEN


WEILINGXIANG
魏岭乡
G75
Taohe River
DONGLINGXIANG
董岭乡
TANGWANGZHEN
唐汪镇
HONGQIXIANG
红旗乡
ZHONGPUZHEN
中铺镇
DABANZHEN
达板镇
DASHUXIANG
大树乡
GAOSHANXIANG
高山乡
TAISHIZHEN
太石镇
YANLINGXIANG
沿岭乡
WANGJIXIANG
汪集乡
FENGSHANXIANG
风山乡
XINDIANZHEN
辛店镇
CHEJIAWANXIANG
车家湾乡
S2
GUOYUANXIANG
果园乡
SANJIAJIZHEN
三甲集镇
ZHAOJIAXIANG
赵家乡
WUJIAXIANG
五家乡
QIJIAJIZHEN
祁家集镇
GUANGHE
广河县
ALIMATUXIANG
阿力麻土
东乡族乡
SHUIQUANXIANG
水泉乡
MAIJIAXIANGZHEN
买家巷镇
Google

The earth surface of the Loess Plateau.

Land degradation results in canyons like this one that cuts the loess plateau in Linxia County, Gansu. Reduced moisture suction due to a degraded vegetation layer formed this creek flowing into the lower Daxia River.

Huang River and Taohe River confluence at Liujiaxia.

Photos of the Llujiaxia Reservoir.

Photos of the Llujiaxia Dam.

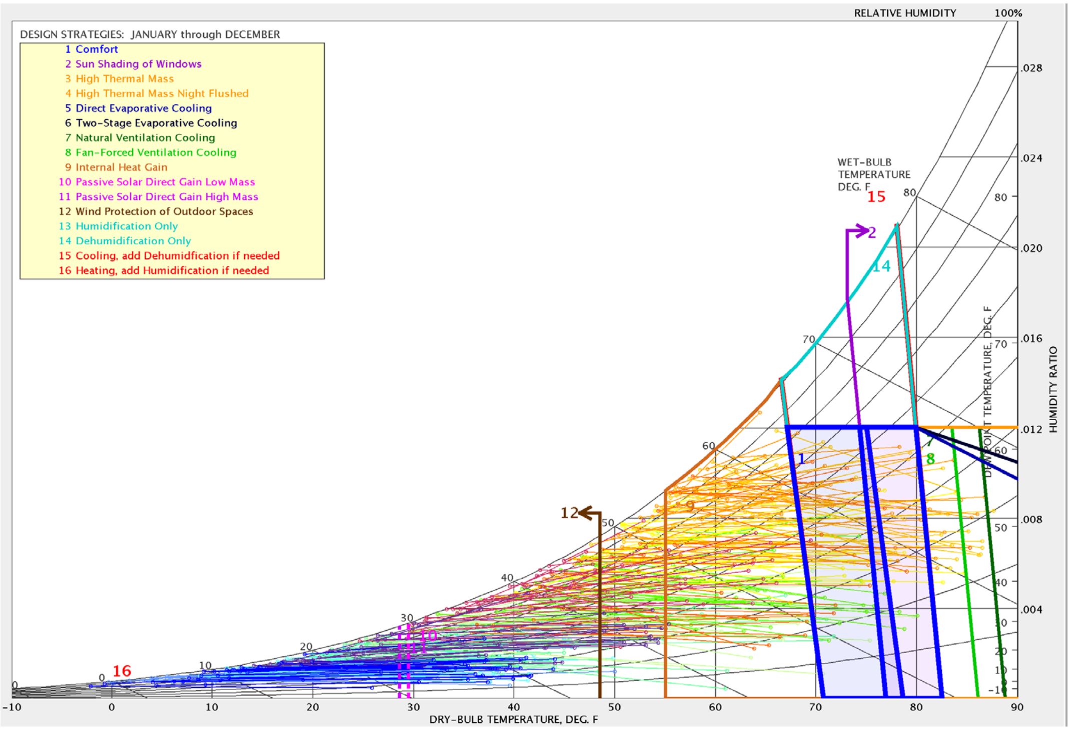
CLIMATE

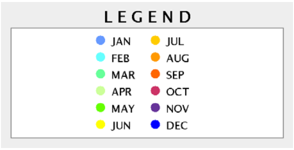
To study the climate of Dongxiang Autonomous County, this thesis uses input weather data of Yuzhong, Gansu, China from EnergyPlus's website and Climate Consultant 6.0 as the output visualization tool. Yuzhong is an administrative district east to Dongxiang Autonomous County, sharing very similar altitude, latitude/longitude, geographic and geological conditions. So this thesis assumes Dongxiang and Yuzhong has similar climate condition. The input weather data are arranged by World Meteorological Organization region and Country.

By putting the weather data into the Climate Consultant 6.0, a series of climate chart are visualized, including annual temperature range, radiation range, wind velocity range, sun shading charts and psychrometric chart. Also a two-hour temperature chart spreadsheet is produced accordingly.

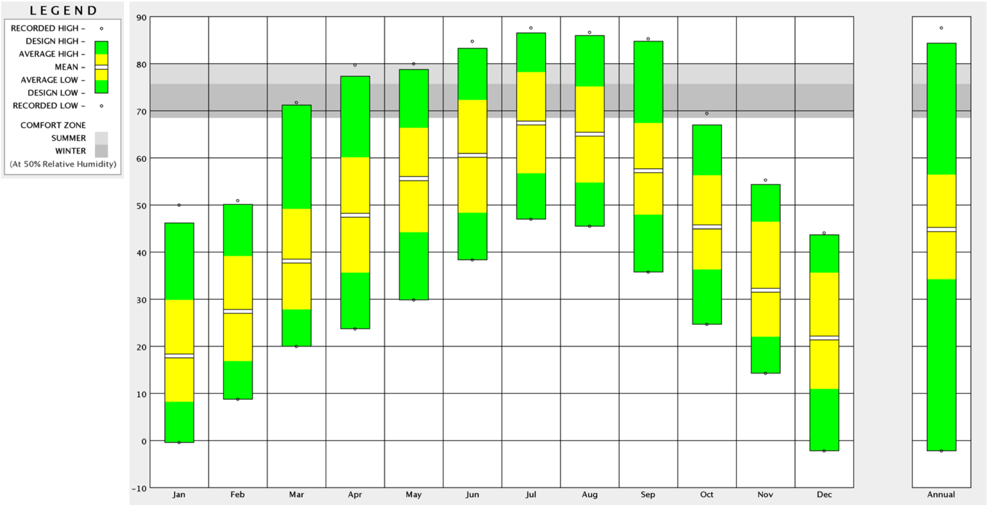
From the weather data outputs, the year's temperature of Dongxiang Autonomous County ranges from as low as -20°C(-3°F) to as high as 31°C(88 °F), with annual average temperature at 8 °C(46.4 °F). There are only 155 frost-free days a year. Winters are long, cold and dry, while summers are warm and mostly comfortable with breeze.

It has a semi-arid climate with extensive monsoonal influence. There is an old saying that "Northwest China has droughts nine years out of ten." Most of the limited precipitation is delivered in the summer months: winters are so dry that snow cover is confined to very high altitudes. Many places in this region face chronic water shortages. Its annual precipitation has only 442 mm (17.4 in). Rainfall tends to be heavily concentrated in summer, and the area receives extensive amounts of solar radiation.

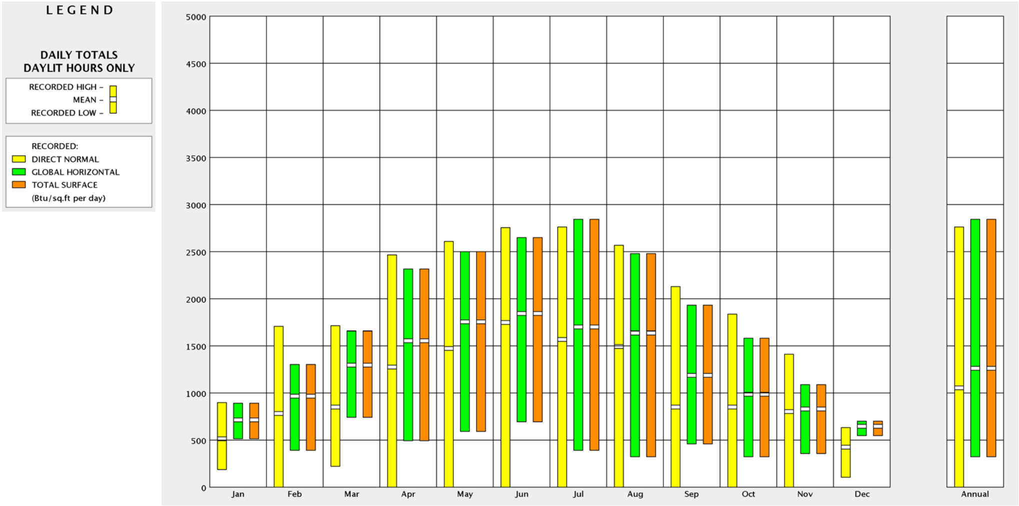




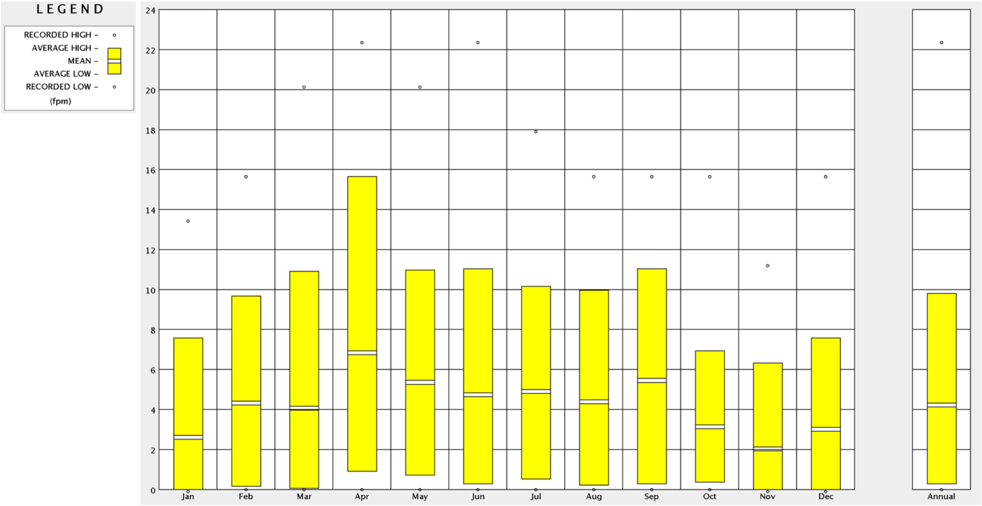
Psychrometric Chart, Climate Consultant 6.0 ASHRAE Standard 55-2004 using PMV



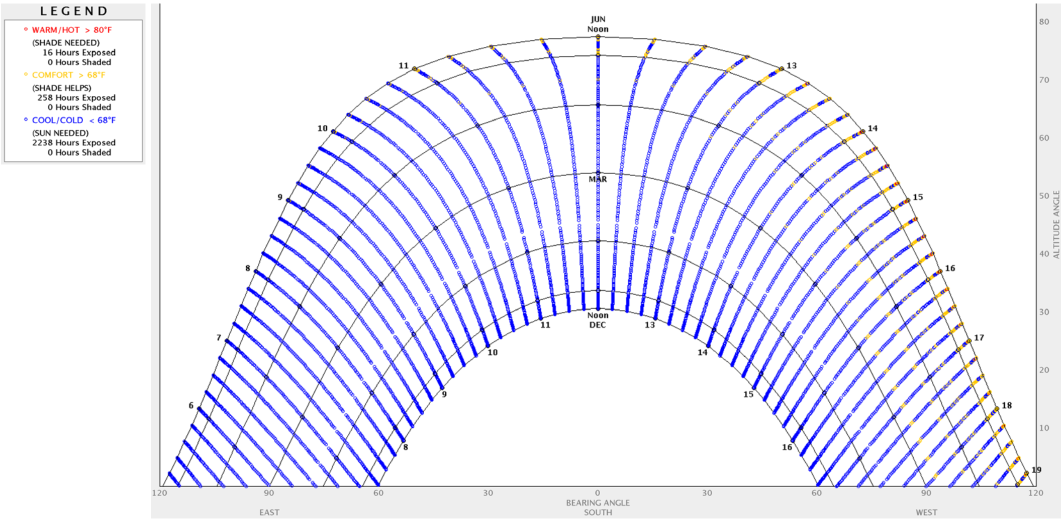
Annual Temperature
Range By Months, Climate
Consultant 6.0



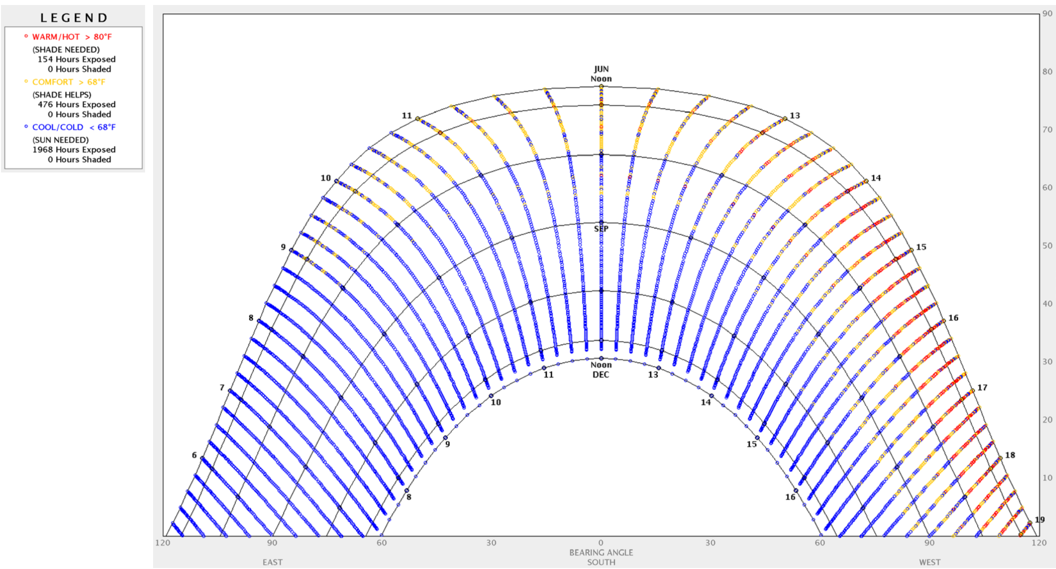
Daily Total Radiation
Range By Months, Climate
Consultant 6.0



Wind Velocity Range By Months in Mph, Climate Consultant 6.0



Winter Spring Sun Shading Chart, Climate Consultant 6.0



Summer Fall Sun Shadig
Chart, Climate Consultant
6.0

Two-Hour Temperature Chart
Balance Point = 55 degrees

55 & 75 Degree Zones

LOCATION: Dongxiang

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
12 midnight	13	22	33	41	49	54	61	59	52	41	28	16
2	11	20	31	38	47	51	59	58	51	40	25	14
4	9	18	29	36	45	49	57	56	49	38	23	12
6	8	17	28	35	44	48	56	55	48	37	22	11
8	10	19	30	38	46	51	58	57	50	39	25	14
10	21	30	40	50	57	63	69	67	60	48	37	25
12 noon	27	36	46	57	63	70	75	72	65	53	44	32
2	30	39	49	60	66	73	78	75	68	56	47	35
4	28	37	47	58	64	71	76	73	66	54	45	33
6	23	32	43	52	59	65	71	69	62	50	39	28
8	18	27	37	46	54	59	66	64	57	45	33	22
10	15	24	34	43	51	56	63	61	54	43	30	18

Two-Hour Temperature Chart

Chapter 3: Culture and Community

PEOPLE

RELIGION

AGRICULTURE AND ENVIRONMENT

HISTORY AND CULTURE

ECONOMY

PEOPLE

The Dongxiang Ethnic Minority

People of the Dongxiang ethnic minority has lived for eight centuries in the dry, forbidding mountains that make the Dongxiang Autonomous County in Gansu Province, one of the most isolated places in China. More than half of their population dwell in the Dongxiang Autonomous County. The rest lives in the surrounding area of Gansu province. According to the 2010 census, their population is 621,500.

The Dongxiang ethnic minority received its name from the place they have been living for hundreds of years — Dongxiang. Historians are divided in their opinions on the origin of the Dongxiang ethnic minority. Some hold that they were descendants of Mongolian troops during Genghis Khan's marching to the west. As far back as the 13th century, Mongolian garrison units were stationed in the Dongxiang area. In these units were Mongols and military scouts and artisans that Genghis Khan brought from West Asia.[2] In time of war, the military scouts would fight as soldiers on the battlefield. While in time of peace, They farmed and raised sheep and cattle. These troops later took local women as their wives, their offsprings later became Dongxiangs. Other historians say they are mixture of many races including Hui, Mongolian, Han and Tibetan groups.

The Dongxiang people had been groaning under national and class

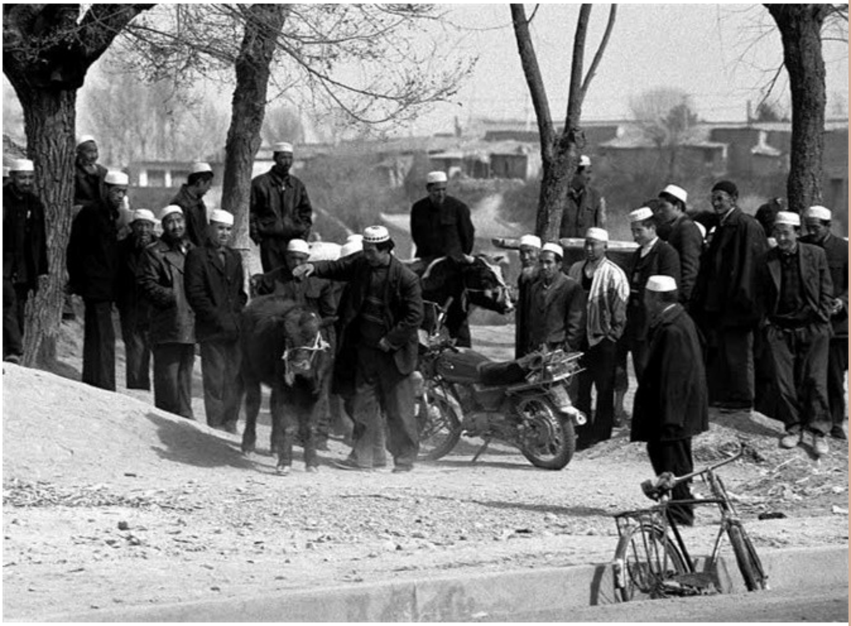
Photo of Dongxiang people.

Chinese president Jinping Xi was visiting Dongxiang Autonomous County.

Some of the Dongxiang people have to walk miles to get fresh water transporting by a donkey.

oppression throughout the ages. This had driven them to take up arms against their oppressors many times. For several decades before the founding of the People's Republic in 1949, the Dongxiang people were suffering under the oppressive rule of the feudal Hui warlords.[3]

The Dongxiang language is basically similar to Mongolian, both belonging to the Mongolian branch of the Altaic language family. It contains quite a number of words borrowed from the Han Chinese language.[4] Most of the Dongxiang people also speak mandarin, which is accepted as their common written language too. Quite a few of them can use Arabic alphabet to spell out and write Dongxiang or Chinese words.



Dongxiang people.in a market.

Dongxiang people are eating lunch with their family.

A China Post stamp
has the figures of
Dongxiang.

A group of Dongxiang elderlys.

The cuisine of Gansu is based on the staple crops grown there: wheat, barley, millet, beans, and sweet potatoes.

RELIGION

Muslims

Dongxiang Autonomous County is one of the predominantly Muslim parts of China. The Dongxiangs are Muslims, and at one time there were 595 mosques and 79 other places of worship in the Dongxiang area. This gave every 30 Dongxiang households a place of worship. Apart from the 12 imams, there were more than 2,000 full-time religious workers. That means every 18 households had to provide for one religious worker. And there were 34 different kinds of religious expenses which had to be borne by the ordinary people.[5]

The Muslims in the Dongxiang area were divided into three sects -- the old, the new and the emerging sects. Carrying out a "divide and rule" policy from the Chinese government, the ruling class sowed dissension among these sects. As a result, the Moslems were at feud among themselves. At times there were armed clashes. Since the early days of 1950s, the Chinese government has pursued a policy of freedom of religious beliefs and taken measures to restore unity among the Moslem people. In 1958, the Dongxiang people carried out the struggle against religious and feudal privileges and the system of oppression and exploitation. This resulted in a further liberation of the productive forces.[6]

A young generation of Dongxiang Muslim.

Dongxiang people are doing the worship.

AGRICULTURE AND ENVIRONMENT

The base of the economy of Dongxiang is agriculture. The main products are potatoes, wheat, maize and broad beans as well as hemp, rapeseed and other industrial crops. They are also recognized craftsmen, specializing in the elaboration of traditional carpets from wool.

Trees and grass were planted on barren hills to mitigate land erosions which had plagued the Dongxiang area for long time. Large tracts of farmland on hill slopes have been transformed into terraced plots. All this, coupled with the construction of irrigation facilities, has greatly raised annual grain production. But still at many places of Dongxiang are suffering from poverty, since quite amount of agricultural productions and the farmers livelihoods depends on the weather. If it is rain, they will have a harvest. If it doesn't rain, then they won't harvest anything. Or if there is heavy hailstorm before the wheat harvest, the farmers will end up with getting nothing.

In 1994 an effort known as the Loess Plateau Watershed Rehabilitation Project was launched to mitigate desertification where now trees and grass have turned green. A major focus of this project was to try to guide the people to use more sustainable ways of living such as keeping goats in pens, not allowed them to roam freely and erode the soft silty soil in the plateau. Many trees were planted and nature is now reclaiming a portion of the Loess Plateau. Restoration has occurred over an area of about 35,000 square kilometers (about 5% of the plateau's total area).[7] Results have reduced the massive silt loads to the Yellow River by about one percent.[8]

The farmers are harvesting potatoes.

Dongxiangs are also recognized craftsmen, specializing in the elaboration of traditional carpets from wool.

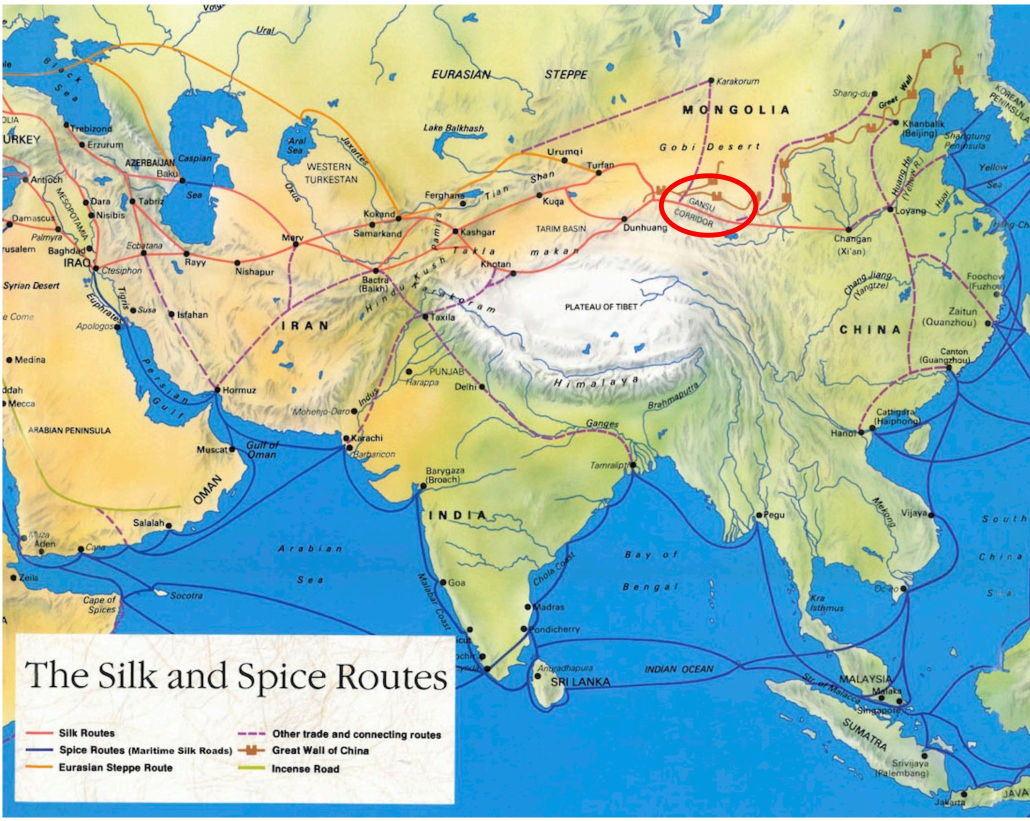

顾湘.2009

The aerial views of the agriculture terraces and Loess Plateau.

HISTORY AND CULTURE

In prehistoric times, Gansu was host to Neolithic cultures. In imperial times, Gansu was an important strategic outpost and communications link for the Chinese empire, as the Hexi Corridor runs along the "neck" of the province. The Han dynasty extended the Great Wall across the Gansu corridor, building the strategic Yumenguan (Jade Gate Pass, near Dunhuang) and Yangguan fort towns along with it. Remains of the towns can be found there. On the Silk Road, Gansu was an economically important place in human's history, as well as a cultural transmission path.

The rammed earth building remains on the Silk Route.



The Silk and Spice Routes.

ECONOMY

The geographic isolation has helped preserve an Islamic culture, as well as its ancient language, but it has also separated the Dongxiang people from the prosperity lifting other parts of China. In addition to frequent earthquakes, droughts and famines, The Dongxiang, one of China's 56 officially recognized ethnic minorities, are now among China's poorest and most illiterate people.

Not only Dongxiang, the economic progress of Gansu province was significantly slower than other provinces of China until recently. Because of the area's abundant mineral resources, it has begun developing into a vital industrial center. However, pollution by heavy metals, such as cadmium in irrigation water, has resulted in the poisoning of many of the agricultural lands.

To conserve the natural resource and get a healthier economic development, Chinese government recently has closed off many mining industries of Gansu province. Industries other than mining include tourist, electricity generation, petrochemicals, oil exploration machinery, and building materials. Despite recent growth in Gansu, it is still considered to be one of the poorest provinces and the most under-developed localities in China.

Mining industry.

Tourist has contributed to the economy.

Chapter 4:

A Pre-established Model: the Existing Rural School

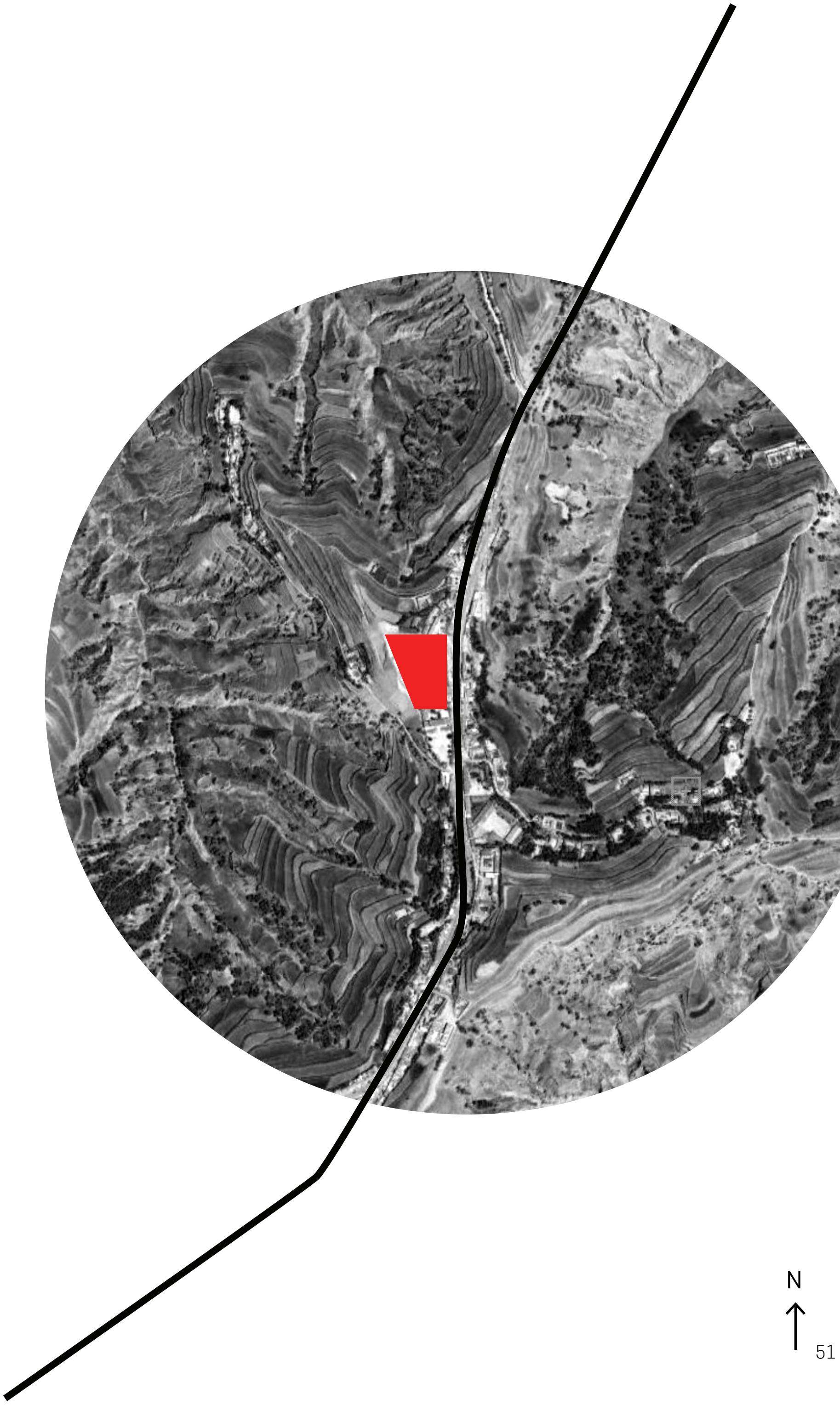
SITE

THE EXISTING RURAL SCHOOL

SITE

The site I have visited for this thesis is a rural school named Wangji school in Wangjixiang Village of Dongxiang Autonomous County, Gansu, China. Wangjixiang Village is a village built along the mountain ridge with population of 9,000 Dongxiang ethnic minority. It is located in the southeastern of Dongxiang Autonomous County which is 16 kilometers(10 miles) from the capita of the county. There is only one county-level road X372 connects Wangjixiang Village to many other villages in similar scale and all the other townships throughout Gansu province.

The site is accessible from the road to its east. Along with the road, there are one or two stories small retails, restaurants and storefronts facing the main road, where all of the commercial activities happen around. Most of the residential dwellings of the village are scattered on the ridge of the mountain along with the road and commercial activities. There are families living in the courtyards north to the site. Agricultural terraces are created on the slope of the mountain which is west to the site. Down from the terraced valley is a creek running through. A four stories government building is located south to the site. From the street east to the site, it experiences a steep topography changing which goes up to 20 feet higher and then gradually goes down becoming the terraced valley.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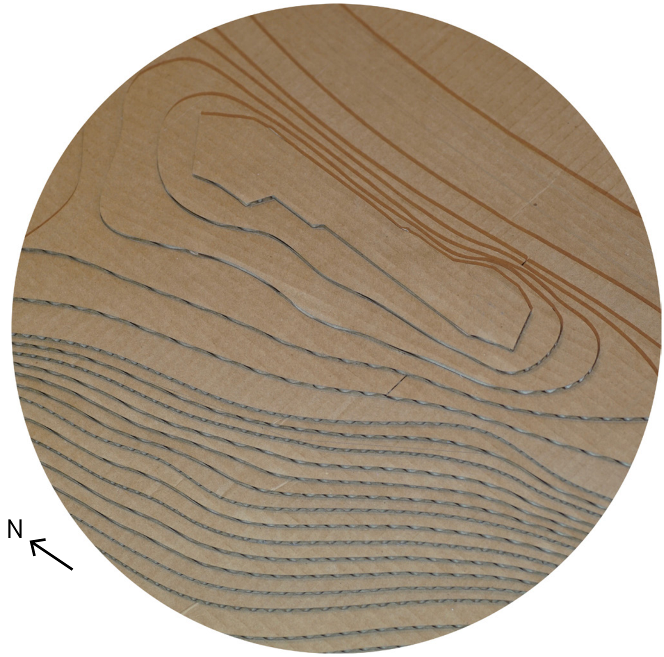
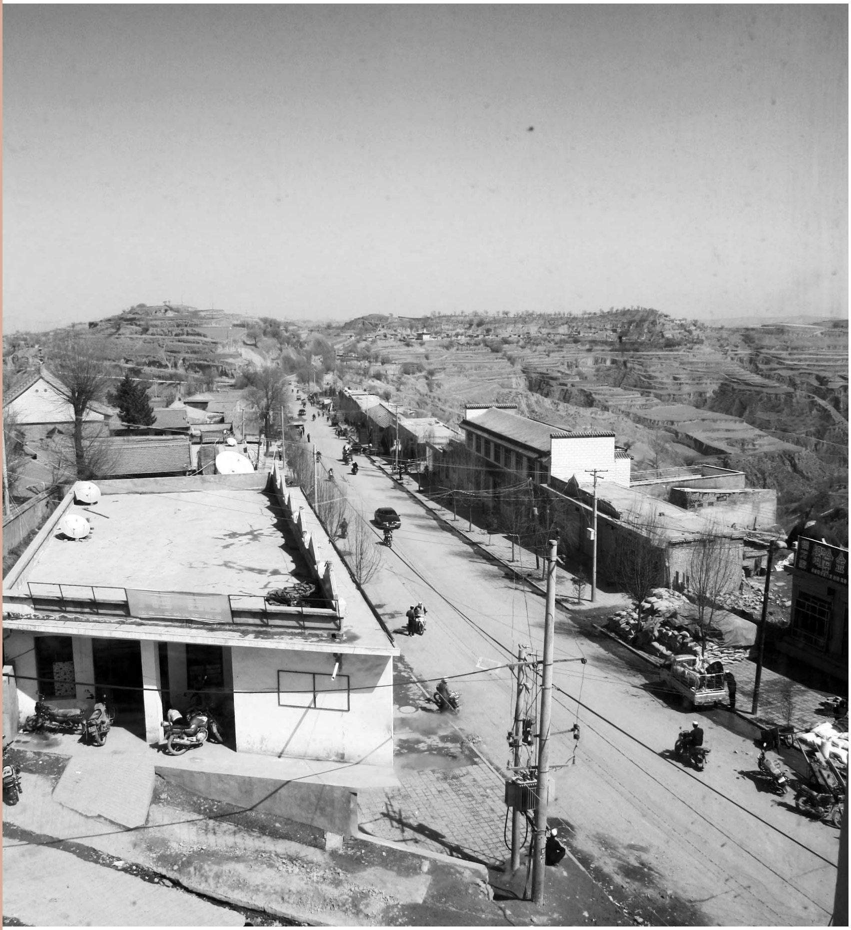


Photo of a physical model that study the topograph of the site.

View from the existing school.

View from the existing school.

View from the existing school.



The main road of Wangjixiang Village.

The main road of Wangjixiang Village.

The main road of Wangjixiang Village.

The public market of Wangjixiang Village.

THE EXISTING RURAL SCHOOL

The existing elementary school, the Wangji School, has six grades with 12 regular classrooms, and three multi-purpose classrooms including labs and digital commons. The school serves for 540 children who live locally and regionally. Some children live miles away from the school who will only go home on weekends or between terms. Among those students, some chridren are left-behind from their parents who have left their hometown for working at cities. So the school also provide dormitories for student's living. There are 45 teachers and about 15 volunteers who temporarily visit this school assisting its education.

Sponsored by the government, the existing school was built in the most "efficient" way one can imagine: three multi-stories concrete buildings on site. The site was divided in two parts, one is leveled with the street, the other part is raised up to 20 feet above with a huge retaining wall. That is how the existing school deals with the steep topography change. One of the main building is located at the lower level, the other two are located on the 20 feet raised platform, where the playground and the dining hall are also located. Considering what the ancestors of the local have done to make the terraced fields, the decision to abruptly cut the site making a cliff is far away from wisdom. It is the result of a government officer wishing to enhance a reputation for getting things efficiently done,

The left behind students.

The site was divided in two parts, one is leveled with the street, the other part is raised up to 20 feet above with a huge retaining wall.

and a financial officer whose job it is to economize on beauty and humanity in the name of fiscal integrity.

This thesis considers the existing building to be the most evil example of what can be done for a rural elementary school building design. Starting from the parti, the three isolated building blocks don't talk to each other in terms of circulation, program, and function. The two main classroom buildings have 20 feet height change, making room move a painful exercise especially in a snowy day. Classrooms spread across both buildings merely because one did not fit all that were needed. Dormitories are mixed with classrooms showing no hierarchy in the program arrangement. What is worse, student dorms are all under comfort sizes and amounts, sometimes even two kids squeeze into one bed during nights.

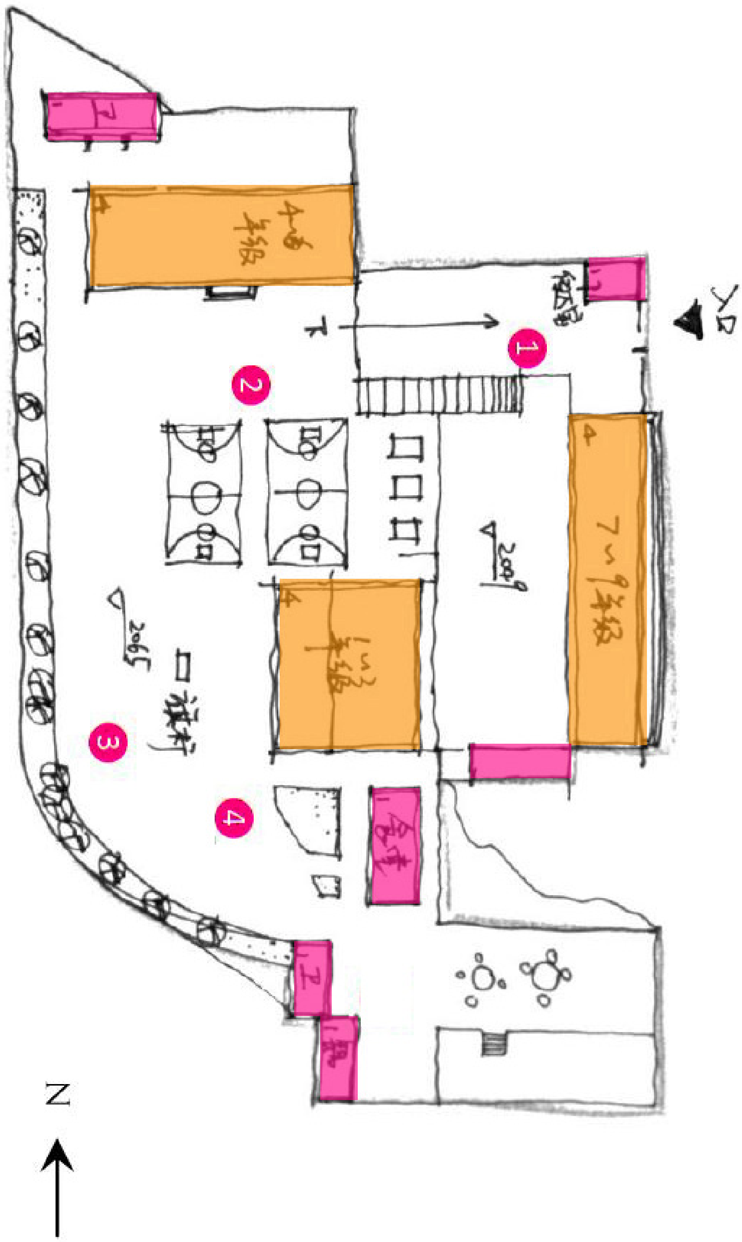
There is no effort making the school fit within its landscape nor the community. A 8 feet tall brick wall on the west edge of the school blocks all of the view to the local community and landscape. The three buildings are out of scale comparing with its one or two stories neighbors. The building material, concrete, is alien to the environment, culture, and climate. What was driving the choice is the mindless simplicity of copying what was done in a city such as Beijing and Shanghai, where climate is milder, electricity is abundant, and construction technology is more matured. Whereas in Wangjixiang, the contractor might have never worked on a concrete

The playground and two main buildings are located on the platform 20 feet above the street level.

The huge retaining wall.

building, nor understanding what the physical properties of concrete is (low in R-Value), that their poor choice of not using any insulation for the plumbing pipes is causing all bathrooms to be entirely useless during cold season.

What's left functional are the dry pit trench bathrooms built at the farthest remote of the site as backups, which is the type of bathroom the local people have in their house, that have been proven to function through the last thousand years.



Existing master plan.

A 8 feet tall brick wall on the west edge of the school blocks all of the view to the local community and landscape.

the three isolated building blocks don’t talk to each other in terms of circulation, program, and function.

A big stair connects the lower level with the raised platform.

The toilet doesn't work because the pipes cracked due to the coldness.

Under-sized dining hall.

Climate damaged the building construction.

Students' dorm with under-sized beds.

Dry pit toilet.

The huge retaining wall.

The stair is the only way to connect the level difference.

No room to day clothes.

Playground.

Chapter 5:

Learning From the Rural

PRECEDENTS

CLIMATE RESPONSIVE PATTERNS

SIMULATION STUDY

LOCAL BUILDING MATERIALS

LOCAL GREEN BUILDING STRATEGY

PRECEDENTS

The following are projects of sensitive government schools located in different places and climate. These are good examples of climate, place and culturally responsive learning environments that address natural resources and cultural needs and traditions of the children.

DRUK WHITE LOTUS SCHOOL, LADAKH, INDIA

GOHAR KHATOON GIRLS' SCHOOL, MAZAR-I-SHARIF, AFGHANISTAN

MAOSI ECOLOGICAL DEMONSTRATION SCHOOL, GANSU, CHINA

DRUK WHITE LOTUS SCHOOL

ARUP ASSOCIATES

The school has been designed to optimize use of natural resources such as solar radiation and natural ventilation. The facility generates its own energy and reduces local emissions by using PV panels that take maximum advantage of Ladakh's high and consistent exposure to direct sunlight.

Water is a limited resource in this region with very little rainfall. The main source of water is snowmelt from the surrounding Himalayas. The water distribution system reuses water for irrigation and directs any rainfall to planted areas. Groundwater from the 105-foot (32-meter) deep water table is pumped by solar energy to a 16,000-gallon (60,000 liter) tank at the surface.[9] Drinking and irrigation water is then gravity fed to gardens and water faucets. When not driving the water pump, the PV panels feed batteries to power the school's computers. The school's toilets use the "ventilated improved pit" system, considering an important and affordable breakthrough for improving sanitation in developing countries. Without using any water, the toilets have a solar-driven flue to eliminate smells and insects.

The school's buildings use local materials and building techniques. Solid granite blocks that are used for the outer wall come from stone found on or adjacent to the site. Inner walls are made from local mud brick which significantly improved insulation and high durability. The roof is made out of a traditional Ladakhi mud construction, including poplar and willow from local plantations, and minimize heat transfer in both winter and summer. Rock wool and felt are used for insulation. On top of this they have added corrugated aluminum sheets and sand to cover the felt to prevent it from melting under the strong solar radiation.[9]

Solid granite blocks used for the outer wall come from stone found on or adjacent to the site. Inner walls are made from local mud brick,

GOHAR KHATOON GIRLS' SCHOOL

MILLER HULL PARTNERSHIP AND THE UNIVERSITY OF WASHINGTON

Schools in Afghanistan are often connected to a limited, or unstable power supply, and these institutions operate on almost no budget, often having insufficient fund for heating fuel. In order to overcome these problems, the buildings of Gohar Khatoon School are positioned to maximize solar heat gain in winter months and natural ventilation during the summer.

The school's thick masonry walls provide high thermal mass for absorbing and retaining the heat from the sun. A central stairwell in each classroom units forms a sunspace that captures heat for warming the building in winter. Operable wall vents and door transoms allow warm air to circulate through the north-facing classrooms. Cooling is achieved with combination of cross and stack ventilation.

The facades design balances daylight with solar heat gain by using wall depth, opening size. It optimize solar gain in winter and shades glass surfaces in summer. Light colored ceilings also help diffuse light for the classrooms.

Educational gardening has a long tradition in Persian culture and several areas on the school grounds have been designated as vegetable and flower garden. Water is in shortage over that area. In this school all of the landscaping is irrigated using biologically treated wastewater.[10]

The Gohar Khatoon Girl's school during construction.

In this school all of the landscaping is irrigated using biologically treated wastewater.

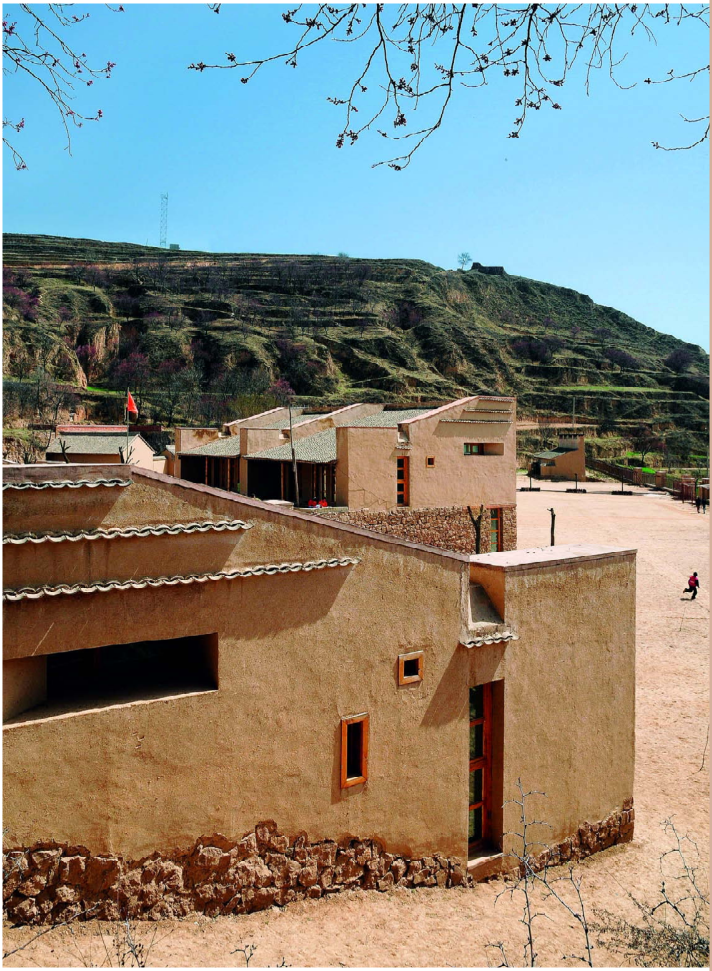
MAOSI ECOLOGICAL DEMONSTRATION PRIMARY SCHOOL

HONG KONG UNIVERSITY

Under the poor conditions of China's Loess Plateau region, the feasibility is limited by low budget and low construction techniques. Considering the economy and resource conditions, the school use ecological and vernacular method to achieve cost-effectiveness, minimum embodied energy in buildings and during construction. It is found that the most basic technique of construction, thermal mass and insulation based on earth and other natural material, are the most effective solution in sustainability and practical feasibility, and hence should be employed as the key strategy in classroom design.

Following original topography, 10 proposed classrooms are planed into 5 units at two levels for maximum exposure to daylight and natural ventilation in summer. Tree-based landscape helps to create a desirable campus ambience for children. The classrooms are derived from local tradition house with timber structure so as to be constructed easily by villagers. Thermal mass and insulations are employed in form of mud-brick walls, the insulated tradition roof, double-glazed window, etc. Construction is implemented by the villagers themselves with simple tools. Most building materials, such as mud bricks, straw and reed, are sourced inside or around the site with minimum embodied energy.

The classrooms are designed to maximum exposure to daylight and natural ventilation.



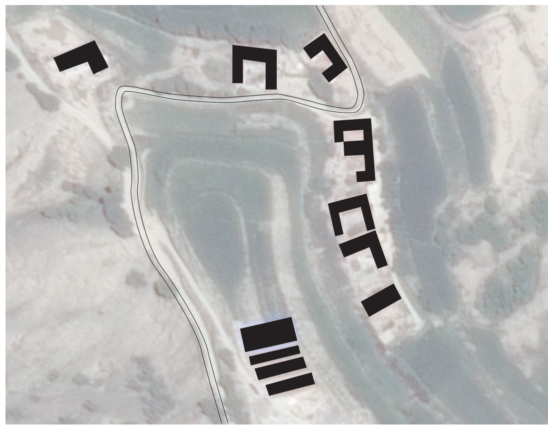
Most building materials, such as mud bricks, straw and reed, are sourced inside or around the site with minimum embodied energy.

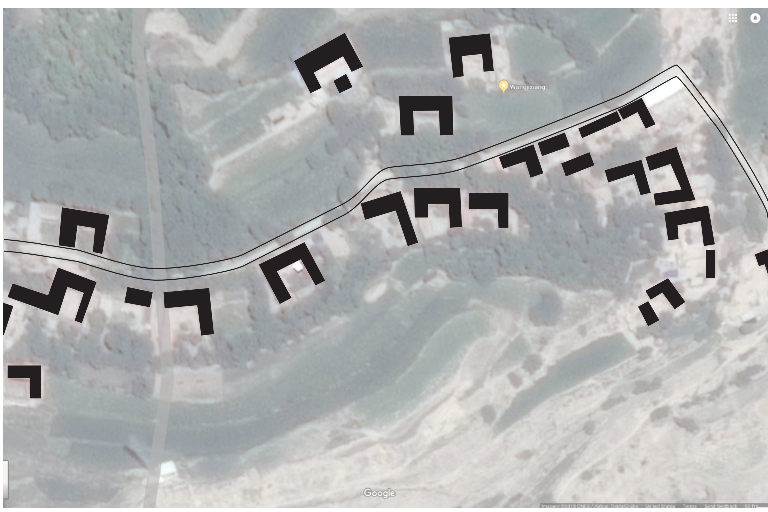
CLIMATE RESPONSIVE PATTERNS

Learning from the rural, this thesis have studied the existing pattern of local residential dwellings of Dongxiang, where they have live from generation to generation. The value of studying their local dwellings is getting to understand the scale of the physical environment they are familiar with, their basic needs for living, as well as learning how does the local architecture deal with its harsh climate.

The residential dwellings are always simple and practical. Dongxiang people usually live in single family houses called "Zhuangke" (庄窠 in Chinese) including a central room, side rooms and kitchen which are in separated buildings adjacent to the central room, with a courtyard. Zhuang is mostly built on the hillside with ten feet high rammed earth walls to enclose an open space, the courtyard. The buildings are about 25 feet wide with tiled shed roofs. The dimension of the courtyards usually ranges from 30 feet to 50 feet wide.
Most of the houses face south to obtain more heat and daylight from the sun. The compact dimension of the buildings are good for natural ventilation when it is warm outside. Some houses face the roads instead to get more accessibility from the road or become commercial storefront.


Google




Wangjixiang
Google

The local dwellings are courtyards typology.

Living within the Loess Plateau.


Local dwelling.


Local dwelling.

The local dwellings are courtyards typology.

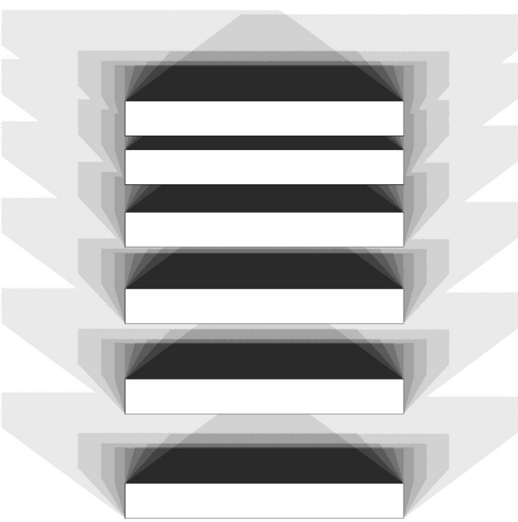
Dongxiang people's home.

Dongxiang people's home.

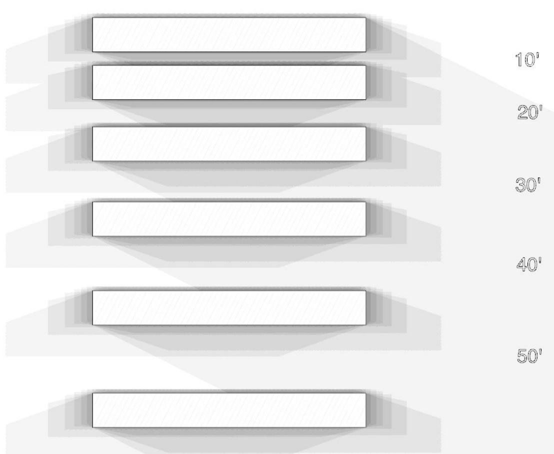
Living within the Loess Plateau.

SIMULATION STUDY

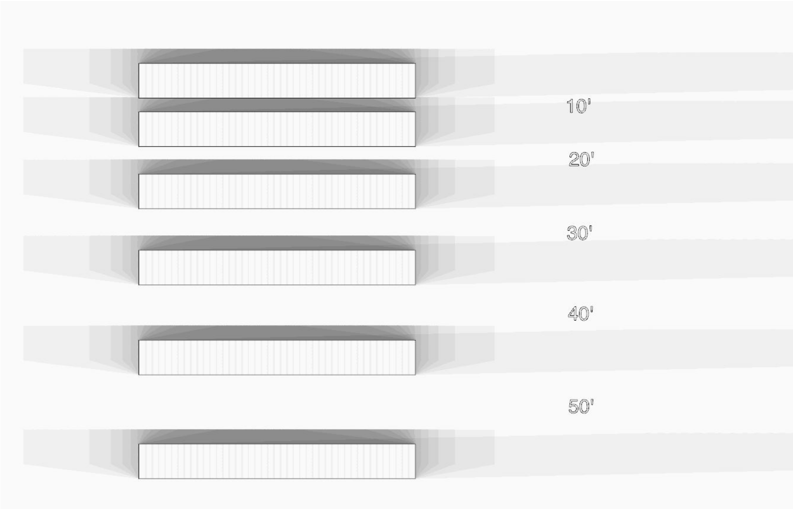
The intention of using the simulation tool is to study how does the proportion and spacing between building effect the sun path and radiation map. The simulation began with a simple horizon bars model which has 15 feet high building with spacing from 10 feet to 50 feet. The result of the simulation shows 30 feet spacing between two buildings is the threshold that allows full direct sunlight and energy from the sun to heat the south facing facade. If adding vertical bars connecting those horizontal bars, they will block part of the energy from sunlight, resulting in less radiation on the south facing facade, which is not desirable if using the south walls as passive heating strategy.



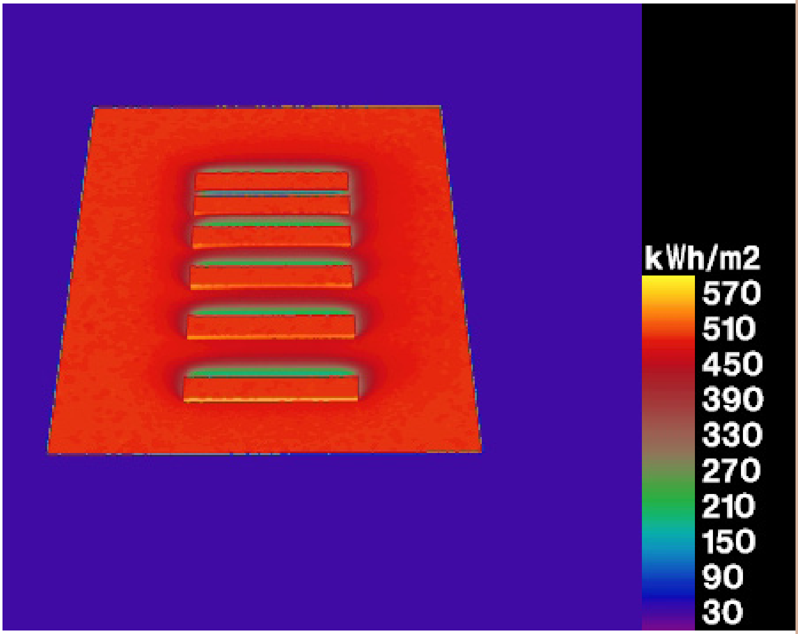
Dec,21th, Sun Path



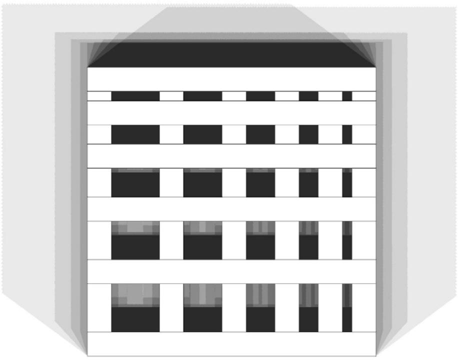
Jun,21th, Sun Path



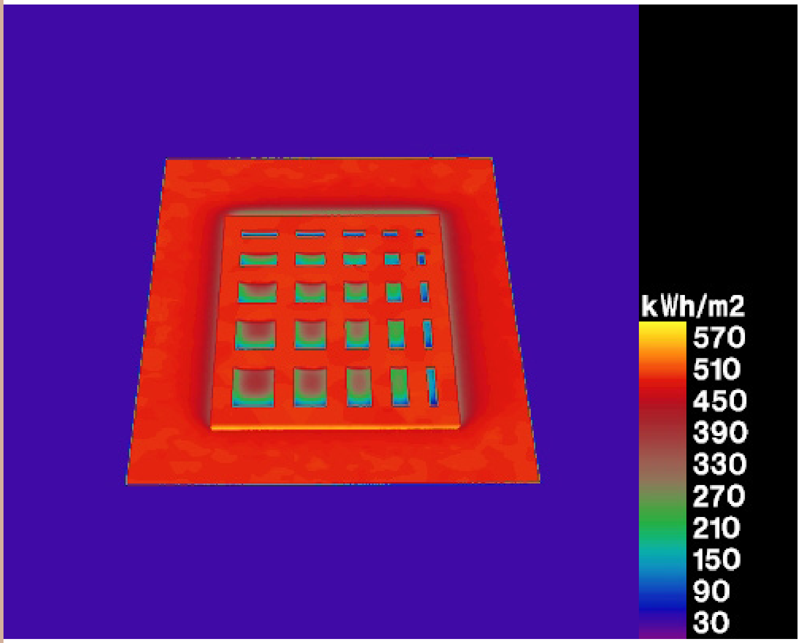
Mar/Sep,21th, Sun Path



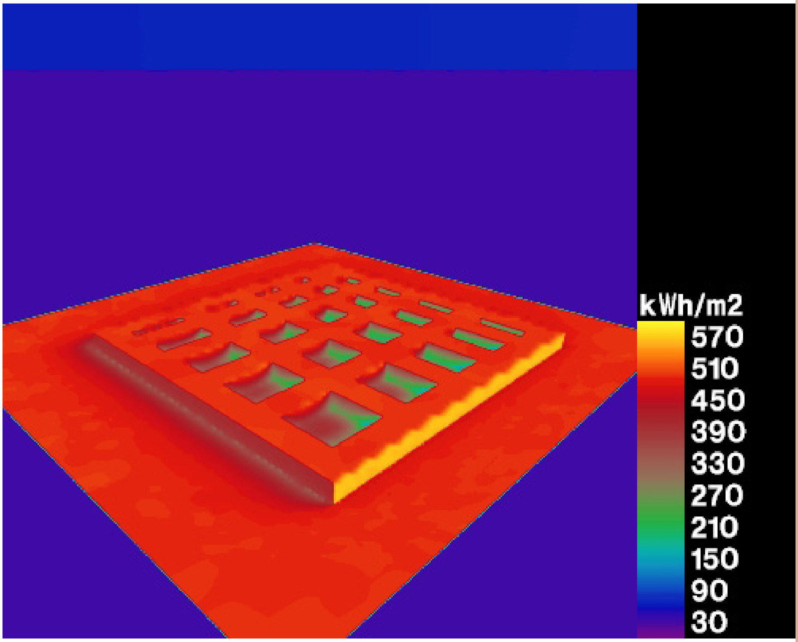
Annual Radiation Map



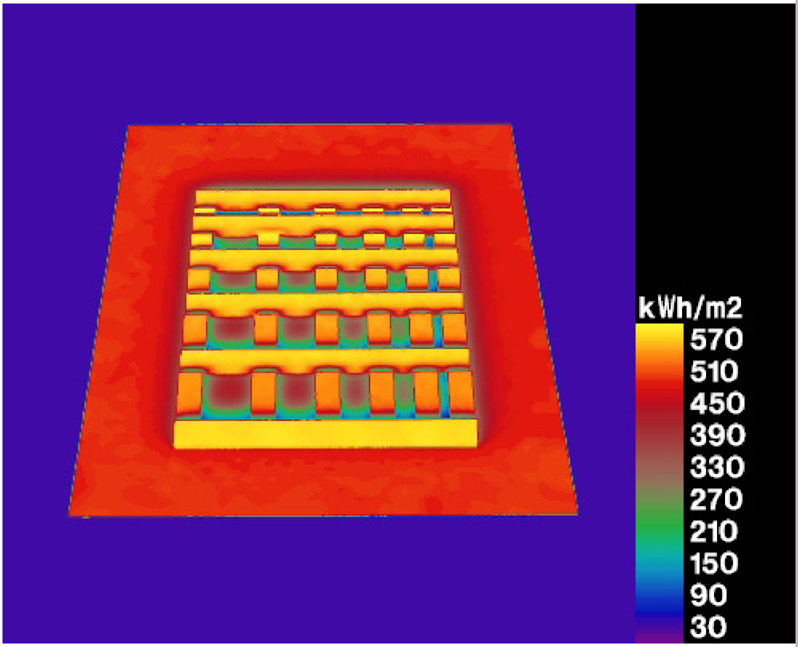
Dec,21th, Sun Path



Annual Radiation Map



Annual Radiation Map



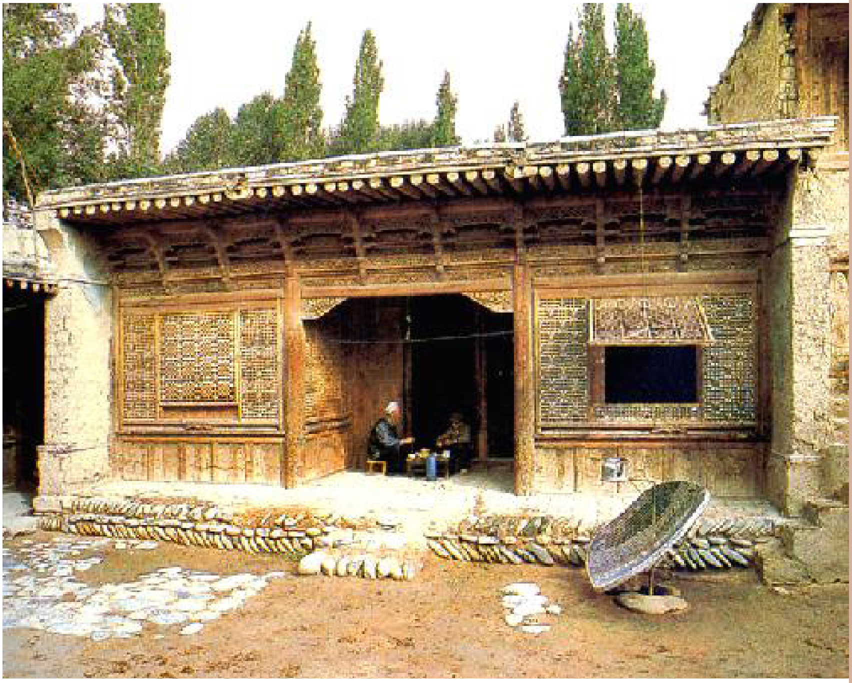
Annual Radiation Map
with shed roof.

LOCAL BUILDING MATERIALS

Living in the Loess Plateau with very limited natural resources, Dongxiang people make most use of what they can get from the nature: the earth and plants grown from the soil. Their single family home are usually made of timber structure, rammed earth or masonry wall, and ceramic tile for the shed roofs. Dongxiang people always leave the structure timber, wood door and window frames unpainted to expose the natural color of the wood.

Rammed earth is considered as a affordable, sustainable and high performed local building material. It works well to retain the heat and stabilize the indoor room temperature. A 12" thick rammed earth wall has effective R value as high as 24. A 18" thick rammed earth wall will increase its R value by 36 which is very well performed. After the 2014 earthquake flattened many traditional rammed-earth buildings, villagers sought brick-concrete construction as a safer alternative but found it cost-prohibitive. But architects have proven rammed earth construction can be modern, economical, and earthquake resistant when introducing new construction components such as steel bars or concrete belts to reinforce it.

Local building materials and low technique construction.



Local building materials.

New rammed earth home.

Local building materials and low technique construction.

LOCAL GREEN BUILDING STRATEGIES

Gansu province has been tested as the ideal location for harvesting solar energy because of its high annual radiation. The United Nations Industrial Development Organization has established the Solar Energy Center for Technology Promotion and Transfer in Lanzhou, the capita of Gansu province. It is also very common to see some local buildings have applied passive solar strategies such as trombe wall, attached sunspace, solar water heater to save energy.

Local building using attached sunspace.

The United Nations Industrial Development Organization has established the Solar Energy Center for Technology Promotion and Transfer in Lanzhou

Local building using trombe wall.

Chapter 6:

Proposal

This thesis speculatively takes the interrupted site back to its virginity, to think again from the scratch what could have been the best practice for the student, community, and ecology using the appropriate building parti, material choice, construction method, and building technology to promote the health of its occupants, and functionality of its programs, the high-performance of its buildings.

Starting from the campus masterplan parti by looking at what was built in the existing building, and using the footprint of rooms as area take-off. The programing can be divided into:

Storefront Retail,

School Offices 1,700 sft,

Laboratory 3*1,505 sft = 4,515 sft,

Library(propose shared with local community) 2,150 sft,

Dining Hall 3,500 sft,

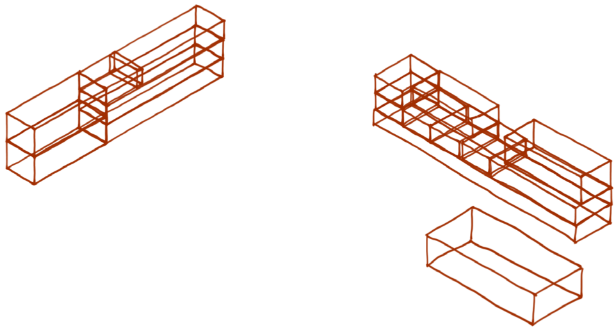
Classrooms 13* 805 sft =14,490 sft, 3*1,075sft =3,225 sft,

Dormitory, Students 6,000 sft total

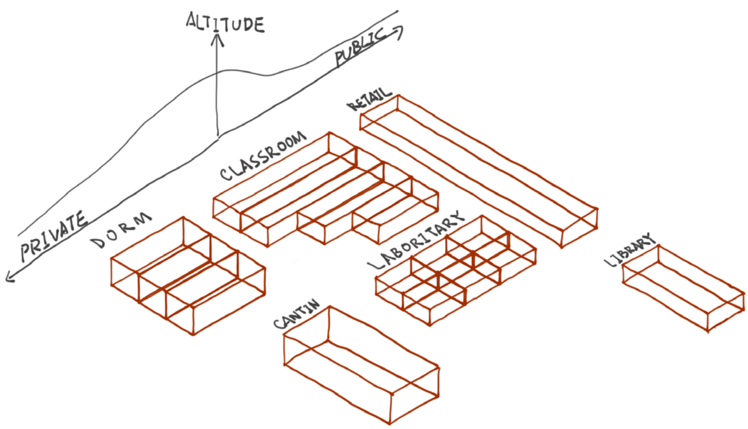
Teachers Dorm 1,200 sft total.

Toilets and Showers

These functions are sortable into that are more public, such as retail, library; that are more demonstrative, such as the laboratory; that are more private, such as the dormitory; and that are in between, such as the classroom and canteen.



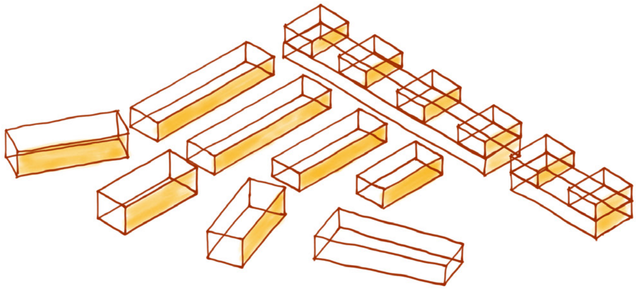
Program diagram
of the existing rural
school.



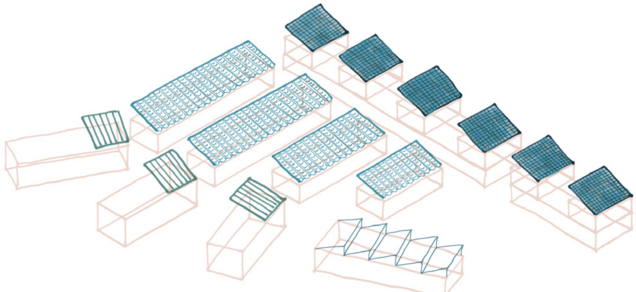
Functions are sorted
into that are more
public to more private
and in-between.

These characteristics of each function can then be arranged on site as its proximity to the public street outside. A row of retail is located north of the school gate, and the library, which is shared with the community is situated south of the school gate as a lantern of knowledge that demonstrates the openness of education. In between the school gate will welcome incoming students, and their parent who wave good-bye to their child. Above the retail / library bar, live the lab rooms, as they are the bigger classrooms comparing to the regular classrooms for its need to store materials and equipments. These labs are spread to receive sunlight that will naturally illuminate the inside and save energy use. The byproduct of this building separation creates the opportunity to have a patio in between each labs for circulation, which will also further strengthening the connection between the school and its community.

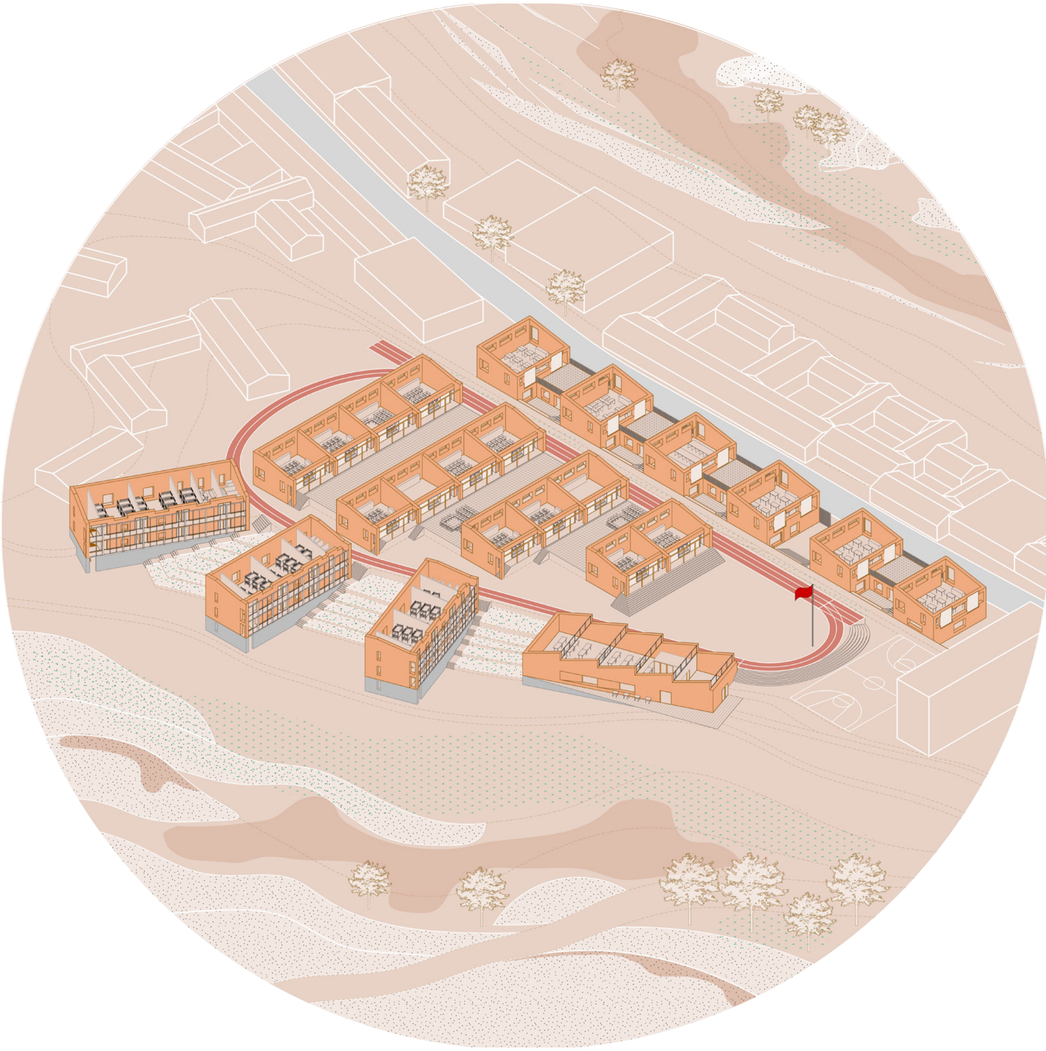
The pedagogy of building comes into play here as on top of the roofs of the lab rooms lay the PV panels. As shown in previous chapter that Gansu province is the demonstration area that deemed by the United nation's development and technology to be the ideal location for harvesting solar energy. This thesis assumes the design EUI of this ecological school is 40 kBTU/sf-yr based on the online tool PV Watts calculator. By using the SunPower high efficiency 61.3 inches by 41.2 inches PV panels, it need about 225 panels to get the school net zero energy. And all of the panels could be located on the roof of



The building layout maximize the solar heat gain.



Potential green strategies on roof.

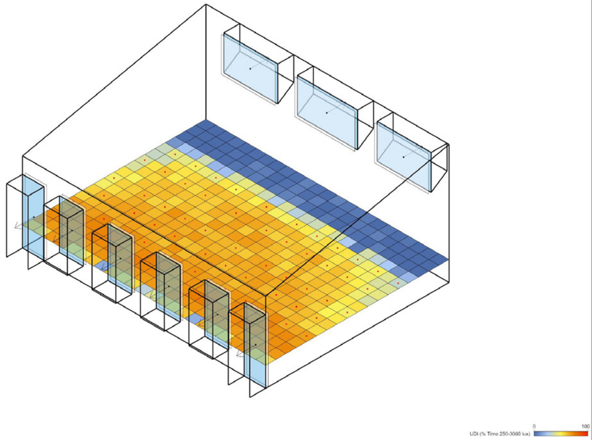


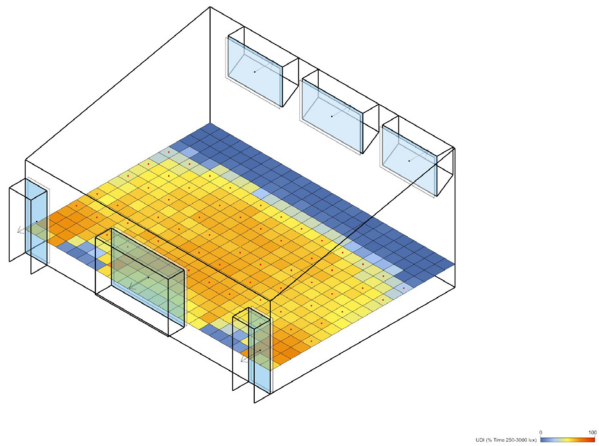

10'
20'
50'
100'

the labs. The visual clue of solar energy use is demonstrated to the community.

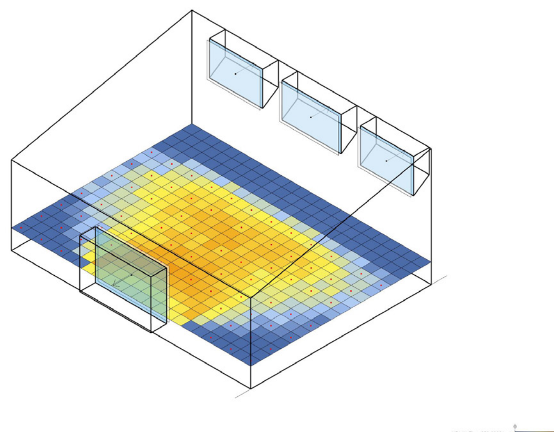
Stepping further to the mid section of the campus, 20 feet above the street level sit all of the classrooms. Different from the existing buildings that have classrooms in both concrete bars, this thesis proposes a little school of classrooms that lives next to each other, creating courtyards that are typical in the local building geometry. Similar to the logic used in determine the lab room separation, the same amount of separation is used for rows of classrooms here to ensure natural light can saturate 100% the height of the wall in the lowest winter sun. This is to make full use of the proposed trombe wall system to passively heat the building. As high-performance building in a low-tech construction is one of the most important goals in this project, the trombe wall plays a huge role in saving energy and providing comfortable building experience.

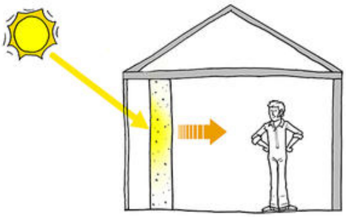
This project will be using rammed earth as the main material for the wall construction. This material is what has been used in this climate since ancient time, and has been able to withstand the test of time and climate. Secondary material will be local wood. Though relatively small in dimension, the lightness of them works perfectly with rammed earth by not adding too much weight to this structural system. On top of the wood truss, lays a layer of reed lied tightly together as sheathing and waterproofing underlayment. And

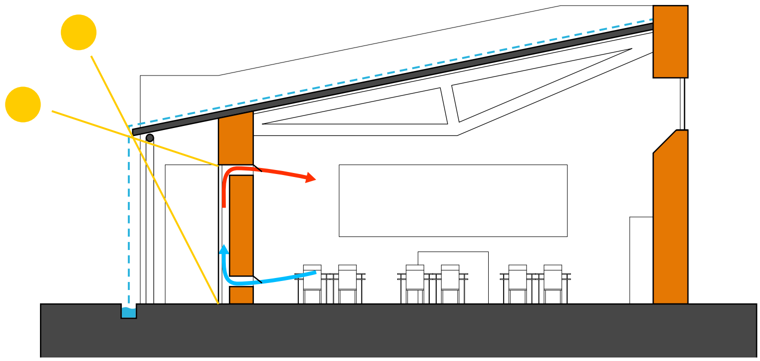




Analysis and prediction simulation tools are integrated in the design process, help to optimize green strategies on building. This simulation shows how the different configurations of openings, different window to wall ratios impact on the Useful Daylighting Index of the classroom.

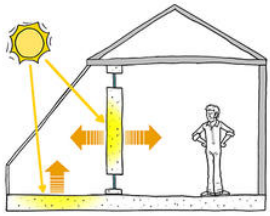


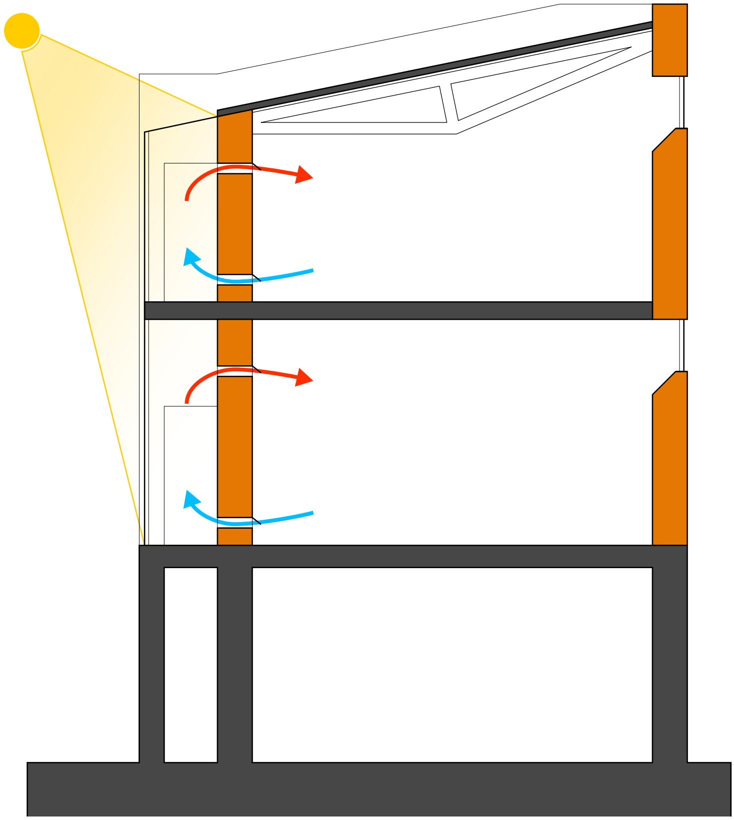




Trombe wall for the classrooms.

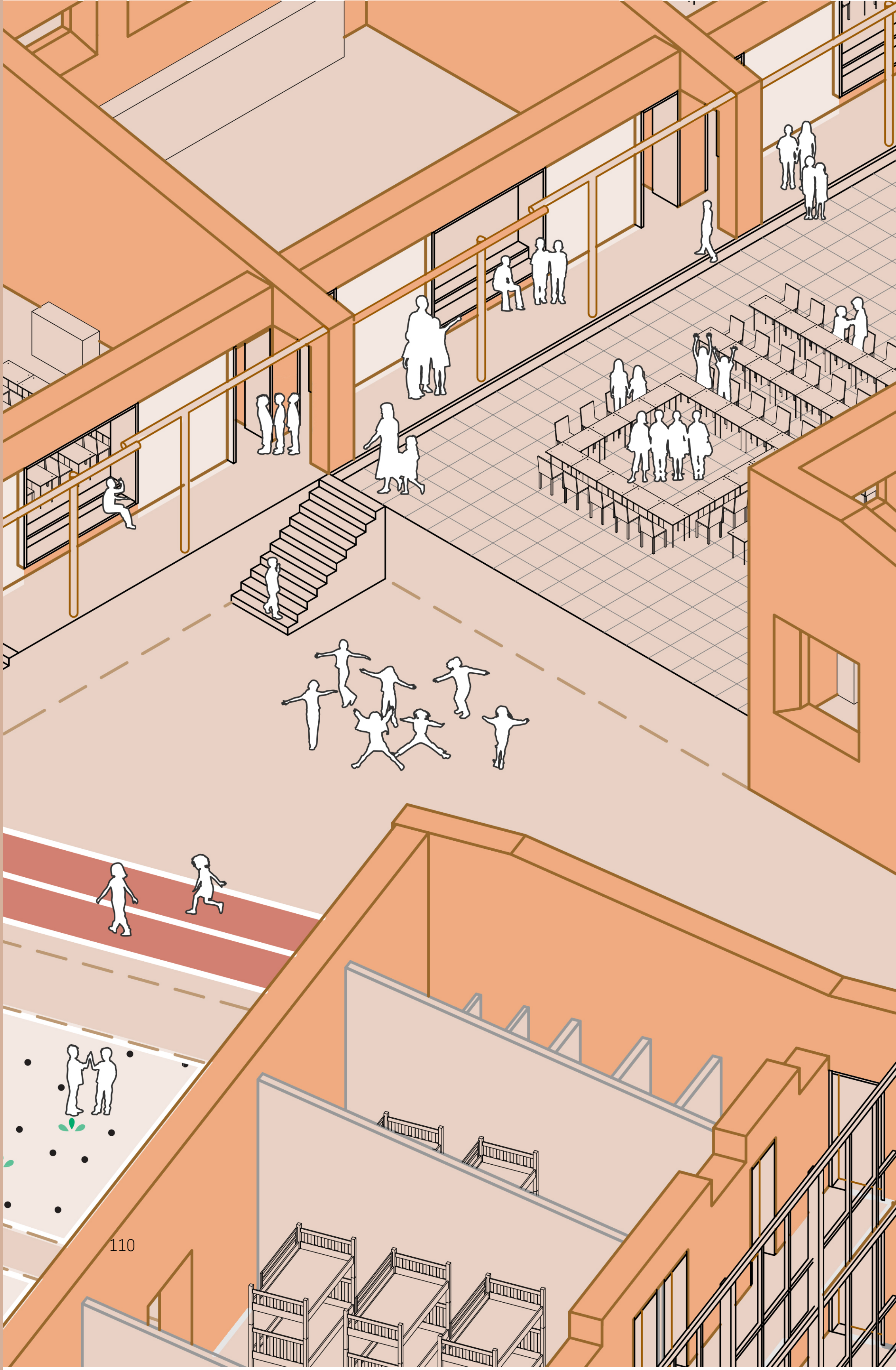
of course on top of it, sits the ceramic roof tiles. The roof overhang 5 feet over the trombe wall. This is to prevent bulk water from washing the face of glass, which is leaked will cause structural damage to the rammed earth thermal mass wall behind. The overhang also creates a circulation space where students come to classroom each day from their dormitory.

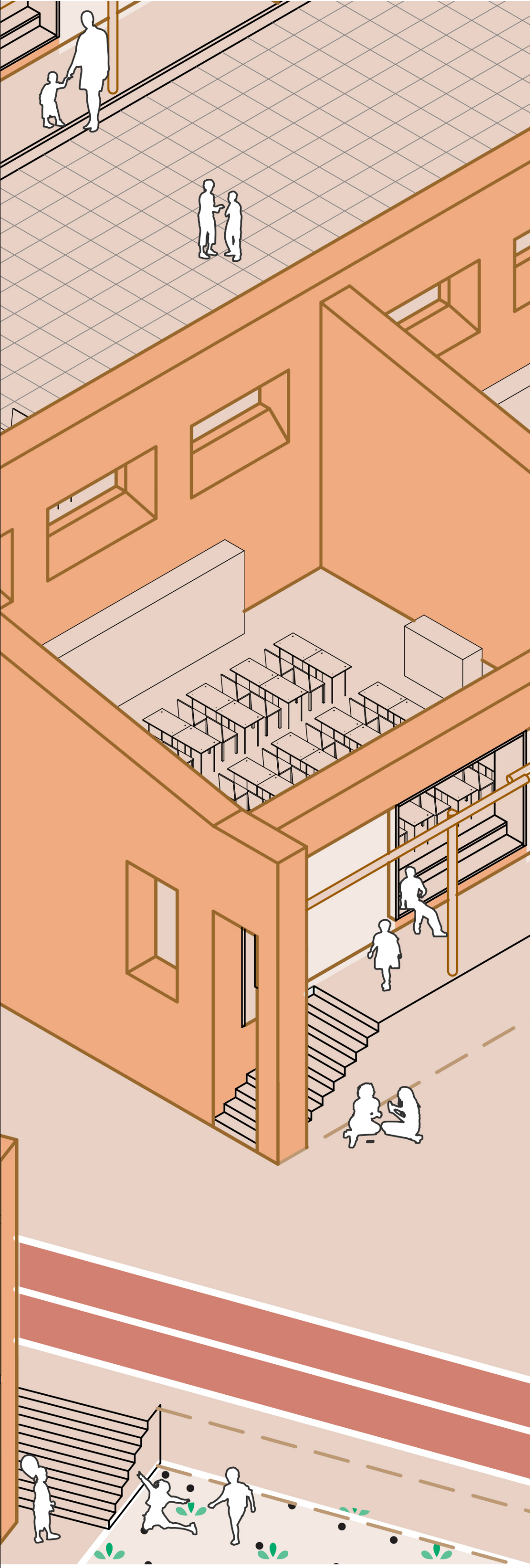




Attached sunspace for the dorms.

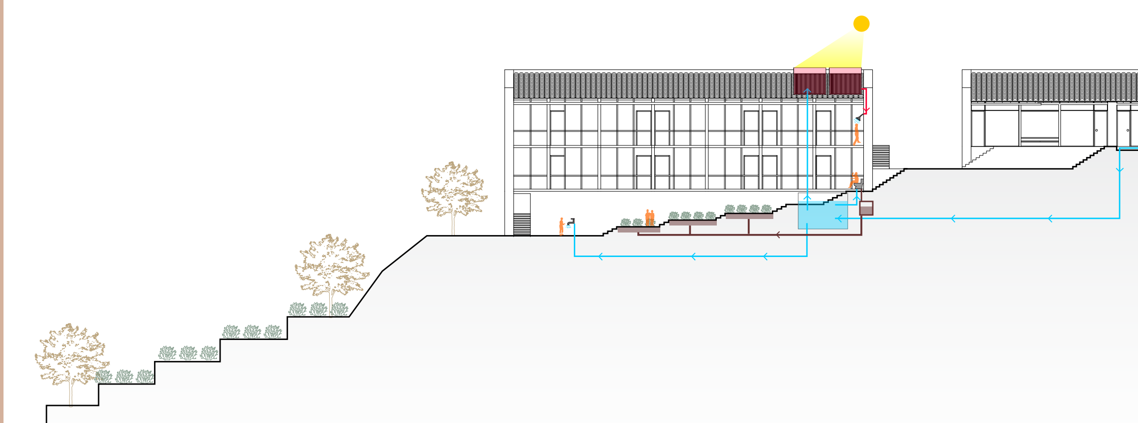
Perspective of the classroom.





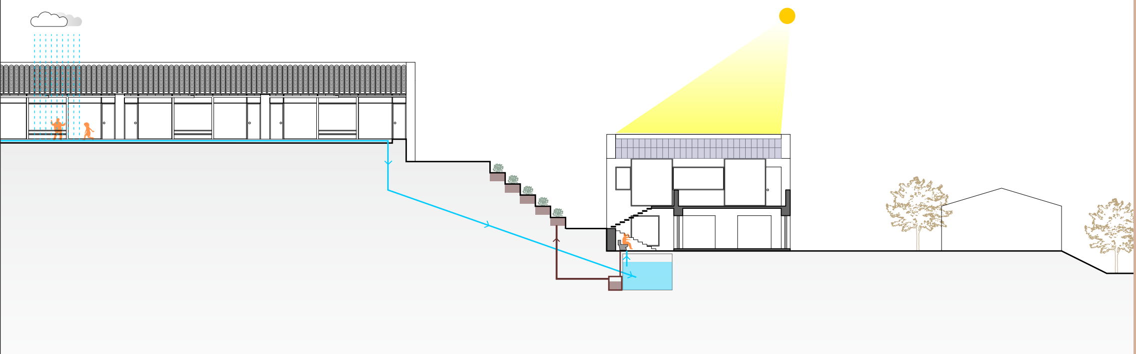
Another low-tech building technology and pedagogy is water collection through the roof tiles and open trench on the ground. As stated in previous chapter, that the water is a scarce resource in this climate, capturing any precipitation is probably the most important task from the building function standpoint. Local vernacular building always uses ceramic roof tiles that is concave and convex in shape for better navigating the water flow off the roof, this project takes it one step further by intentionally create water channel that lead rain water into the trench created directly below the roof on the ground. This trench will also capture snow melts. By making the trench visible, it creates a signal for the students to see the water that they are using to know the scarcity of resources, and the necessity of trying to save them.

The dormitory buildings are the extension of the classroom building bar, but rotated to spread out more for extra sun exposure and view. The low-tech high-performance strategy is to use attached sun

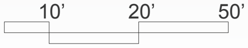


space that collects solar heat by the rammed earth wall behind, and the floor. The difference between a trombe wall system and an attached sun space system is the distance between glass and the thermal mass wall. The former is several inches, the latter is 4 feet in this case to create a corridor space. Sitting pods are created similar to that in the classroom buildings, where kids can hang out and keep warm. The dormitory buildings have the same roof elevation with the classroom buildings with the idea that they will not create shadow onto each other, so that the most solar radiation can be obtained.

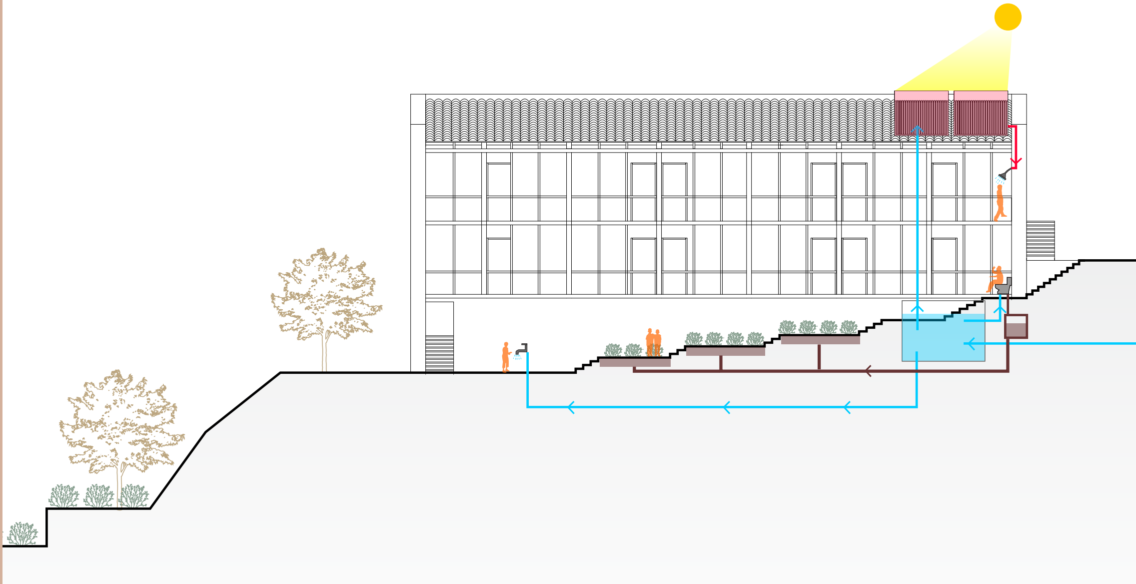
For the dormitory building, three sets of solar water heater will be installed on top of the roof towards the classroom side, as a pedagogy of showing where the heated shower water is from, and that students should learn to save it by not wasting water in the shower and sink. The roof line of the dormitory is kept flush with the

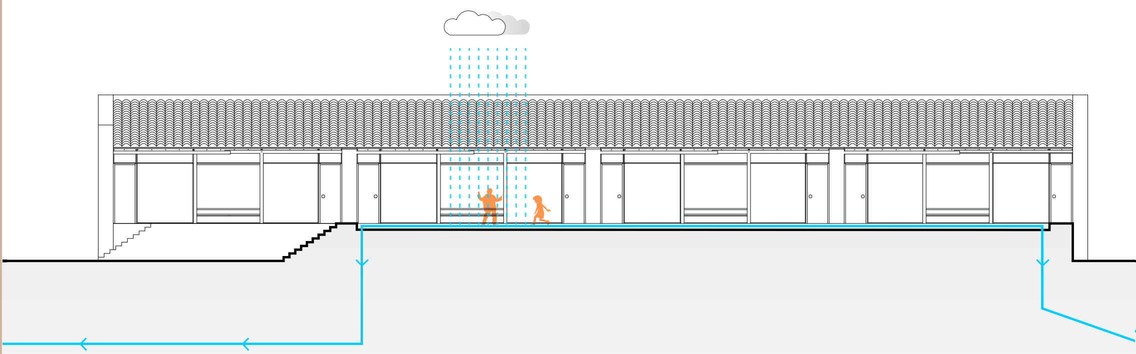


W-E Section



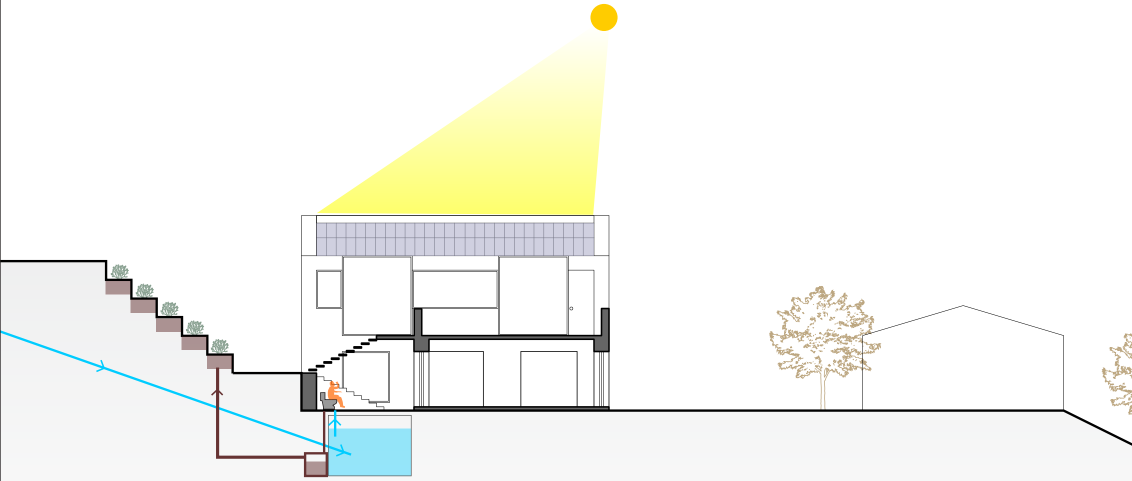
classroom, but because the topography tops at the classrooms, and descends along the dormitory building, the dormitory room are two stories, and a further lower floor hosts laundry room and cistern room that collects the water run from the roof of classroom through



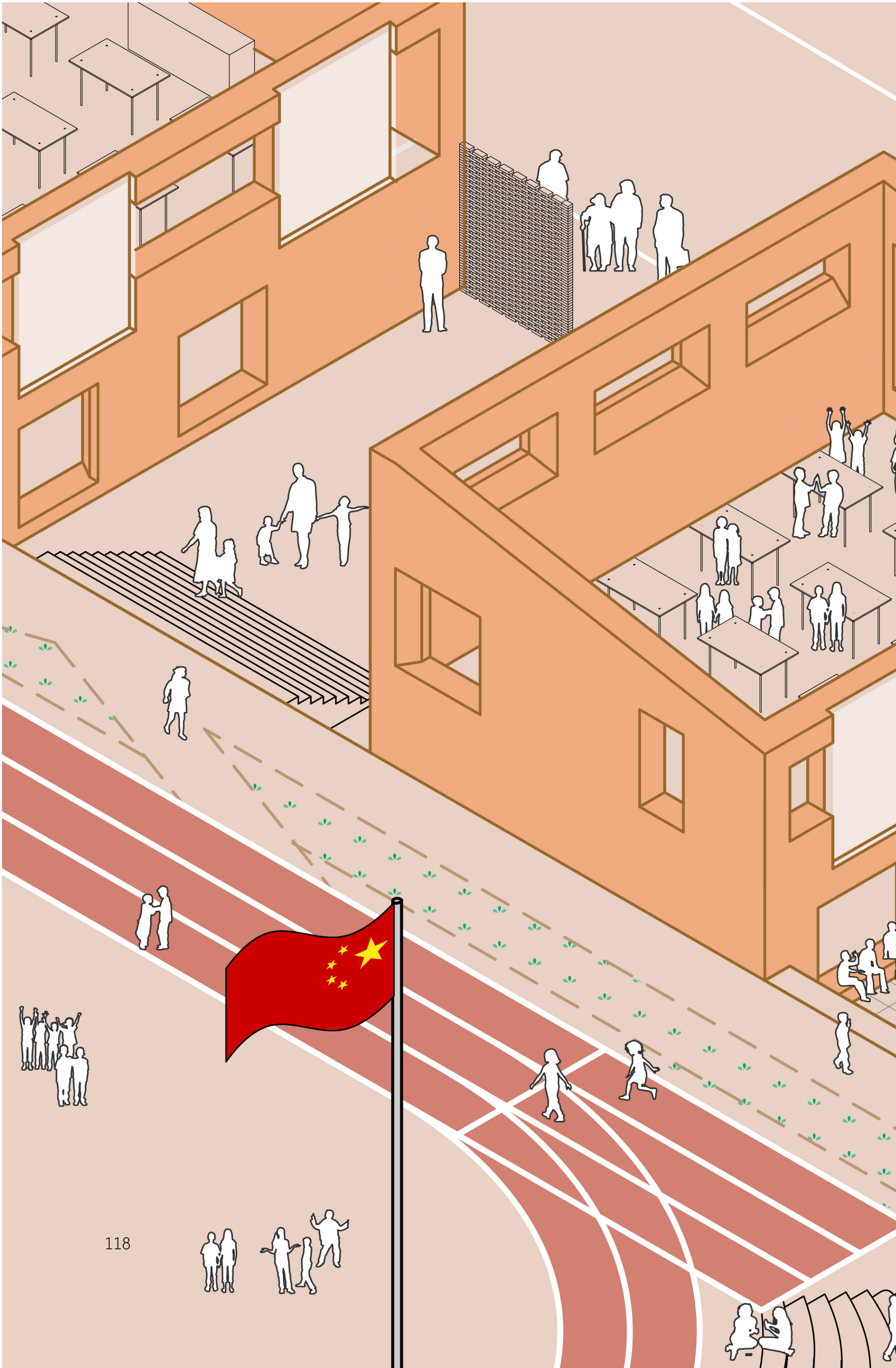


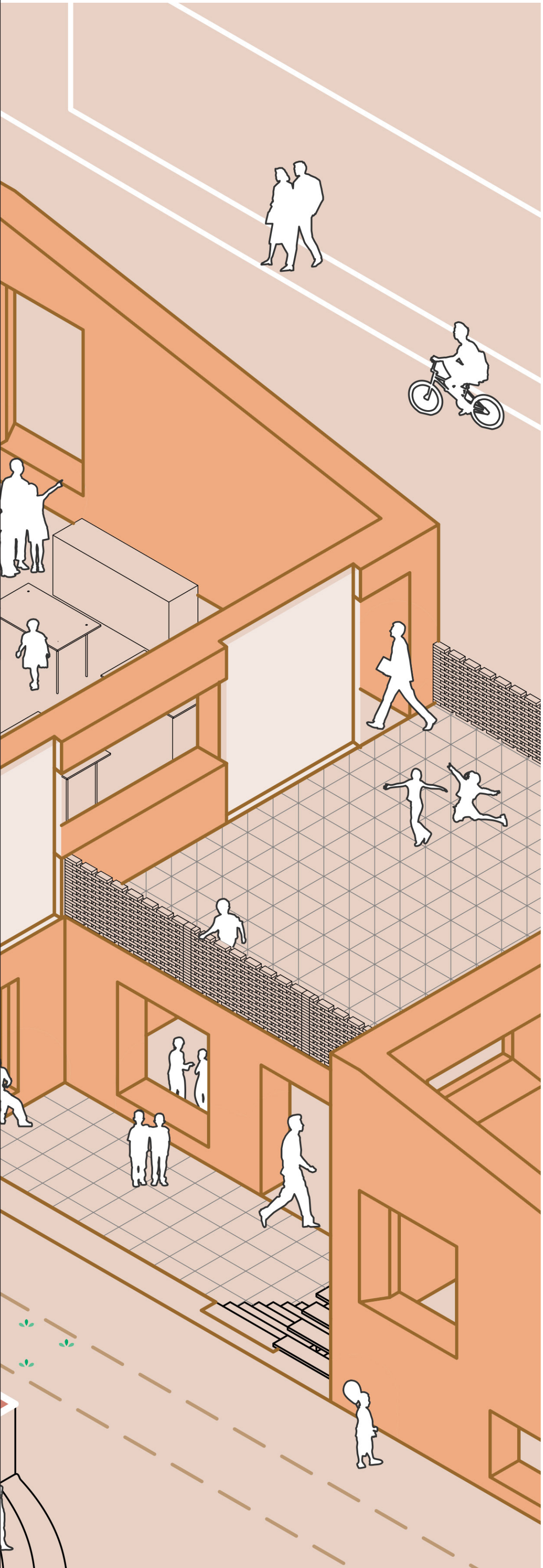
the trench. The water is filtered and then sent to the roof solar water heater for used in the shower, or used to irrigate the school farm terrace in between each dormitory buildings.

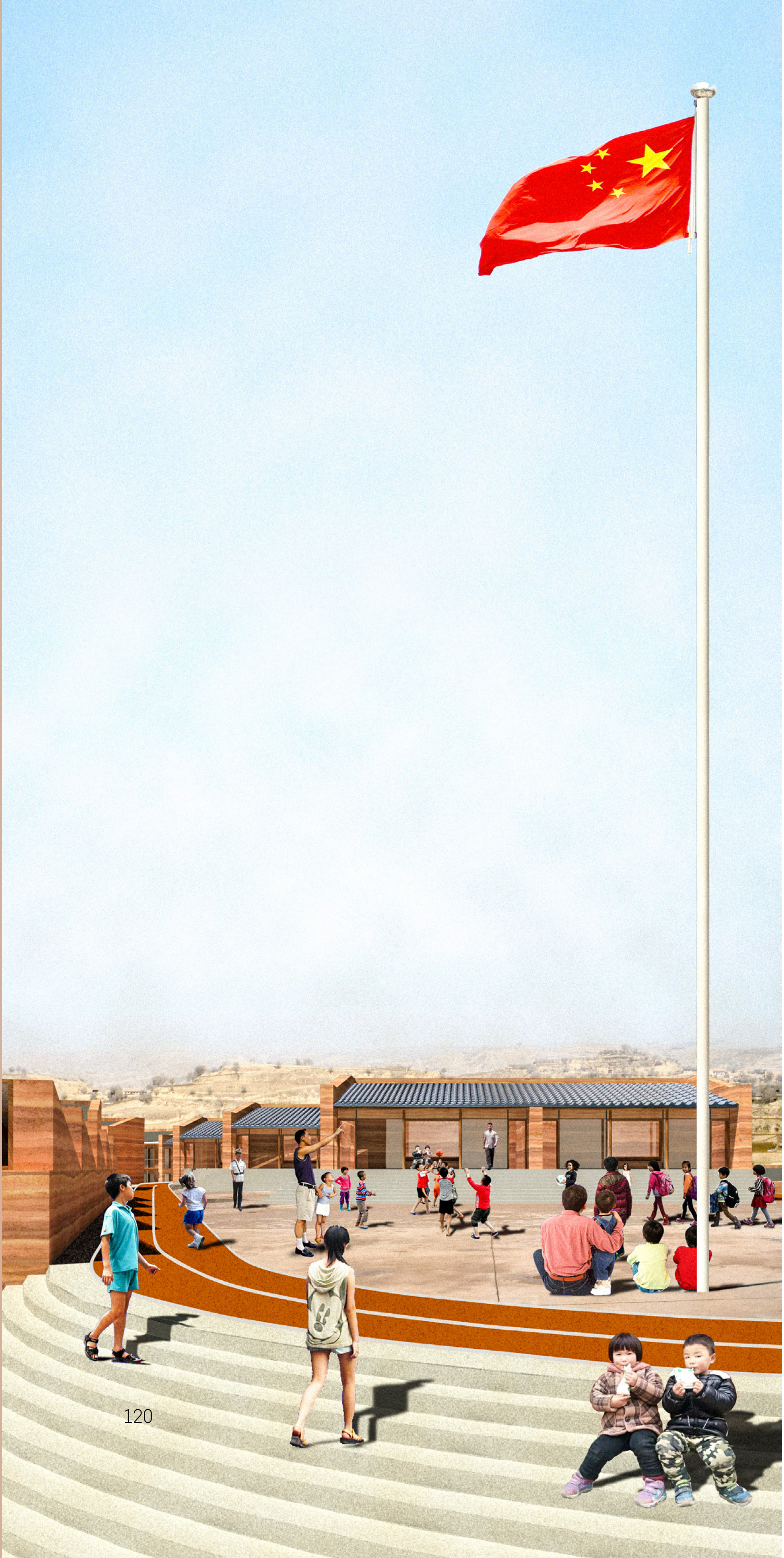
Lastly, the canteen building takes a quite opposite strategy from the other buildings by flipping the direction of roof slope and openings to capture the noon sun for a more pleasant dinning experience for the students. The building is also made of rammed earth as all other buildings do, but kept fairly low in height along the slope of the site to create less shadow on the play ground to the east. Then the entire campus is stitched together through a oval shaped running track that unite all the buildings at the same time creating zone for small group gathering and activities. The flag pole to the far south conclude the campus planning by adding the center of attention, at where all students will gather together for the Monday morning flag raise and national anthem singing.



Perspective of the
dorms and agriculture
terraces.







Perspective of the playground.

Perspective from the street.

Perspective from the
remote.

CONCLUSION

The value embedded in rural area is often-time overlooked. That might be a part of why more and more people from rural places are moving to the city for work. However the essential skill and know-how that was established through the test of time surviving its environment and climate from history is nothing but deep level of intelligence, and should never be overlooked. Indeed, these vernacular is the root for the human culture and the root where a civilization should look back to as a reminder of their background. Learning from rural, one can get the most basic needs for surviving skills, the most efficient way to utilize and balance with the natural resources. What is more important, each village, local community, and ethnic groups has its unique culture which is important for the diversity in civilization. "Chinese culture in the city, after it is destroyed, we all need to go to the countryside to recover our traditions, reflect on our inner experiences in relation to nature,"[11] says Wang Shu. Take this thesis for example, the existing school that neglected the vernacularity of local, that ignored the know-how with the climate and environment, that blindly adopted what is inappropriate building style and material choice for the culture, had no other way than being humiliated by that culture, environment, and climate, resulting in the leaky pipes, fast deteriorating building, and much more significant potential hazard.

Nowadays, people tend to advocate modernity as the symbol of rapid social development, regardless of the nature of site nor the tradition from its culture. Rural is our hope to refuse to yield to the powerful grinder of globalized generic productions and hypermodernity. This thesis is a version of interpretation to what we can do to rethink the education building that roots in the culture, tailored to the environment and climate, serves the people of local, and essentially becomes the tool of pedagogy presenting the know-how, the genius-loci of the rural culture the school resides in. Through basic building planning and parti, relationship of public and private, and multiple environmental devices such as trombe walls and solar utilization tools, students and locals will be able to truly live with the building, and learn from the building, while a broader knowledge will be taught here. Building as a pedagogy is the ultimate goal that will need further pursuit, and endeavor from more people sharing this ideology. Hopefully this thesis could be a part of it.

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