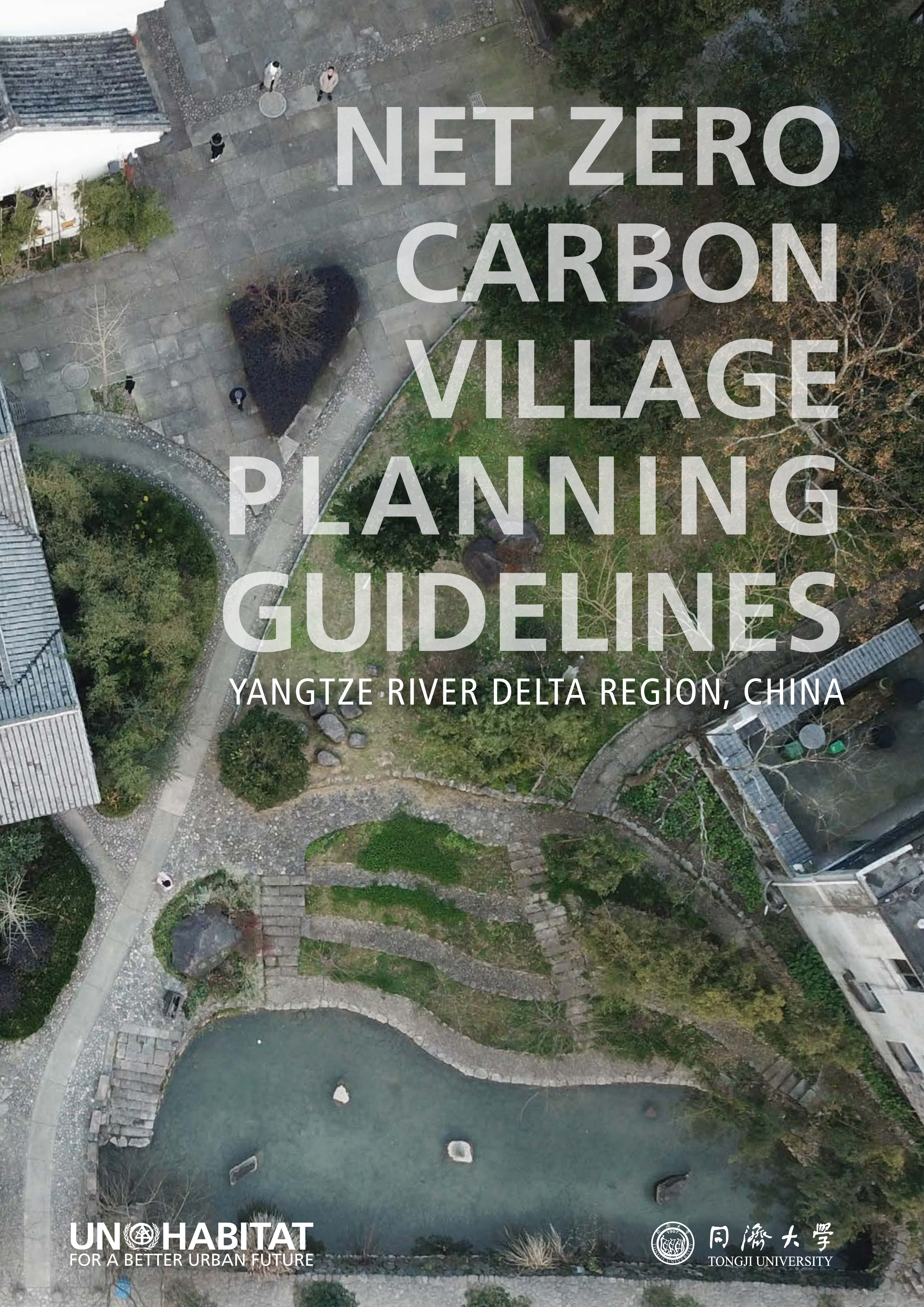

# NET ZERO CARBON VILLAGE PLANNING GUIDELINES

## YANGTZE RIVER DELTA REGION, CHINA

UN-HABITAT
FOR A BETTER URBAN FUTURE

同濟大學
TONGJI UNIVERSITY

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Net Zero Carbon Village Planning Guidelines
For the Yangtze River Delta Region in China

1st Edition

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This report has been prepared by UN-Habitat's Urban Lab in collaboration with Tongji University. The Lab is UN-Habitat's multidisciplinary facility supporting cities and Member States with innovative methodologies and multi-stakeholder processes. The Lab aims to achieve sustainable urbanization through integrated and transformative urban interventions that contribute to the implementation of the 2030 Agenda for Sustainable Development.

# Contents

# Foreword

In recent years, the Yangtze River Delta (YRD) region in eastern China has become a strategic focus of environmental protection and eco-development efforts. The region is facing unprecedented risk to its natural and urban environments. The inherent vulnerability of this highly valued eco-system and agricultural area due to the large concentration of neighbouring metropolitan areas, economically strategic position along major shipping lanes and manufacturing hubs as well as the interlinked conflict between social and economic development and environmental conservation, needs to be addressed. These conditions make it, with time, increasingly harder to govern urban and rural settlements resulting in lost opportunities for sound economic growth that respects strong ecological balance.

This challenging context is not only relevant to the YRD region but also to other Chinese and international regions where connectivity could be enhanced through rural and urban linkages. This is especially pertinent since 2007, when more than half of the world's population lives in cities, and in relation to China's substantial work in promoting eco-cities. In addition to this, following more than two decades of urban expansion, there is a renewed focus in China to address the status quo where rapid economic growth was prioritised at the expense of land and environmental resources and a growing inequality between rural and urban areas. It is under this perspective that there is a growing need to propose methodologies to establish a more balanced urban-rural relationship.

The 2030 Agenda for Sustainable Development outlines sustainable development as a process in harmony with people, planet, prosperity, peace and partnership, not driven by isolated actions. This is well reflected in the New Urban Agenda (NUA) which translates the Sustainable Development Goals (SDGs) into practice regarding areas of human settlements, urban planning, at its many levels and scales including planning of peri-urban and urban/rural settlements. This is a vital tool that can integrate multiple complexities to guide settlement growth in a way that promotes inclusive, integrated and sustainable development.

For more than forty years, UN-Habitat has supported countries worldwide to develop urban planning methodologies and strategies to address current urbanization challenges such as population growth, urban sprawl, poverty, inequality, pollution, and climate change at national, city and neighbourhood level, including urban-rural linkages. It is for this reason that UN-Habitat and Tongji University have collaborated to produce guidelines on net-zero carbon strategies for the development of villages in the Yangtze River Delta. The research is part of a wider project in partnership with the Shanghai Municipal Government as well as Shanghai Research Institute of Building Sciences and Shanghai Academy of Environmental Sciences working on technological and scientific dimensions of zero carbon solutions and coordinated by Tongji University.

The overall project analyzes and defines the structuring elements of zero carbon settlements, illustrating development strategies for planning, implementing and managing energy and resource efficient urban-rural areas. The project aims to develop a holistic approach where urban planning will be the tool that brings together climatic conditions, land use, local economies, renewable use of energy, zero-waste, water cycles, biodiversity, and transport, to achieve a sustainable low carbon settlement system. These guidelines have a two-fold objective. On the one hand, the guidelines can be used to help standardize and codify ecological planning principles for villages in the Yangtze River Delta and on the other they can set an example of zero carbon planning strategies that can be escalated and replicated in other relevant towns at the national and international level.

The project responds to UN-Habitat's mandate of promoting socially and environmentally sustainable towns and cities, while addressing the New Urban Agenda through the implementation of the 2030 Sustainable Development Goals (SDGs). The project primarily contributes to the progressive achievement of Target Goal 11 "Sustainable Cities and Communities", and Target Goal 13 on "Climate Action", Goal 6 "Ensure availability and sustainable management of water and sanitation for all" and Goal 7 "Ensure access to affordable, reliable, sustainable and modern energy for all", with reference to the following:

7.2: By 2030, increase substantially the share of renewable energy in the global energy mix;

7.3: By 2030, double the global rate of improvement in energy efficiency;

11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management;

11.A: Support positive economic, social and environmental links between urban, per-urban and rural areas by strengthening national and regional development planning;

13.2: Integrate climate change measures into national policies, strategies and planning;

13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

**Maimunah Modh Sharif**
UN Human Settlements Programme, Executive Director

Xinjian Community, Zhoushan

# 0 Introduction

# Objectives

The Guidelines focus on the current situation of the Yangtze River Delta (YRD) region, developing an approach that aims to build upon normative research on climate resilient, energy and resource efficient planning principles to develop tools for the development of net-zero carbon village guidelines. Chapter one examines the net-zero carbon village from a global perspective, shifting the notion of zero carbon planning from a focus on carbon accounting, to a focus on circular metabolisms and economies. Chapter two outlines guiding principles for villages and the private sector to adopt to direct development towards sustainable outcomes. The guidelines build on the current situation in the Yangtze River Delta region—which includes Shanghai, northern Zhejiang Province, southern Jiangsu Province, and eastern Anhui Province—and aim to look beyond merely the green and low carbon features of a single building, extending low carbon principles to villages and their surroundings. Chapter three presents case studies, including design recommendations, to demonstrate how net-zero carbon principles can be implemented in three villages selected from Shanghai, Zhejiang and Jiangsu. Chapter four focuses on Xiebei Village—adjacent to Shanghai on Chongming Island—and presents a more detailed methodology for how net-zero carbon village development principles can be spatially integrated into a village through the development of a conceptual plan. Collectively, the four chapters introduce the global and historical relevance of net-zero carbon planning, set guidelines for its application in the YRD region in China, and demonstrate how those guidelines could be integrated into existing village contexts.

In order to accomplish the aforementioned goals of this document, the following universal principles and concepts have been taken into account.

### NET-ZERO CARBON EMISSIONS

Net-zero carbon emissions, or carbon neutrality, refers to achieving a balance of carbon emissions and carbon removal. As one of the most developed regions in China, the Yangtze River Delta is a carbon emissions intensive region due to rapid industrialization and urbanization.

### ENERGY

The total energy consumption of Shanghai Municipality in 2016 was 117 million tons standard coal equivalent (SCE)[1], In Zhejiang Province it was 202.76 million tons SCE, in Jiangsu Province it was 310 million tons SCE[2], and in Anhui Province it was 127 million tons SCE[3].

Chongming Island, which has set a goal of becoming a net-zero carbon island, emphasized a sustainable energy strategy in its 2016-2040 Masterplan. This strategy includes promoting clean and renewable energy sources. Natural gas will replace traditional fossil energy such as coal and kerosene and wind, solar and biomass will meet 60-80% of energy needs by the end of 2040.

The stability of the power grid and the its ability to absorb new energy are also emphasized in the Chongming Island Masterplan, as is the construction of a micro-grid system based on renewable energy, solar, wind, and biomass resources in Chongming Island. The segmented construction of an energy generator is also planned, while a segmental natural gas energy system is planned in a regional energy center. Rooftops of industrial and public buildings are demarcated for solar energy generation.

### SOUND PLANNING PRINCIPLES

The basis for any low carbon strategy needs to be underpinned by sound urban planning principles, focusing on how to achieve energy and resource efficiency through urban form and systems design. For example, transport-oriented development, the adoption of mixed-use planning zones, and the achievement of adequate settlement densities all contribute to the long-term de-carbonization of a settlement, as well as representing sound settlement planning. This highlights its potential as the leading tool in promoting strong and integrated low-carbon development strategies, and mitigating climate change. A zero carbon planning approach that does not also take into account adaptation to climate change is futile: climate projections must be taken into account in settlement design to enable social, economic and environmental resilience in the face of expected future climate changes.

In the case of rural areas of the YRD region, an absence of long-term planning has led to inefficient resource use and poor living conditions, where planning guidelines are in urgent need in order to optimize carbon performance and achieve sustainable development. For this reason, UN-Habitat and Tongji University have partnered to produce these guidelines for net-zero carbon villages in the Yangtze River Delta in China. This guidance addresses the specific rural context of Yangtze River Delta, using village planning and sustainable technology as a tool to achieve the goal of net-zero carbon development.

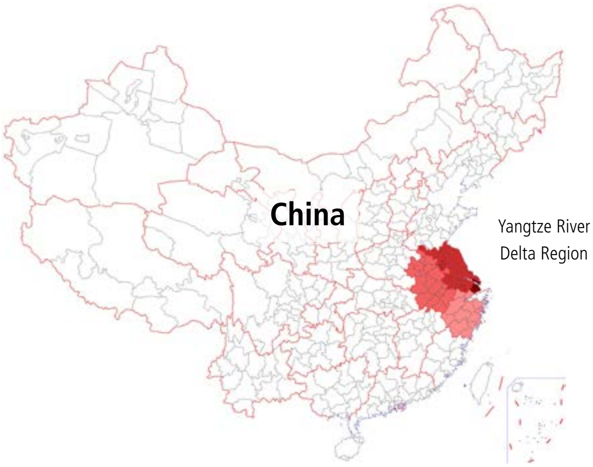



*Fig. 0.1* *Location of the Yangtze River Delta region in China*


*Fig. 0.2* *Map of the Yangtze River Delta region and case studies selected in Chapter 3*

Planning policy should both incentivize and regulate for an integrated low-carbon infrastructure approach; which promotes energy efficiency, renewable energy, sustainable transport, waste reduction and management, water efficiency, and low-carbon economic and industrial activities at the building, neighbourhood and village, town, or city scale. A multitude of planning principles, incentives, technological investments, business codes and behaviour change interventions can support the delivery of the low-carbon settlement, that in this case can be tailored to interact with the overall island settlement and farming pattern. Special care can be given to the energy and human flows between urban and rural areas on the island, including flows of food, energy, goods and services.

## URBAN- RURAL LINKAGES

Enhancing rural and urban linkages is vital for the efficiency of sustainable human settlements growth planning. Priority issues surrounding urban-rural linkages are often addressed within the context of spatial planning, with a primary focus on improved integration of different sectors (such as housing, energy, transport and industry), territorial cohesion, urban-rural cooperation, improved systems of development and environmental sustainability. The SDG's and the NUA have both identified Urban-Rural linkages as potential transformative interventions that promote rural urbanization through the strengthening of intermediate towns and establishment of rural service centres for integrated territorial development.

## SENSITIVE SOCIO-ECONOMIC PRINCIPLES

In order for low carbon strategies to have positive outcomes for all, they should take into consideration economic, environmental and social contexts, such as the urban/rural agricultural livelihood patterns of Chongming Island as well as the inherent value in terms of heritage and social structures. Social equity is an important component that indirectly affects habits and consumption patterns and is linked to adequate allocation of basic public facilities. This is particularly important in terms of the enhancement of quality of production/living and the equalization of basic services based on development demands alongside protection of traditional typologies and systems where relevant. From a perspective of village planning, the direction of economic development is inextricably bound to this and needs to be supported by well-planned land and economic systems to support continued economic development.

# Context: the Yangtze River Delta region, past and present

## NATIONAL AND LOCAL POLICIES

In addition to the global policy frameworks of the SDGs and the NUA, the guidelines are built upon and aligned with national and local policies. In 2015 the People's Republic of China submitted its climate change action plan to the UN Framework Convention on Climate Change which was followed by China's ratification of the Paris Agreement. The following year, China's 13th five-year plan was released, outlining targets and measures to address sustainability challenges including climate change, air pollution, urbanization, ecosystems and the environment, and public wellbeing. In 2016, the National Development and Reform Commission and the Ministry of Housing and Urban-Rural Development issued a report on "Regional Planning of the Yangtze River Delta 2016-2020", prioritizing the construction of "green cities" particularly through accelerating the construction of "sponge cities", "forest cities" and "low-carbon eco-cities". Meanwhile, the City of Shanghai's strategic plan (2015-2040) has also set out a long-term low-carbon goal which aims to reduce carbon emissions as well as protect carbon sink spaces and to peak carbon emissions in the city by 2025. By 2040, total carbon emissions are expected to be reduced from peak carbon by at least 25%.

## GEOGRAPHY

The Yangtze River Delta is the largest alluvial delta in China. It has a marine monsoon subtropical climate with four distinct seasons, hot and humid summers, cool and dry winters, and warm spring and autumn months. Winter temperatures can drop as low as -10°C (recorded minimum); however, large temperature fluctuations can occur.

Abundant freshwater resources and a central location within the Asia-Pacific Economic Zone have enabled the development of a robust water transport system including the largest shipping port in the world, the Port of Shanghai[4], which saw a throughput of 82.24 million TEU (twenty-foot equivalent unit) in 2017[5]. The world's third largest container port (also in the YRD region), Ningbo Zhoushan Port, had a throughput of 50.96 million TEU. In 2017, the whole YRD region had a throughput of 4.514 billion tons, accounting for 35.7% of national cargo—an increase of 8.1% from the previous year.

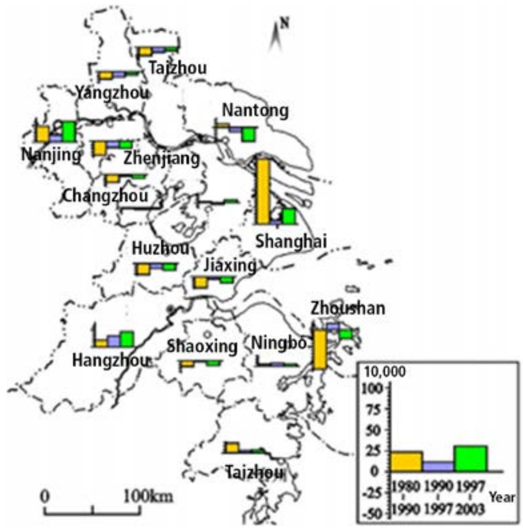



*Fig. 0.3* *Population growth shift of cities Changjiang River Delta since 1980*

## DEMOGRAPHY

Since 2000, the population of the Delta has continued to show strong growth despite a gradual shift from high birth rate/low death rate to low birth rate/low death rate. After two population booms in the early-to-mid-20th Century, recent years have seen low natural population growth rates in Jiangsu and Zhejiang provinces and negative growth rates in Shanghai.

However, even with a low natural population growth rate, between 2000 and 2010, the total population of the Yangtze River Delta increased from 87.43 million to 107.63 million, an increase of 23.11%, primarily due to migration from other regions of China[6].

The YRD region as a whole is one of the most densely populated areas in China. It includes 26 cities in Shanghai, Jiangsu, Zhejiang and Anhui provinces and accounts for 217,700 km$^2$, approximately 2.2% of the country's land mass[7]. However, despite its relatively small land mass, the region accommodated 150 million people and generated 12.67 trillion RMB in 2014, which is roughly 11.0% China's total population and 18.5% of its GDP. In 2020, the YRD region is likely to contain 11.8% of the Chinese population and produce 21% of China's GDP.

A strong shift in the region's "centre of gravity" in terms of population density, from northeast to southwest, has also become clear. In addition to the growth of Shanghai, which increased in density by nearly 1,000 people/km$^2$, the City of Suzhou has also experienced rapid growth, with an increase in density of nearly 600 people/km[28]. The resulting agglomerations which have developed around core areas of each city indicates that the cities are still in a stage of centripetal urbanization. In the future, small-to-mid-sized cities and towns in the Delta will be encouraged to develop further alongside the multi-centre trend whereby Shanghai is no longer a fulcrum of economic power, but economic opportunities and population become more diffused around Suzhou, Wuixi, Changzhou, Ningbo, Nanjing and Hangzhou.

## URBANIZATION AND INFRASTRUCTURE

Over the past 30 years, China's rate of urbanization—as measured by the proportion of the population dwelling in an urban area—has nearly tripled, increasing from 17.9% in 1978 to 58.5% in 2017. The urbanization rate of permanent residents in the Yangtze River Delta urban agglomeration rose from 50% in 2000 to 68% in 2016[9].

This rate provides a solid foundation for the region to become a world-class urban agglomeration. Shanghai has made a clear goal of building a global city and has a prominent position in the Yangtze River Delta region. Major cities such as Nanjing, Suzhou, Wuxi, Hangzhou, and Ningbo occupy an important position in the region and country. According to the national 'Yangtze River Delta Regional Plan (2009-2020)', by 2020, the urbanization level of the Yangtze River Delta region will reach 72%, per capita GDP will reach RMB 110,000, and the proportion of service industry will reach 53%.
'The Yangtze River Regional Plan' also requires extending urban infrastructure to rural areas and the integration of urban and rural infrastructure; coordinating the construction of major infrastructure such as urban and rural water supply and drainage, gas supply, power supply, communication, garbage and sewage treatment, regional flood control and drainage, and pollution control projects; and promoting the construction of new energy infrastructure such as wind power, tides, and ocean currents. According to the national plan, the proportion of new energy in the total energy structure needs to exceed 4%.

## LAND OWNERSHIP IN CHINA

In rural areas, development land and non-development land are the major two land categorizations. Development land includes "construction land", "traffic land", "infrastructure land" and "special land reserves". "Construction land" refers to both land that can be developed for residential use by villagers (agricultural residents) and as administrative space for governmental offices. "Traffic land" is land occupied by transit ways such as railways, roads, harbours and airports; whereas land used for energy and/or water facilities and communication networks is zoned as "infrastructure land". "Special land reserves" pertains specifically to land used for military, religious, and diplomatic purposes. Non-development land includes "agricultural land", "permanent basic farmland", "waterbodies" and "special land". "Agricultural land" is managed by villagers with agricultural citizenship, allowing them ownership rights over land occupied by gardens (which can include, but is not limited to the growth of edible foodstuff), forests, and grasslands. "Permanent basic farmland" is preserved specifically for the cultivation of edible foodstuff and is subject to stricter protections against conversion to development land than general "agricultural land". "Waterbodies" include rivers, lakes, water reservoirs, canals, tidal land and wetlands. "Special land" refers to land typically exploited for raw mineral use such as land used for salt fields, mines, but also includes nature reserves.

## LAND USE CHANGES

Over the past 50 years, the amount of cultivated land in the Yangtze River Delta region has fluctuated significantly with urban encroachment on cropland as the dominant land use change. Since China's reform and opening up at the turn of the 20$^{th}$ Century, the area of cultivated land in the Yangtze River Delta has been rapidly declining. From 1980 to 1998, the total area of cultivated land was reduced by 25,600 km$^2$, and the annual average rate of decline reached 0.48%[10]. From 1995 to 2000, the decrease of arable land in the YRD region was conspicuous; 2300 km$^2$ of cropland was transformed to urban use while the conversion nearly doubled between 2000-2005 and 2005-2010[11]. In 2013, the total construction land in the Yangtze River Delta urban agglomeration reached 36,153 km$^2$, increasing from 600 km$^2$ in 1989 and reaching 17.1% of the total area of the YRD region[12]. The most dramatic expansion

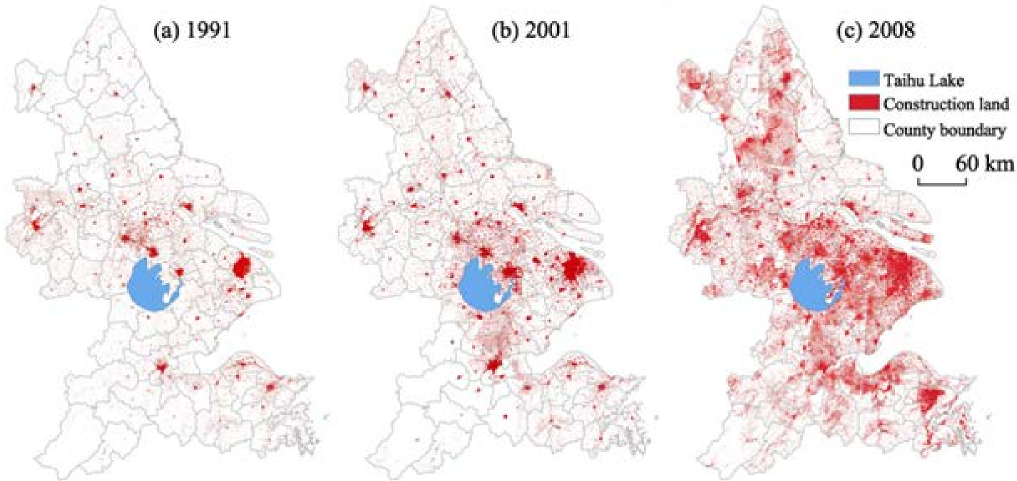



*Fig. 0.4 Construction land in the Yangtze River Delta Region*

of urban land occurred in the Nanjing-Shanghai corridor and the Hangzhou Bay area, which are also the most developed commercial and business zones. From 1995-2000, to make up for both the conversion of forest and water bodies to cropland and the loss of cropland overall, the Chinese government converted 900 $km^2$ of cropland into forest, and between 2000-2010, 1300 $km^2$ of water was reclaimed to provide additional land for agriculture. Changes in land use have significantly altered the structure and pattern of regional ecosystems, and many ecological and environmental risks related to water and climate regulations have become increasingly grave.

Rapid industrialization and urbanization have also caused significant reductions in the area and volume of freshwater sources in the YRD region. This has resulted in a reduced storage capacity of reclamation areas around the lakes, which has led to a sharp rise in water levels, the long-lasting effect of which includes increasing pressure on regional flood control measures. Moreover, increasing living standards and economic and social development coupled with the required expansion of urban ecosystem services and the decline in urban resource and environmental carrying capacity due to increasing urbanization rates will continue to exist. Despite its former abundance of cropland, the Yangtze River Delta region is currently considered a food-deficient region, unable to meet the increasing demands of its population. This trend will continue to develop in the next 15 years[13].

Finally, conflicts between the huge demand for land and limited land resources are currently intense and will likely become even more so in the future.

## SOCIO-ECONOMIC TRENDS

The Yangtze River Delta is the largest estuary delta in China; as such, the climate is ideal for agriculture and people began cultivating the land for rice 7000 years ago[14]. Due to its accommodating climate, diverse natural resources, and strategic geographic position along the East China Sea, the YRD is one of the cradles of Chinese agriculture and civilization, consequently developing as the most populous and economically prosperous region in China[15].

After China's opening-up, many societal, political and economic changes took place in the Yangtze River Delta region and have resulted in the rapid development of rural areas.

From 1960 to 1978, during the "Cultural Revolution" (1966-1976) and the "Down to the Countryside Movement" (1968-1978), economic development was significantly hindered, and citizens were organized to work and live in rural areas. Consequently, the urban population sharply decreased and urban growth drastically slowed.

After the economic reform of 1978, urbanization in the YRD began accelerating (1978-1989). The reform of the household registration system in 1984 allowed more rural inhabitants to move into cities and work. Since 1993, YRD as a New Economic Development Zone has entered an accelerated stage of urbanization.

Starting in the 1970s in rural areas of the YRD, "five small industries", were allowed to operate. Thus, small-scale steel, machinery, chemical fertilizer, coal, and cement industries, began to replace traditionally agricultural areas, offering a more lucrative alternative to farming for many villagers. The industrialization

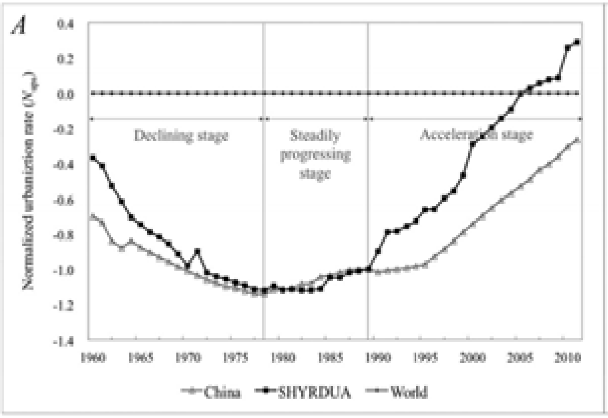



*Fig. 0.5* *Urbanization process of YRD (a three-staged trajectory of population urbanization in the world context)*

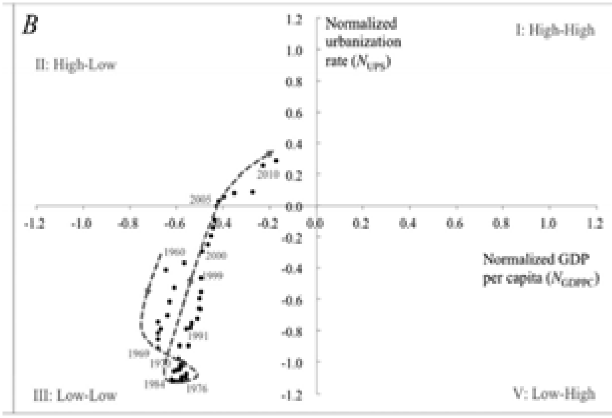



*Fig. 0.6* *Coordination between urbanization and economic development[19]*

of zones in rural areas combined with urbanization pressures on small towns led to the emergence of Rural Economic Development Zones in the YRD region. These zones encouraged the switch from extensive to intensive farming practices, which simultaneously lessened the income gap between urban and rural areas, while contributing to higher GHG emissions, water and soil pollution. However, in the long run, intensive practices have reduced the amount of necessary human labour, leading to a lack of jobs in villages and their surrounding environs. At the same time, Shanghai, Nanjing, Suzhou, Wuxi, Hangzhou, and Ningbo have attracted increasing numbers of job-seekers, further draining the demographic balance of rural regions and making the preservation of distinctive characteristics of rural culture—whose preservation has been accounted for in the Strategic Plan for Rural Revitalization (2018-2022)[16], issued by the Central Committee of the Chinese Communist Party—more difficult. While the Yangtze River Delta region currently leads the country in terms of per capita resident income growth rate[17], access to the labour force and lack of coordinated village planning practices create large inconsistencies between rural and urban areas.

Urban areas have also suffered from growing pains. Although the rate of economic development in the region is impressive, broad social changes and drastic improvements to quality of life have increased the anthropic pressure on natural and agricultural ecosystems, stressing the capacity of natural resource regeneration as well as the provision of basic services.

The present work should be considered among the policy actions aimed to revamp the attractiveness of rural villages and achieve a more balanced quality of life between urban and rural communities.

## CLIMATE CHANGE

The Yangtze River Delta region has experienced significant impacts from climate change over the past few decades, affecting the region's environment and development.

**Typhoons:**

Typhoons are endemic to the east coast of China, frequenting the area once or twice a year in the flood season. In 2018, Super Typhoon Maria caused a direct economy loss of US$38.5 million and affected 340,000 people.

**Flooding:**

The region experiences a rainy season each year around May. Minor floods typically hit the region around the same time on a semi-annual basis. Major floods occurred in 1870, 1931, 1954, 1998, 2010 and 2016. The flood in 2016 alone, which was the biggest in two decades, affected 56 million people and caused US$25.15 billion loss[18].

**High temperatures:**

In 2018, the peak temperature in the YRD region reached 41˚C (Jiangsu), with 50 days over 35˚C (Htd). Both peak temperature and Htd are on an upward trend.

Canal on Chongming Island

# 1 Zero carbon village as a prototype of future sustainable rural settlements

A zero carbon rural village is a prototype of future sustainable rural settlements. As such, it has to fulfil all the requirements of sustainability. In a transition path it will fulfil some of them but with the awareness of what is still lacking and of the gap to bridge for the full implementation of a sustainable development model.

The following paragraph deals with the concept of sustainable development, on which any design process of a zero carbon village should be based.

## The planetary boundaries and the SDGs

The concept of planetary boundaries involves Earth system processes which contain environmental boundaries, proposed in 2009 by a group of Earth system and environmental scientists[20]. The scientists proposed quantitative planetary boundaries within which humanity can continue to develop and thrive for generations to come. Crossing these boundaries increases the risk of generating large-scale abrupt or irreversible environmental changes.

The group wanted to define a "safe operating space for humanity" as a precondition for sustainable development. The framework is based on scientific evidence that human actions since the Industrial Revolution have become the main driver of global environmental change

Nine planetary boundaries were identified (Figure 1.1), mostly mutually interconnected:

1. Stratospheric ozone depletion
2. Loss of biosphere integrity (biodiversity loss and extinctions)
3. Chemical pollution and the release of novel entities
4. Climate Change
5. Ocean acidification
6. Freshwater consumption and the global hydrological cycle
7. Land system change
8. Nitrogen and phosphorus flows to the biosphere and oceans
9. Atmospheric aerosol loading

At present four safe boundaries have been transgressed[21]: climate change, biodiversity loss, shifts in nutrient cycles (nitrogen and phosphorus), and land use.

Three of these boundaries, which we have already transgressed or we are close to transgressing are related to four planetary cycles on which the stability of the biosphere is based: the water, nitrogen, phosphorous and $CO_2$ cycles (Figure 1.2). It is not by chance: man,

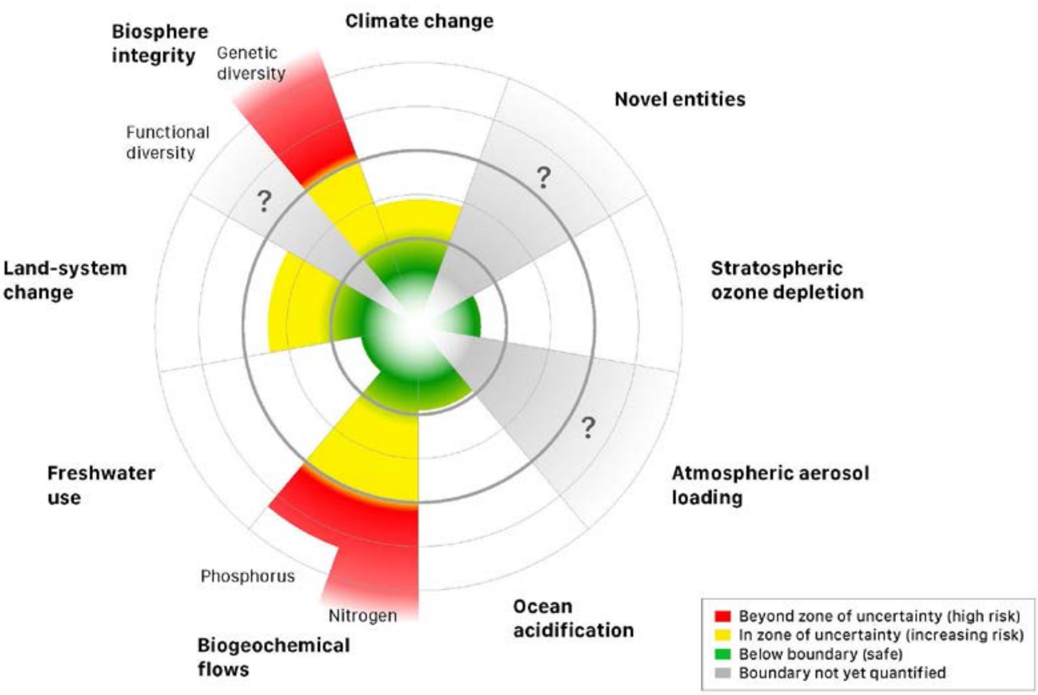



*Fig. 1.1 The Planetary Boundaries[28]*

from Industrial Revolution onwards, has being altering these cycles by introducing new flows into them: a new $CO_2$ flow due to the burning of fossil fuels; a new nitrogen compounds flow as it is due to the spreading of artificial nitrogen fertilisers; a new phosphorous flow mined and spread as a fertiliser; a new water flow due to the withdrawal of underground water and its distribution on the earth's surface.

The breaking of the nitrogen and phosphorous flows, with the injection of excess material, has caused the alteration of ecosystems, thus contributing to the transgression of a fourth planetary boundary, the biosphere integrity, through the reduction of biodiversity caused by the eutrophication of water bodies and the modification of the soil microbiome, in addition to the alteration due to temperature increase and the change in the land-system induced by human activities.

All this considered, and being aware that another planetary boundary, ocean acidification, is due to climate change and to the alteration of biochemical flows and that this acidification causes further biodiversity loss in the seas, it is clear that sustainable development has to tackle more than just the problem of climate change. Sustainable development entails restoring, in addition to the $CO_2$ cycle, all the other cycles that we have altered. If we do not take action to do this, not only will we have to face more frequent and extreme floods, droughts, heat waves, illnesses, reduction of the agricultural production, etc., but also fast acceleration in the - usually unperceived - rate of biodiversity loss. Biodiversity is fundamental to the operation of ecosystems. By altering it, we risk losing a large number of free services crucial for our survival, ranging from pollination to water purification, from raw materials to medicine and food provision, just to mention a few (Figure 1.3).

When dealing with sustainable development we should also be aware of the fact that agriculture is a major driver of the transgression of planetary boundaries. Two planetary boundaries have been completely transgressed, biosphere integrity and biogeochemical flows, and agriculture has been the major driver of these transgressions. Three are in a zone of uncertainty i.e., at increasing risk, with agriculture the major driver of two of these, land-system change and freshwater use, and is a significant contributor to the third, climate change. Agriculture is also a significant or major contributor to change for many of the planetary boundaries that are still in the safe zone. Therefore, a significant modification of agricultural processes – towards agro-ecology – is the necessary condition for respecting the planetary boundaries.

Thus zero carbon rural villages have a critical role to play in the path towards a sustainable future, as they can be a showcase of how a settlement should be and should work in order to be sustainable and of how food should be produced, and what kind of food.

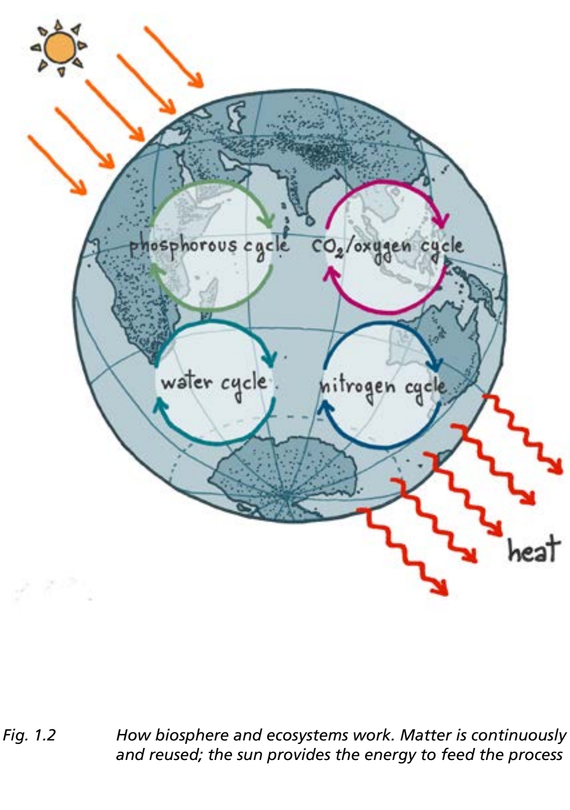



*Fig. 1.2 How biosphere and ecosystems work. Matter is continuously recycled and reused; the sun provides the energy to feed the process*

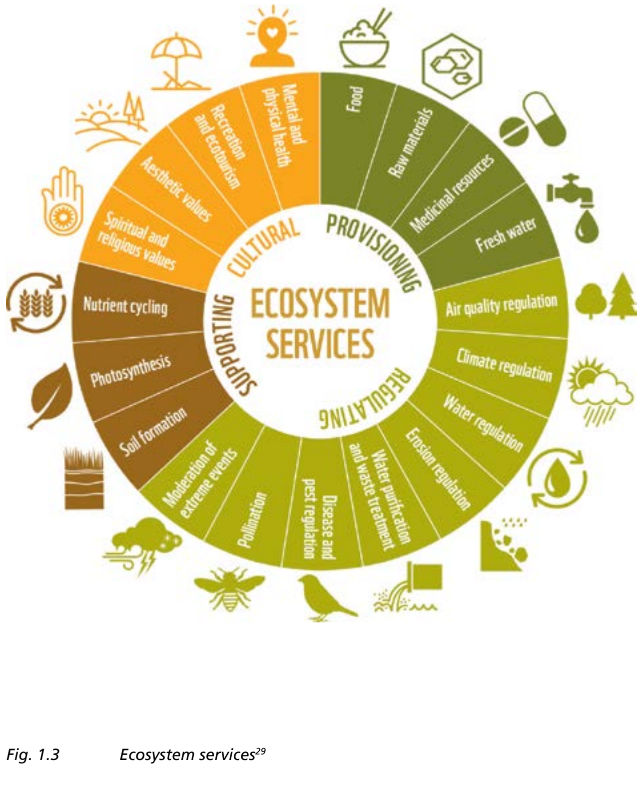



*Fig. 1.3 Ecosystem services*[29]

In fact, the design and the implementation of zero carbon villages involves most of the planetary boundaries. The first, most evident, is the contribution to climate change mitigation, because of their having zero emissions. But other planetary boundaries, no less critical, are involved. The first is land-use control, which is related to two other planetary boundaries: the amount of carbon absorbed by vegetation and biodiversity loss. The second boundary is the flow of industrially produced nitrogen and mined phosphorus, the amount of which can be reduced in agriculture if the nutrients contained in the food consumed in the settlement are returned to the soil In which the food was grown; this boundary is also linked a) to climate change, because of the $CO_2$ released in the production of nitrogen fertilisers and because of the nitrous oxide released into the atmosphere, and b) to biodiversity loss, due to the excess of nitrogen and phosphorous in water bodies.

The shift from industrial agriculture to agro-ecology, which should characterise the new life of zero carbon rural villages, will permit a reduction in the use of chemicals such as pesticides, herbicides, etc., which have a negative impact on biodiversity.

Even if most carbon emissions are produced in cities, when the share due to agriculture (almost 25%) and the impact of agriculture on planetary boundaries are considered, zero carbon villages could be a milestone in Chinese policy mitigating global warming[22] and in the conservation[23] of biodiversity.

On the other hand, not only the planet but also human societies need to be brought back to health, as well as the individuals who make them up. Too many people still live in unacceptable conditions or are unable to fulfil some basic needs, sometimes because of the transgression of planetary boundaries, but that is not the only reason. The 17 Sustainable Development Goals (SDGs), launched by the United Nations (Figure1.4) stem from these considerations

Thus, the aim should be to fulfil the SDGs and at the same time keep humankind within the planetary boundaries, the Safe Operating Space (Figure 1.5). For most of the SDGs there is also a boundary below which the quality of life is unacceptable, thus a Just and Safe Space between these two boundaries can be defined[24], as in Figure 1.6, where the SDGs are translated into 11 needs, elements which characterise the quality of life, which constitute the social foundation, and for which a minimum threshold has been identified.

These social foundations must also be met in zero carbon villages. This is a further challenge that implies the implementation of policies aiming to revitalize these villages through ecologically sound and innovation-based economic development[25].


*Fig. 1.4 The UN Sustainable Development Goals*

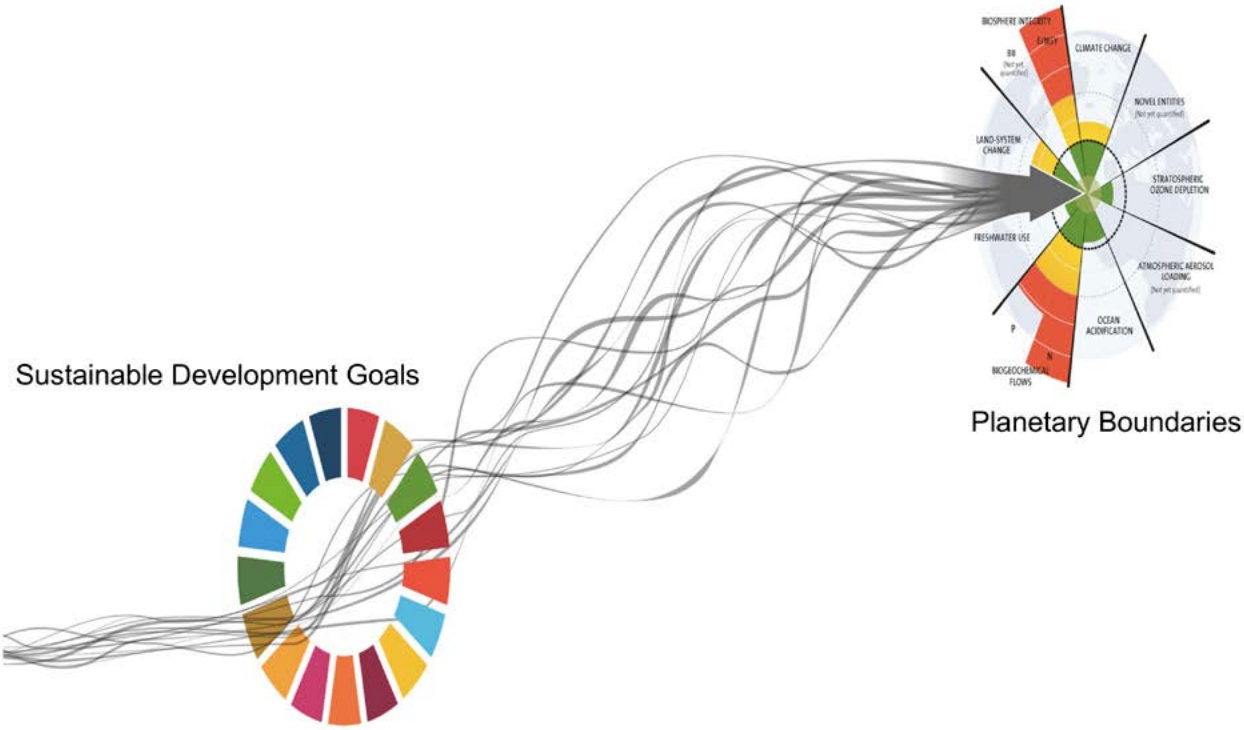



*Fig. 1.5 Combination of SDGs and Planetary Boundaries*[30]

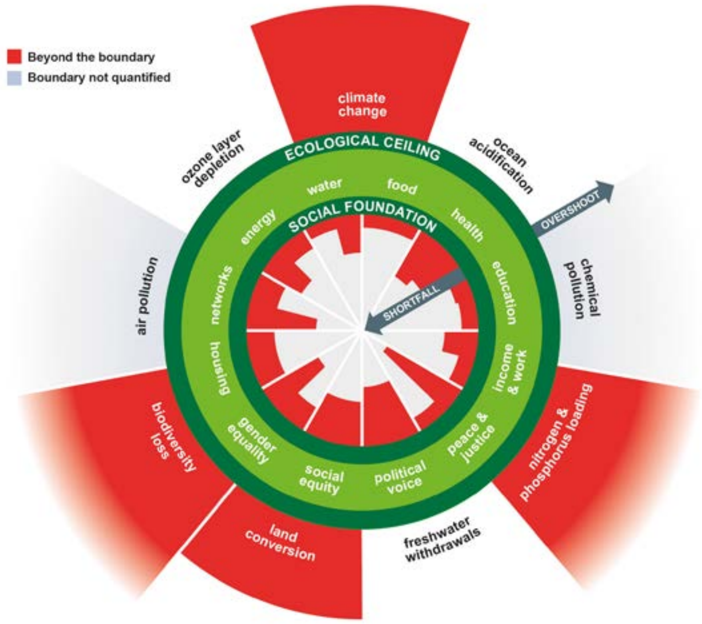



*Fig. 1.6 The Just and Safe Space*[31]

# From linear to circular metabolism

"The notion of urban metabolism is loosely based on an analogy with the metabolism of organisms, although in other respects parallels can also be made between cities and ecosystems. Cities are similar to organisms in that they consume resources from their surroundings and excrete wastes. Thus, the notion that cities are like ecosystems is also appropriate. Indeed, the model of a natural ecosystem is in some respects the objective for developing sustainable cities. Natural ecosystems are generally energy self-sufficient, or are subsidized by sustainable inputs, and often conserve mass, through recycling by detritivores. Were cities to have such traits, they would be far more sustainable"[26].

Not just cities, but any human settlement, however small, in order to live, grow and prosper, needs to be fed with energy, goods, food and water. These flows are processed and consumed, i.e. metabolised in it, and the products of the metabolism are GHG emissions, heat, inorganic and organic wastes, and wastewater (Figure 1.7, top).

The metabolism of today's settlements is generally linear, i.e. the inputs crossing their borders are distributed inside the settlement and used to keep all the functions working; then, after their use, they are disposed of as waste (inorganic, organic and emissions) outside the borders; in this model, the development and the growth of settlements is accompanied by a corresponding increase of the inputs and, consequently, of waste. This linear production path of inputs and outputs is not sustainable as settlements continue to grow. The linear "Take - Make – Dispose" lifestyle we are used to increasingly depletes finite natural reserves producing wastes in quantities that the environment is not capable of absorbing without damage.

A new model of metabolism is needed for settlements, reducing resource consumption and waste production simultaneously.

A sustainable settlement should reduce to a minimum the dependence on the input flows by maximising dependence on local, small scale, reliable production of energy and food, and by maximising reuse/recycling of water and goods (Figure 1.7, bottom). This entails: (i) decentralized energy production mainly from renewable energy sources coupled with energy efficient buildings and appliances; (ii) improved efficiency of the transport system for goods and people, substituting private-car-based mobility with a mobility based on public transport, car sharing, bicycles and walking (supported by a "mixed use" planning policy); (iii) local food consumption

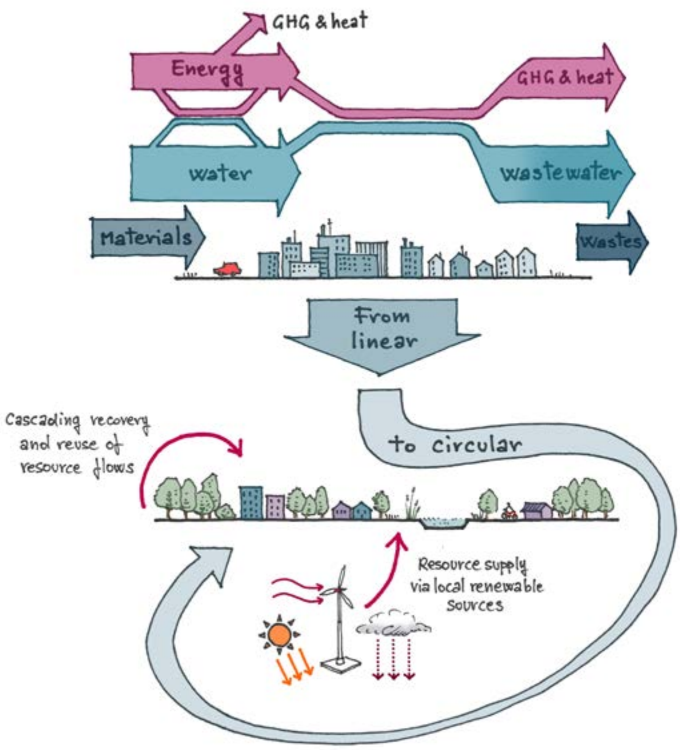



*Fig. 1.7 From linear to circular metabolism*

connected to a proper return of organic waste in the soil; (iv) optimised water cycle coupled with energy production from wastewater; (v) reduction of the flow of goods and related waste through their maintenance, repair and reuse, according to the concept of a circular economy - with the consequent reduction of waste.

The adoption of the concept of circular economy is crucial. The transition to a circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized, should be the driving principle in the design of a zero carbon village, in order to be sustainable.

According to the definition of a circular economy given by the European Union, recycling is only a part, important but only a part, of its implementation (Figure 1.8).

Circular economy approaches 'design out' waste and typically involve innovation throughout the value chain, rather than relying solely on solutions at the end of the life of a product. For example, they may include[27]:

- reducing the quantity of materials required to deliver a particular service (lightweighting);
- lengthening the useful life of products (durability);
- reducing the use of energy and materials in production and use phases (efficiency);
- reducing the use of materials that are hazardous or difficult to recycle both in products and production processes (substitution);
- creating markets for secondary raw materials (recyclates) (based on standards, public procurement, etc.);
- designing products that are easier to maintain, repair, upgrade, remanufacture or recycle (ecodesign);
- developing the necessary services for consumers in this regard (maintenance/repair services, etc.);
- incentivizing separation and supporting waste reduction and high-quality separation by consumers;
- incentivizing separation, and collection systems that minimize the costs of recycling, and reuse;
- facilitating the clustering of activities to prevent by-products from becoming wastes (industrial symbiosis); and
- encouraging wider and better consumer choice through renting, lending or sharing services as an alternative to owning products, while safeguarding consumer interests (in terms of costs, protection, information, contract terms, insurance aspects, etc).

From the above list it is clear that the design of a zero carbon village is strictly interconnected with rules and decisions that must be taken at provincial or national scale, but also that – combining appropriate technological solutions with appropriate governance – much can be done at village scale, if all the stakeholders are involved in the process from the beginning and awareness raising on environmental issues is put at the centre of the political action.

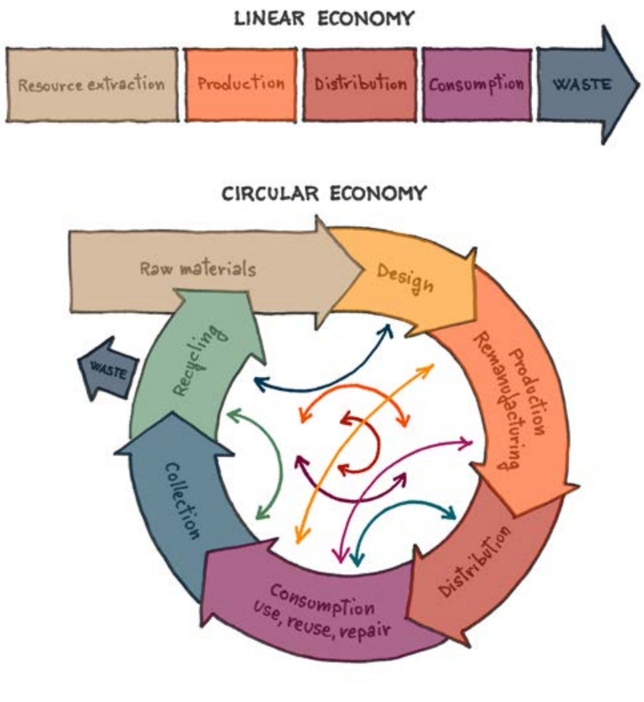
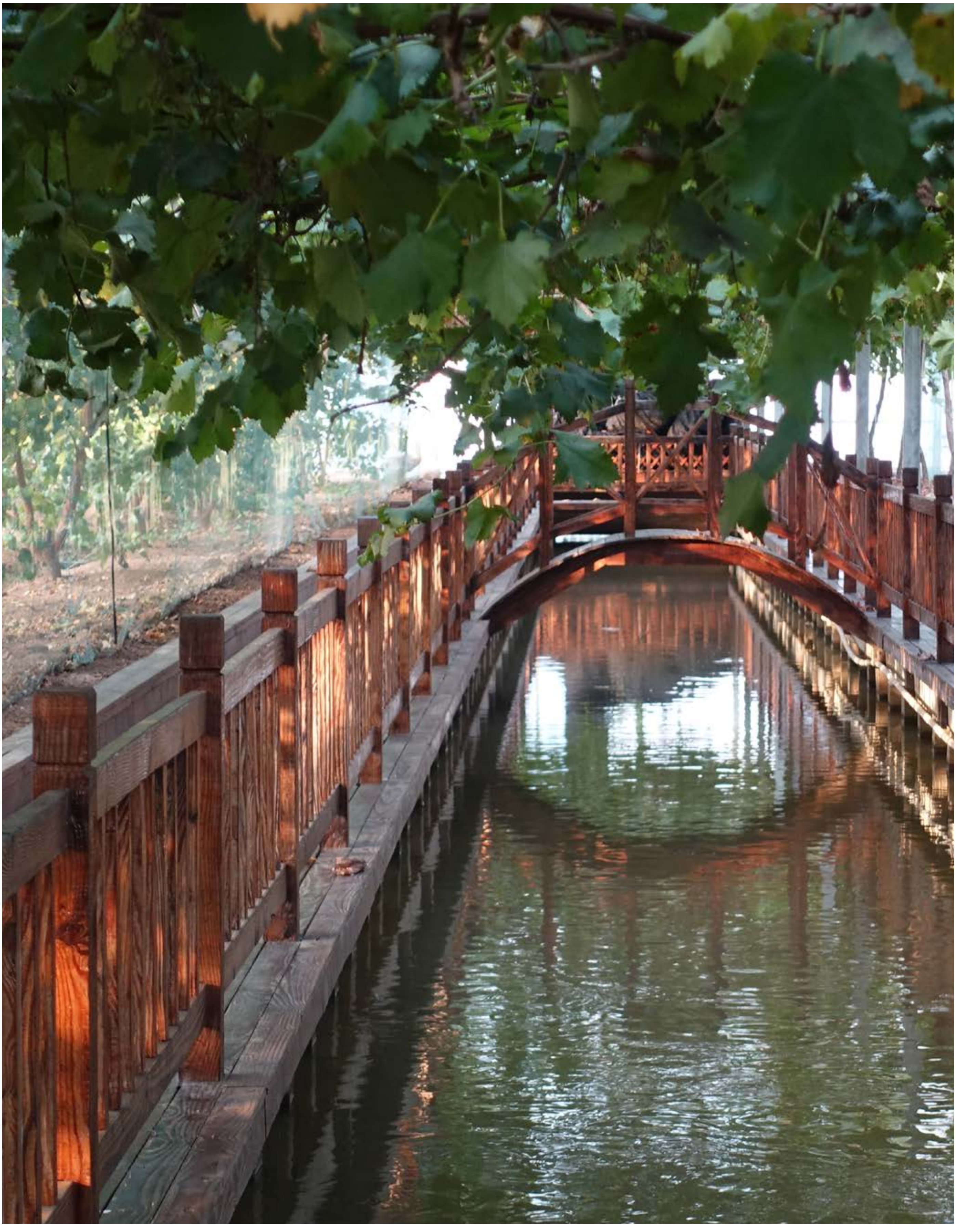



*Fig. 1.8 The concept of circular economy*



"You pick" farm on Chongming Island

# 2 Ten key principles for zero carbon rural village design

Economic development through industrialization causes the abandonment of the countryside and a flow of workers moving from rural villages and small towns to big cities, because of the combined effects of the mechanisation of agriculture, which reduces the need for manpower, and the job opportunities offered by the cities.

Now all industrialized countries are trying to reverse the flow, and even the industrializing countries are trying to mitigate this process. Thus, the issue of revitalizing rural villages has become a political priority all over the world, from the United States to Japan, from Europe to China[32].

The problem is that rural areas, to become attractive, must change their present characteristics. An opportunity is presented by both the inescapable need to shift from the current model of industrialized agriculture to a new, sustainable one, and from the growing awareness of the need to reconcile humans and nature through a harmonious interaction.

The shift from industrialized to sustainable agriculture while maintaining the same productivity, implies the injection of innovation into tradition. A seamless combination of modern science and technology with inherited cultural values and wisdom should be pursued. Young motivated and skilled people could be attracted by such a task, a new generation of new-style professional peasants who love nature and agriculture, understand science and technology and at the same time are open to a peer dialogue with older farmers.

The search for reconciliation between humans and nature implies the existence of a place where a sustainable lifestyle can be pursued. A beautiful place where the principles of sustainability are applied to the built environment. A beautiful and vibrant place, a rural village or small town, providing multiple benefits such as ecological conservation, leisure and sightseeing, cultural experience, and healthy food.

These conditions would attract people to move and work there and would also be attractive to tourists and retired people, who could move to the village to live. A positive demographic drift would arise from the activities that would derive from the practice of sustainable, advanced agriculture, from small scale food processing, and from tourism, which would mitigate or even reverse the flow of migration towards cities due to the lack of local jobs.

Therefore, rural revitalization and ecological liveability would be the key and twin features of a zero carbon village.

At present, rural villages are quite small, because of the exodus of the younger generation and because they were small to start with. Their revitalization would make the villages grow, and new buildings, roads, infrastructure would be needed, besides the refurbishment of the existing ones. It is crucial to plan this growth in such a way as to avoid any drawbacks for the model of a zero carbon village, that should be a resilient example, a champion, of an ecologically liveable and beautiful settlement that is also capable of attracting economic activities, developing innovation and creating employment for all the skill levels, in a fully balanced process.

Therefore, the urban design process is a crucial part of the foundation of a renewed rural development strategy. Current models of human settlements do not address the environmental challenges and are not sensitive to the rapid technological advancements from which our built environment could benefit.

An ecologically sound new development should be designed for minimizing energy and resource consumption, being as far as possible self-sufficient in energy, relying on renewable sources and implementing the principles of a circular economy.

A paradigm shift is required, i.e. a different, holistic design approach, which affects a settlement's form, texture and land use, and the way the basic services, such as energy, water, food and waste treatment, are designed and provided.

# Implementation of zero carbon villages in the Yangtze River Delta

The implementation of the general model of a zero carbon village described above needs to be adapted to specific geographic, social and cultural conditions which may lead to different planning actions. In the following, the implementation of the general model is translated into specific planning guidelines for the Yangtze River Delta context. The YRD was chosen because of its significance for the issue of the rural-urban relationship: an area of strong economic development rich in large cities that have been attracting people from rural villages, emptying them of the younger population.

Some additional information on the Yangtze River Delta area is given in the box below.

## THE YANGTZE RIVER DELTA REGIONAL CONTEXT

**General geographical context**

Located on the eastern coast of mainland China, the Yangtze River Delta is an alluvial plain formed by Yangtze River before it flows into the East China sea. It is quite a wide area, ranging roughly from 28 to 32 degrees latitude north. The area includes Shanghai, Jiangsu Province and Zhejiang Province, with a regional area of 217,700 square kilometres, accounting for 2.19% of the country's land area. The land area is 186,802.8 square kilometres and the water surface area is 23,937.2 square kilometres[33]. The Yangtze River Delta has a developed water system, abundant fresh water resources, mostly flat terrain, fertile soil, rich port resources along the shoreline and along the beach, and natural conditions suitable for urban and economic development. In addition, due to its location in the central area of the Asia-Pacific Economic Zone and the Pacific West Coast, the Yangtze River Delta region is also an important gateway for the Asia-Pacific region.

**Climate**

The Yangtze Delta has a marine monsoon subtropical climate; it has four distinct seasons with hot and humid summers, cool and dry winters, and warm springs and falls. Winter temperatures can drop as low as -10°C ( the recorded minimum), however, and even in springtime, large temperature fluctuations can occur[34].

**Demography**

According to the sixth national census of population carried out in 2010, the resident population in Jiangsu province, Zhejiang province, and Shanghai has reached 156.1 million[35]. After two baby booms following the founding of the People's Republic of China, the population reproduction rates of the two provinces and one city in the Yangtze River Delta have gradually shifted from 'high birth rate, low death rate, and high growth speed' to 'low birth rate, low death rate, and low growth speed'. The natural population growth rate of Jiangsu and Zhejiang provinces has been maintained at a low level in recent years, while the natural population change in Shanghai continues to maintain negative growth. The most obvious trend in the composition of the population in the Yangtze River Delta region is the aging of the population. Due to the strict implementation of the family planning policy, as well as the improvement of living standards and medical conditions, the proportion of children in the population is declining, while the ratio of aging people is growing fast. This trend leads to the formation of an aging society and has accelerated in the Yangtze River Delta.

**Urbanization and infrastructures**

At present, the urbanization rate of the central area of Yangtze River Delta is over 60%[36]. This rate provides a solid foundation for the region to become a world-class urban agglomeration. Shanghai has made a clear goal of building a global city and has a prominent core position in the Yangtze River Delta region. Major cities such as Nanjing, Suzhou, Wuxi, Hangzhou, and Ningbo occupy an important position in the region and indeed the whole country. These cities and towns have made the Yangtze River Delta region an area with dense cities with distinctive characteristics and strong development vitality. According to the national 'Yangtze River Delta Regional Plan (2009-2020)', by 2020, the urbanization level of the Yangtze River Delta region will reach 72% (about 75% in the core area), and the per capita GDP will reach 110,000 yuan (130,000 Yuan in the core area), and the proportion of service industry will reach 53% (55% in the core area).

'The Yangtze River Regional Plan' also requires extending urban infrastructure to rural areas and the integration of urban and rural infrastructure; coordinating the construction of major infrastructure such as urban and rural water supply and drainage, gas supply, power supply, communication, garbage and sewage treatment, regional flood control and drainage, and pollution control projects; and promoting the construction of new energy infrastructure such as wind power, tides, and ocean currents. According to the national plan, the proportion of new energy in the total energy structure needs to exceed 4%.

**Agriculture**

The Yangtze River Delta contains the most fertile soils in all of China. Rice is the dominant crop of the delta. In addition, the Yangtze River Delta region is also rich in cotton, wheat, rapeseed, peanuts, silk, fish and shrimp. From the perspective of industrial structure, the value of the agricultural output of the Yangtze River Delta region accounts for about 10% of the national total. In the Yangtze River Delta region, the proportion of agricultural industry accounts for about 5% of the total proportion of the primary, secondary and tertiary industries[37]

**Environmental challenges**

The development, orientation and division of labour among different cities in the Yangtze River Delta region are not equitable. The overall advantages of the region have not been fully utilized. Meanwhile, some important infrastructures such as transportation, energy, and communications have not yet formed an effective supporting and connecting system. The institutional environment and market system for promoting the rational flow of capital, labour and knowledge still needs further improvement. What is more, the level of industrial development is not high enough. The development of a modern service industry is relatively slow, while the industrialization level and service functions also need to be further improved. The dependence on foreign trade is too high. The trade structure needs to be optimised. The capacity for independent innovation is not strong enough, and international competitiveness still needs to be improved. Land and energy are relatively scarce. Constraints to development from resources and the environment are increasingly obvious in the Yangtze River Delta. Besides, social welfare is not being developed in a balanced way, and, when it comes to public services, there is still a large gap between urban and rural areas in the region. Reforms in administrative management and social management systems are still not well established. Therefore, reform and further development are still arduous tasks for the delta region. As an important economic area, the Yangtze River Delta is the most prosperous region in China and is responsible for a large proportion of energy consumption and carbon emissions[38]

**Social and cultural trends**

The Yangtze River Delta region is characterized by a positive social environment, which is built upon a rational, open, innovative and inclusive culture.

The Jiangsu economy has been developing for a long time under the influence of a spirit of optimism, which has been driving the so-called "Southern Jiangsu model", which resulted in a miracle of economic growth.
In this era of rapid transformations, the people in the Yangtze River Delta region are again combining "entrepreneurship, innovation, and excellence" to overcome the deficiencies in traditional economic models and to adapt their society to the modern market economy, which has been established as the reference system for economic development.

This new course is enhancing some of the characteristics of the people in the region: freedom, equality, openness, entrepreneurship, honesty and creditability, pioneering and innovation have become even more distinctive features. Thanks to this dynamism, the region is presently leading the country in terms of per capita resident income growth rate[39].

Of course, the impressive rate of economic development, as well as the fundamental social changes, are increasing the anthropic pressure on natural and agricultural ecosystems, stressing the capacity for regeneration of the natural resources and services. At the same time, the attractiveness of urbanized areas, because of the availability of jobs and services, is threatening the demographic balance of the rural regions, as well as the preservation of the distinctive characteristics of the rural culture, whose preservation has been included in the Strategic plan for the rural revitalization (2018-2022)[40], issued by the Central Committee of the Chinese Communist Party. The present work can be counted among the policy actions aimed at revamping the attractiveness of the rural villages, targeting a more balanced equilibrium between urban and rural societies.

## The 10 principles

To create zero carbon villages in the Yangtze River Delta, first of all a sharper focus on the relationship between the physical aspects of new developments (structure, texture, volumes, layout), and climate and the energy demand is required. Secondly, the infrastructures necessary to ensure the closure of the energy, water, waste and food cycles, aiming for a high level of self-sufficiency, must be identified and integrated – creating a relationship between the physical structure and form of the built environment and the vital fluxes feeding it and metabolised from it.

Finally, the social and economic dimensions should be taken into account and harmonized with the urban design methodologies and goals, validating the resilience of the model against the possible transformations that will be induced by the desired growth and development.

### SUSTAINABLE VILLAGE DESIGN: CONCEPTUAL PILLARS

When designing a sustainable village development, the designer should bear in mind that:

1. a prerequisite for reaching the goal of limiting global temperature increase to 1.5 °C by the year 2050 is that new developments should aim for zero emissions;
2. key drivers of GHG emissions are density, urban layout and texture, land use mix, energy, water and waste management systems, food production;
3. form and infrastructure significantly affect not only direct (operational), but also indirect (embodied) GHG emissions;
4. the circular economy principles should be implemented
5. a systems perspective must be adopted, as all these factors are interrelated and interdependent.

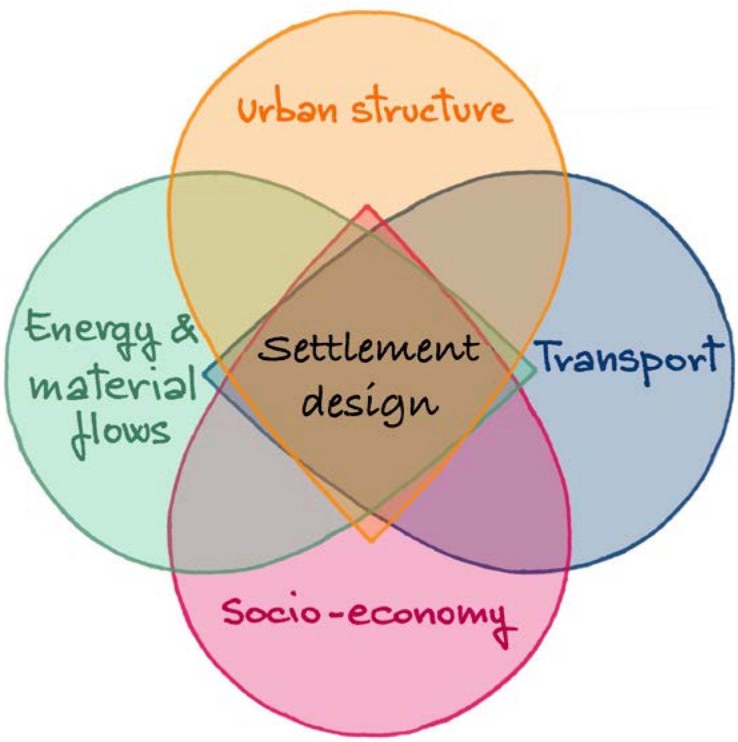



*Fig. 2.1 Integrated design components of a sustainable settlement*

The issue of sustainable settlement design is not new, and a large amount of authoritative literature has been produced about it, mostly focussing on socio-economic and transport issues, the latter because of their impact on energy consumption and air pollution, but usually overlooking the interactions with energy, water, food and material flows, which are a substantial part of the settlement's metabolism.

To complete the picture, features related to energy and materials, to water and waste must also be added (Figure 2.1), to encompass the whole metabolism of the settlement.

The interactions between structure (layout, form, land use, materials, greenery), energy, water and waste can be used to minimize the flow of resources needed for the operation of a settlement and – at the same time – can make it more resilient, thus more capable of coping with the challenges of climate change.

The conceptual framework depicted above can be summarised in 10 principles, which should be followed for designing zero carbon villages:

1. **Climate data and greenhouse gas inventory**
2. **Well-connected mixed-use nodes**
3. **Heating and cooling**
4. **GHG emissions**
5. **Renewable energy sources**
6. **Water cycle**
7. **Solid waste**
8. **Energy, water, food and waste cycles**
9. **Employment opportunities and leisure**
10. **Ecological awareness**

## PRINCIPLE 1 – CLIMATE DATA AND GREENHOUSE GAS INVENTORY

The first, essential, step in the design process towards the creation of a zero carbon village is knowledge of the starting point. The most important information, to this end, is related to the climate and to the present environmental impact of the village's activities, i.e. climate data and greenhouse gas emissions.

### Climate characterization

The climate of a site greatly affects both the energy consumption of buildings for heating and cooling and the potential for harnessing renewable energy. Moreover, the local climate affects the type of measures to be undertaken by the settlements' designers for mitigating outdoor comfort conditions and also affects people's willingness to walk or cycle that, in turn, affects the emissions due to motorised transport.

The area of the Yangtze River Delta is characterized by what climatologists define as a "marine monsoon subtropical climate". Within this definition, however, different climates are present, according to the distance from the coast, the height above the sea level and other local topographic peculiarities. This implies that a more detailed analysis of the climatic data of each examined village must be carried out.

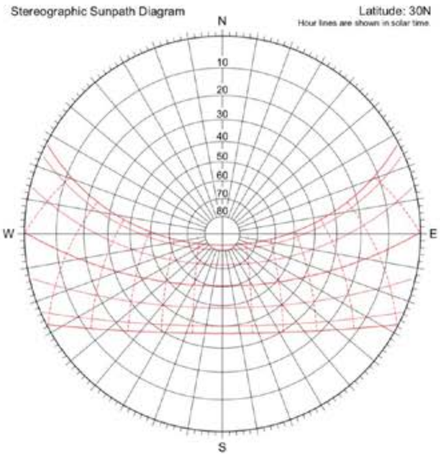
An important parameter affecting local climate is the latitude, on which depends the hourly, daily and seasonal patterns of solar energy availability, and thus the range of climates - from tropical around the equator to polar at the higher latitudes. However, it should be borne in mind that the same latitude does not mean the same climate, as other factors such as seasonal winds like trade winds and monsoons, or ocean and continental masses have a great effect on the local climate.

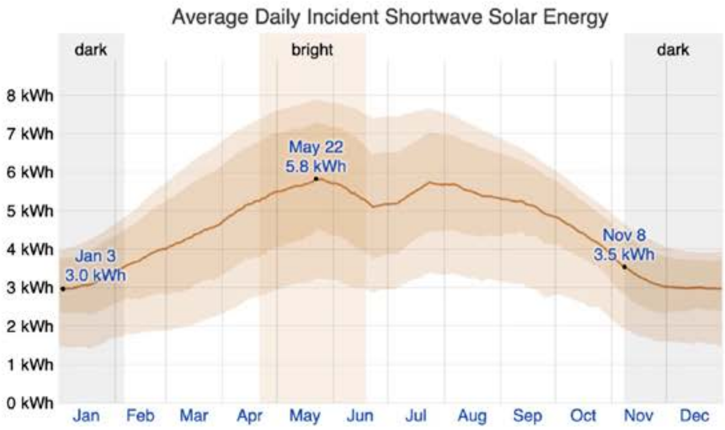
Even if different climates can be found at the same latitude, the sun's position in the sky is a common feature, and the sun's position dictates the shade pattern in the built environment.

The sun's position in the sky, at each hour of each month is usually represented, for each latitude, by sun charts, such as the one in Figure 2.2, top left, plotted for 30N latitude, the mean value for the YDR area.

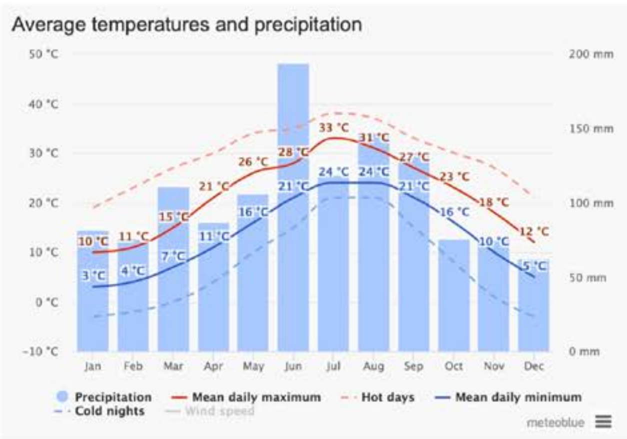
The main climatic parameters, in a given place, influencing the energy performance of a building and the quality of the outdoor environment are:

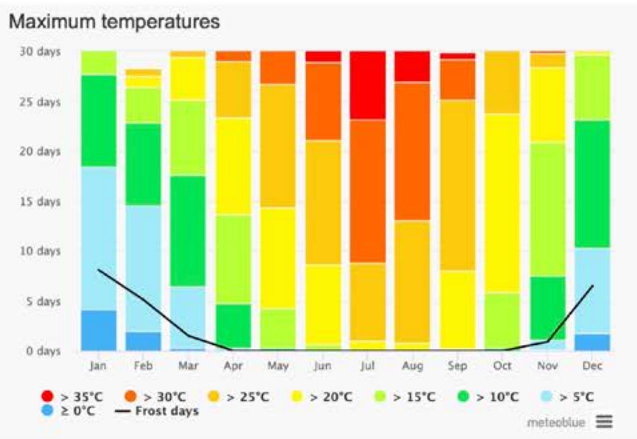
- solar radiation;
- air temperature;
- relative humidity;
- wind.

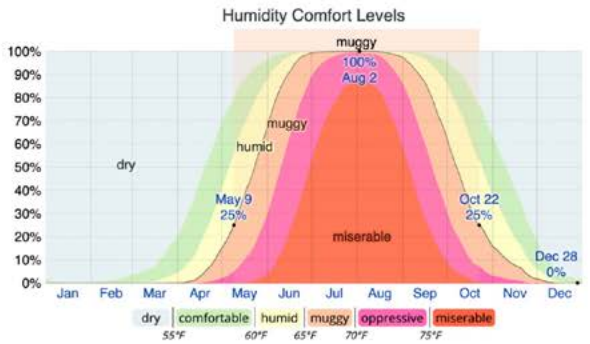



The average daily shortwave solar energy reaching the ground per square meter ( orange line), with 25th to 75th and 10th to 90 th percentile bands




The percentage of time spent at various humidity comfort leels, categorized by dew point

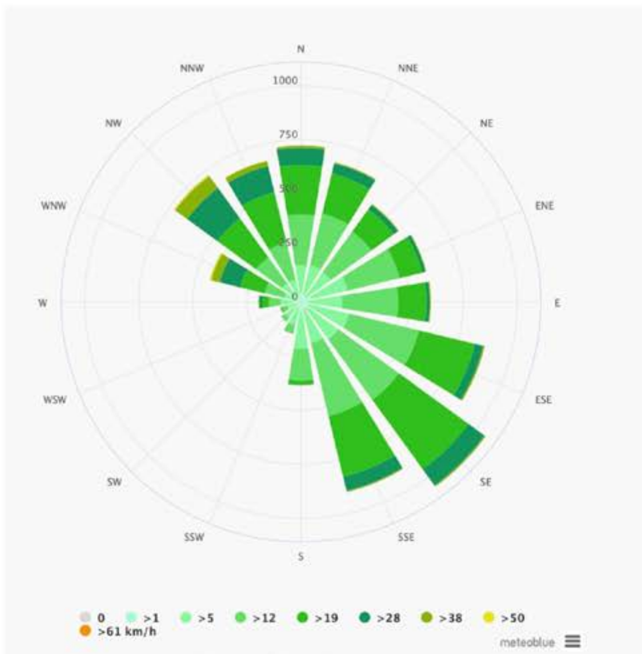



*Fig. 2.2* *Climatic data for Zhoushan city. Top left: sun chart: top right: monthly solar radiation; middle left: monthly temperature (average, mean max and min) and precipitation; middle right: monthly maximum temperature frequency; bottom left: monthly relative humidity; bottom right: wind rose[74].*

The figures for these are usually available in the visual form shown in Figure 2.2, or as tables, or both.

Solar radiation, air temperature and wind velocity affect the thermal balance of a building in winter, thus affecting its energy demand. In summer, relative humidity also plays a critical role, because energy is required for reducing it to a comfortable level[41] , but at the same time air movement can become beneficial because it improves comfort conditions.

Solar radiation and wind are, in turn, valuable sources of renewable energy that can be used to fulfil the building's energy needs.

A designer's task is to design buildings and outdoor spaces in such a way as to minimize energy demand and – at the same time – maximise thermal and visual comfort. To reach this goal climatic data need to be carefully analysed and possibly used as input in appropriate simulation models. Even in apparently similar climatic conditions, a technical or technological solution optimised for one place may not be the optimum for another.

### Greenhouse gas inventory

The first step for a settlement aiming to achieve zero carbon status is to have a picture of the initial conditions, which implies the implementation of a greenhouse gas inventory. This is also the very first action required by the EU Covenant of Mayors initiative[42], the world's largest movement for local climate and energy actions now gathering 7,000+ local and regional authorities across 57 countries.

According to the guidelines provided by the Covenant of Mayors initiative[43] and by the Greenhouse Gas Protocol[44], after the boundaries within which carrying out the inventory[45] have been defined, a preliminary decision to be taken is whether "carbon" refers just to $CO_2$ emissions or to $CO_2$ equivalent ($CO_2$-eq) emissions. In the first case, only a part of the GHG emissions are accounted for; in the second they are all considered; i.e. besides carbon dioxide[46], also nitrous oxide, methane and F-gases.

A second decision to be taken before starting the GHG emissions inventory is to choose "what to count", i.e. which emissions to include in the inventory. Both the Covenant of Mayors initiative and the Greenhouse Gas Protocol consider three levels of inventory:

Level 1: a very basic one including only the $CO_2$ emissions due to heating, hot water production, cooking, transport and any other $CO_2$ emissions produced in buildings, industries or services (private and municipal) due to the combustion of fossil fuel, including those $CO_2$ emissions due to the production of the electricity and the heat used within the boundaries of the settlement, even if the production takes place elsewhere;

Level 2: a more complete one, which includes all the GHG gases, i.e. methane, nitrous oxides, F-gas, plus the effects of land use change (e.g., forested land being cleared for cropland or settlements, or afforestation). GHG emissions other than $CO_2$ are, for example: landfill and livestock methane emissions (the latter deriving from enteric fermentation and manure management), nitrous combustion products, fertilisers nitrous emissions, rice paddy methane emissions, etc.;

Level 3: a very comprehensive one, which includes: a) the indirect emissions due to activities, taking place out the settlement's boundaries, but carried out by settlement's residents, such as air, train or car travel, b) treatment of waste transported outside the boundaries of the settlement, c) water treatment (potabilization and waste water processing) taking place outside the settlement, d) embodied emissions of the materials and goods entering the settlements, i.e. the emissions deriving from the production and transport of such materials and goods (this is the most difficult, often impossible task to fulfil for many goods).

To this end, the Greenhouse Gas Protocol classifies the emissions into three categories, namely (see also Figure 2.3):

Scope 1 - the GHG emissions from sources located within the settlement's boundaries

Scope 2 - the GHG emissions occurring outside the settlement's boundaries as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the settlement's boundaries

Scope 3 - all other GHG emissions occurring outside the settlement's boundaries as a result of activities taking places within the settlement's boundaries.

In greater detail, scope 1 includes:

- emissions from the combustion of fuel in residential, commercial and institutional buildings and facilities and manufacturing industries and construction, as well as in power plants to generate grid-supplied energy and, in general, generators used as back-up or to substitute grid provided electricity
- Emissions from transportation, that covers – for both people and goods – all journeys by motorised vehicles within the boundaries of the settlement
- Emissions from waste disposal and treatment through aerobic or anaerobic decomposition, or incineration. If methane is recovered from solid waste or wastewater treatment facilities as an energy source, these should be calculated

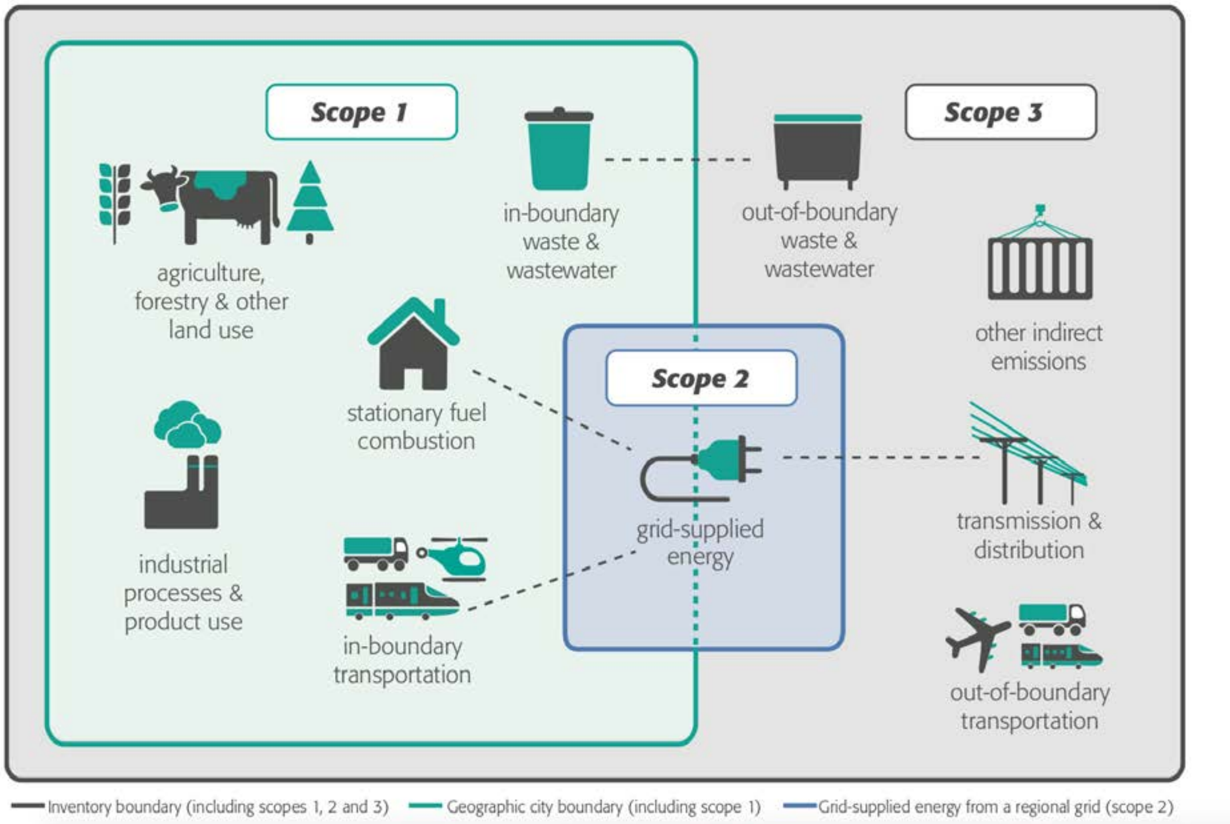



*Fig. 2.3 Classification of GHG emissions according to the Greenhouse Gas Protocol*[75]

as negative emissions; similarly, emissions from incineration with energy recovery.

- Emissions from agricultural activities, i.e. nitrous oxides from fertilisers, methane form livestock and from rice paddies
- Emissions due to land use change

Scope 2 emissions depend on the amount of grid electricity that is consumed within the settlement's boundaries, plus the distribution losses, and on the structure of the national supply system, i.e. its fuel mix. The larger the contribution of high $CO_2$ emitters such as the coal-fired power station, the higher the amount of scope 2 emissions.

As already noted, to calculate all the emissions included in scope 3 is very difficult and in some cases at present impossible. However, it would be fair to include at least some of them, such as the ones due to the journeys by road, rail or air attributable to settlement's residents and the emissions embodied in construction materials, primarily cement, because of its high contribution to the overall GHG emissions.

Renewable energy production and increase of forest or wetland areas should be counted as negative emissions.

The GHG inventory level 1 is the most popular, but – especially because we are dealing with rural villages – the second level of inventory should be carried out, as the first level would give a largely incomplete picture of the starting point, making it very difficult to identify all the measures to be taken to lead the settlement towards a real zero carbon status (agricultural activities are important and contribute mainly with GHG emissions other than $CO_2$).

Both the Covenant of Mayors Initiative and the Greenhouse Gas Protocol provide a detailed methodology and tools for carrying out the greenhouse gas inventory, the latter also being specifically developed for Chinese settlements. The methodology includes setting up milestones and a monitoring system to check the compliance of the actual status with the planned one.

**Design suggestions**

◊ Build-up a baseline emissions inventory to use as a starting point in the process towards achieving zero carbon status. In order to carry out this task:
  - Define carefully the physical boundaries of the settlement, i.e. of the area covered by the inventory, as the inclusion or exclusion of agricultural or industrial activities, and of forest areas can significantly modify the amount of GHG gases emissions attributed to the village

- Decide whether the inventory is limited to $CO_2$ or if it includes all the main GHG gases (nitrous oxide, methane and F-gases.). This second option is strongly recommended, especially in a rural village where nitrous oxide and methane emissions may be significantly high;
- Decide whether the inventory should be level 1 or level 2. The latter is strongly recommended, possibly including some parts of level 3, such as waste and water treatment if they take place outside the settlement borders and – if the settlement's development plan includes a significant number of new buildings – the embodied emissions of construction materials.

◊ Set up a path from the baseline to the zero carbon status, with milestones to be reached periodically

◊ Create a structure with the task of monitoring the emissions inventory on a regular basis (Covenant of Mayors suggest every four years), checking compliance with milestones and highlighting possible critical issues.

## PRINCIPLE 2: WELL-CONNECTED MIXED-USE NODES

In general, two main, interconnected, design principles are crucial if we are to respond to the multiple dimensions of sustainability: i) diversity of both land use and types of environment and ii) adequately connected and easily accessible places. Both of these are related to the settlement's density.

Provision at village scale for facilitating cycling and collective and individual high efficiency transport are also key to reducing energy demand and consumption.

### Density

Density is a critical but controversial settlement planning parameter, as the issue of its impact on GHG emissions is a complex one. It has been widely explored and is considered to be most important at city scale, but at rural village scale it affects only some aspects of development, namely:

- extent of infrastructures — such as water, sewer, and electricity facilities — to serve the inhabitants, affecting economics and energy consumption: the denser the settlement the less extensive the networks and the grid.
- land use, as mixed land use (work, home and services close to each other) reduces both transport-related energy consumption, and soil consumption, which also affects $CO_2$ emissions (green areas wiped out).

Given the number of parameters involved and the complexity of the system, however, the optimum density of a village should also be based on traditional and culturally relevant dwelling patterns. Moreover, in choosing a density that is consistent with the goal of achieving a net-zero carbon village, human comfort and cultural heritage also need to be prioritized.

**Design suggestions**

◊ Aim to accommodate at about 50-70 people/ha in the medium-long term.

### Connectivity

Traditionally, villages in the Yangtze River Delta followed similar spatial configurations with minor differences typically attributed to geographic, ecological, political, and cultural nuances. Such spatial configurations, including land use and building typologies have developed over hundreds, and in some cases thousands of years, contributing to a cultural heritage that should be respected. For example, whereas strip-style development may be a more recent phenomenon that discourages non-motorized transport and consumes large tracts of land for development, examination of village layouts dating back centuries reveals a more sustainable system.

Traditional layouts and amenities provided by traditional villages promoted a more sustainable model whereby villagers were able to meet most of their daily needs locally, with services being well connected between each other and with the dwellings, in such a way as to be reachable within a short walk.

### Mixed land use

A mix of uses and services, besides being consistent with tradition, is the key for a successful strategy aiming to create a zero carbon settlement, and it is closely connected to mobility patterns.

If the most frequently accessed services are appropriately distributed around the households and are easily accessible because of an appropriate street network, the use of motorised transport is significantly reduced because it will be substituted by walking and cycling, health is improved and meeting people becomes easier, with great advantages for enhancing human interactions, which improves the quality of the village life.

### Walkability: the five-minute-walk shed

Density, connectivity and mixed use, appropriately balanced, make a zero carbon village walkable, i.e. a place where motorised transport is minimized, as services and amenities are at a walkable distance, as they were in traditional villages: daily needs should be met within a 5-10 minute walk, yet should still respect rural values - particularly villagers' connection to the land.

Thus, walkability is the first and the most important principle to consider when designing a zero carbon village. All the daily services, including retail and access to transit, have to be provided within five to ten minutes' walk (400-800 m) from home (Figure 2.4 – Mixed use in a walkable settlement), in order to make car travel unnecessary in normal conditions; for special services or city-scale functions (hospital, theatres) that are rarely used, travel budget time can be higher.

Walkability is a measure of the conditions of an area that promote walking, and the ped-shed (short for five-minute-walk shed or pedestrian shed), even if it is the most important, cannot give a complete picture of a settlement's walkability, as the following factors should be also considered, namely:

- Residential density; an indicator of the density of the neighbourhood.
- Commercial density; an indicator of the amount of businesses, restaurants, retail shops and other commercial uses that are located in the area.
- Intersection density; the connectivity of the street network, an indicator of the density of connections in path or road networks and the directness of links (Figure 2.5).
- Land use mix, or entropy score; the degree to which a diversity of land use types is present in a block group.

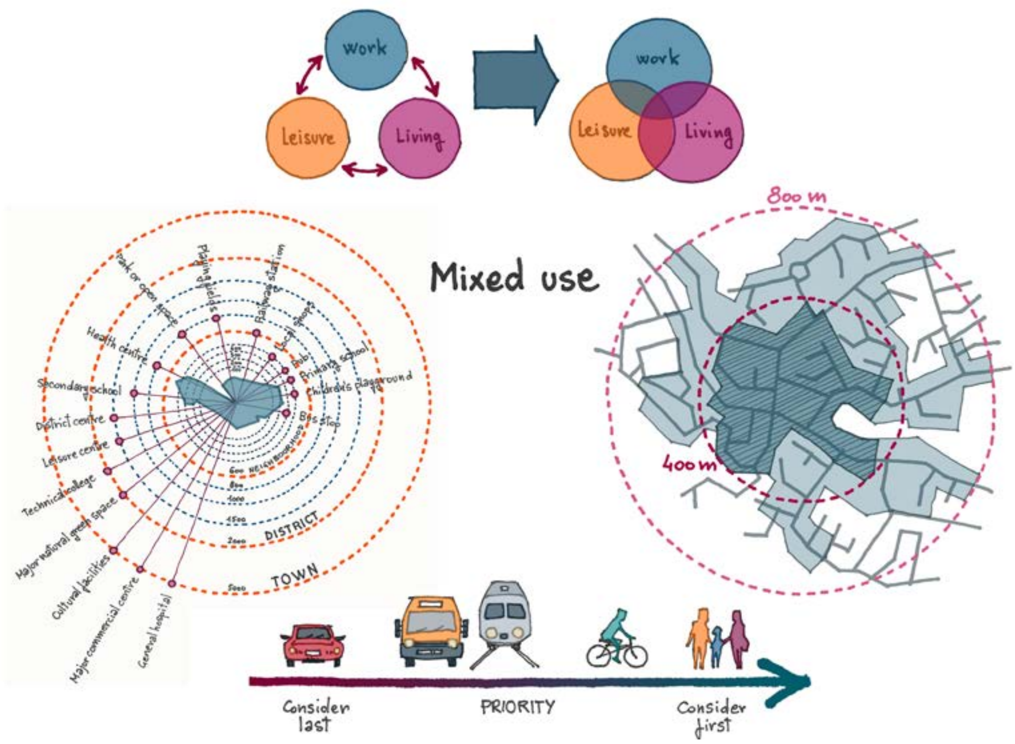



*Fig. 2.4* *Conceptual description of the connectivity index. From left to right: increasing connectivity index. A well-connected road or path network has many short links, numerous intersections, and minimal dead-ends. As connectivity increases, travel distances decrease and route options increase*

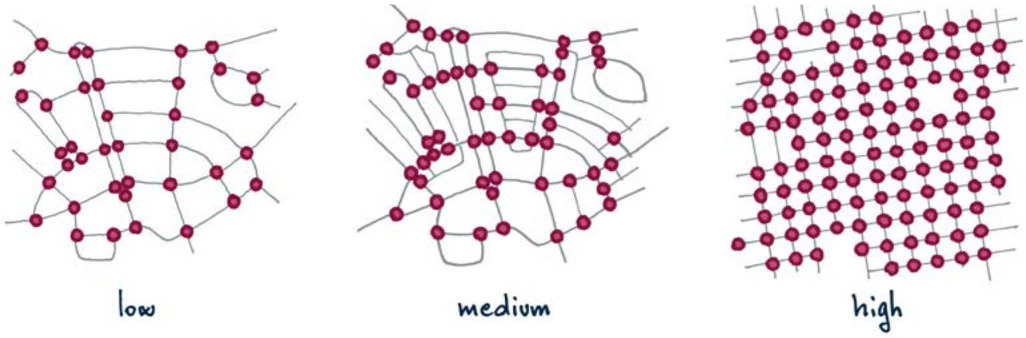



*Fig. 2.5 From left to right: increasing connectivity index. A well-connected road or path network has many short links, numerous intersections, and minimal dead-ends. As connectivity increases, travel distances decrease and route options*

**Design suggestions**

◊ Ensure that at least 50% of a village's dwelling units are within a 400-800 m walk from at least one use from each of the four categories of diverse land uses listed in the table below[47].
◊ Provide space for local food markets
◊ Place the community core with services at the centre of the settlement, close to public transport nodes.
◊ Provide comfortable street landscapes
◊ Increase sustainable mobility opportunities by creating space for bike lanes or bike-friendly streets and safe and enclosed storage places for each building.
◊ Count the total linear extension of bike lanes and bike-friendly streets and compare it to the total motorised linear extension. They should be at least equal.

| Food or Retail | Civic and community facilities |
|---|---|
| Supermarket<br>Other food store with produce<br><br>**Community-serving retail**<br>Clothing store or department store selling clothes<br>Convenience store<br>Farmer's market<br>Hardware store<br>Pharmacy<br>Other rental<br><br>**Services**<br>Bank<br>Gym, health club, exercise studio<br>Hair Care<br>Laundry, dry cleaner<br>Restaurant, cafe, diner | Adult or senior care (licensed)<br>Child care<br>Community or recreation centre<br>Cultural arts facility (museum, performing arts)<br>Educational facility<br>Family entertainment venue (theatre, sports)<br>Government office that serves public on-site place of worship<br>Medical clinic or office that treats patients<br>Police or fire station<br>Post office<br>Public Library<br>Public Park<br>Social service centre |

◊ Provide shaded and rain sheltered pedestrian and cycling paths to promote low energy mobility

## Car accessibility

In the near future, new districts will experience a radical change in mobility patterns. The use of the private car will be drastically reduced (or avoided in cases where car ownership is still not dominant) thanks to three main reasons, namely: the emergence of sharing principles applied to motorised (car sharing) and non-motorised vehicles (bike sharing); the increased availability of public transport and sustainable mobility systems; and the demand for improved overall urban environmental quality.

Attractive zero carbon village streets are not flanked by parked cars and garage doors.

The new trends in mobility, characterized by an expanded use of electric vehicles, the sharing of different means of transport, and the integration of advanced ICT solutions, are leading to a significant reduction in the number of vehicles circulating and, thus, a significant reduction in the parking areas. Besides, car sharing (or, in future, driverless cars) will call for a number of smaller parking areas.

**Design suggestions**

◊ Avoid putting car parking in the ground floors of buildings.
◊ Take into account the possibility of creating car-free residential areas at the borders of which are a number of parking lots.
◊ Look ahead, making provisions for the new trends in mobility, based on electric car sharing (conventional or self-driving), which implies a number of small parking lots distributed within the village, at walking distance from residences and services, and provided with charging stations.

## Street types

Three main road typologies should be considered in traditional villages in the YRD region: transit, access and local streets. It should be clear, however, that, in contrast to what presently happens, street design should not be dictated only by the requirements of cars, and thus be the same design everywhere, but should also consider other functions and the climatic, socio-cultural and economic context.

Hence, the hierarchy level of each street type should express the character of the hosted functions. Considering the local character of a village, we mainly

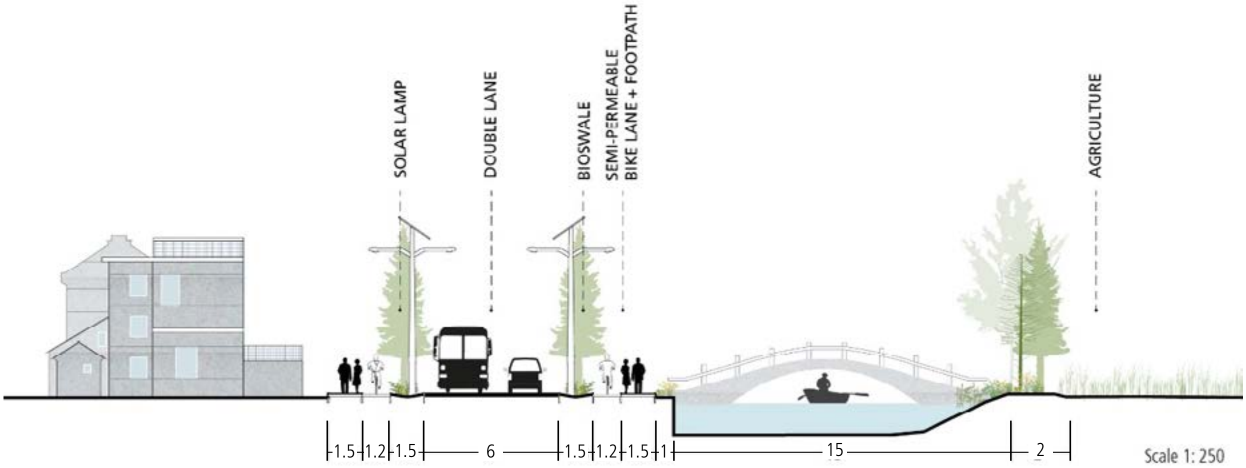



*Fig. 2.6 Access Street*

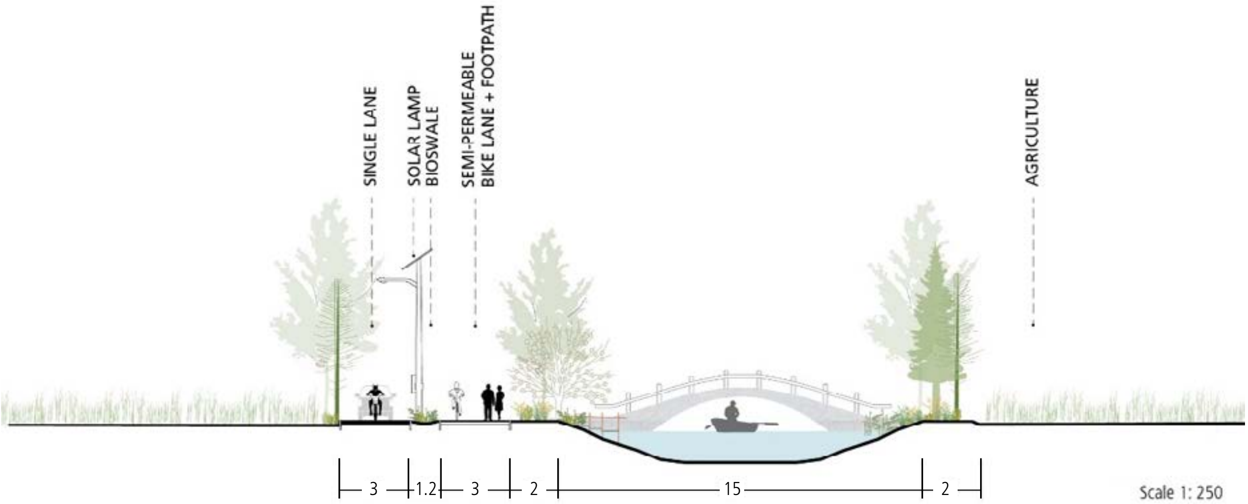



*Fig. 2.7 Local Street*

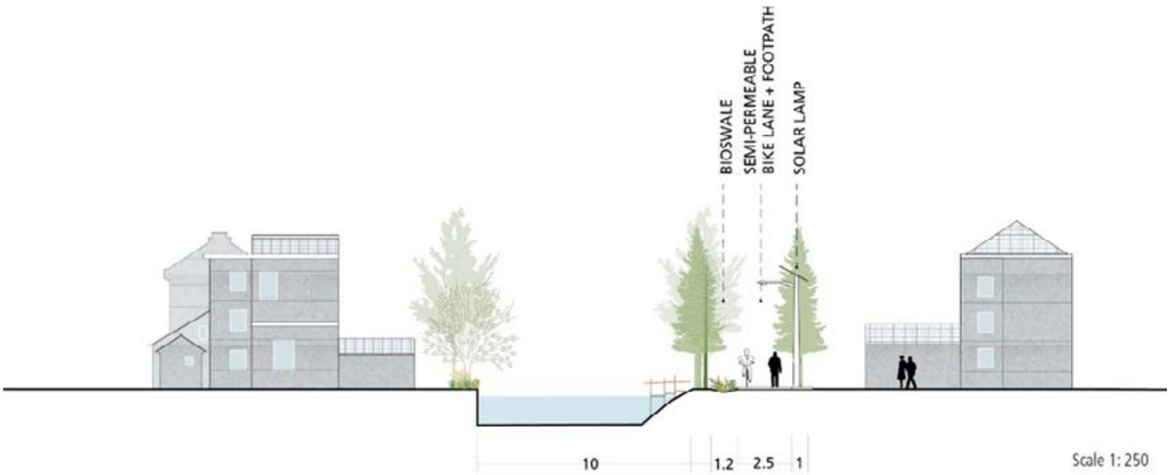



*Fig. 2.8 Footpath*

refer to access streets with a high access ratio (Figure 2.6), local roads (Figure 2.7) and footpaths (Figure 2.8).

**Design suggestions**

◊ When defining the width of village streets, consider that streets should accommodate pedestrians and cyclists, and that they should have priority over all the other forms of mobility.
◊ Consider that in a walkable settlement sidewalk size is of foremost importance, and depends on the activities planned on the sidewalk, in addition to the pedestrian flow.

## Carbon sinks

Green areas, where nature's power and beauty can express itself and biodiversity is enhanced, are of paramount importance for several reasons: ecological, climatic, aesthetic and recreational. These areas may fulfil all these requisites or only some of them according to their scale (regional, village, household) and their design.

Parks and nature reserves are the backbone of a policy aiming to enhance a harmonious interaction between humans and nature. They have a high ecological value and – at the same time – can have a high educational and recreational value. Most important, among the nature reserves, are forests and wetlands, whose role as carbon sinks is also fundamental, besides their biodiversity.

**Green areas at village scale**

At village scale green areas are necessarily anthropized, and thus more "artificial". The nature of a village green spot, whatever size it is, is artificial, in the same way that cultivated land is artificial. The essential condition for fulfilling the aim of a harmonious interaction human-nature, however, is to manage these artificial green areas according to nature's laws, based on cycles of matter powered by solar energy.

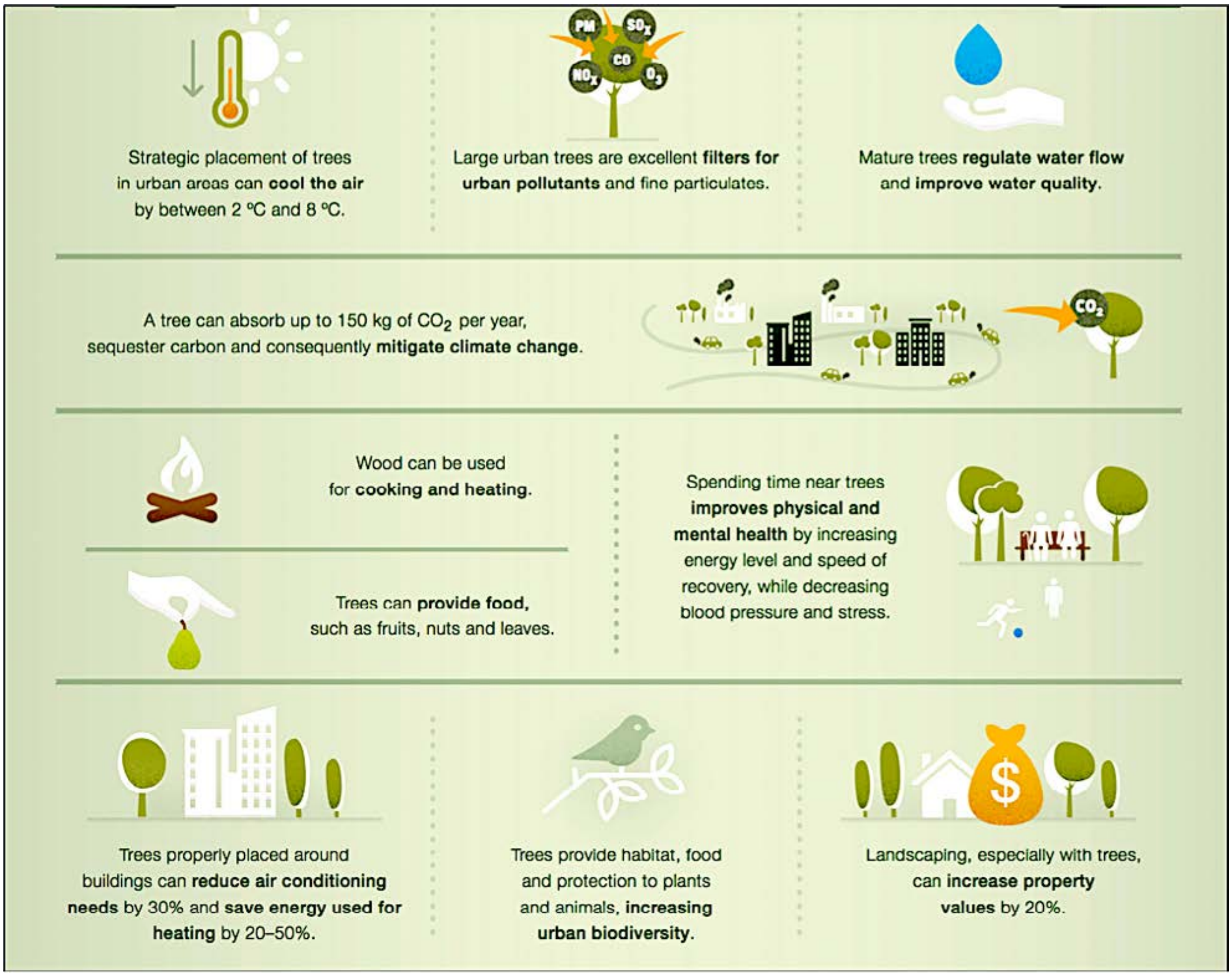



*Fig. 2.9 Multiple benefits of urban trees*[76]

**Public space: village parks, playgrounds, and rest areas**

Greening, i.e. extensive roadside tree planting, green spaces, parks and gardens, are very efficient and effective means of improving outdoor and indoor thermal comfort in summer and of reducing energy consumption for cooling buildings.

Air and surface temperature in parks may be significantly lower than in the surrounding built-up area, creating what is called a "park cool island".

A settlement full of green areas is also a pleasant and healthy place to live in.

Greening requires water: providing water for trees, parks, small green areas may be a challenging task, because of the large amount required and its cost, especially when potable water is used, whose quality is far higher than that needed for watering plants.

The issue of vegetation, then, intersects the issue of the settlement's water cycle: decentralized water management, based on the exploitation of rainwater and on the recycling of wastewater is closely connected with the availability and cost of water for irrigation, and is a prerequisite for a sustainable integration of green areas into new and existing settlements.

Green areas are important because they are carbon sinks.

**Trees, green roofs**

Trees provide multiple benefits (Figure 2.9). They provide shade, which is beneficial both for outdoor comfort and for buildings' energy demand for cooling.

Another quality of trees is their ability to sequester and store carbon in their trunks, leaves, and roots, acting as carbon sinks, so contributing to a reduction in GHG emissions.

A green roof is a vegetative layer grown on a rooftop. Vegetation on a green roof shades surfaces and removes heat from the air through evapotranspiration. These two mechanisms reduce the temperatures of the roof's surface and the surrounding air, which is beneficial in summer. In winter the benefit is linked to the increased thermal mass and insulation of the roof. Nevertheless, their lifecycle cost may be high, if compared with other insulating systems.

Green roofs act also as a buffer for water runoff in case of heavy rains.

**Agriculture**

As shown in Chapter 1, agriculture is a major driver of the transgression of planetary boundaries, thus management of the land cultivated by village farmers is crucial for a zero carbon village.

The challenge is to transform agricultural production from carbon emitter to net carbon sink, or at least to make it neutral. This can be achieved by combining the principles of traditional (before artificial fertilisers were available) farming practices with the most advanced scientific and technological methods available nowadays. Such a form of agriculture is not only ecologically sound but is also a living example of restored harmony between humans and nature that can be enjoyed by tourists and residents, as well as farmers: it is a way to add educational, recreational and ecological value to a productive activity.

**Household scale: kitchen gardens**

In rural villages households have their adjacent small plot of land where they grow vegetables and fruit, and raise a few animals (poultry, mainly) for personal use and often also for local sale.

These green patches contribute to the general benefits of greening and usually provide good, healthy food. In a zero carbon village sustainable kitchen gardens should be promoted, by educating – whenever necessary – households to sustainable agricultural practices, by minimizing the use of artificial fertilisers, pesticides and herbicides through appropriate farming techniques.

**Design suggestions**

◊ Make sure your settlement provides:
    - A small-medium sized park
    - Tree lined streets
    - Pocket parks with diffused small green interventions (potted green plants, green shelters, roofs and walls)

◊ Consider local traditions and species in designing green spots and areas.

◊ Use trees extensively, wherever possible: along the streets, in the squares, in parking areas, etc.

◊ Consider the life-cycle cost of a green roof system when measuring the total benefits, especially if compared to the lifecycle costs of a well-insulated roof, which also reduces heat losses in winter and heat gains in summer.

## PRINCIPLE 3 - HEATING AND COOLING

Zero carbon buildings are the prerequisite for a zero carbon village.

Although villages in the Yangtze River Delta Region show low energy consumption for space heating and cooling, when planning for an increase in population (residents and/or tourists) and an improvement in economic conditions, a significant rise in energy required for heating and cooling can be expected and should be mitigated[48]. This phenomenon has been common to all countries as a consequence of their economic development, which changed the expectations of comfort. A significant increase in per capita energy consumption for space heating has been witnessed, for example, in all the European countries whose economic development took place after the Second World War, and is also being witnessed in China, where today urban residents, who are wealthier than those in rural areas, use 1.5–5 times the energy of rural residents on a per capita basis[49].

Local climate is the main driver of energy consumption for heating or cooling, and therefore $CO_2$ emissions. The path to a zero carbon village, thus, starts from climatically responsive building design to minimize energy demand. The effectiveness of a climate responsive building design, on the other hand, is also affected by the way buildings are arranged in a settlement, as this plays a significant role in determining the amount of energy needed, for two reasons: a) the orientation of a building is crucial for the exploitation of solar gains in winter and for sun protection in summer, and b) the settlement's texture affects the local climate.

### Climate responsive building design

Energy is required in buildings to provide heating or cooling for shifting from indoor conditions in the absence of any heating or cooling system, to comfortable conditions. The greater the distance between these two conditions the greater the amount of energy required.

This distance derives primarily from the outdoor climatic conditions: the more extreme they are, i.e. the less comfortable, the wider the gap to fill to make the indoor environment comfortable and, thus, the higher the amount of energy required to fill this gap by means of some technological device.

The width of the gap, however, also depends – to a great extent – on the way the building is designed, and it is minimal when the building is climate responsive.
A building is climate responsive when it is capable of interacting with its environment in such a way as to minimize the occupants' discomfort in winter by means of:

- appropriate balance between solar gains and heat losses in all seasons
- effective exploitation of its thermal mass
- capability to exploit the beneficial effect exerted on summer comfort by the air movement.

A climate responsive building is capable of minimizing the heat flow needed to add or subtract heat in order to reach the comfort conditions, not to bring it to zero. Thus, another issue regarding zero carbon buildings is the energy conversion technology used for providing this flow. Not all technologies are equally efficient, and heating and cooling systems, in a zero carbon building, should be chosen according to their efficiency and to their appropriateness to the building's thermal characteristics.

In order to fulfil the requirements of the base of the triangle in Figure 2.10, the designer should follow some basic rules.

Building shape and orientation are the first choices in the design process. They are also the most critical because they have the most impact on both thermal and visual comfort and on energy consumption.

Building shape is important because the higher the building's surface to volume ratio, the greater the thermal losses (and gains). Orientation is important because the amount of solar energy incident on windows, and thus their effectiveness as solar collectors depends on it. This

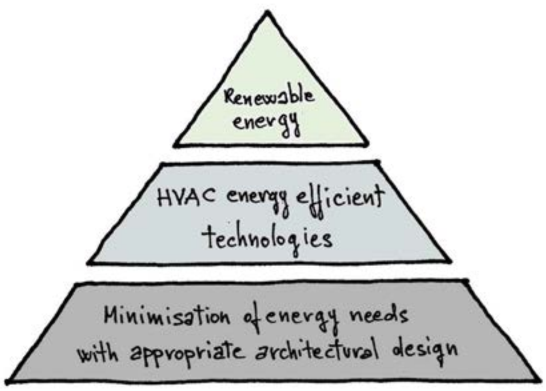



*Fig. 2.10 Towards zero carbon, high comfort buildings: design strategy*

amount is maximum when a façade, and thus windows, face south; this implies that the building should be elongated east-west. This orientation is also the one that makes it easier to protect windows with shading in summer.

After a building's shape and orientation, the third most important decision is related to the thermal mass and the insulation of the envelope, together with the sizing of the openings.

Thus, it is the appropriate interplay between solar gains, envelope losses and the thermal inertia of the fabric that makes a building climate responsive, and the optimum solution is a consequence of the characteristics of the local climate. This is why the availability of climatic data is a crucial issue.

The prerequisite for achieving a zero carbon village is that existing buildings should be as far as possible energy efficient and new buildings should be zero carbon. This implies that not only should they be designed to maximise solar gains in winter and to minimize them in summer by means of appropriate window size and overhangs, but they should also be designed to minimize heat losses in winter and heat gains in summer through the envelope, which is obtained by means of appropriate insulation and light-coloured walls. Another way to improve the thermal performance of a building in winter is by providing sunspaces on the south facing façade. To avoid overheating in summer, these sunspaces should be fully openable.

In cases of retrofit, the effectiveness of sunspaces can be improved by substituting the existing glazing with a more efficient one (low-e glazing) (Figure 2.11).

Of course, in case of existing buildings to renovate for making them more energy efficient, shape and orientation cannot be modified, but it could be possible to intervene on thermal mass and windows size and type, and certainly some insulation can be added.

Window size and type does not affect only the winter performance of a building, but also the summer performance, through natural ventilation, i.e. the intentional airflow through windows, doors or other openings designed for the purpose, obtained without the use of fans.

Natural ventilation affects both the energy balance of the building and the thermal comfort. It affects the energy balance of buildings because the flow of external air subtracts or adds heat to the internal space, according to the outdoor-indoor temperature difference. It directly affects thermal comfort because air velocity affects the body's energy balance through convective exchange and evaporation: the higher the air velocity the higher

*Fig. 2.11 Retrofitted sunspace on a south facing balcony*

the body's heat loss, thus affecting comfort in summer.

In summer, a climate responsive building must be capable of protecting its envelope, and especially its windows, from the direct sun. Shading is a strategy that – when well implemented – significantly improves the occupants' comfort and reduces the energy demands for cooling. Thus, an appropriate shading strategy is another typical feature of a climate responsive building. The easiest solution is to protect south facing windows by means of overhangs on each floor, protruding as much as necessary to shade the façade during the hottest part of summer, i.e. July-August.

In many cases, valuable suggestions about design strategies aiming to create climate responsive buildings and about the appropriate use of materials may come from traditional, or vernacular, architecture: very often it demonstrates the best response to the local climate, taking into account the availability of local resources for minimizing energy demands for heating in winter and maximizing comfort in summer by natural means.

It is worth mentioning that prescriptions for a wise orientation and climatic design of buildings and dwellings were fully embedded in historical Chinese building design practices, and were a consequence of the attitude of observing and understanding Nature, underpinned by traditional Chinese philosophy[50]. Because of this, most traditional rural buildings show good orientation and solar gain solutions, which is helpful for improving the energy efficiency of existing buildings.

**Design suggestions**

- ◊ Optimise the south facing façade's window to wall ratio (0.3<Wwr<0.5 As first guess) aiming to minimize energy demand for heating, taking profit of solar gains, but taking into account thermal mass and insulation for avoiding wasteful and uncomfortable overheating
- ◊ Minimize the north facing façade's wwr, provided that daylighting standards are met, for reducing heat losses and infiltrations due to cold winds blowing from the north in winter;
- ◊ Insulate the envelope appropriately, considering that energy savings will offset the cost of insulation, both in new buildings and in the retrofit of existing buildings
- ◊ Design fully openable windows to exploit natural ventilation in summer.
- ◊ Protect south facing windows with appropriate shading devices. For the latitude of the yangtze river delta, with exactly south facing facades, overhangs spaced vertically by 3 m should protrude by about 0.9 M. The same effect can be obtained with different spacing or depth, provided that the ratio of spacing to depth of overhangs h/w is $\leq$ 3.3. In this way the south facing façade is shaded during the summer months, but windows remain exposed to the sun during the winter months.
- ◊ Avoid the use of tinted glass
- ◊ Optimise thermal mass, envelope colour and insulation, window size and glazing type treating the building as a system and evaluating its energy and comfort performance by means of computer simulations.
- ◊ Consider, in existing buildings, the possibility of creating sunspaces on south facing balconies or to substitute single glazing with double glazing, if the sunspace already exists.

### Climate responsive settlement design

The growth of a zero carbon village would be the consequence of its successful development, and this growth needs to managed in order to minimize energy demand.

In order to contribute to minimizing the energy demand of buildings, the layout of the new development should be designed in such a way as to let buildings, and the space around them, receive as much solar radiation in winter as possible and, in summer, to create as much shade as possible and to favour air movements.

According to Principle 2's suggestions about density and mixed use, and because of the need to have south facing buildings, part of the village's new developments should be characterized by east-west running streets delimited by buildings. In this case, to maximise the solar exposure of south facing facades in winter, the distance between buildings along the north-south line should be such that reciprocal shadowing is avoided. In this way, by combining appropriate window sizing, envelope insulation and thermal mass, it is possible to offset – partially or totally - heat losses with the solar gains, whenever the sun is shining.

The role of settlement design in minimizing energy consumption for cooling is more multifaceted and challenging. This is a very critical issue, as energy consumption for cooling has been growing very steeply (Figure 2.12, top), and – according to the International Energy Agency – will continue to grow, sustained by climate change and the growing per-capita income (Figure 2.12, bottom).

This is especially true for the YRD area, because of its climate. In summer, high temperatures are combined with high relative humidity, creating very uncomfortable conditions and making natural ventilation less effective, because a body's heat loss also depends on the relative humidity: the higher the humidity the lower the amount of heat subtracted by the air flow; this is one of the

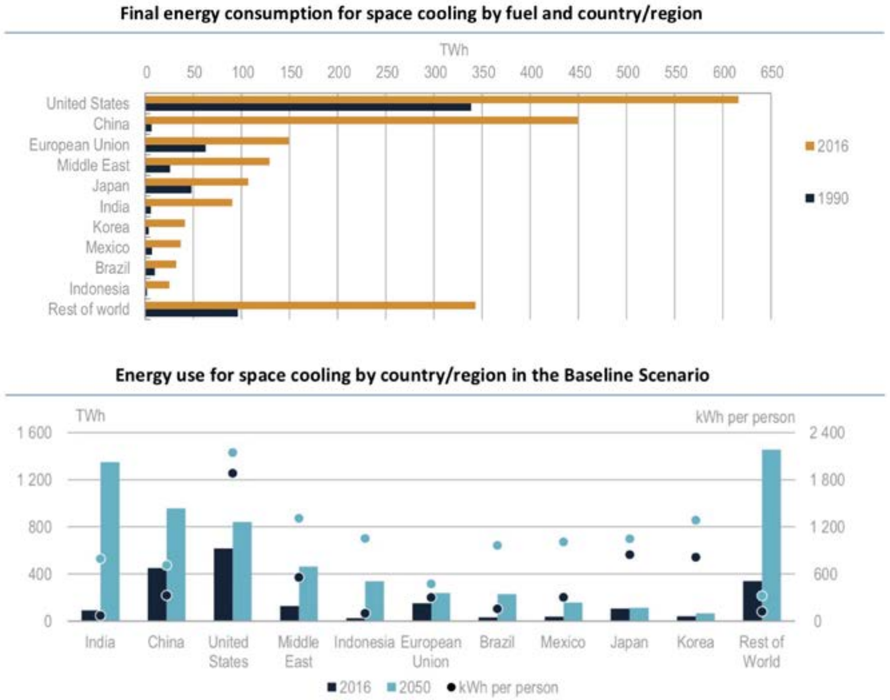



*Fig. 2.12 World air conditioning energy consumption growth. In 2050 China will be second only to India[77].*

reasons why, in the YRD, where summer humidity is generally high, the demand for air conditioning also tends to be high.

### Street width and orientation

The design of constructed canyons, here defined as streets delimited by buildings, is a most critical issue in a climate where winters are cold enough to require space heating and summers are hot and humid enough to require space cooling. It is a critical issue because it has to face two conflicting requirements: buildings and streets should be exposed to the sun as much as possible in winter and shaded as much as possible in summer. Taking into account the sun's path at this latitude, considered in these guidelines (around 30° N), combining the two requirements entails careful design of the buildings' orientation and facades, of the materials' albedo, and of greening.

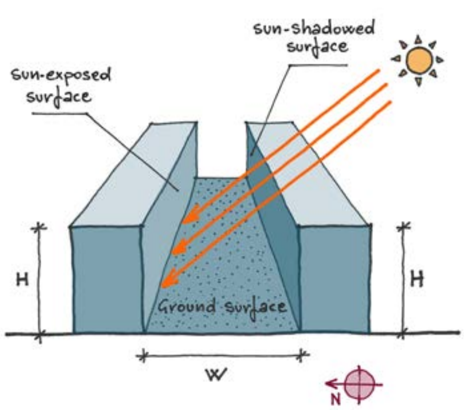



*Fig. 2.13 Sun lit south facing canyon's wall*

Constructed canyons are characterized by their height/width (H/W) and length/width (L/W) ratios and by their orientation. In order to maximise solar gains in winter, i.e. minimize energy demand for heating, canyons should be east-west oriented and have a H/W ratio such as to have the south facing building's façade fully exposed to the sun for most of the day on December 21st (Figure 2.13), when the sun is lowest at noon.

This condition, for latitudes around 30N, is met with low H/W ratio, not higher than 1 for full exposure from 10:00 hrs to 14:00 hrs[51].

If the ground floor of the building is used to host shops or workshops, and the other floors for apartments, then full exposure to sun can start from the first floor. In this case the canyon's H/W ratio can be higher, in function of the street width, according to the graph in Figure 2.14.

To evaluate the exposure to the sun of façades with an orientation different from that of due south, the simple procedure described in Appendices 3 and 4 of UN-Habitat's Energy and Resource Efficient Urban Neighbourhood Design Principles for Tropical Countries - A Practitioner's Guidebook can be used.

In conclusion, since to meet the requirement of minimizing energy demands in a new settlement, buildings should be south facing, canyons should be east-west running.

This, of course, has consequences on the layout and on the density of the settlement: a layout matching the traditional Chinese urban layout.

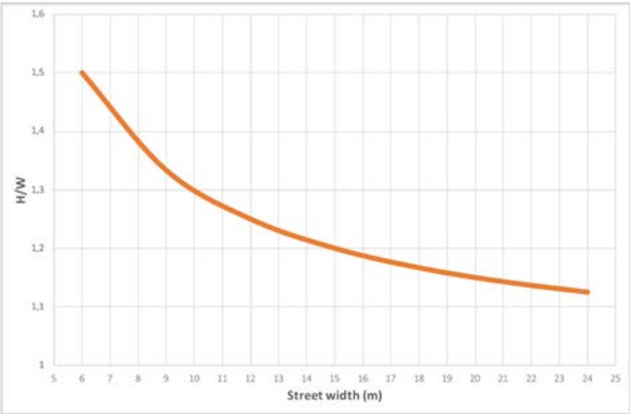



*Fig. 2.14 Canyon H/W ratio to achieve full sun exposure on 21 December between 10:00 hrs and 14:00 hrs from 1st floor upwards as a function of street width, at the latitude of Yangtze river delta (30-31° N latitude*

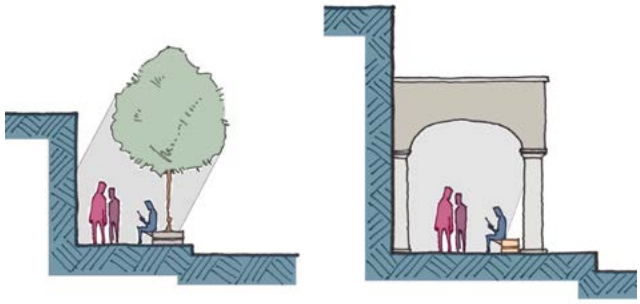


*Fig. 2.15 Shadowed walkways*

Canyons running east-west are the best for minimizing the winter energy demand of buildings, if they are appropriately designed, but they are not ideal for summer, because the street is exposed to the sun for most of the time, thus the outdoor comfort conditions are not acceptable unless some appropriate shading devices are provided, such as the ones shown in Figure 2.15.

**Design suggestions**

◊ Design a north-south/east-west street grid.
◊ Use east-west canyons with h/w $\leq$ 1 to host comfortable pedestrian pathways, shops, coffee houses, small artisan workshops, as one sidewalk is sunlit in winter and both sidewalks can be shaded if the street is tree lined. The upper floors should host residences, as the height above the street level favours sun exposure in winter and ventilation in summer.
◊ Consider using north-south streets mainly for vehicular traffic and leave the east-west oriented streets mainly for pedestrians, as they are more liveable in winter and also in summer if appropriately shaded.

## Air movement

Air movement plays an important role in the energy balance of the built environment, greatly affecting outdoor and indoor thermal comfort, as well as the energy exchanges of the buildings.
It is not easy to predict air movements in an area with many buildings, and reliable predictions can be obtained only by means of computer simulations or wind tunnels. Some rules of thumb, however, can be used, such as the ones related to the effect of wind direction on air movement in canyons. The deeper the canyon the less effective the ventilation, which is greatly reduced when the aspect ratio H/W is greater than 2. Also, the maximum attenuation of wind speed occurs when it blows perpendicular to the canyon's axis and the minimum when parallel.

Another rule of thumb states that the optimum incidence angle of wind through a window, for indoor ventilation, is between 0° (perpendicular) and 45°. Putting together these rules and considering the climatic context of Yangtze River Delta, it appears that the optimum orientation and spacing of buildings for solar exposure is also optimum for ventilation in summer, considering that the prevailing winds blow from SE (Figure 2.16). A settlement's grid north-south/east-west, in fact, favour both wind flow through north-south streets (so improving outdoor comfort conditions) and natural ventilation indoors.

**Design suggestions**

◊ Do not design canyons with aspect ratio h/w $\geq$, to avoid poor ventilation in summer, besides poor solar gains because of the shadowing.

## Pavements

A large proportion of the ground surface of a settlement is covered with pavements, which are usually made of asphalt or concrete. However, because of the low albedo of such materials, on clear summer clear days, when the sun is high in the sky, their surface can reach peak temperatures of up to 60-70 °C, as they absorb

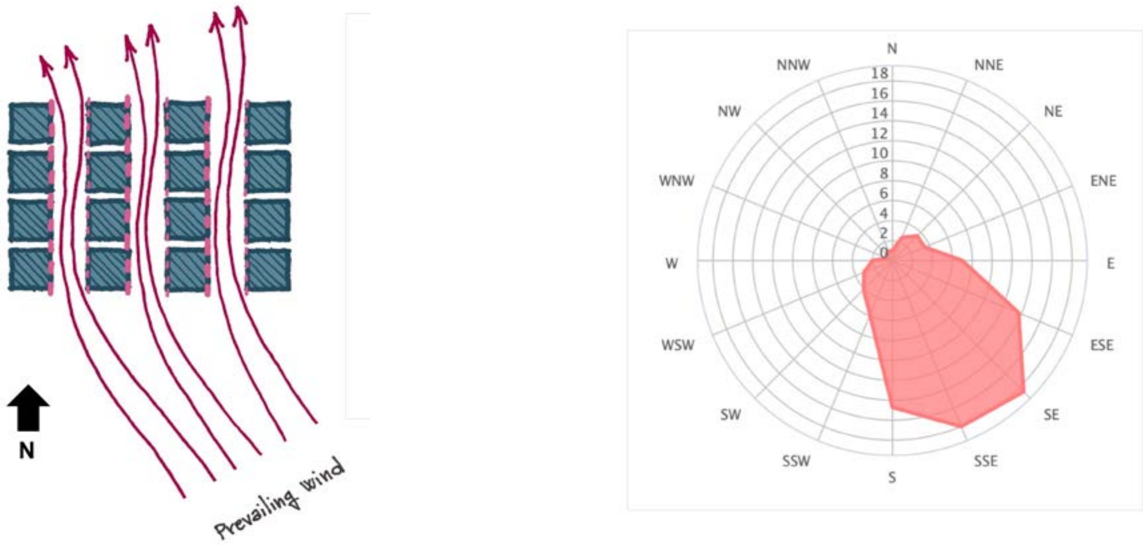



*Fig. 2.16 Wind pattern in the month of July. Wind data of Pudong Airport (Shanghai)[78].*

65 to 95% of the solar radiation reaching them. They contribute significantly to outdoor discomfort in summer and to energy consumption for cooling buildings, whose walls are hit by an additional flux of longwave radiant heat.

During the rainy periods, on the other hand, they collect rainwater and, when there is heavy rain, the runoff can contribute to flooding in streets and squares.

The first, most effective way to reduce the heating effect and their contribution to street flooding is to reduce the need to pave. The second is to have pavements with high albedo and water permeability. One simple possibility is to use, for pedestrian reserved spaces or for parking areas, the kind of permeable pavements that allow vegetation to grow between the spaces, with a double dividend: attenuate both runoff and heating effect.

**Design suggestions**

◊ Use trees to shade pavements.
◊ Reduce parking space requirements, connecting parking and mass transit services and allowing for narrower streets.
◊ Increase the pavements' albedo, by mixing the binder with light coloured aggregates or by using permeable pavements with vegetation growing between spaces
◊ Make pavement pervious.

## Water bodies

Water bodies are widely distributed in the YDR as canals and small water ponds. They have several potential advantages for cooling the local environment due to their thermal and optical properties:

- The evaporation of water requires a high amount of energy, which is extracted from the air, thus lowering its temperature.
- The high specific heat of water delays and buffers the maximum temperature.

Combining these effects, a water body can be a little cooler than the surrounding urban environment in summer, and a little warmer in winter.

Thus, water bodies could have a positive effect upon the microclimate of the surroundings; in addition, they may play a crucial role in the local ecosystem.

On the other hand, water bodies increase local relative humidity, worsening the comfort conditions in summer. Moreover, water bodies may reduce the beneficial night cooling in summer, because of their high thermal inertia.

It should also be considered that water bodies, if not properly managed, could act as mosquito and other pest breeders.

**Design suggestions**

◊ Considering the multiple function that a water body can have (from leisure to productive, to environmental) analyse their functions carefully, in consultation with biologists, ecologists, agricultural experts, water treatment experts and hydrologists

## PRINCIPLE 4: GHG EMISSIONS

A complete analysis of a settlement's GHG emissions, i.e. including scope 3 emissions of the GHG Protocol, shows that a large proportion is due to those embodied in the material flow, i.e. the ones associated with the extraction, production, and transportation of products or services entering the settlement.

Part of these embodied emissions (also called indirect emissions, to distinguish them from the direct ones, the ones deriving from the operation of the settlement) can be controlled by the settlement's design, as they are affected by the design choices.

The largest proportion of embodied emissions consequent to the design choices is that deriving from the production of concrete, steel, glass, aluminium and fired bricks, which are the basic building materials for most modern constructions, and for infrastructures. These materials have very high environmental impact, consume a significant amount of energy and cause most of the GHG emissions of the construction sector[52]. Figure 2.17 gives some idea of the environmental impact of different construction materials, on the basis of their embodied energy, the amount of which is generally proportional to their $CO_2$ emissions.

As in many other contexts, and also in rural China, a dramatic change occurred in the building industry, with the introduction of industrial materials, which became dominant over traditional, place-based solutions[53]. This trend should be reversed and building materials like stone, timber, bamboo, stabilised compressed bricks, etc., which have low embodied emissions, should be favoured. They are consistent with the cultural heritage and can also be produced locally, reducing the need for transport energy and reinforcing the local economy.

A significant reduction in the indirect emissions due to building materials can also be obtained by minimizing the quantity of resources used. There is an inverse relationship, for example, between urban density and indirect GHG emissions, due to the fact that the lower the surface to volume (S/V) ratio of buildings, the lower the amount of material required for providing a given useful floor area (Figure 2.18), and the lower the amount of embodied GHG emissions.

A careful choice of building materials and of building shape is only one of the steps towards sustainable building design, as it is necessary to evaluate the entire building's life cycle (Figure 2.19), according to the principles of circular economy.

Thus, the use of materials and components that can be reused or recycled should be prioritised: the after-use phase of a building can have a significant impact on its total emissions budget, as depicted in Figure 2.20, showing the components of the overall GHG emissions of a building during its complete life-cycle, from emissions related to the before-use phase of the buildings, e.g. raw material extraction, transport, manufacturing and installation, to after-use activities such demolition or re-use, recycling and waste disposal.

It should be noted that, as the aim of a zero carbon village is to reduce to zero, or nearly zero, the amount of fossil energy needed for the operation of the buildings, the main impact of the building stock on global warming would be due to the embodied emissions, and their control becomes of paramount importance.

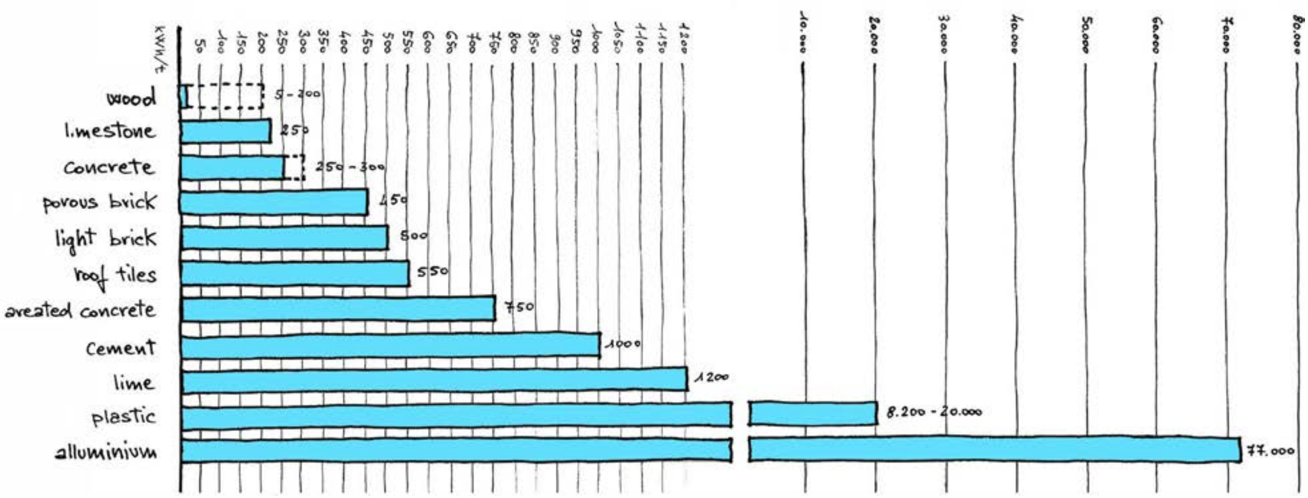



*Fig. 2.17 Embodied energy for selected building materials[79]*

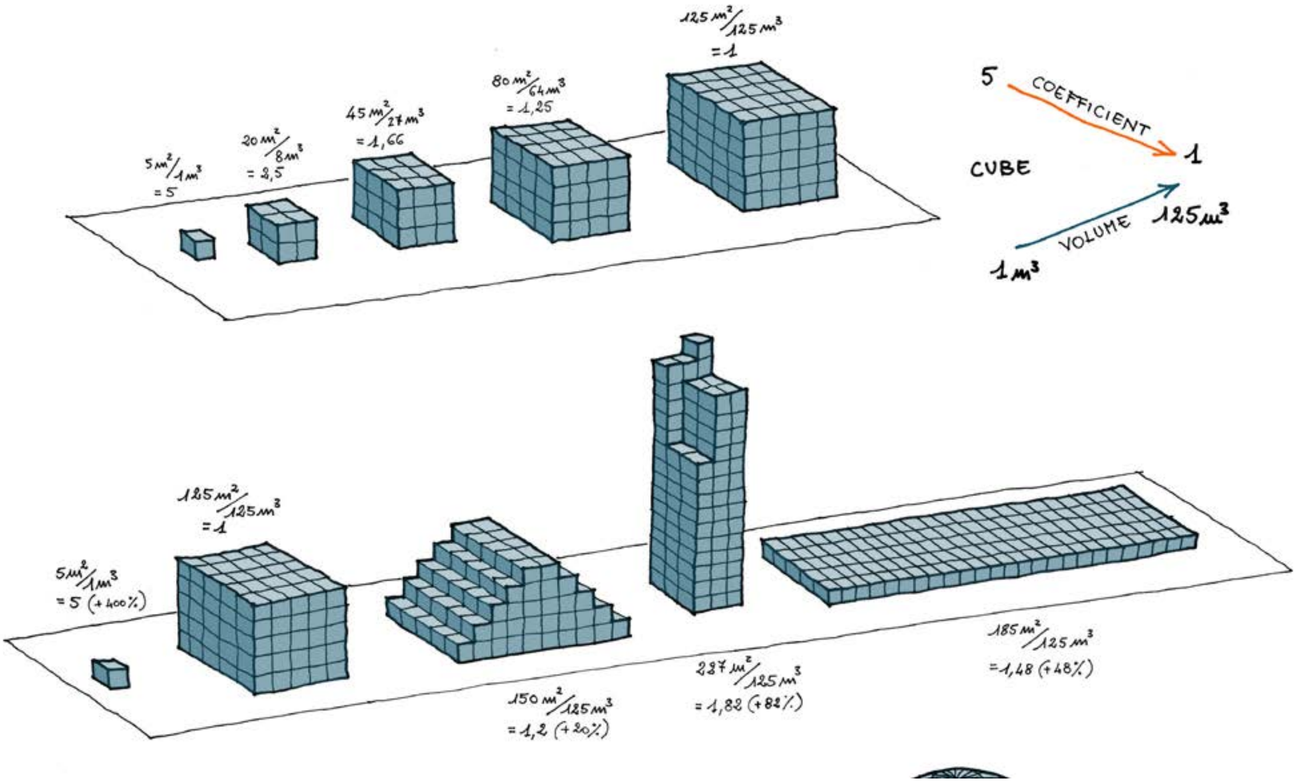



*Fig. 2.18 Variation of surface to volume ratio (S/V)) for increasing volume of a cube.*

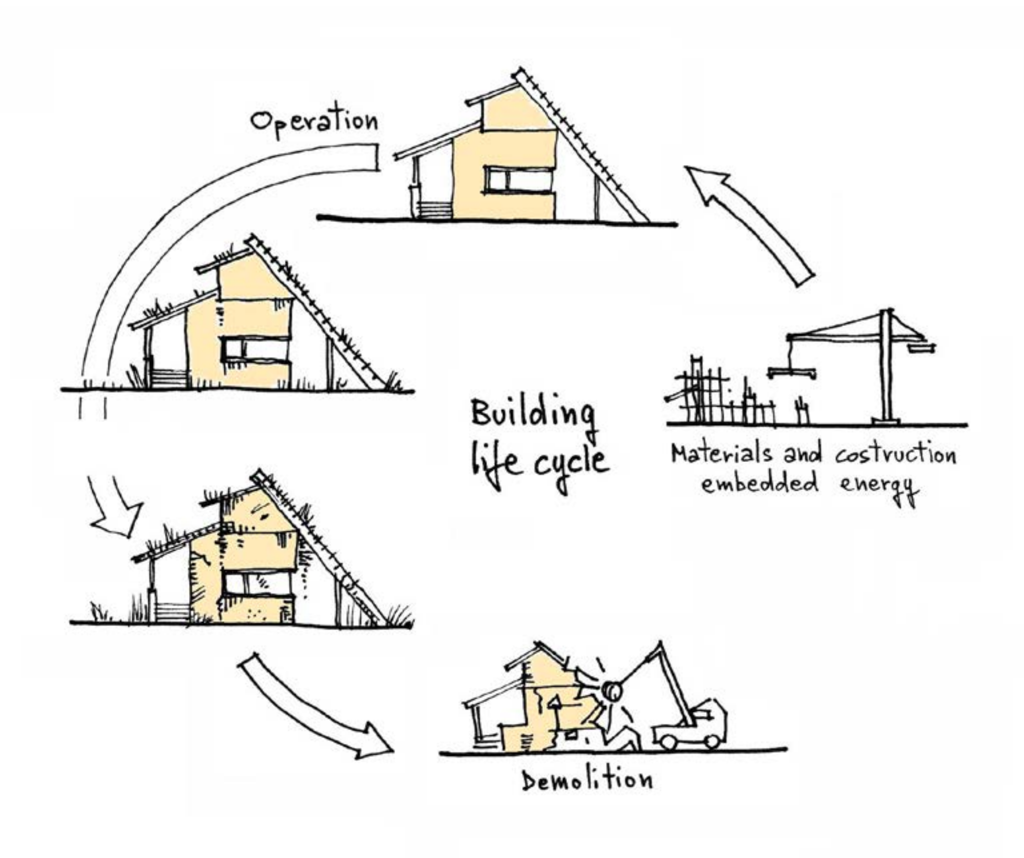



*Fig. 2.19 Building life-cycle*

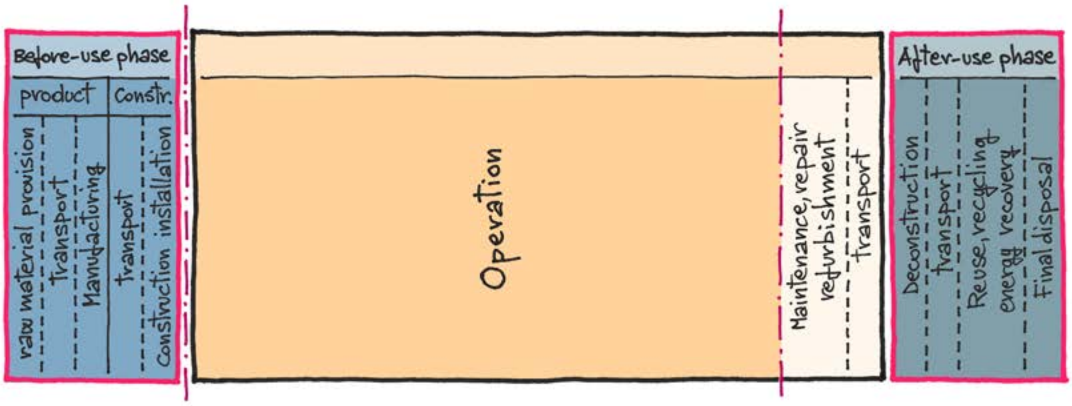



*Fig. 2.20 GHG emissions of buildings across their life-cycle[80]*

The way urban mobility is designed also affects embodied emissions. In fact, the more limited the use of private vehicles, because of an appropriate mix of functions, the less the need for private cars and thus the lower the overall amount of GHG emissions embodied in the village's fleet of cars. Moreover, a reduced number of cars reduces the road infrastructure needed, with a consequent reduction in the materials used, thus in indirect emissions.

In a more complete approach, even the energy embodied in durable goods (i.e. furniture, appliances, etc.) and less lasting items (i.e. garments, crockery and cutlery, etc.) should be considered, as the attitude to repair, recycle and reuse, will greatly contribute to the reduction of embodied emissions. At the same time, opportunities for economic diversification and new jobs will be generated at a local level.

**Design suggestions**

◊ Consider the full life cycle of the building when choosing the construction materials
◊ Minimize the use of construction materials, considering the compactness of buildings through the surface to volume ratio (s/v) indicator, trying to minimize it.
◊ Make choices that ensure reduction of scrap materials; this is very significant particularly for high embodied energy materials;
◊ Select low embodied energy materials and low energy construction systems. For example, use domestic, certified timber in place of concrete for beams, lime-pozzolana mortars in place of cement mortars, soil or stabilized soil blocks or sand-lime blocks over burnt clay bricks, gypsum and plasters over cement plasters. Use low-energy structural systems like load-bearing masonry in place of steel frames;
◊ Use naturally available materials, especially organic renewable materials like timber, trees, straw, grass, bamboo etc. Even non-renewable inorganic materials like stone and clay are useful, since they can be reused or recycled;
◊ Use durable materials and components. The utilisation of structural and functional durable components and materials allow long-term use as well as the reduction of maintenance and renovation and refurbishment costs during the lifetime of buildings;
◊ Use locally available materials and technologies, employing local work force;
◊ Use materials with more reusable and recyclable potential; pure material like bricks, wood, concrete, stone, metal sheets are the most suitable for this purpose. Composite materials like prefabricated solid foam-metal or foam-plaster elements are difficult to separate and to recycle;
◊ Plan the recycling or salvaging of at least 50% of construction waste[54].
◊ Use industrial waste-based bricks/blocks for non-structural or infill wall system;
◊ Reuse/recycle construction debris;
◊ Use products and materials with reduced packaging.

## PRINCIPLE 5: RENEWABLE ENERGY SOURCES

Energy efficient conversion technologies are a prerequisite for the extensive use of renewable energy sources because, in order to have a cost-effective village energy system, the more efficient and appropriate the energy conversion technologies, the less the energy required to fulfil a given task and the smaller (and cheaper) the production system providing the necessary renewable energy.

### Efficient Energy conversion technologies

In the climate of the Yangtze River Delta, given the need for both heating in winter and cooling in summer, the most efficient technology for providing indoor comfort is the heat pump, exchanging heat with water bodies or groundwater. If a nearby water body is not available, and underground water is not easily reachable, ambient air can be used as a heat sink in summer and a heat source in winter, and still give good efficiency. Even if water that can be used as heat sink/source is available, a cost-effectiveness comparison between the water-to-water and the air-to-water systems is recommended.

Air to air heat pumps may be especially suitable in buildings or dwellings occupied occasionally or only for some part of the year, such as hotels and accommodation for tourists.
Heat pumps should also be used for hot water production, either as part of the heating/cooling system or with independent devices.

These considerations, however, do not give the complete picture, as the efficiency and the emissions of the national electricity production and distribution system also have to be considered. If electricity is produced mainly with coal, for example, heating with gas boilers would produce less emissions than electricity fuelled heat pumps. This would not be the case for zero carbon villages, as the electricity they use should derive only from renewable energy sources. Another possible drawback of heat pumps is the leakage of the refrigerant gas into the atmosphere. As refrigerant gases have a very high greenhouse effect, their management along the whole lifecycle of the heat pump must be assured.

In such a context - where gas or oil is no longer used for heating, the heat pump being more efficient - cooking should also shift to electricity, but not with resistance electric stoves and cookers, but with the more advanced and more efficient induction stovetop and range, which is also more efficient than the gas cooker.

Solar thermal domestic water heaters, which have been widely installed in the Yangtze River Delta region, may still have their place in the transition to the zero carbon village, but eventually they will have to be progressively replaced by the heat pump water heaters powered with renewable electricity. Electric resistance water heaters should have no place at all.

Energy efficiency also applies to means of transport. Electric vehicles are the most efficient, because the electric motor is far more efficient than an internal combustion one. Moreover, while a combustion engine emits GHG gases ($CO_2$ and NOx), the electric motor emits none. However, the same consideration as for heat pumps applies to electric vehicles: their GHG emissions are lower or higher than those produced by internal combustion vehicles in relation to the fuel mix used to produce the electricity supplied by the main grid. In a zero carbon village, where all the electricity used, including that used for charging the batteries of electric cars, is produced with renewable energy sources, only electric vehicles should be allowed.

The production of electricity by burning a fuel at high temperature, with a thermodynamic cycle, necessarily implies the production of heat at low temperatures (70-90 °C). If this heat is used for space heating and/or hot water production, instead of releasing it into the atmosphere or water bodies, the overall efficiency of the system is significantly improved. This technological approach is named cogeneration, or CHP (Combined Heat & Power), and could be appropriate for hotels or for industrial processes requiring low-medium temperatures, such as the ones typical of agro-industry.
In a zero carbon village the fuel used for fuelling a cogeneration plant must be renewable, i.e. biomass. The biomass can be transformed into biogas or syngas supplied to an internal combustion engine or a gas mini-turbine.

Biomass fuelled CHP systems could be appropriate for industrial processes requiring low-medium temperatures, such as the ones typical of agro-industry, and for buildings requiring heating in winter and cooling in summer, such as hotels and office buildings, because the low temperature heat can produce cooling by feeding absorption chillers.

Alternatively, during mid-seasons and in summer only or during the whole year, waste heat can be used for producing potable water from treated waste water by means of distillation.

In conclusion, the maximisation of energy conversion technologies for supplying a zero carbon village necessarily leads to a shift towards the electricity fuelled ones and, whenever possible and appropriate, to CHP (Figure 2.21).

**Design suggestions**

◊ Consider that in the medium-long run the only energy vector in the village will be electricity, possibly complemented with heat produced by a biogas or syngas fuelled CHP system, thus a natural gas network would become obsolete

## Renewable energy sources

The use of efficient energy conversion technologies, in a zero carbon village, is a necessary condition but is not the only one. The other condition is the production of the renewable energy that has to feed them.

Thus, the next step is to identify the renewable energy sources available within the borders of the village, whether the administrative or physical borders – as previously pointed out – including the non-built areas surrounding it.

The potential for renewable energy sources depends on the technologies used (Figure 2.22), on climate, on the design of the village and on the characteristics of the surrounding land. The potential for solar and wind energy depends on the availability of solar radiation and wind, but also on the number of suitable surfaces that can be covered with solar panels and on the texture of the settlement, as this affects wind velocity. Biomass potential depends on the village design, as it may include wood and leaves from the pruning of trees in the green areas, and in the streets, and from kitchen gardens. It also depends on the type of wastewater treatment system. The surrounding land (use and topography) could contribute to the renewable energy potential not only through the agriculture residuals, but also through biomass deriving from the management of nearby forests (silviculture) and through the hydropower if permanent or seasonal water flows are present or there are water reservoirs.

Agriculture residuals and livestock wastes can also be used as renewable energy sources.

The use of renewable energy technologies is a very challenging issue for the design of a zero carbon village, as it may impose significant constraints on the design of new developments. PV systems, for example, may limit the height of zero energy buildings (see BOX – Maximum height of a zero-energy building); the reason is that there is a relationship between the building's energy demand, the size of the PV system required to supply it, and the roof area available to install it. This relationship may affect the density of the settlement.

PV systems could be used for supplying electricity to fleets of electric cars, and the ideal would be to park these cars in dedicated outdoor parking plots equipped with PV canopies; in this case the challenge is to optimise the size and the position of the parking lots in relation to the number of cars and of the PV area needed to charge them.

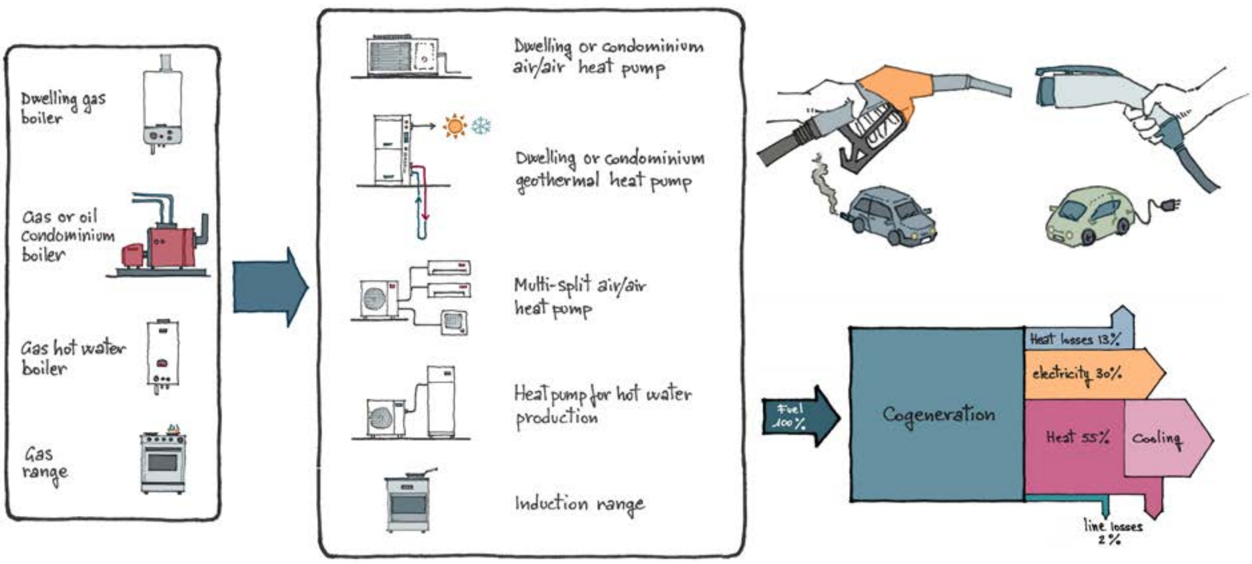



*Fig. 2.21 Shift towards electricity driven energy conversion technologies and CHP.*

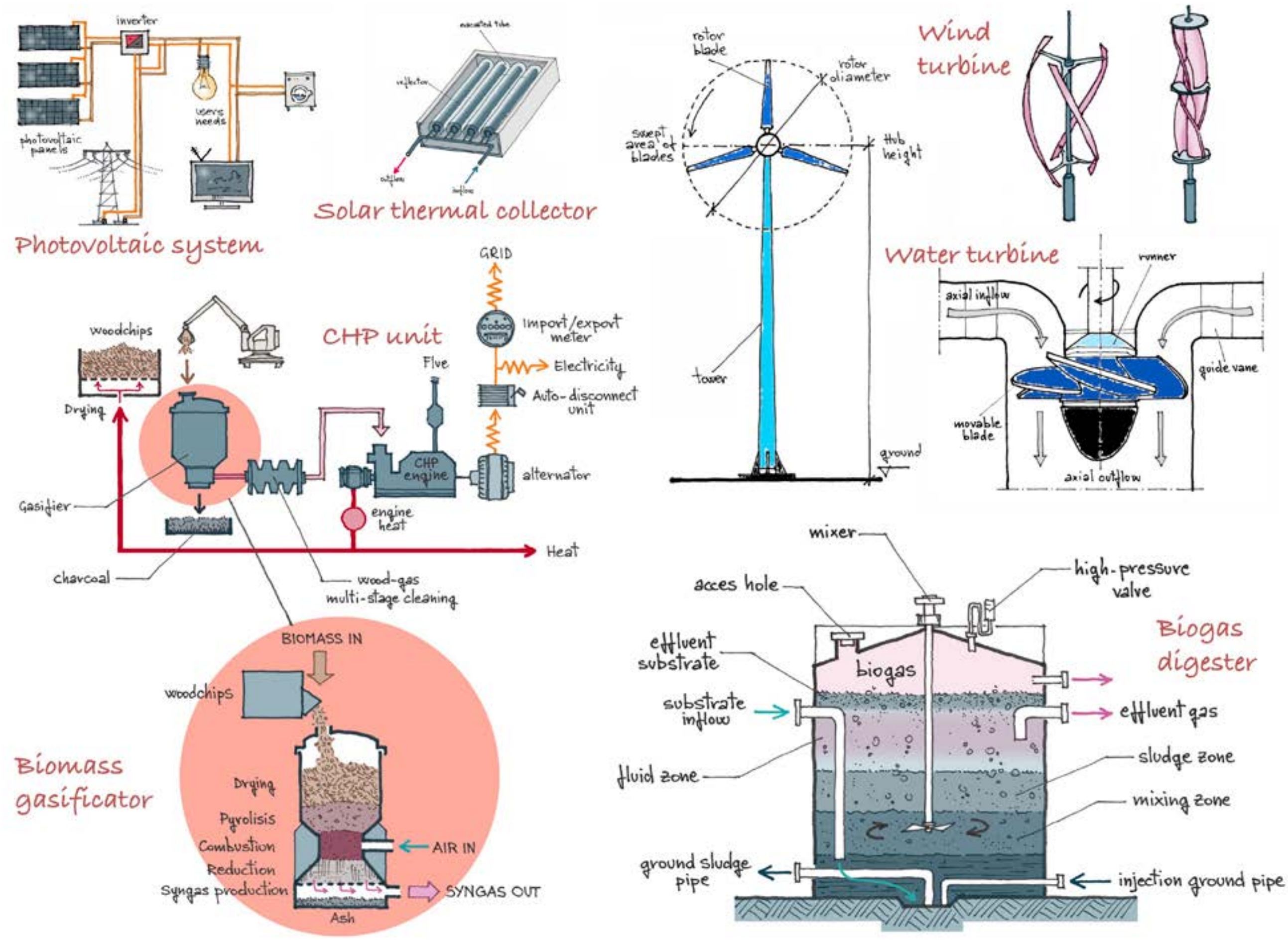



*Fig. 2.22* *Renewable energy technology suitable to supply a zero carbon village: Solar PV, solar thermal, mini and micro wind turbines, mini hydro plants, biomass gasification unit combined with an internal combustion engine driving an alternator for providing electricity and heat, biomass digesters for biogas production from sewage water and food waste, to be used also in a CHP system.*

## MAXIMUM HEIGHT OF A ZERO ENERGY BUILDING IN A VILLAGE WITH THE SAME CLIMATE AS SHANGHAI

Example:

a) highly efficient building (European Class A standard) with 100 m$^2$ apartments,
b) household electricity consumption (plug loads only) as in the European best practices (Germany and Italy),
c) electricity for cars not produced in the village,
then the overall (plug loads + heat pumps for heating, cooling and hot water + cooking with induction cooktop) household electricity consumption would be between 4,500 and 5,000 kWh/year. Figure 2.23 shows that the maximum number of floors compatible with the condition of zero carbon buildings is 5. If also the electricity consumption of electric vehicles is included, the maximum number of floors is 4 or less.

In case of smaller area dwellings, the maximum number of floors decreases.

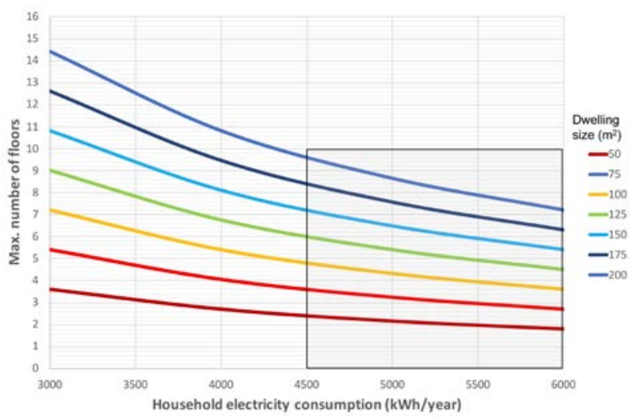



*Fig. 2.23* *Relationship between annual electricity consumption of an average dwelling in a building and the maximum number of floors in the same building for balancing the annual consumption of all dwellings, for different dwelling sizes. Calculation for Shanghai (Pudong Airport) solar radiation data.*

Biogas production from liquid organic waste requires appropriate design of the sewerage and provision for the necessary space to accommodate the anaerobic digestion plant or, alternatively, individual digesters for each building.

Syngas production requires space to be allocated not only for the gasifier, but also for wood storage and pre-processing.

Electricity production from solar and wind energy is not programmable, as PV systems cannot produce at night and both PV and wind systems produce more or less electricity according to the meteorological conditions; it is very unlikely, thus, that instantaneous demand and power supply match. This is the main limiting factor of self-consumption, defined as the amount of renewable electricity consumed while it is being produced. Even if the annual amount of renewable energy produced equals the annual consumption, it is necessary to store energy when production exceeds consumption and to recover this energy when consumption exceeds production.

The easiest solution is to be connected to the main grid, which provides power when the renewable production is insufficient and absorbs power when production exceeds demand. Then an economic problem in managing the system arises: usually – unless the PV produced is temporarily incentivized – the renewable electricity given to the grid is paid for at far less than the electricity taken from the grid. In order to minimize this imbalance, self-consumption must be maximised by means of storage systems.

If a connection to the main grid is not available or the power supply is unreliable, there are two options, which can be used in combination. The first option is the storage of electricity by means of batteries, or other technology, such as pumped hydroelectric storage, or flywheels, or compressed air; this storage can be either concentrated or distributed, i.e. with individual batteries in each house and connecting electric car batteries to the mini-grid, using them as energy source when the car is idle. The second is to have a backup provided by a generator supplied with programmable energy sources, such as fossil fuels or biomass, which intervenes as the main grid would do. A control system is necessary for the management of both the storage option and the generator, to regulate their output so that instantaneous power demand is met by the corresponding instantaneous power production.

The same options can be usefully adopted for maximising self-consumption when the connection to the main grid is available and reliable.

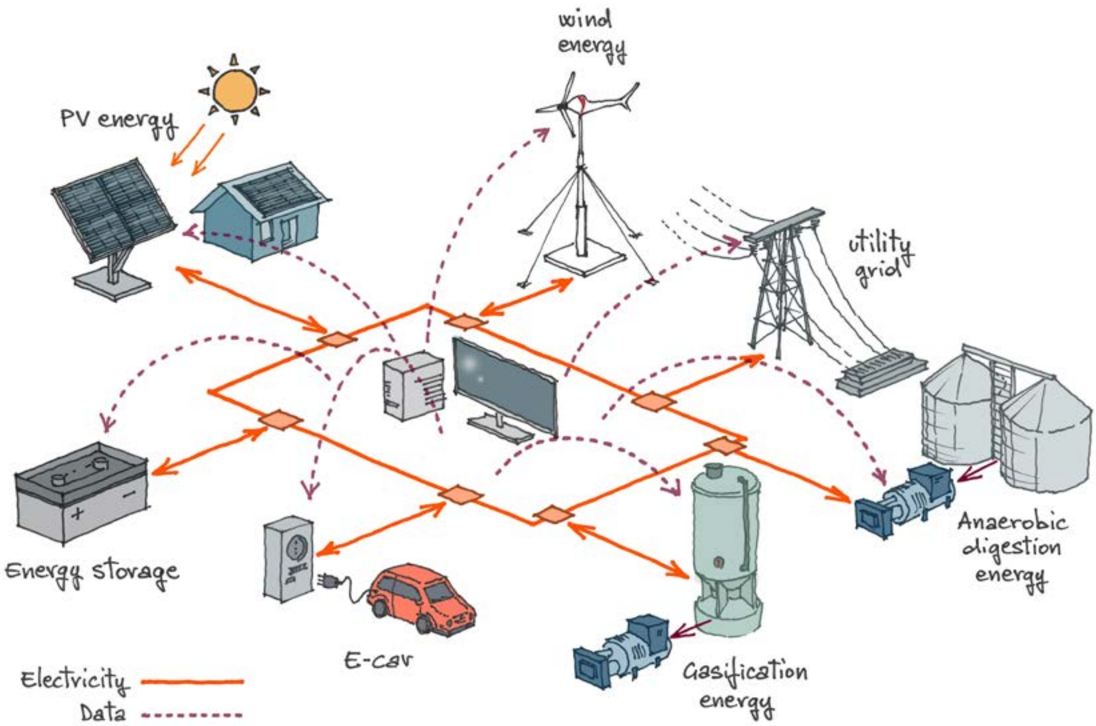



*Fig. 2.24 Concept of a mini-grid*

### Smart grid

All these options should be complemented by a system capable of controlling the electricity demand, creating a sort of virtual storage by interrupting the power to heating or cooling systems, for example, for a few minutes. In this way no change can be perceived by final users in terms of thermal comfort, but for the same period some extra power is made available for other loads of the grid, avoiding the purchase of power from the main grid or the discharge of the storage.

Mini-grids, or micro-grids, and smart grids derive from this approach, and they are defined as local energy systems of distributed energy resources, distributed consumers and storage.

A microgrid designed for a zero carbon village includes programmable and non-programmable renewable generation, energy storage facilities and load control (Figure 2.24). This system is scalable, which means that growing loads may require the installation of additional generators without any negative effect on the stable and reliable operation of the existing microgrid.

Diversity of building functions (mixed land use) and socio-economic diversity make a positive, very important, contribution to the development of cost-effective mini and micro grids and to their resilience. The increased cost-effectiveness is due to the fact that such diversity allows the daily electricity load patterns to be smoothed, thus reducing the size of the storage needed, as the load moves from productive/services uses to residential uses, when people go home from work. Socio-economic diversity also helps, as it means there is a variety of behaviours.

The increased resilience of the local energy system derives from the variety of renewable energy sources and technologies used. For this reason, reliance on a single renewable energy source is not a wise option, and a resilient settlement's energy system should be designed including as many sources and technologies as possible, and the provision of some excess installed power is recommended.

**Design suggestions**

- ◊ Minimize dependence on a greater municipal grid for the energy needs of the community. Take advantage of onsite renewable resources to generate the energy required to make the village operate
- ◊ Consider that small scale (micro and mini) wind turbines, if local wind potential is sufficiently high, are a great opportunity if coupled with pv panels, because they complement solar production when the sun is not available and they reduce back-up power needs.
- ◊ Consider biomass fuelled CHP production based on gasification process with wood coming from surrounding forest management and/or complemented by street and park tree pruning.
- ◊ Consider biogas production. Bio-digesters using organic waste products are another frontier for achieving local self-sufficiency by using the gas for fuelling a chp system
- ◊ Consider the possibility of establishing a smart-grid system at the village scale. Smart-grids or micro-grids are a great option not only when a reliable centralized energy network is lacking or unreliable, but in any case, because it is the prerequisite for a zero carbon village.
- ◊ Consider that biomass fuelled chp systems, being a potentially programmable energy source, could have the function of energy storage, reducing the need for battery or other kinds of energy storage.

## PRINCIPLE 6: WATER CYCLE

All through the last century water has usually been subject to a linear process: (i) catchment, (ii) transport to the settlement, (iii) treatment to make it potable, (iv) capillary distribution to each apartment via a network, (v) disposal of waste water through individual collection systems connected to the settlement's sewerage network, (vi) conveyance to a centralized wastewater treatment plant, from which two products derive: water clean enough to be acceptable for discharge into the sea, a lake or a river, and a sludge that, dehydrated, can be disposed of in a landfill or burned in an incinerator.

With a growing population, the demand for water has been rising and more and more often water shortages are being experienced, because of the linear approach used in settlements' water management: the more people, the higher the demand, the higher the supply from aqueducts or wells. In turn, the growing demand is not satisfied because of the natural limits of the source, the capabilities of the infrastructure and the effects of climate change, which has made the usual supply systems unreliable, because of changes in both the precipitation pattern and river flow which affects water reservoirs.

This linear approach is not consistent with a zero carbon village, not only because of the above mentioned reasons, but also because the usual water system requires energy for pumping, distributing potable water and treating wastewater, but it is not capable of recovering the energy potential of wastewater. Instead, a circular approach, instead, should be adopted.

We must view water as part of a circular economy, where it retains full value after each use and eventually returns to the system: a system in which water circulates in closed loops, allowing repeated use. A safe, sustainable and resilient village should be able to rely mainly on rainwater and treated wastewater for providing, at different quality levels, all the water necessary to fulfil the communities' needs, based on the cycle depicted in Figure 2.25.

Sustainable water management embraces:

- conservation of water sources;
- use of multiple water sources including rainwater harvesting, storm water management and wastewater reuse;
- treatment of water to the extent it is needed, exploiting the energy that wastewater can produce for the benefit of the village and the nutrient potential of wastewater for the benefit of agriculture.

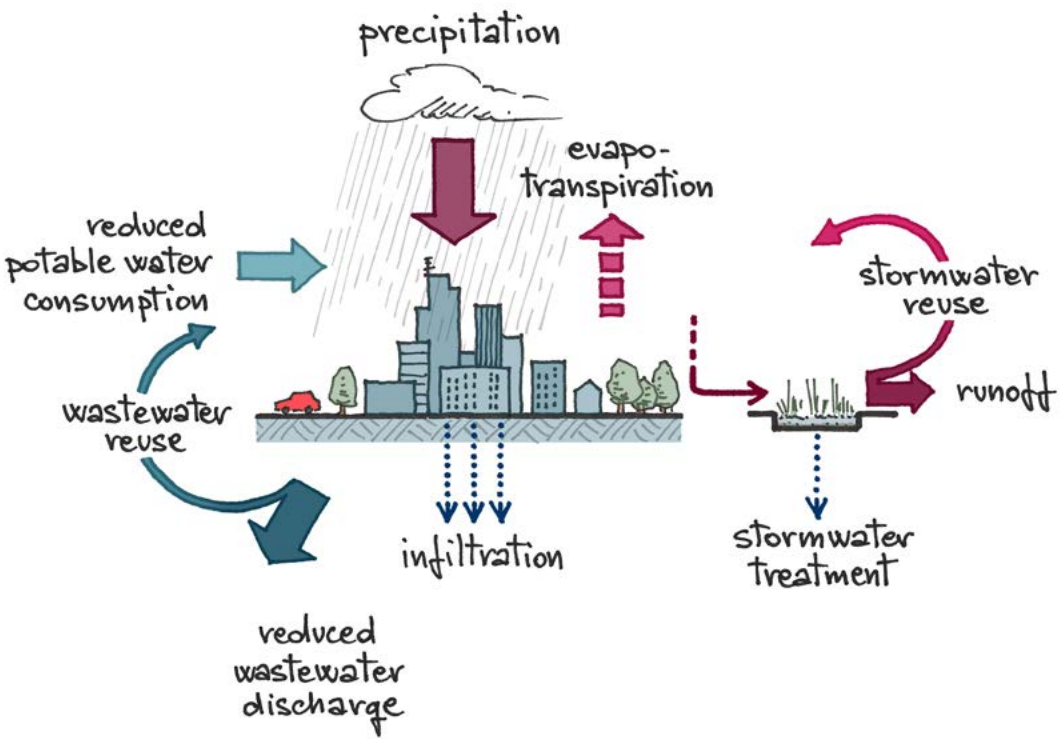



*Fig. 2.25 The ideal water cycle of a settlement*

## Rainwater harvesting

Rainwater is a free source of nearly pure water, and can be harvested from:

- rooftops.
- paved and unpaved areas, i.e. storm water drains, roads and pavements and other open areas.

Rainwater harvesting is an important water source at the building level, and in many cases could meet all the water needs of a building, or a village; part of the rainwater harvested can be conveyed to wells for groundwater recharge (Figure 2.26).

If the entire demand for water of a building is to be met with rainwater, there is a limit to the maximum building height – in the same way there is for energy self-sufficiency - deriving from the balance between water demand and water collection; high-rise residential buildings provide a small roof area/water demand ratio, so that the amount harvested is insufficient to meet the demand.

With a few exceptions, rainwater collected contains impurities. Once rain comes into contact with a roof or collection surface, it can wash many types of bacteria and other contaminants into the cistern or storage tank. If rainwater is for potable use, it needs to be treated (Figure 2.27).

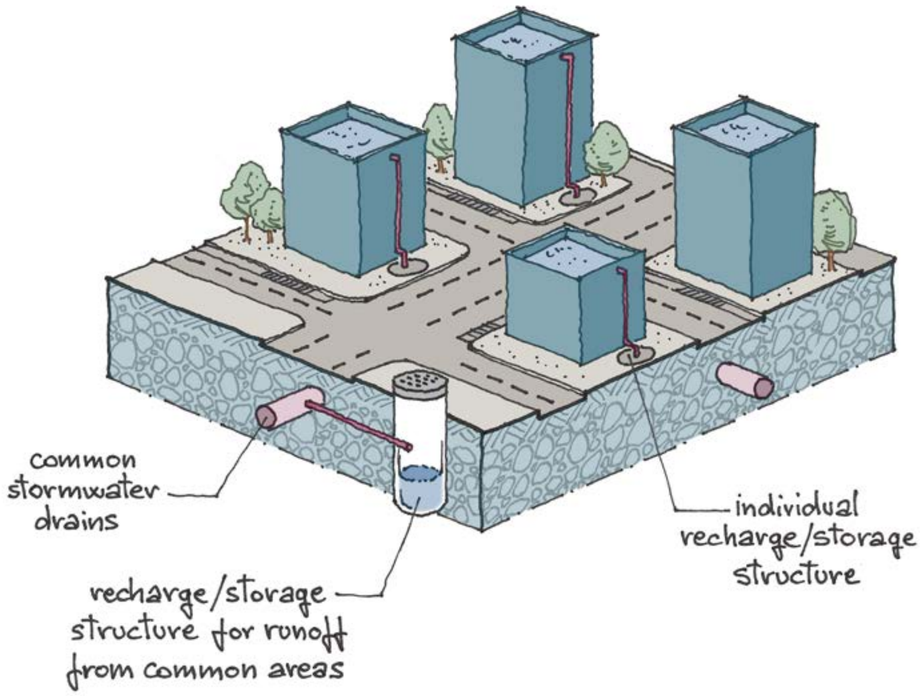



*Fig. 2.26 Rooftop rainwater harvesting system*

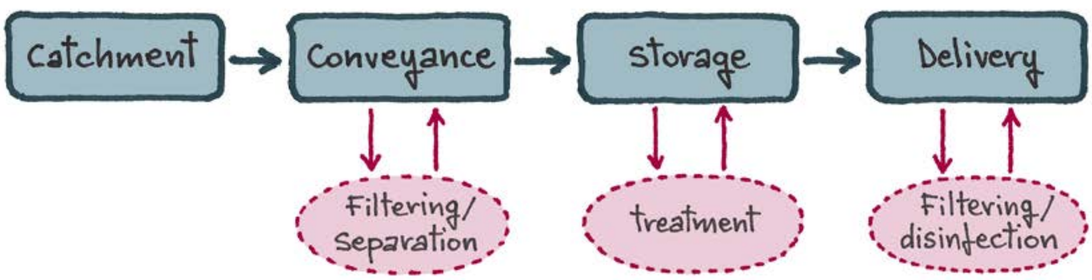



*Fig. 2.27 Rainwater harvesting: process diagram for drinking water*

At village scale a rooftop rainwater collection system with a single large common storage tank should be considered, as part of the village's infrastructure, as well as a filtering/disinfection system for making stored rainwater potable. The advantages, compared with individual storage tanks, could be in the lower cost of storage and maintenance, and in the possibility of obtaining safer water quality, as skilled operators can manage the water treatment system.

If potable water is available through an existing centralized network, rainwater should be considered for non-potable uses, so reducing the flow of potable water that needs to be provided to the settlement, with the consequent economic benefits deriving from smaller piping.

This use of rainwater implies the need for separate piping for non-potable water uses, whose cost could be entirely or partially offset by the savings deriving from the smaller size of the piping required for the potable water network.

### Runoff

Runoff is that component of rainwater which flows over a surface and out of the catchment area: it is generated when the intensity of the rainfall reaching the ground exceeds the infiltration rate of the soil.

Runoff in rural areas or in parks is a very limited part of the rainfall, as the infiltration rate is high; the opposite occurs in built-up contexts, due to the large extent of impervious surfaces (Figure 2.28).

Usually, storm water conveyance systems are designed to convey the rainwater that falls in the catchment areas to the nearest storm water drain or to the sewerage.
In order to reuse this water later on and to avoid overloading the sewerage, collected rainwater should instead be directed to a recharge structure, to restore aquifer extraction potential.

Alternatively, or in conjunction, aquifers can be recharged by collecting intercepted storm water, slowing it down,

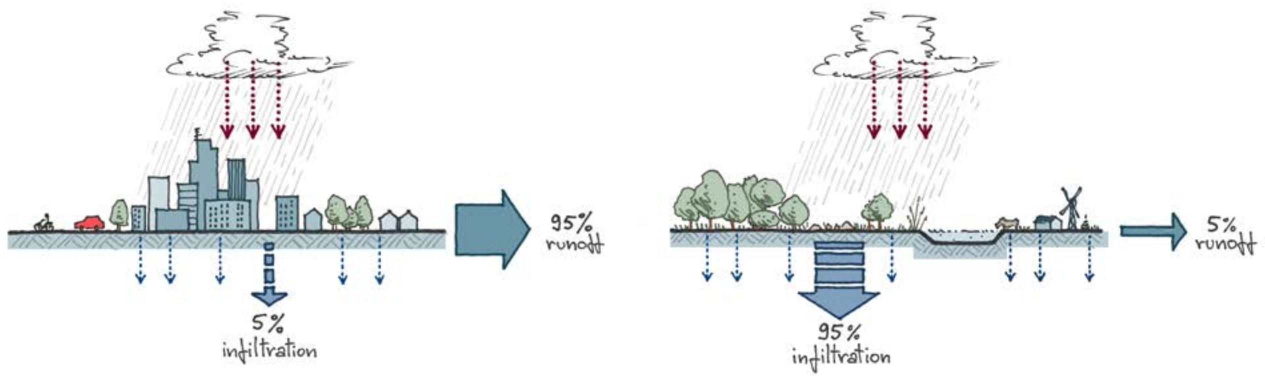



*Fig. 2.28 Runoff percentage in urban (left) and rural (right) context. The values are indicative and represent the opposite extremes.*

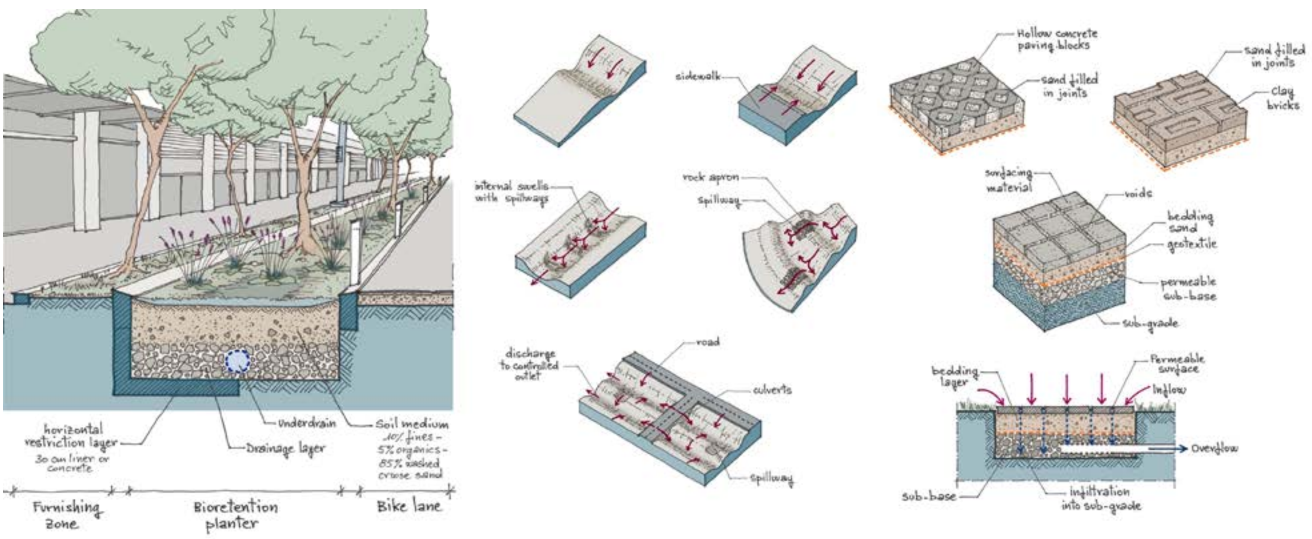



*Fig. 2.29 Microbasins, swales and porous pavements*

and retaining or routing it through the site's landscape using micro basins, swales and other water harvesting structures, such as porous pavements (Figure 2.29).

Capturing and using storm water runoff also reduces site discharge and erosion. A village appropriately implementing the above techniques for managing storm water and runoff fulfils the principles of the urban water management programme called "Sponge City" put forward in China in 2014. A sponge city, or in general a sponge settlement, is designed in such a way as to make sustainable drainage systems possible (Figure 2.30). The aim of sustainable drainage systems is to relieve the load on the sewer system, reuse/recycle storm water as a contribution to the closure of the water cycle, with the added advantage of reducing the risk of floods and water damage.

### Decentralized wastewater management

Wastewater produced by households is usually subdivided into black water, grey water and storm water (Figure 2.31). Black water is the wastewater from the toilet and the kitchen sink; grey water consists of the wastewater from washing/bathing and the washing of clothes.

What usually happens, when a sewage network exists, is that the three sources of water are all conveyed to the sewage, mixed, and then sent to the centralized wastewater plant. It would be far better to collect rainwater separately and to treat grey water locally, which requires a simple process because of its low level of contamination, and reuse it locally for non-potable uses such as toilet flushing, laundry washing, plant watering, etc. The reuse of both rain and grey water has the potential to reduce the demand for a new water supply, reduce both the carbon and the water footprint of water services, and meet a wide range of social and economic needs. In particular, it can help reduce the demand for more costly high-quality potable water.

On the other hand, the reuse of grey water and/or the direct use of rainwater requires dedicated piping, other than the usual one for potable water. A dual piping system, of course, is more expensive than a single one.

The treatment of black water, mixed or not with grey water, is a more complex issue, because there are also health hazard implications. The current trend is to centralize the treatment systems: when many small villages are scattered in a territory, usually their wastewater is conveyed to a single treatment plant. Conventional wastewater treatment plants require a significant amount of energy.

A sustainable alternative to centralized wastewater treatment plants is a decentralized, village scale, water treatment system such as the DEWATS (Decentralized Wastewater Treatment System), or other systems based on the same basic principles. DEWATS is a modular system approach which ensures efficient performance in wastewater treatment and allows the on-site closure of the water cycle. In addition, it is an approach that does not necessarily have highly skilled manpower and maintenance requirements (but has high quality standards in planning and construction) and its energy demand is far less than conventional treatment systems. An indirect advantage of the system, thus, is that it creates employment opportunities for low skilled workers, which is consistent with the requirement of mixed income, that has been highlighted in Principles

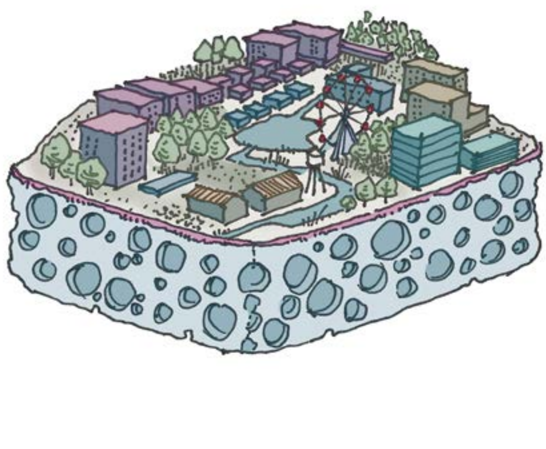


*Fig. 2.30 Concept of sponge village*

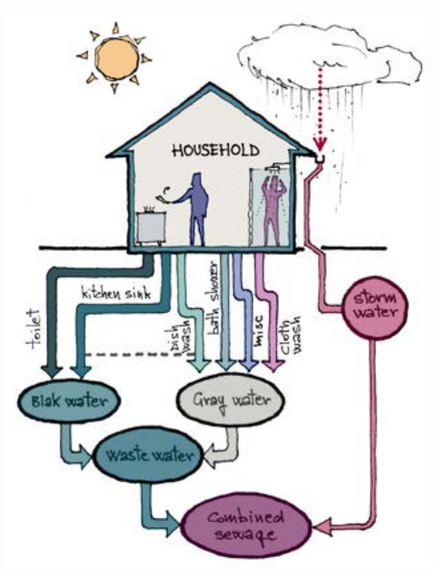



*Fig. 2.31 Concept of sponge village*

2 and 5 and that will be further discussed in Principles 9 and 10.

Typical DEWATS applications suitable for wastewater treatment at village scale are based on three basic modules, which are combined according to demand (Figure 2.32):

- primary treatment in septic tanks, Imhoff tanks, or bio-digesters (the benefits of anaerobic digestion of sewage sludge are widely recognised and the technology is well established)
- secondary anaerobic treatment in baffled reactors (baffled septic tanks) and fixed-bed filters
- tertiary aerobic treatment in sub-surface flow filters constructed wetlands (horizontal gravel filters)

A post-treatment in aerobic polishing ponds may be considered according to the final conditions of effluents and their intended use.

DEWATS is just an example. Other, technologically advanced systems for decentralized wastewater treatment are available, and should also be considered, provided that they produce biogas, allow the use of digestate for agriculture purposes, allow the reuse of treated water and do not require much energy to be operated.

Sludge derived from wastewater treatment is rich in nutrients and can be used as fertiliser in the form of a solid product, after it has been dewatered, dried and/or composted. Treated domestic or community wastewater is suitable for irrigating parks, flower

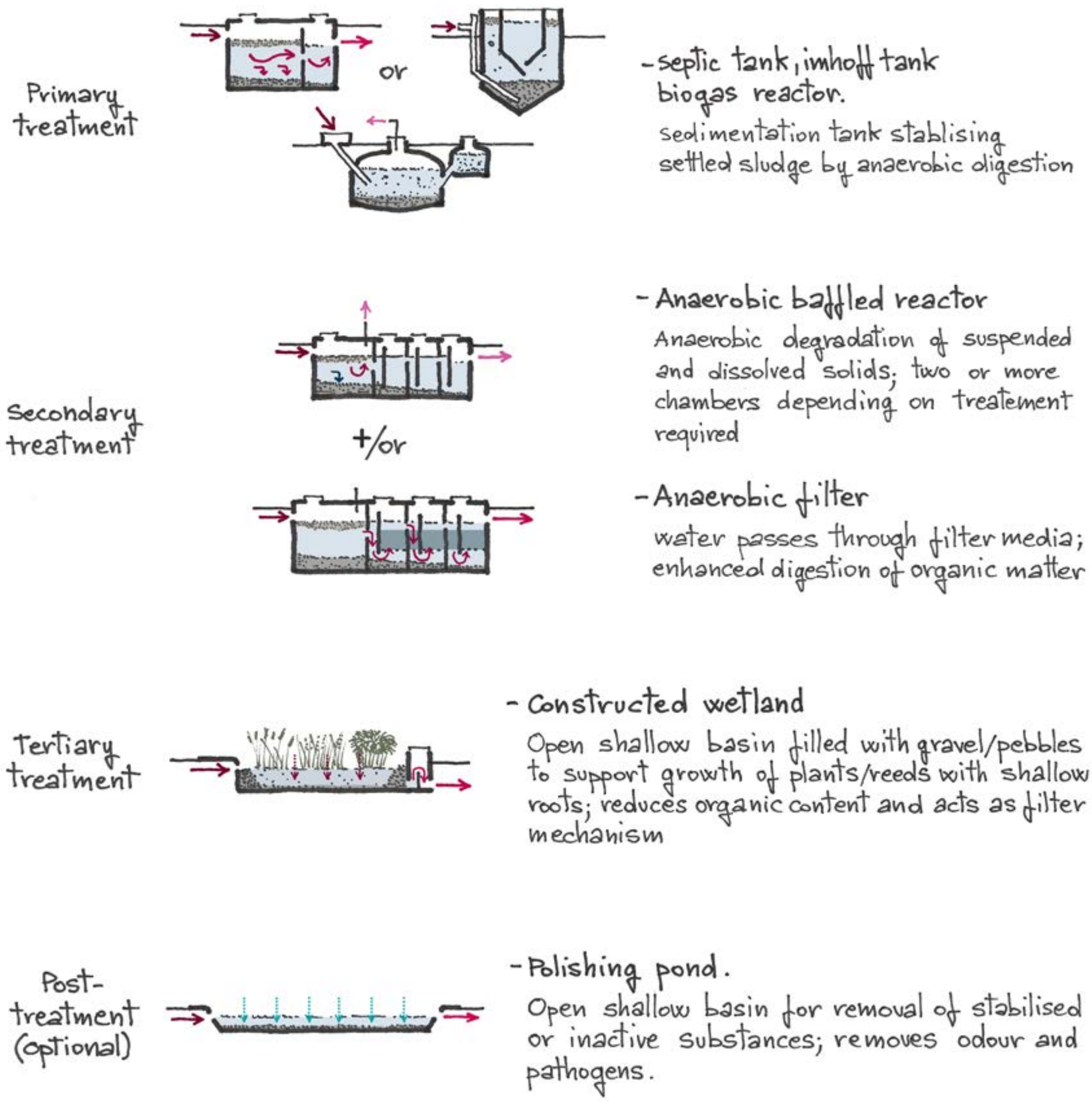



*Fig. 2.32 DEWATS configuration scheme suitable for small-scale decentralized wastewater treatment[81]*

gardens and agriculture plots around the village, thus reducing dependence on potable water, provided that compatibility between the pathogen content and the kind of agricultural products being fertilised can be guaranteed, i.e. that no health hazard derives from this practice.

Irrigation water percolates through the soil, contributing to aquifer replenishment. Recharge of groundwater is probably the best way to reuse wastewater, as groundwater tables tend to be lowered almost everywhere.

Wastewater was once freshwater, and freshwater drawn from wells has previously been groundwater. Sustainable development is directly related to the availability of water from the ground. Thus, the recharging of this source becomes absolutely vital. The main question is to what extent the wastewater needs treatment before it can be discharged into the ground. Due to the high risk of groundwater pollution, this topic is very delicate and needs to be handled with the greatest precaution.

In a sustainable water cycle at village scale the following water flows have to be considered and combined:

1. Potable water flow from a centralized network, if any
2. Potable water flow from common village wells
3. Roof rainwater flow to storage
4. Rainwater flow, from storage to domestic uses, i.e. WC flushing, washing machine, irrigation
5. Rainwater flow from storage, filtered and disinfected to make it potable, for domestic uses, i.e. kitchen and bathroom taps
6. Roof rainwater flow diverted for recharging groundwater aquifers
7. Stormwater flow collected from impervious surfaces to storage or for recharging groundwater aquifers
8. Wastewater flow from households to the treatment system (could be two separate flows, if black water and grey water are not mixed).
9. Treated wastewater flow to green areas (parks, street greening, around-the-village agriculture etc.)
10. Treated wastewater flow to recharge wells or recharge basins
11. Treated wastewater flow to water bodies (alternative to flows 9 and 10)

Flows 2, 3, 4 and 5 could be used as a substitute, partial or total, to the conventional potable water network. The extra cost due to the piping to and from the storage and the piping for non-potable water (dual water system), plus the extra cost of filtering/disinfection devices, could be counterbalanced by the savings obtainable by not having the connection to the centralized water network or, if connected, because of the average smaller piping diameter of the connection. Such a distributed, local provision of water would also be far more resilient than the usual, centralized system.

The extra cost of recharging the aquifer with both the excess roof rainwater and storm water is counterbalanced by the consequent high reliability of the water system and by the effective defence against flooding.

**Design suggestions**

- ◊ Minimize dependence on centralized network for the water needs of the village. Collect rainwater on rooftops and store it for non-potable uses such as flushing toilets and onsite irrigation; use bio-swales and surface systems instead of storm drains whenever possible.
- ◊ Consider the community self-sufficiency chance offered by rainwater harvesting and local village scale treatment to make it potable
- ◊ The location and design of public open space, where it incorporates water management measures, should promote the detention of run-off through the use of swales, depressions, contour banks, rock channels, pebble paths, reed beds or other suitable measures without compromising the principal function of the public open space
- ◊ Streets should all include runoff mitigation systems such as swales or other pervious surfaces capable to absorb and store storm water. Hence, provide enough extra space for hosting sustainable urban drainage systems
- ◊ Try to have the largest pervious areas possible, as they reduce runoff, and thus the flooding danger
- ◊ Consider the importance of the potential contribution of biogas production from wastewater to the renewable energy system, not much for the amount but mainly for its capability to produce electricity on demand, thus improving the micro-grid self-consumption share
- ◊ Consider decentralized wastewater treatment as a sustainable option increasing the community resilience and offering employment opportunities, because wastewater is a resource, in terms of energy, soil nutrients, irrigation and water tables replenishment via percolation and this resource is best exploited at local level.
- ◊ Consider the need for closing nutrients cycle, i.e. That the ones contained in the wastewater should always be returned to the soil used for providing food
- ◊ Treat and reuse at least 50% of wastewater on-site[55].
- ◊ Evaluate the threat to health that may derive by the possible contamination of water table caused by incompletely treated wastewater. Involve hydro-geology and water-borne diseases experts.

## PRINCIPLE 7: SOLID WASTE

Modern societies are suffering from the problem of waste more and more. Waste management constitutes a huge cost, both economic and environmental.

Waste can be subdivided into two main streams, according to their nature: inorganic and organic waste.

### Inorganic waste management

Per capita, inorganic solid waste, has been growing as a consequence of four factors: a) improved economic conditions, b) a sharp increase in goods available on the market which are mostly fashionable, useless after a short time and thus discarded, c) single use goods and d) packaging.

The very first action about waste management should be – according to the principles of circular economy – a reduction in the inflow of goods, which is the primary cause of the waste flow.

A zero carbon village, to be sustainable and capable of showing how a harmonious coexistence between humans and nature can be achieved in the process of improving the quality of life, should implement several actions with the aim of reducing inorganic waste.

For example, packaging can be reduced by encouraging the sale of products in bulk; reuse can be encouraged by implementing a bottle and can deposit return scheme; the repair of appliances and clothing can be encouraged in several ways, at the same time creating new employment; single use goods can be banned; and so on.

In such a village, the amount of inorganic solid waste would be significantly reduced. It would be separated at origin (i.e. by citizens before their collection) into the main types, such as glass, metals, paper and plastic and other. Alternatively, the sorting can be done later, in a special facility, thus reducing the citizens' commitment and effort, as they would only be required to separate organic and inorganic waste.

### Organic waste management

To reduce organic waste, the first priority should be to reduce food waste (in Europe and North-America the per capita consumers' food waste can reach 95-115 kg/year[56]). This requires two combined actions:

a) reduction of the excess food purchased, which implies behavioural change
b) increase the number and proximity of shops where food can be bought every day, instead of driving to a supermarket every week, which implies appropriate village design and governance.

After measures have been taken to reduce organic waste, it should be reintroduced into the wider nutrient cycle and exploited for its energy potential.

### Domestic and services waste management at village scale

To sum up, the best practice in waste management consists of the implementation of the circular economy principles, i.e.: the organic waste transformed into energy (biogas, via anaerobic digestion) and fertiliser (or only fertiliser, via composting); the reusable and the recyclable materials sorted out, pre-processed and sent back into the production cycle; the part that is left conveyed to landfill or, better, incinerated in a CHP plant.

This approach, already practiced in the most advanced and environmentally sensitive settlements, is best implemented at village scale, for two reasons. The first is that sorting and pre-processing the inorganic waste locally and processing the organic part locally reduces the distance travelled by waste, thus reducing the emissions of the waste management system; moreover, the distance travelled by the organic fertiliser from the production site to the fields is also shortened, with further environmental advantages (besides the economic one).

Segregation at source provides recyclables that have the least degree of contamination, but it requires the cooperation of citizens. This cooperation can be more easily obtained if the benefits of a well-managed segregation are clearly visible to the village's inhabitants and if the stakeholders in the process, from collection to the recycled product, are local, i.e. they live and work in the same village. This requirement fits perfectly into the mixed income requirement which has been pointed out in Principles 2 and 5 and will be further discussed in Principles 9 and 10.

In a waste management system at village scale where citizens are requested to separate only organic and inorganic fractions (Figure 2.33), sorted solid, non-organic, waste is brought to a facility where the recyclable materials are further sorted, and cleaned if necessary, and from there are handed over to the dealers who will buy them. Non-recyclable materials are sent from the facility to landfill or to the incinerator.

The advantages, both economic and ecological, of this approach are many. Plastic items such as bottles, or in general containers, once sorted in relation to their chemical constituents, can be compressed with very simple and inexpensive machines. In this way plastic waste acquires an economic value, instead of being a cost for the citizen. There are also advantages for metals: copper wiring, for example, once separated from the protective materials, can be sold at a good price,

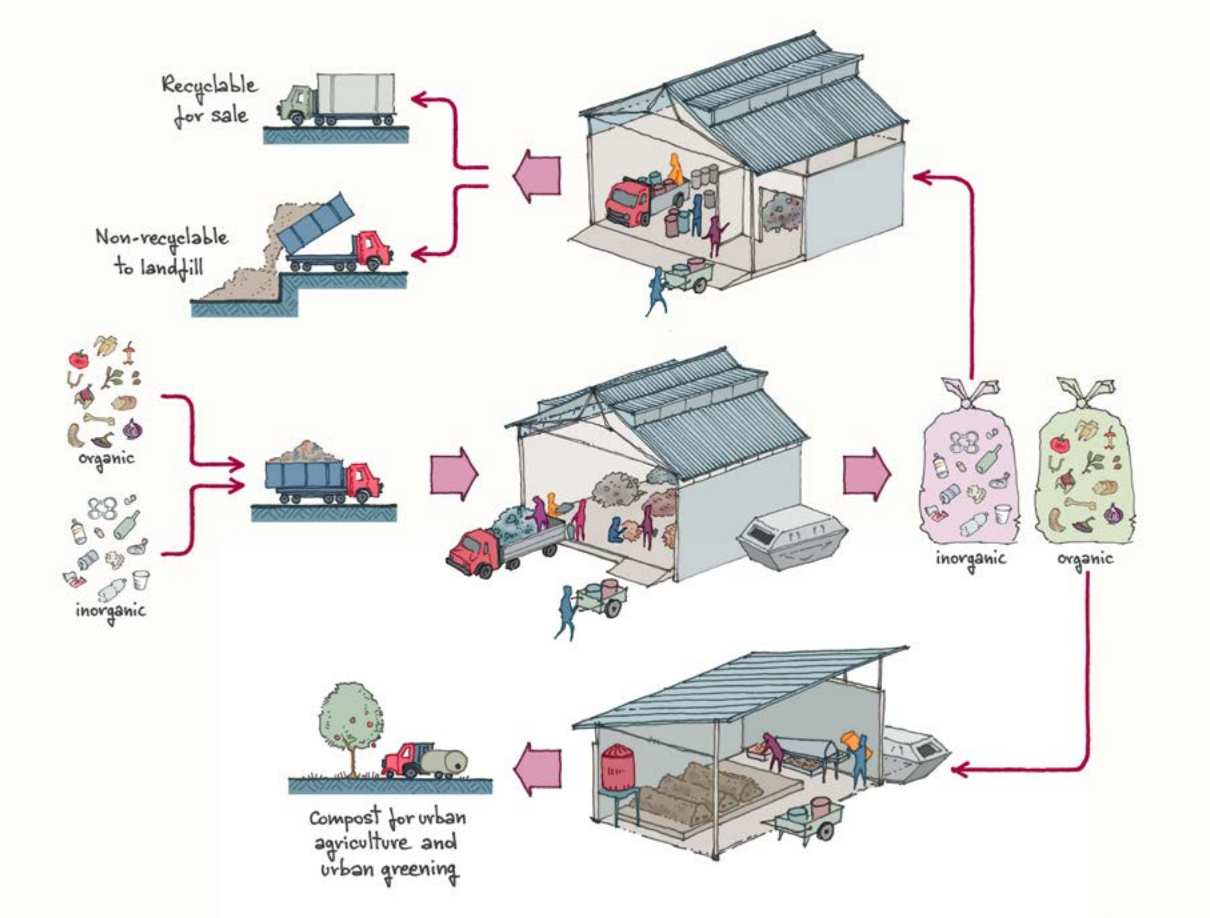



*Fig. 2.33 Decentralized solid waste management*

instead of paying for its delivery to a centralized waste management centre; the same applies to aluminium and other metals. Similarly, electronic waste, can gain value if already separated into its most valuable components ready for recycling.

Small scale entrepreneurial initiatives can be triggered, and employment opportunities enhanced.

Organic waste follows a different pattern, as it is food waste containing nutrients that come from the soil and that should return to the soil to close the nutrients cycle. Returning the food waste to the soil, after appropriate treatment, has a double advantage in terms of emissions reduction. One advantage derives from the fact that food waste can be used to feed an anaerobic digester, thus producing biogas and a slurry that can be used as fertiliser directly or after appropriate processing (the second option is safer from the heath point of view). The problem with the slurry is that food waste may contain not only natural nutrients, but also contaminants deriving from the agricultural production process. If food waste comes from industrial agriculture, and pesticides, herbicides and other chemical components have been used in large amounts, traces of them will be found in food waste and the deriving slurry would contain contaminants that would reach the soil. Other contaminants may derive from meat waste, when it is the meat of animals from intensive breeding, which thus contains antibiotics, hormones or other biological components. This is a problem affecting many countries, where in some cases, for this reason, the use of slurry as fertiliser is not allowed. In a zero carbon rural village, however, this problem should not arise, as its farms should adopt organic farming, intensive breeding should not exist and village's inhabitants should eat primarily locally produced food, this being one of the most distinctive features of a zero carbon village's economy.

Another problem, however, may arise from inappropriate behaviour of the village's inhabitants, if they include anything other than food waste into the organic bag (such as residual medicines, for example, or non-organic waste), thus contaminating the organic waste. These contaminants would either hamper the anaerobic fermentation process or make the slurry unsuitable as fertiliser to return to the soil. In a zero- carbon village, which should be a showroom of sustainability, the inhabitants' awareness should be such that this problem does not arise.

Initially, during the process of awareness raising, it may be wise to use only food waste from restaurants, this being more easily controllable.

Less effective for fighting climate change, but still a practice fulfilling the principles of a circular economy is conveying organic waste to the village's composting plant. The fertiliser from the composting plant or from the digester can be used either in the rural areas surrounding the village or in the village's green spaces.

### Other organic waste management

Other organic waste, such as landscaping waste (parks, lawns, street trees residuals) and, if available, around-the-village agriculture residuals or livestock manure can also feed the biogas digester; alternatively, all the vegetal waste can be sent to a composting unit. As previously mentioned in relation to domestic organic waste, a problem may arise if agriculture residuals are contaminated by chemicals (pesticides, herbicides, artificial fertilisers) and/or livestock manure contains antibiotics, hormones or chemical contaminants deriving from the breeding process: in both cases the anaerobic fermentation could be impaired and/or the slurry may become unusable as fertiliser.

To complete the closure of the village's organic waste cycle, branches from tree pruning could feed a village's gasifier, also producing biochar which can be used as a soil improver.

Finally, a separate route must be provided for the fraction of hazardous waste that may derive from industrial processes, if any, or may be related to chemicals used in agriculture. For this kind of waste, the usual procedures, regulated by law, have to be followed.

**Design suggestions**

◊ Consider including in the plan a recycling or reuse facility, dedicated to the collection, separation, pre-treatment and storage of materials for recycling.
◊ Consider the possibility of reusing locally both the organic part of solid waste and the vegetation residuals (like trees leaves) to produce energy and fertilizers through bio-digestion, or fertilisers only through composting; this implies to provide the necessary space.

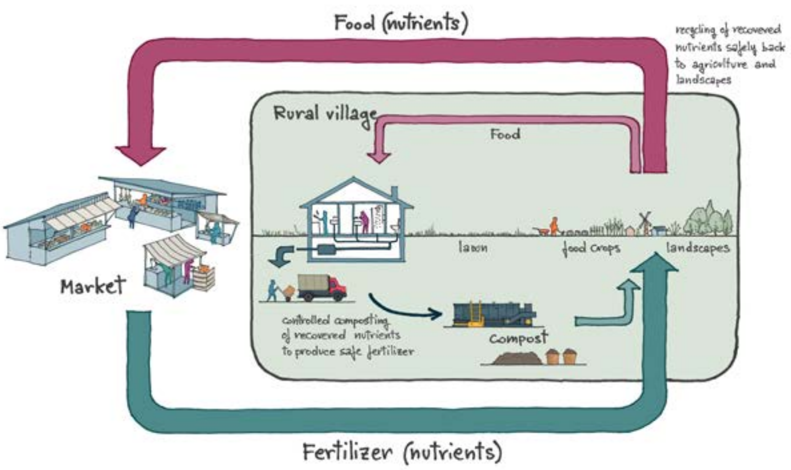



*Fig. 2.34 The optimised urban-rural nexus*

## PRINCIPLE 8: ENERGY, WATER, FOOD AND WASTE CYCLES

"At the beginning of the centralised wastewater treatment practice, the system was also conceived as a means to help farmers capture the nutrients in the sewage pouring out of rapidly growing cities; but by the end of the century the widespread availability of inexpensive synthetic fertilizers had taken away the economic incentives for sewage farming. Without a market for the nutrients, it was hard to justify doing anything other than discharging sewage directly to surface waters[57]."

Thus, the long-established relationship of mutual exchange of nutrients between the settlement and its surrounding rural areas was broken, with two effects: waste of the nutrients contained in wastewater, often producing environmental damage, and at the same time production of nutrients artificially, also with environmental damage.

### The nutrient cycle

A sustainable settlement needs, with more modern and effective technologies and techniques, to recover the old principle (Figure 2.34). This can be easier for small settlements if they are fed mainly by food produced in the surrounding rural area. It is more difficult for extensive food chains, where the food is produced by highly specialized agro-industries and distributed to wide and distant markets: in this model, it is a far more challenging task to close the nutrient cycle.

### The water-energy-food nexus: linear vs. circular metabolism

Water, energy and food are related. Water is used in the production of electricity (for cooling in thermodynamic power plants and as energy vector in hydro-electric plants), and energy is used to pump, treat and distribute water (Figure 2.35). Water requires energy for irrigation to produce food, which in turn also requires energy for making fertilisers, for harvesting, tillage, processing, storage and transport. Food waste, in turn, can produce energy via anaerobic digestion.

The water-food-energy nexus is central to sustainable development. Demand for all three is increasing, driven by a rising global population, rapid urbanization, changing diets and economic growth. Agriculture is the largest consumer of the world's freshwater, nitrogen and phosphorous flows and more than one-quarter of the energy used globally is expended on food production and supply. These global challenges need to be faced first of all at local scale, and zero carbon villages are the places to do it, the places to take advantage of the energy-water-food interconnections, moving from the present linear metabolism to a circular one.

The starting point should be that a zero carbon village rejects the idea of waste, be it of energy, water, food or materials; instead, it should seek to minimize waste and transform it into beneficial uses. In so doing, it should seek to reduce inputs of water and energy from afar and to reduce the flow of materials. This concept leads to efforts to decentralize the production of energy and food. It also powers the three "R's" (Reduce, Reuse, Recycle) of decentralized solid waste management.

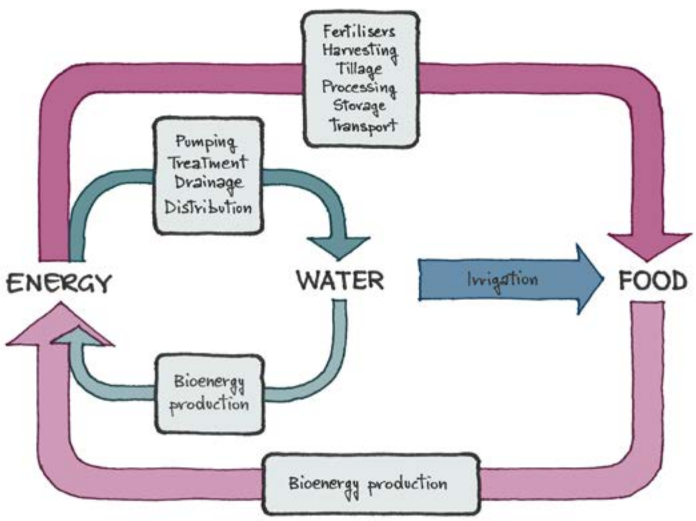



*Fig. 2.35 The water-energy-food nexus*

In the metabolism of conventional, centralized, linear, settlements, the connections are one-way: the higher the standard for providing water to households, the higher the water input, and the higher the energy consumption for water purification and for pumping; the higher the standard of sanitation, the higher the energy consumption for wastewater treatment; the better the solid waste collection and disposal system, the higher the energy consumption for transport; the higher the wealth, the higher the food input and waste.

In the metabolism of conventional, centralized, linear, settlements, the connections are one-way: the higher the standard for providing water to households, the higher the water input, and the higher the energy consumption for water purification and for pumping; the higher the standard of sanitation, the higher the energy consumption for wastewater treatment; the better the solid waste collection and disposal system, the higher the energy consumption for transport; the higher the wealth, the higher the food input and waste

In the circular metabolism, on the other hand, energy, water, waste and food are linked in other ways (Figure 2.36):

- the use of treated wastewater for vegetated areas makes them flourish, which is also beneficial for both outdoor and indoor comfort, reducing the need for air conditioning
- the availability of natural fertilisers and water means that part of the nutrients needed by the surrounding agricultural production can be supplied by the village's metabolism, and the use of locally produced food also reduces the energy consumed for supplying it from distant locations
- organic waste and wastewater can produce biogas, which, among other uses, can be used in a cogeneration system whose waste heat can make potable water from treated wastewater via vacuum distillation, or can feed agro-industrial processes
- organic waste from agriculture production around the village and residuals from maintenance of green spaces can provide energy, via digesters and/or gasifiers.
- Biogas and syngas can be exploited for providing extra storage capacity for the village's smart grid

Moreover:

- the use of rainwater and treated wastewater for replenishing water tables stops them from getting lower and less pumping power is required
- the reduction of the need for private transport deriving from mixed land use reduces energy consumption and - because of the reduced traffic - the necessary street width, with a consequent reduction in the impervious areas, in favour of pervious surfaces which allow storm water to percolate and replenish the water tables

In a zero carbon village, conventional linear processes are substituted by circular ones; each individual building is integrated into a system where renewable energy, rainwater, wastewater, organic waste, food and nutrients for plants are all interconnected and the cycles

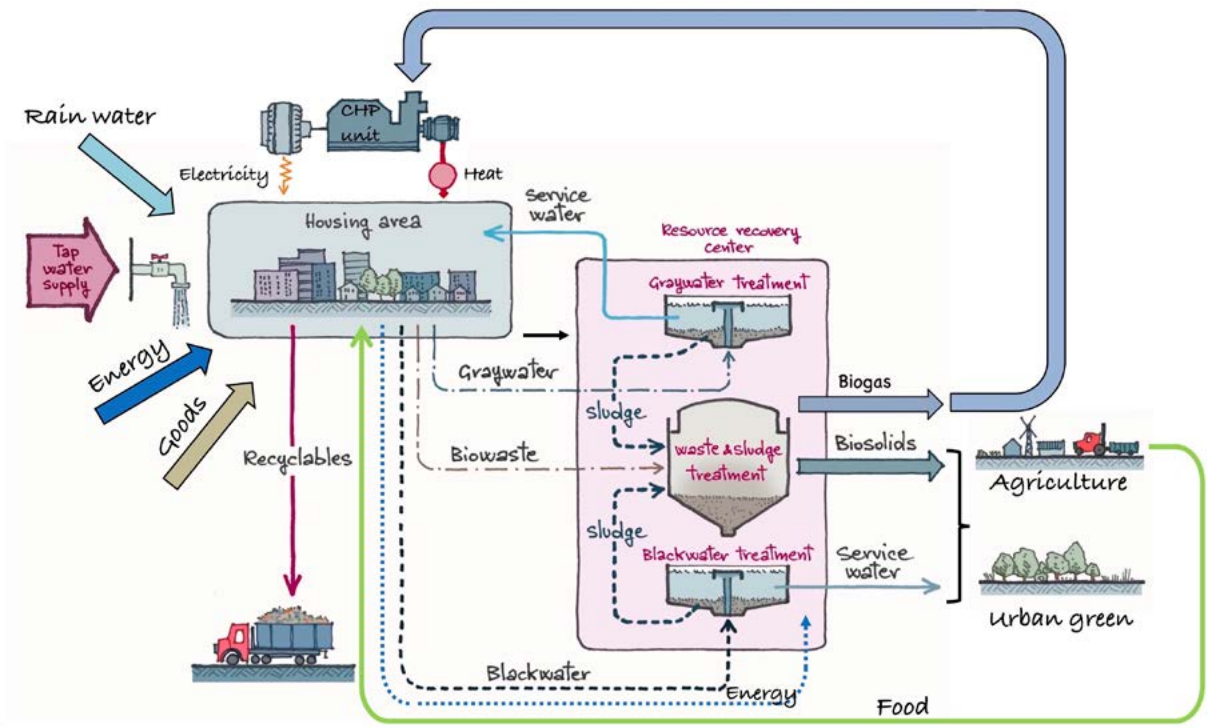



*Fig. 2.36 The ideal waste and wastewater system, producing energy*

of biological matter are, as far as possible, closed, in close connection with the surrounding rural area (Figure 2.37).

## Beyond zero carbon

A zero carbon village is capable of coping with the threats of climate change better than a conventional one, because of its higher resilience. This improved resilience derives mainly from the diversity of both the energy supply (sun, biomass, water and wind, according to their availability) and of the water supply (rainwater, wastewater, well water plus water from the centralized distribution system, if available).

Further resilience is created by the reduced flood danger, which is the result of a more controlled runoff, because of the large percolating areas, i.e. the green spaces.

Moreover, a zero carbon village is not only more resilient, but also more secure, as political or economic crises will have less effect on the availability of energy, water and food.

The combination of demand management and efficient supply of energy and water, based on decentralized systems and a closed cycle approach applied to both municipal waste and food is the only way to drive settlements towards their aim of zero carbon, but that is not the only goal. In fact, "zero carbon" is the necessary condition for coping with future challenges, but by itself it is not sufficient, as these challenges also include the need for coping with the other natural material and biological cycles that mankind has broken, i.e. the need to keep our development within the planetary boundaries. It is especially important that the threat to biodiversity should be mitigated as the main pressure on endangered species comes from the destruction of natural habitats by the change of the natural landscape into farmed fields.

### Design suggestions

◊ Consider that organic waste from households and surrounding rural areas can be used for biogas and fertiliser production, alone or in combination with the organic waste from the local sewerage network. Bio-digestion is convenient at local scale as it optimizes the closing of cycles and reduces waste production.

◊ Consider always the principles of circular economy when designing the water, energy and waste systems: these systems are the backbone of a sustainable village.

◊ Consider involving, from the beginning of the design process, experts in energy, water and waste energy, enabling interaction between them, together with biologists, ecologists and medical doctors: energy, water and waste systems are integrated and affect the environment as well as human health.

◊ Prepare the expansion of the zero carbon approach to a broader consideration of all the planetary boundaries, i.e. Start reducing pressure on biodiversity by farming activities.

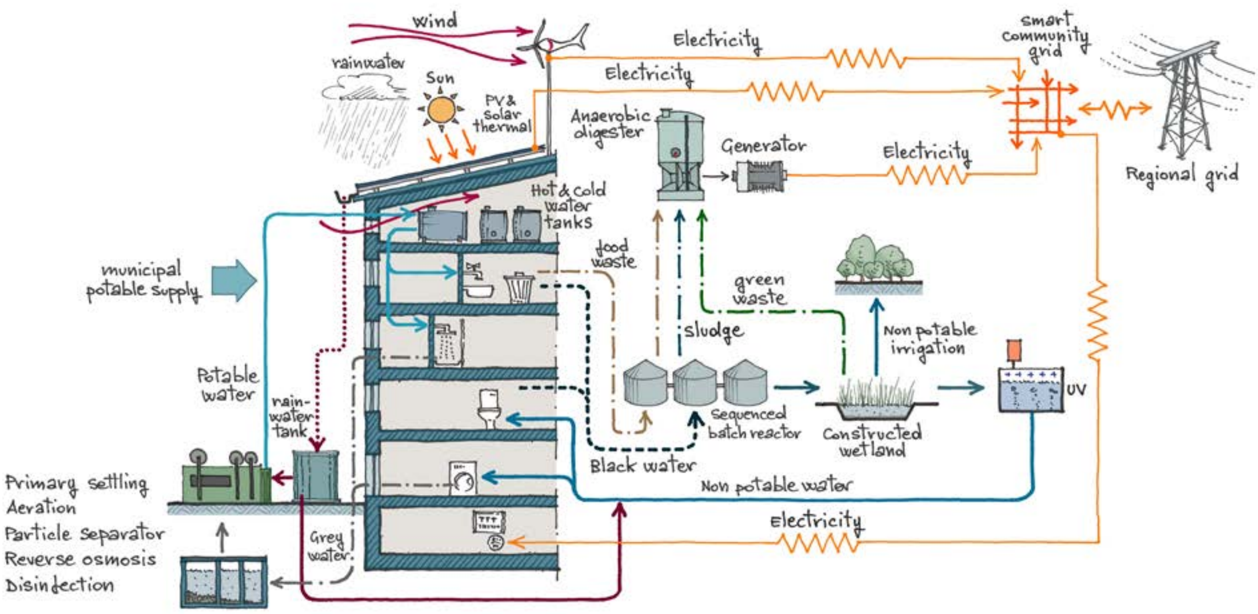



*Fig. 2.37 Schematic of a building integrated into the zero carbon village's water, waste and energy systems*

## PRINCIPLE 9: EMPLOYMENT OPPORTUNITIES AND LEISURE

The zero carbon village should implement an integrated socio-economic model for leveraging the ecological transition in terms of sustainable jobs and improved quality of life. Rural communities have been progressively aging because of the lack of employment opportunities, which is forcing the younger generations to move towards urbanized areas. The availability of jobs is a necessary condition for the resilience of the rural settlement, but this is not sufficient, as the jobs must also be appealing and promising, from both personal satisfaction and career perspectives.

To be successful in making the zero carbon village a good place to live, systemic attention should be paid to the enabling factors of both employment opportunities and desirable lifestyle. Social innovation should be combined with the implementation of zero carbon solutions and circular economy models both in agriculture and tourism.

Positions in innovative and advanced activities should be made available in order to bring back young skilled people, those who were forced to move to the city to find a job, and to prevent more young people leaving in the future.

These innovative activities should be linked to the transition towards a modernised, sustainable agriculture, enriched by the use of new technologies and techniques. Farming should be promoted as a highly regarded profession, which brings together tradition and innovation. The critical role of ecologically minded farmers in the preservation of the environmental equilibrium should be socially recognized.

Thanks to digital technologies, the zero carbon village can host "light" companies, which offer qualified jobs with a minimum environmental footprint:

- decentralized R&D, design and product development offices
- software development
- call centres
- online professional services
- digital media production (web series, cartoons, videogames)
- online educational services.

The localization of such service companies should be incentivized, through attractive policies and support to start-ups.

A settlement is also made more attractive by the pleasantness of the built area and its surroundings and by the services and leisure opportunities offered. Finally, a settlement can be more appealing than others

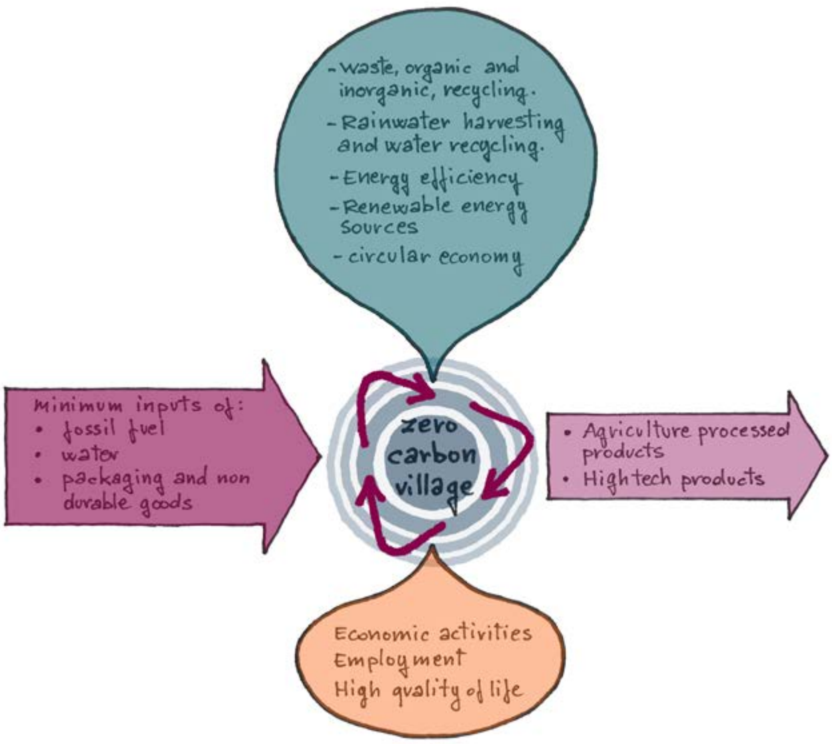



*Fig. 2.38 The main features of a successful zero carbon rural village.*

because it gives to its inhabitants both the advantages of living in a beautiful, healthy context and the pride of experiencing the anticipation of a sustainable future. These characteristics would also attract tourism and wealthy retired people who would choose to move to the zero carbon village from the congested city areas. In addition, digital nomads, who can establish their working place without specific constraints, could be persuaded to consider the zero carbon village as an option for their move to a better place to live.

By combining all the sustainability measures suggested in the previous principles, and the above considerations, a zero carbon rural village can be depicted, in short, as in Figure 2.38.

### Recommendations for socio-economic policies

- Local socio-economic policies should consider the following recommendations:
- Promote the combination of high-quality agricultural production with the contextual preservation of natural landscapes and natural biodiversity.
- Magnify the health-food nexus, promoting the qualities of local, high quality food in healthy diets. This approach should also involve primary food brands that should be encouraged to introduce such traceable ingredients into their supply chain.
- Promote and implement the circular economy principles; start connecting the village's metabolism with the agricultural production system by treating and reusing wastewater and food waste in order to close the nutrients cycle as stated in Principle 8.
- Use sustainable agriculture for triggering indirect economic activities, such as the sale of locally produced food, handicrafts, farmhouse small scale agro-industry, rental activities, building maintenance, but also high-tech start-ups related to sustainable farming practices, precision agriculture, IT applications for crop and soil monitoring, e-commerce, etc.
- Expand digital connectivity and favour innovation infrastructures in the village, such as fab-labs[58] and hubs where citizens can meet and develop solutions for improving the community.
- Promote the culture of the 3Rs, reduce, repair, recycle[59].
- Introduce positions for highly skilled as well as medium and low skilled workers in the management and maintenance of the advanced, integrated village service systems (water, energy, waste).
- Introduce attractive projects for creative young people in order to develop a local creative class (artists' residencies, small grants for start-ups, the offer of spaces to be regenerated, projects matching older local people and young urban innovators[60]).
- Support service companies in opening decentralized offices employing local people.
- Improve the science and technology support system to rural areas. Promote the cooperation of industry, academia and research, highlighting the scientific connotation of rural revitalization.
- Favour the local processing of agricultural products.
- Develop ecotourism, ecological breeding and other industries, and build a rural ecological industrial chain.
- Promote the village as a desirable residence for retired people. Specific attention should be paid to those who are socially active and could contribute with their time and connections to the development of the community.
- Support the "sense of community" as a distinctive characteristic of rural villages in contrast to a more individualistic urban lifestyle.
- Give the village the brand of a sustainable and vibrant place where life is comfortable, pleasant and slow: the ideal place for children to grow up in, for adults to work in, and for the elderly to spend their time.

### Towards a mixed income population

To be really attractive, the village should be beautiful, with well-maintained buildings, green spaces and a clear identity deriving from its cultural heritage, which is visible in its layout and in its buildings.

A prerequisite for creating such a pleasant context, is to achieve not only a mixed land use but also a mixed income population. This is desirable for many reasons:

- Evidence suggests that walkable (i.e., denser, mixed-use and more connected) environments and the presence of a variety of destinations and housing types and population sub-groups enhance a sense of community by encouraging and facilitating social ties or community connections through opportunities for residents to meet, interact and engage[61].
- Mixed income housing is also crucial for social equity and for supporting the operation of decentralized energy, water wastewater and solid waste systems. The provision of several building typologies and dwelling unit types enables an effective social mix and the creation of varied places where different environmental qualities can satisfy different people's needs.
- A socio-economic mix leads to a mix of energy demand patterns: the more diversified in quality, quantity and time distribution the energy demand, the smaller the physical energy storage required, the larger the "virtual" energy storage that can be controlled with the smart grid and the lower the cost of the system.
- In a decentralized vision, the availability of low/medium skilled manpower will allow the possibility of local sorting and treatment of solid waste. This

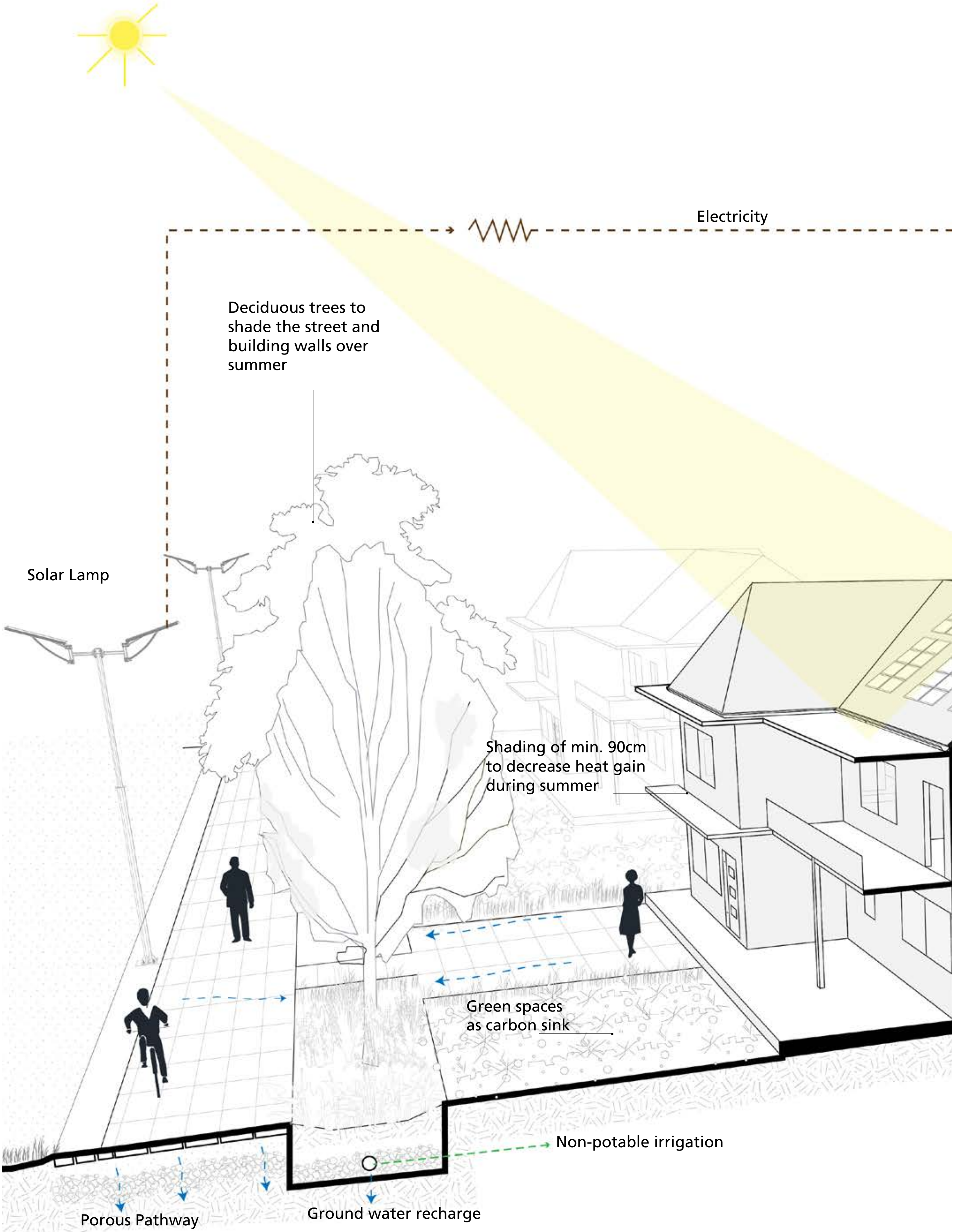
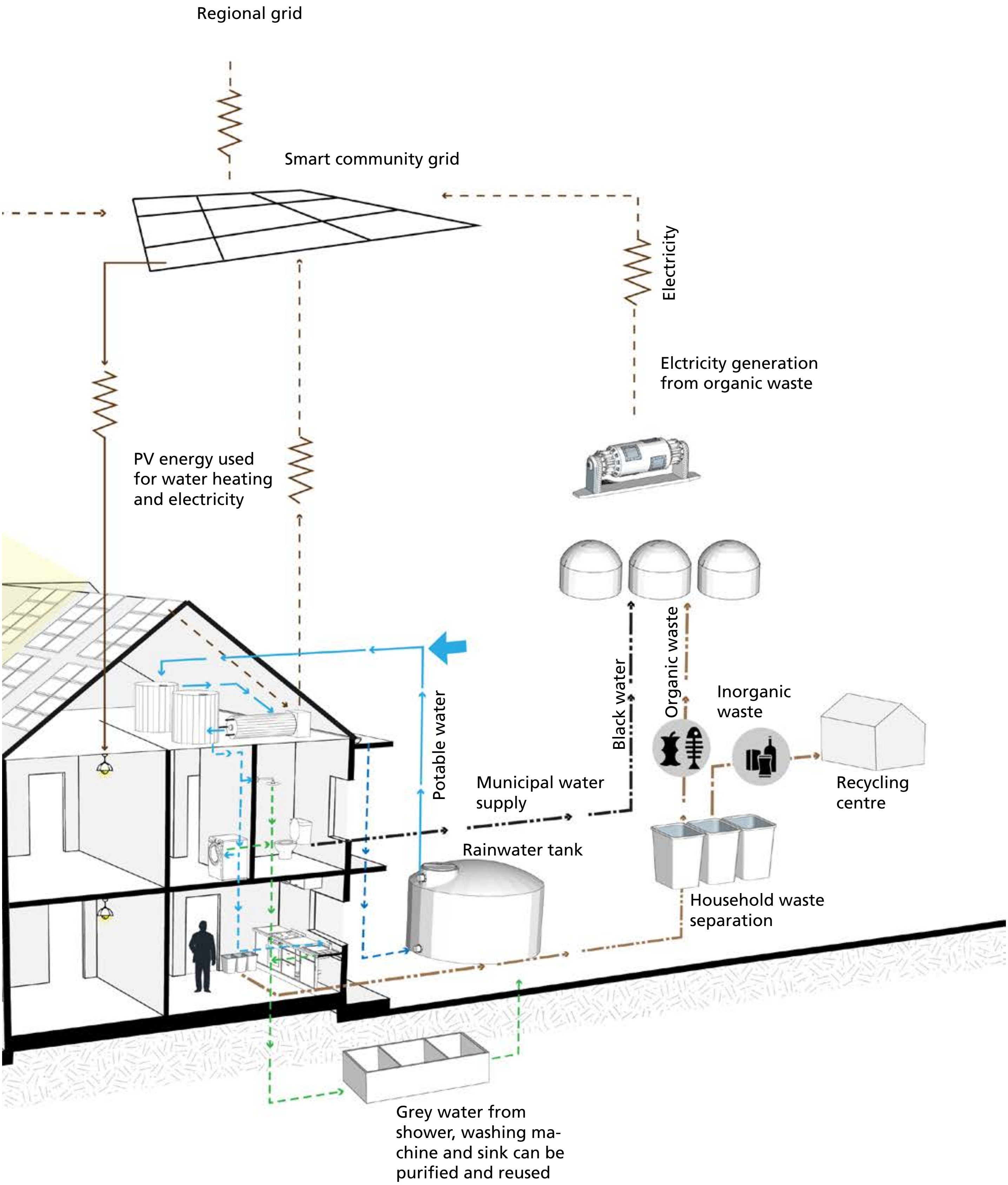



*Fig. 2.39 Illustration of sustainable technologies on a neighborhood scale*


Regional grid
Smart community grid
Electricity
Elctricity generation from organic waste
PV energy used for water heating and electricity
Potable water
Black water
Organic waste
Inorganic waste
Recycling centre
Municipal water supply
Rainwater tank
Household waste separation
Grey water from shower, washing machine and sink can be purified and reused

would create employment for the poorer local residents, and would deal with the waste issue in a sustainable and inclusive way.
- The repair of products, which a circular economy promotes, would also require a wide range of skills, of diverse craftsmen and professionals.

The issues of social inclusion, high employment and attractiveness are thus closely connected to a circular economy and sustainable energy management in a zero carbon village. In order to obtain such a social mix, the prerequisite is the availability of affordable housing for the different components of the desired social mix (i.e. pre-existing population, incoming retired wealthy people, new low-income workers, mid-high-income professionals, young creative workers and entrepreneurs).

In order to make the village attractive, and generate such a social mix, the following conditions should be met, whenever possible:
- Surroundings are pleasant and allow the inhabitants to live in contact with both wild and agricultural landscapes. Easy access (bike lanes, walkable paths) is provided for people to explore the landscape.
- All services are easy to reach at a walkable distance, which is especially important for elderly people. Moving around in the village is pleasant in winter (arcades offering protection from rain) and in summer (shaded walkways).
- Cycle lanes are shaded with trees in summer.
- Connections with urban areas and services are efficient and reliable.
- High quality digital infrastructure is available.

### Creating a cost advantage for the residents and investors

The capital investment of a zero carbon village is generally higher than that of a conventional one, but in evaluating its economics the following issues should be considered:
- The attractiveness for tourism or retirement creates a potential multiple revenue stream such as the return on real estate investments in the village.
- Organic agricultural practices make the surrounding land more valuable as it won't be contaminated with pesticides or super-strains of bacteria; it will also reduce cost of fertilizers and pesticides and reliance on GMOs.
- The re-introduction of heritage crop varieties is a point of attraction/uniqueness not only to enhance the pride in and the culture of the village, but also to attract tourists and increase the worth of value-added products.
- As the buildings are very efficient, the cost of heating and cooling is lower, electricity is largely self-generated, thus the extra cost is offset in a short period of time.
- Mixed uses with short travel distances and close proximity to work, childcare and schools, the extensive availability of stores and services, safe pedestrian environments and frequent and easily accessible public transportation systems allows both the capital and operational expenses of private vehicles to be avoided, thus making living cheaper.
- The health system has a cost for both the individuals and the community; the village is healthier than average villages, for several reasons:
  - A well-designed sustainable village is cooler in summer than a conventionally designed one, because of the UHI control, reducing the number of illnesses and deaths due to heat waves, especially for the elderly, infants and children, who are the most vulnerable.
  - A connected street network pattern, combined with mixed-use and higher-density development, promotes walking and cycling for transport, as opposed to car-based mobility, and physical activity has several beneficial consequences on health, such as: less heart disease, lung cancer, and both chronic and acute respiratory diseases[62]; fewer road traffic injuries and deaths; less exposure to road traffic nois, which influences physical health outcomes such as cardiovascular disease, hypertension and mental health; less risk of major non-communicable diseases, as well as increasing life expectancy[63].
  - The high value given to green areas is beneficial because scientific evidence shows that green spaces and parks are associated with improvements in physical and mental health[64].
  - Greater availability of locally produced fresh and healthy food is also associated with a lower prevalence of diet-related diseases[65].

### A long-term "durable" community

Additionally, it should be considered that a zero carbon village must also aim to encompass other sustainability issues besides GHG emissions, as outlined in Chapter 1, and that sustainability is closely connected to the issue of time. It is not by chance that the word "sustainable" in other languages such as French is translated as "durable" and that durability should be a key characteristic of products in a circular economy. This has a great impact on economic evaluations or the cost effectiveness of investments that aim to improve the sustainability of a village, as the return time of most "green" investments cannot be achieved in the short term, but in the medium-long run. Moreover, it should be considered that many benefits deriving from sustainability measures are very difficult or sometimes impossible to quantify in monetary terms, such as:
- costs avoided due to increased resilience (lower impact of catastrophic events, such as flooding or

water or food shortages)
- overall economic impact of increased entrepreneurial activity and employment rate
- quality of life, deriving from the availability of parks and by the reliability of basic services, such as energy, water and sanitation and from a reasonable income
- improvement of the local economy due to the attraction of wealthy residents and new economic activities.

### Governance

A participatory model of governance should be established at the village level. Quantitative and qualitative Key Performance Indicators (KPIs) should be introduced to evaluate the level of implementation of the zero carbon model that has been achieved. KPIs can be derived from the design suggestions and targets should be modulated according to the ex-ante analysis and a reasonable action plan.

A radar visualization of the conformity profile of the 10 principles is suggested by Figure 2.39, where a scale of 0 to 5 in the level of implementation has been used as an example. The degree of implementation of the 10 principles should be periodically monitored together with the amount of emissions.

Key stakeholders should be involved in the planning phase in order to share both vision and envisaged actions. Some "flagship" projects should be established, which aim to attract wide participation of the population and to create pride in the achievement of the ecological goals. Examples of flagship initiatives could be the introduction of a "plastic free" area, the banning of single use products, the switch to 100% recyclable packaging, the regeneration of a polluted field to create a public leisure space.

Appropriate governance should also be developed for the approval of regulations which are consistent with the 10 principles and for monitoring their implementation. The mixed income and the mixed use goals especially, which are socio-economic mid-long term targets, suggest the implementation of an observatory panel and a periodic consultation process.

The promotion of innovation and sustainable businesses should have a clearly established governance structure (i.e. a delegate/committee/office), so as to support the characteristically long-term targets.

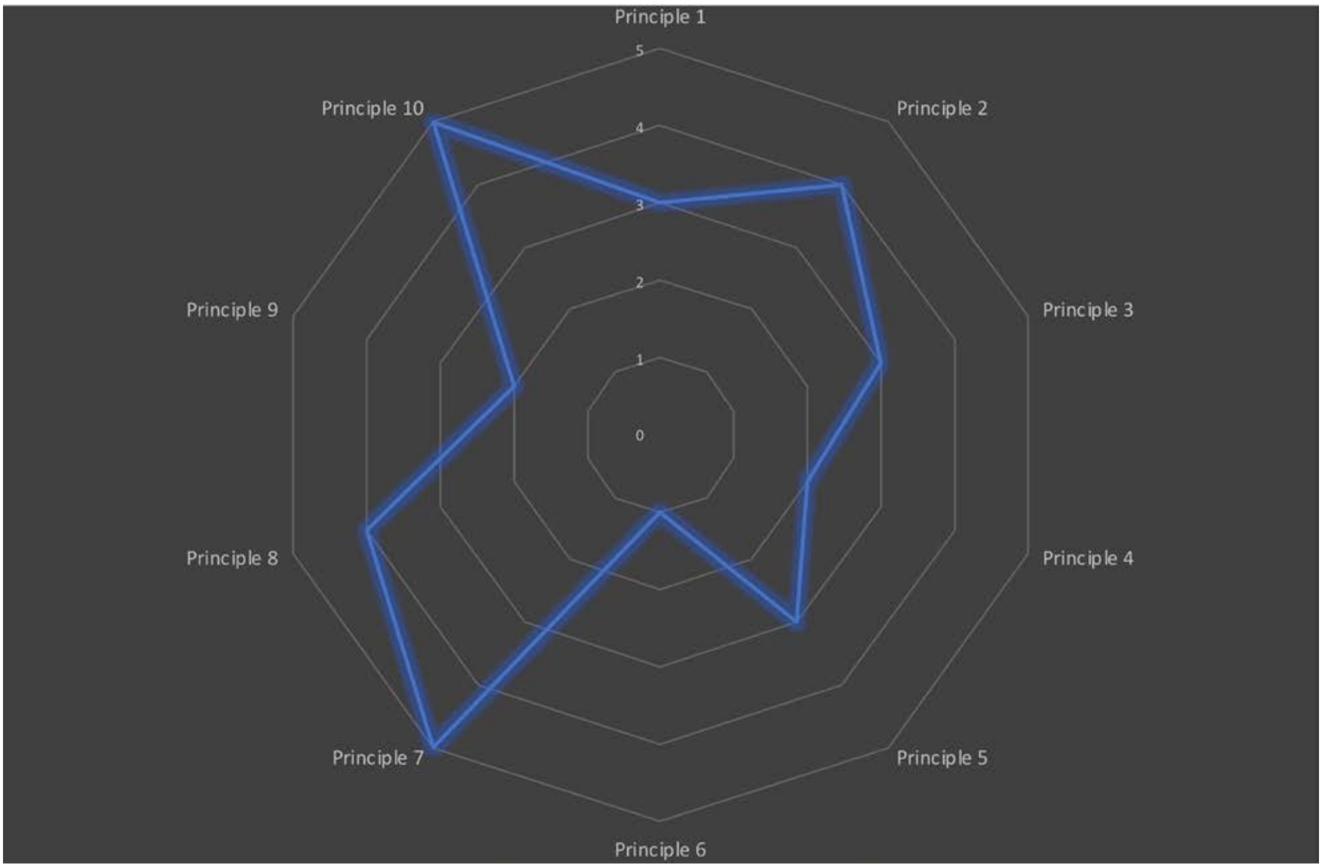



*Fig. 2.40 Radar graph showing the level of implementation of each principle, in a scale from 0 (not implemented at all) to 5 (fully implemented)*

**Design suggestions**

- ◊ 20 to 50% of the residential floor area should be for low cost housing; and each tenure type should be not more than 50 per cent of the total[66].
- ◊ Community hubs and guest houses should be available for social innovation actions. Schools and existing community houses could be the right places to host the social innovation hubs.
- ◊ In the economic evaluation of infrastructures for sustainable development, consider always the entire life cycle[67].
- ◊ Discover, regenerate and enhance the local cultural heritage as an identity mark and a generator of economic activities
- ◊ Put sustainable agriculture at the core of the development process
- ◊ Experiment advanced agricultural practices
- ◊ Use biodiversity preservation as an attractor and a landmark
- ◊ Invite representative of creative class (digital nomads, artists, designers) to experience the village and contribute to the community design process
- ◊ Invite service and light manufacturing companies to establish branches in the village, employing local people
- ◊ Promote local urban service firms, possibly cooperatives of village's dwellers, providing urban services: energy, water, wastewater treatment, solid waste management and transport. These will best tackle resilience strategies and find the suitable local solutions. A decentralized approach to energy production and environmental services provision are potential sources for local job production, according to circular economy principles
- ◊ Provide an appropriate amount and size of spaces for handicraft business: it could become the spine of the village's economy.
- ◊ Provide an appropriate amount and size of spaces for activities related to the shared and circular economy. Village fablabs should be established to support high tech handcrafting and culture of reparation and reuse of goods.

## PRINCIPLE 10: ECOLOGICAL AWARENESS

Creation of the zero carbon village is an important step towards future sustainable, harmonious, settlements: it implements a model that will characterise all the human communities of the post-carbon society. It is a settlement that aims, inter alia, to restore and give new momentum to rural activities and to rural life, in a context of technological and technical innovation, re-establishing the "ancient alliance"[68] between humans and nature. According to this principle, it should become a living example for educating visitors, supporting learning and replication actions.

As a showcase of the renewed harmony, a zero carbon village will demonstrate its relationship with the surrounding rural area and with the wilderness, showing a sort of symbiosis, instead of the present relationship of parasitism.

### The zero carbon village: a demonstration project of resilience through diversity

The establishment of the new nexus implies not only the use of emerging technologies and techniques, but mainly new ways of interconnecting with the existing ones, in a holistic and systemic approach. People are, by their nature, always reluctant to change their habits, uses, and views, and the best way to induce them to change is to show, with clearly visible examples, that the new habits, uses, and views are better than the old ones. This is the main function of the demonstration projects. They are living examples of how a new product or system, a settlement in our case, works, and how it is better than the previous one. This is not an easy task, as a zero carbon village is new not only in terms of applied technologies, but also because of the behavioural changes required of the people living in it: changes that are a direct consequence of the adoption of the concept of a circular economy. The novel approach can also be seen in the different trends that the development of a community has to follow with respect to the past, trends emphasizing the concept of diversity both biological and productive and social.

The need to nurture diversity arises from the requirement to achieve greater resilience, which is mandatory for facing the anticipated effects of climate change, such as floods, typhoons, droughts, pests, etc. An appropriately designed zero carbon village can meet the need for diversity and resilience, both social and technological/ technical, as mixed use and mixed income mean diversity, as does the use of multiple renewable energy sources in the microgrid.

Diversity should also govern the preservation of the forms, structures and practices that come from the past, when diversity and resilience were part of the culture. They must be preserved not only as inanimate records, cultural fossils of a past that no longer exists, but as precious, living messages from which we can learn. This is particularly true in buildings (see Principle 3 and 4), and in agricultural production.

### A living education facility towards the behavioural change

By anticipating all the future post-carbon settlements, the zero carbon village showcases the techniques, technologies, lifestyles, social organisation and individual behaviours that a community should have in order to cope with climate change and be sustainable. Policies are built around the long-term perspective of a happier, self-aware human community, conscious of its connection with Nature and perfectly situated within the planetary boundaries. To this end, the village has a powerful educational value, for raising ecological awareness – which is the core of a post-carbon society. It is a showcase for systemic behavioural change, which should be promoted on a broader scale, especially in urbanized areas. In this sense, the proposed model redefines rural-urban relationships, offering a new perspective in terms of mutual dependencies and cultural dialogue, where the rural villages take the lead in the fundamental ecological transition and show the way by example. The simple life of the zero carbon villagers should become an enlightening educational paradigm to be emulated by direct experience and appropriate narratives and studies.

The zero carbon village, as a showcase of a new lifestyle, must make its positive and hopeful message explicit. For people living in it, the attractiveness of the zero carbon village is self-explanatory. Nevertheless, this would not be the case for people visiting the village only occasionally, and are thus not able to fully understand the way the village works, its relationships with the rural and the natural surroundings (forest, wetland, pastureland, etc.), or the way people in such a village live, in harmony with nature.

To make the village a living educational facility for ecological awareness raising it is necessary to provide the appropriate means of presenting the narrative paths, ranging from appealing experiential locations, to the general attitude of the villagers who should be eager to describe their efforts to advance in the transition to sustainability. Well-designed events, cross-media productions, social channels, posters and leaflets should be part of a coordinated communication plan, capable of attracting attention and at the same time transferring knowledge and suggesting replicable solutions.

It means that, in order to make the diffusion of the ecological message effective and fast enough, zero carbon villages should invest some resources in this communication process. This would also improve the economy of the village, encouraging more people to come, visit and learn.

Activities consistent with a sustainable economy could be generated by this flow, in a positive interaction with principle 9.

There is a danger, however, that should not be underestimated: the excess of short-term tourists (the so-called hit-and-run tourists), whose action is usually disruptive, as they are mainly waste makers and have little interaction with the village and also leave little in economic terms. It is a problem that arises when a tourist venue becomes very popular, and it is already a problem that in many places is very difficult to manage, because it creates significant environmental damage, which comes to be accepted as an unavoidable drawback of touristic development.

Specific action should be taken to tackle this problem through educational activities directed at improving the behaviour of the tourists, who should be urged to behave as if they were members of the village community.
The "showcase model", as stated in Principle 10, should be embedded in the governance model, as described in Principle 9. It is suggested that the educational actions should be subjected to the same level of scrutiny as the innovation actions.

**Design suggestions**

◊ Try to design the systems servicing the village (water, energy, waste, transport) having in mind that they should not completely be hidden, but leave visible some parts, to show how they work
◊ Co-design the visiting paths and narrative materials with the local community built according to principle 9
◊ Involve the community actors in the narrative process, everybody should be involved in the storytelling, showing her/his contribution to the zero carbon model
◊ Consider designing an "environmental awareness raising centre", where training on environmentally sound practices can be provided by experience and accessible exhibits. In this location residents and visitors can be informed not only about the attractiveness of the village and of its surroundings, but also about its sustainability features, explaining:
  - Why buildings are designed in the way they are designed, showing the energy efficiency features and the savings obtained
  - How sustainability was addressed considering also traditional practices and solutions
  - Why shops, bars, restaurants, hotels and

residences are distributed the way they are distributed and why the streets are designed the way they are designed emphasizing that there is no need for owing a car, and that mobility is based on healthy walking and cycling

- How the energy system works, with its microgrid, renewable energy source and storage
- How solid waste is treated for recycling
- How food waste and wastewater become biogas and nutrient for the soil producing the food, so closing the cycle and avoiding or reducing the need for artificial fertilisers, emphasizing the consumption of locally produced food
- How the water cycle works, rainwater harvesting, water recycling for non-potable uses, runoff control, sponge city concept, etc.
- Behavioural good practices for energy conservation and for waste reduction
- How sustainable agricultural practices work and their advantage
- The relationship between food production, diet and health
- How the circular economy concepts are applied
- How all the systems mutually interact

# Case Studies

In this section four significant case studies are reported. These represent best practices in terms of planning, development and management of sustainable settlements, where the concepts expressed by the 10 Principles can be seen.

## HAMMARBY SJOSTAD[69] (STOCKOLM, SWEDEN)

The total energy supply for the community which lives and works in Hammarby Sjostad is based mainly on renewable sources (Figure 2.41): electricity is provided by photovoltaic, hydropower and bio-fuel technology, thermal energy is provided by district heating plants (Principle 5).

The water cycle (Figure 2.42) is closed as much as possible (Principle 6).

In order to reduce the amount of runoff entering the drainage system of Hammarby Sjostad, surface water is cleaned locally. The rainwater from surrounding houses and gardens is channelled by an open drain system that drains out to an attractive channel. The water then runs into a series of basins, known as equalizers, where the water is purified and filtered through sand filters or in the artificially established wetlands of the area. After this purification process, the water then travels out into Lake Hammarby Sjo, re-energizing the water levels in the lakes.

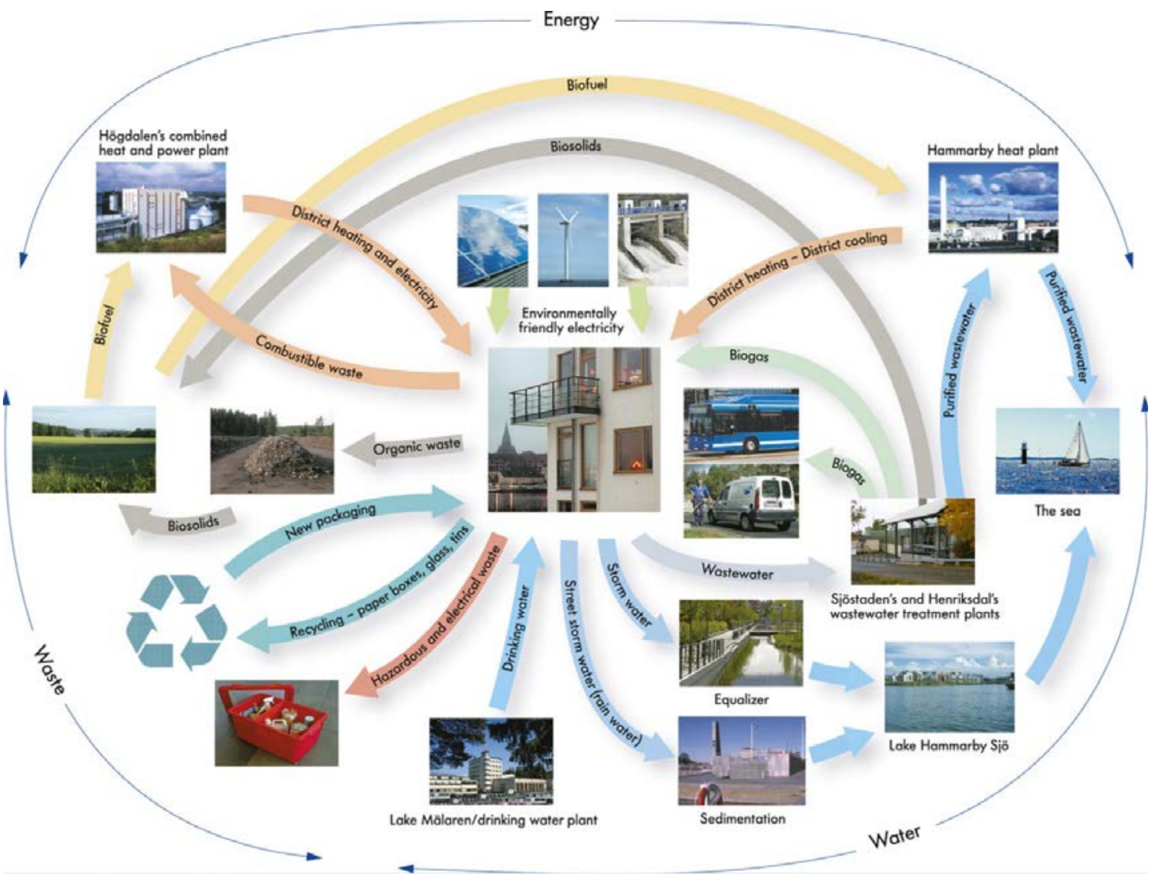



*Fig. 2.41* *Concept of the closed-loop urban metabolism*

Roof gardens also serve to reduce roof run-off during storms, by allowing the water to be absorbed, stored and purified through the soil and partially by the transpiration of the plants. In such way, the rainwater that would otherwise drain into the sewers is absorbed by the roof gardens.

To further enhance the traditional ways of recycling and reuse, the district has opened (in 2003) its own pilot sewage treatment centre. The wastewater treatment plant is testing new technologies for recycling waste. The system recycles nutrients from sewage, which are then used as fertilizer in agricultural land, and creates methane, which is used as biogas to supply energy not only for homes, but also for cars and buses.

Waste is separated and then reused and recycled closing the waste cycle (Principle 7) as much as possible (Figure 2.43).

Hammarby Sjostad uses a vacuum system to sort solid waste and refuse. The heaviest and bulkiest waste portions are sorted and collected via an underground waste collection system. The waste is sucked down through pipes into a block-based recycling room, one portion at a time. The containers are then collected from the room by refuse collection trucks.

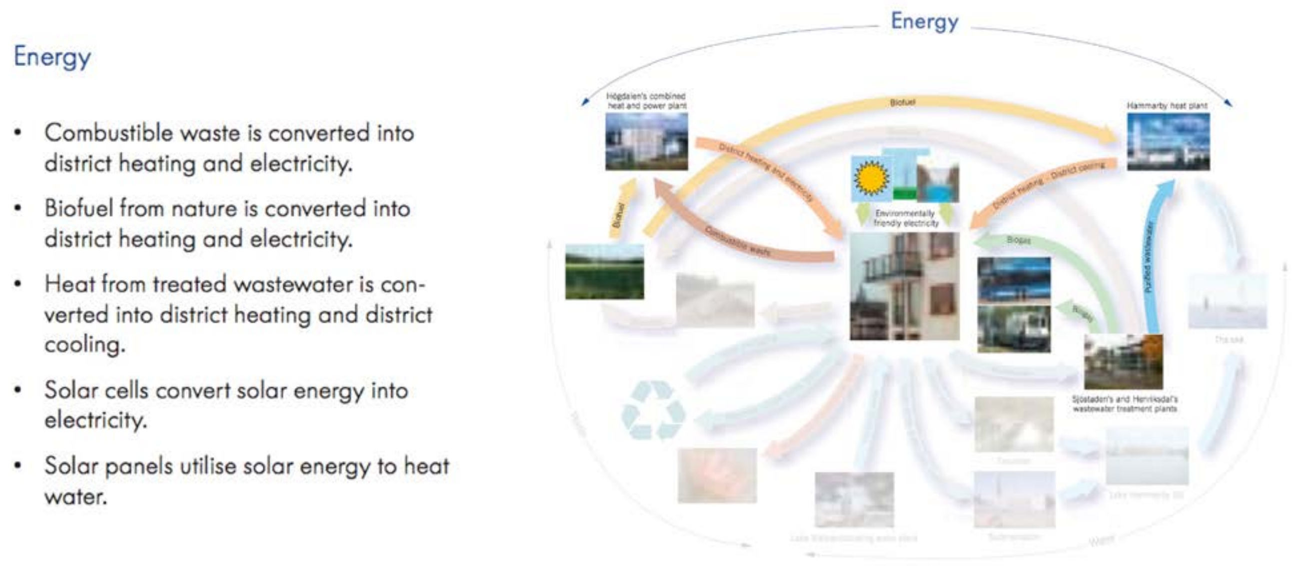



*Fig. 2.42* *The energy cycle*

## Water

- Water consumption is reduced through the use of eco-friendly installations, low flush toilets and air mixer taps.
- A pilot wastewater treatment plant has been built specifically for the area in order to evaluate new sewage treatment techniques.
- Digestion is used to extract biogas from the sewage sludge.
- The digested biosolids can be used for fertilisation.
- Rainwater from yards and roofs is drained into Hammarby Sjö, rather than into the wastewater treatment plant.
- Rainwater from streets is treated locally using settling basins and then drained into Hammarby Sjö, rather than being drained into the wastewater treatment plant.

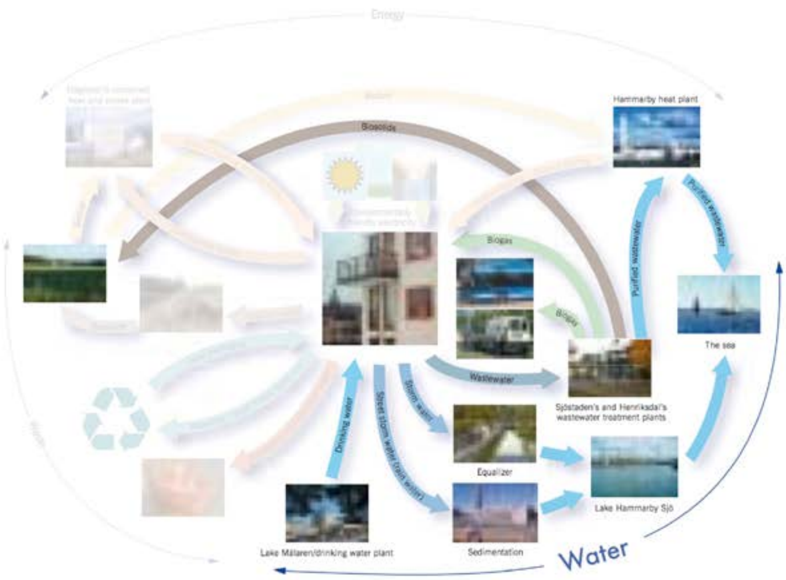



*Fig. 2.43* *The water cycle*

## Waste

- An automated waste disposal system with various deposit chutes, a block-based system of recycling rooms and an area-based environmental station system help the residents sort their waste.
- Organic waste is converted/digested into biosolids and used as fertiliser.
- Combustible waste is converted into district heating and electricity.
- All recyclable material is sent for recycling: newspapers, glass, cardboard, metal, etc.
- Hazardous waste is incinerated or recycled.

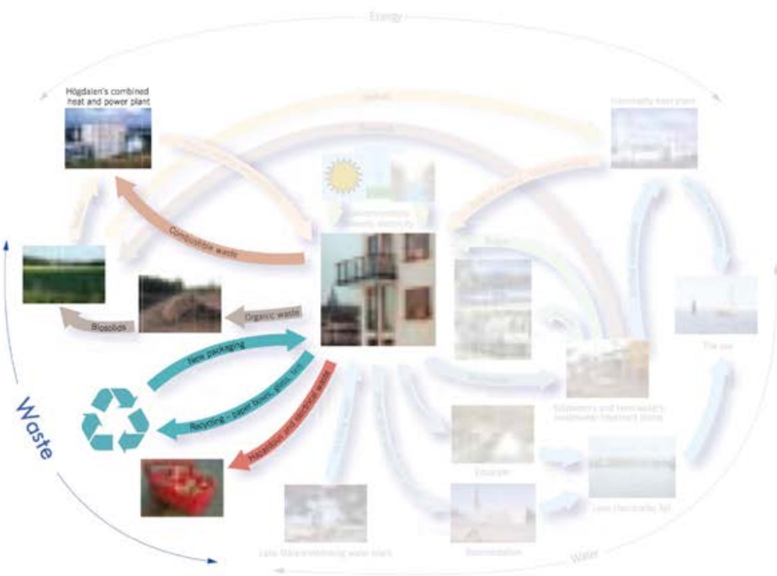



*Fig. 2.44* *The waste cycle*

## REGEN VILLAGE (THE NETHERLANDS)[70, 71]

ReGen Villages were founded in 2015. The ReGen Village will house 100 families on about 50 acres. Between 300 to 400 residents are expected to live in the community (which means about 3 to 4 persons per house) and more than 1,000 people are on the waiting list.

The ReGen villages are designed to give people an environmentally friendly alternative to urban life and to help make agriculture more sustainable and less wasteful.

The village adds not only environmental and financial value, but also social value, by creating a framework for empowering families and developing a sense of community, where people become part of a shared local ecosystem. Thus, the village is reconnecting people with nature and consumption with production (Principle 9).
The concept of this visionary real estate project is to develop a village where the resources will be used in a closed loop. The outputs of one system will be the inputs of another. ReGen stands indeed for "regenerative".
In this village it will be possible to recycle waste and water, to grow food and to produce energy that will be smartly redistributed in each household.

The ReGen village relies on five pillars:

- Water, waste and nutrient recycling (Principles 6, 7 and 8)
- Door-step high-yield organic food production (Principle 8)
- Mixed renewable energy and storage (Principle 5)
- Energy positive homes (Principle 3)
- Empowerment of local communities (Principle 9).

Already existing technologies will be applied to an integrated community design, providing clean energy, water and food. All the urban agriculture technologies such as aquaponics, aeroponics or permaculture will be used in the ReGen village.
The construction of the village should start in 2019.

**Technologies**

ReGen Villages are all about applied technology. A ReGen Village is a Tech-Integrated and Regenerative Residential Real Estate Development (Figure 2.44 and Figure 2.45).

Already existing technologies will be applied to an integrated community design, providing clean energy, water and food. All the urban agriculture technologies such as aquaponics, aeroponics or permaculture will be used in the ReGen village.

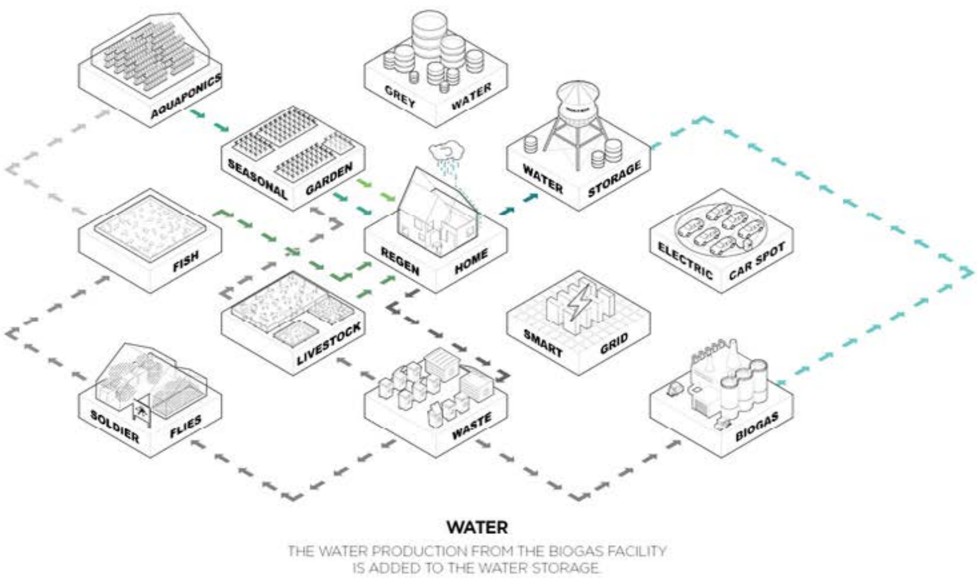



*Fig. 2.45 The Regen system. Households' black water and part of food waste feed the biogas facility, integrated into the wastewater treatment system; outputs are biogas feeding the energy system and water that is stored. The main part of households' food waste is used to feed livestock and soldier flies. Flies are used as food for fishes in their pond; water with fishes' excreta is used in the hydroponics facility for growing vegetables; purified water is sent back to the fish pond. Livestock manure is used as fertiliser in the garden, together with the treated water from black and grey water, that was stored; the garden provides food for Regen households. Livestock and fish is the protein bases complement to the Regen Village dwellers diet. Electricity, produced by PV systems and a biogas generator is feeds the smart grid.*

**Water management**

These innovative technologies are thought to use less water and less land than traditional agriculture and to produce more. In fact, the agricultural systems put in place in the ReGen Village, make it possible to produce 10 times more products than in a similar area with traditional agriculture, and above all, with 90% less water, thanks to the use of the urban agricultural technologies.

The ReGen system is based on the collection of rainwater from the roofs of the homes. This collected rainwater will be stored and distributed afterwards, in response to the needs of the community. It will be the main water resource of the village. Another source of water will be the biogas facility (which is part of the water treatment system). Both water resources (rainwater and water produced from the biogas facility) will be stored.

The clean water from the water storage will be distributed to the aquaponics system, which is a water farming technique in which fish faeces serve as fertilizer for the vegetables. In addition to the aquatic ecosystem, aeroponics is another technique allowing fruit and vegetables to be grown in the ReGen village. Aeroponics is a soil free culture system in which plants grow in an air or mist environment. In addition, grey water will be separated and filtered to be reused for irrigation of the seasonal gardens.

**Food production**

The purpose of the ReGen Village is to offer food security. Indeed, the whole ReGen system will be built to grow organic food in abundance: fruit, vegetables, oleaginous and leguminous plants but also protein foods, such as fish, eggs, chickens and other small animals rich in lipids and proteins. Food will be permanently produced, inside the vertical cultivations as a complement to the seasonal gardens and the farms (Figure 2.46). Moreover, families will be able to grow their own vegetables and fruit, all year round in connected greenhouses. In fact, each family’s house will have an attached greenhouse for growing personal crops. Together, the ReGen houses will form a “shared local ecosystem.” The village will produce enough fresh food to take care of 50-100% of the needs of its residents.

**Waste recycling**

The ReGen system, is based on waste-to-resource systems. The waste resulting from the households will be sorted into different categories in order to be reused for multiple purposes.

The organic waste will become food for the livestock and the soldier flies. The flies will become, in their turn, food for the fish, and the fish faeces will be used to fertilise the plants in the aquaponics system. Manure

*Fig. 2.46 View of Regen Village*

*Fig. 2.47 Vertical cultivation*

from the livestock will become fertiliser for the seasonal gardens.

The organic waste as well as the potential unconsumed food will be transformed into biogas or used to feed the animals.

**Renewable energies**

In addition to the production of food, the Regen Village will produce its own energy, thanks to solar cells on the roofs of the homes. The latter will be linked to a smart grid, which will provide

energy for the homes and allow the inhabitants to feed stored electricity back onto the grid when not needed. This surplus of energy in the smart grid will be used to charge electric cars. Furthermore, the energy produced by the biogas facility will be added to the smart grid.

**Homes**

The ReGen village involves not only the construction of housing, but also the achievement of a complete system including waste, food, water and energy organization.

In this complete system, homes will obviously be designed for totally sustainable living (Figure 2.47). They will be energy positive homes. They will be powered by photovoltaic solar panels, and passive heating and cooling systems will take the pressure off the use of electricity in each house. In fact, the houses will be adjustable. Homes will be extendable in order to take advantage of the sunny weather in the summer and to preheat the air in winter. Thanks to these techniques along with the system of water collection and solar energy, homes will produce more energy than they consume.


*Fig. 2.48 Regen Village houses*

## QINGDAO ECOBLOCK (CHINA)[72]

In recent years, China has been developing "superblocks", which are roughly 1 square kilometre areas that contain 2,000-10,000 residential units within them. The city provides the arterial streets and the developer buys the rights to build everything inside the blocks. Harrison Fraker and a team of students at UC Berkeley designed the Qindao EcoBlock Project, an alternative to the superblock system. The EcoBlock prototype can be mass replicated, but is completely off the grid, generates its own electricity and processes its own water and waste. The project has not been implemented.

The plan proposed an integrated system of energy generation, water conservation and supply, and waste treatment (Principles 5, 6, 7). With various design features (Figure 2.48) such as building shading, high-performance glazing, passive solar heating, shaded walkways, and energy efficient equipment, the energy consumption was expected to be 40% lower than conventional development (Principle 3). The remaining demand should be covered by the energy supply generated internally through a comprehensive system of building integrated wind turbines (53%), photovoltaics (40%), and anaerobic digesters (7%) which convert waste from sewage sludge, kitchens and green waste, into gas (Figure 2.49). Electric storage systems are part of the system, to give the Ecoblock the chance of being entirely self-sufficient, with no need for the connection to the regional grid.

EcoBlocks are also semiautonomous water management/ drainage units that receive water, implement water conservation inside the structural components throughout the cluster, capture and store rainfall and stormwater, reclaim sewage for reuse, recover biogas from organic solids.

Water and waste reclamation and reuse are carried out in a double loop consisting of grey and black water reclamation (Figure 2.50). Such a system accomplishes the following objectives (partial application of Principle 8):

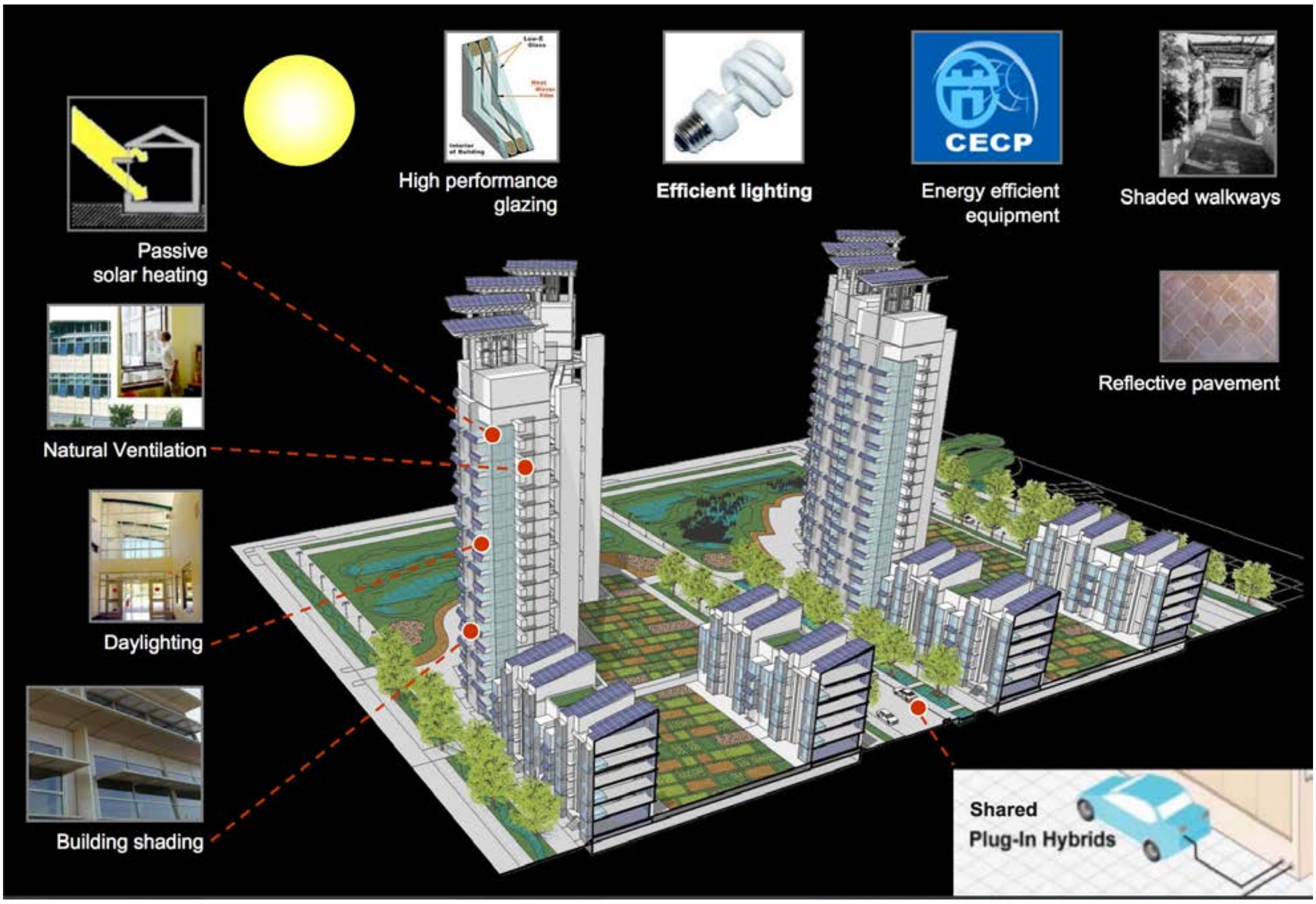



*Fig. 2.49 EcoBlock's technical system*

(1) it collects rainwater, makes it potable and mixes it with some potable water from the municipal network, to be used for kitchen, bathroom sinks and for showers
(2) it treats grey and black water to almost potable water quality for several in-house uses although direct potable use is not contemplated, making use of a "Living Machine™" system:
(3) it reuses treated water for WC flushing and washing machines
(4) in addition to providing water to inhabitants, the double loop system also provides some water flow to the surface water bodies within the city and for garden irrigation
(5) it recovers some energy in the form of biogas and heat.

Heat recovery is an important part of the project because household water heating for washing, showers, laundry and dish washing represents the largest domestic energy expenditure related to water and, consequently, the largest energy recovery which can be done efficiently (e.g., by a heat pump) by a local household or cluster. Furthermore, at local cluster/ecoblock scale, aquifer recharge will be accomplished by infiltration of captured stormwater by means of pervious pavements, ponds, wetlands and gardens (Figure 2.51). The synergic operation of all mentioned systems, are combined to make Qingdao a closed cycle neighbourhood.

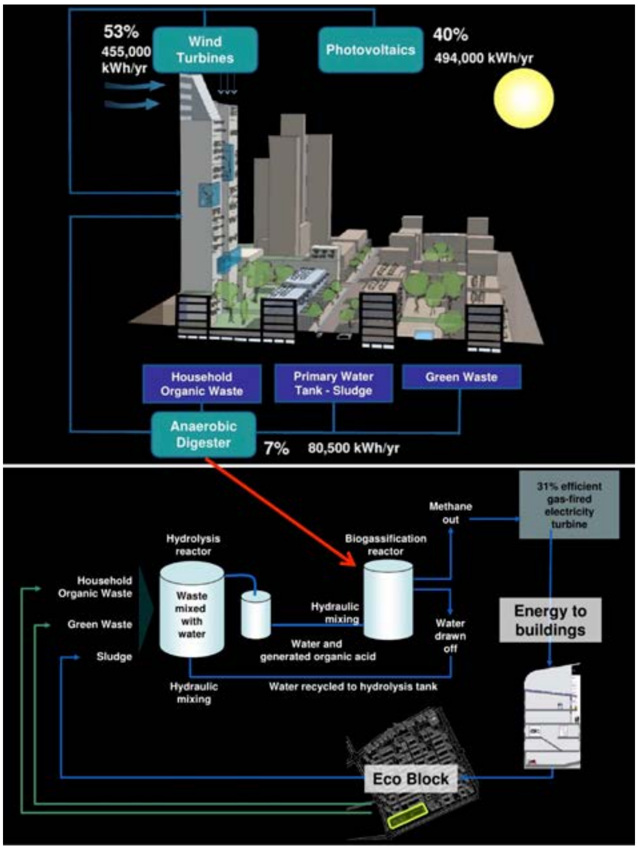



Fig. 2.50 Integrated energy generation system adopted in the project

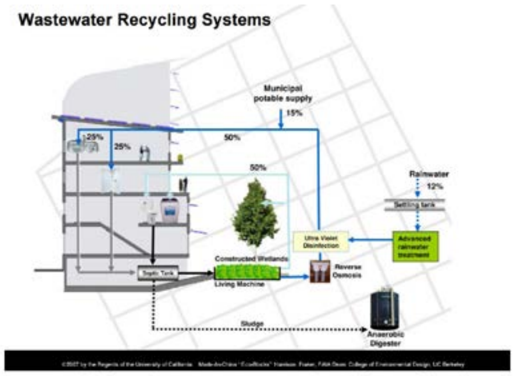



Fig. 2.51 The water cycle


Fig. 2.52 Concept of the EcoBlock's strategy (source: Fraker 2008)

## GÜSSING (AUSTRIA): AN ENERGY SELF-SUFFICIENT COMMUNITY[73]

Güssing, a major town in south Burgenland (Austria), a district comprising around 27,000 inhabitants, is the first community in the European Union to produce its whole energy demand – electricity, heating/cooling, fuels – from renewable resources, all the resources are found within the region.

In the early 1990s, a group of families spontaneously started to use shared biomass heaters to reduce the consumption of fuels. After the success of this initiative, a policy was proposed which called for a complete abandonment of fossil-fuel-based energy (Principle 5). The objective was to supply, as a first step, the town of Güssing and subsequently the whole district with regionally available renewable energy sources. The first step taken was to order that all public buildings in the town should stop using fossil fuels.

As result of the energy optimisation of buildings in the town, expenditure on energy was reduced by almost 50%. Then a wood burning plant that provided heating for 27 houses was built. Furthermore, a facility was constructed which turned rapeseed into car fuel.
In 1998 a pilot project was implemented for gasifying wood chips under high temperature conditions. Gas fuels an engine that produces electricity and the "by-product" heat is used to produce warm water for the district heating system.

The renewable-energy project expanded to other sources, as shown in Figure 2.52

The transition to a local biomass-based economy boosted the net income of the citizens (Principle 9). Güssing was recognized as a successful case of local energy sovereignty and a lot of media attention was focussed on it, other communities, even from abroad, started to visit and imitate the model (Principle 10). An increasing number of specialized companies were attracted by the "Güssing showcase", creating new and employment opportunities for qualified people. In addition, ecological tourism is now contributing to a sustainable local economy.

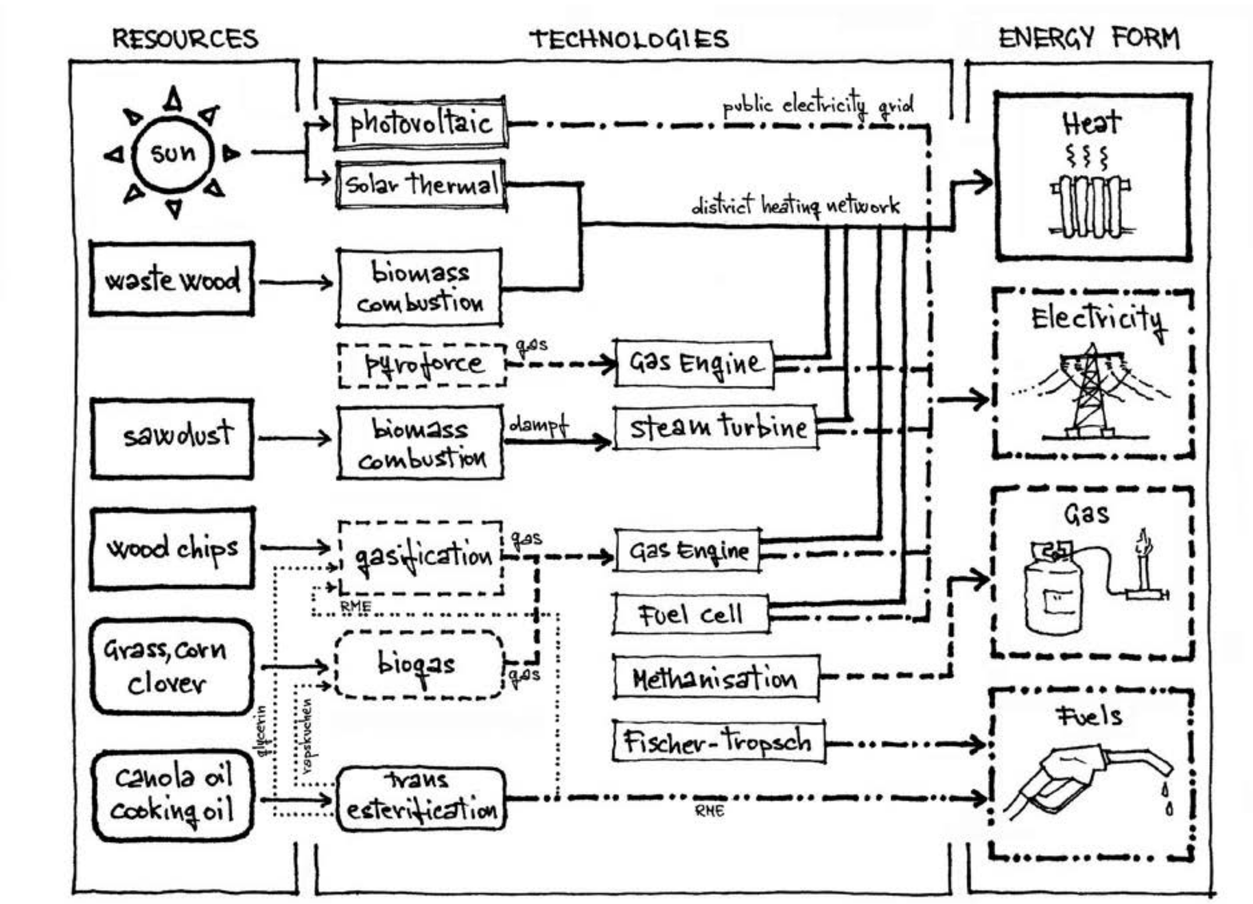



*Fig. 2.53* *Güssing energy system*

Bird's-eye view of Meilin Village, Changzhou

# 3 Contextualizing the principles

# Shatan Village, Taizhou

Shatan Village's agriculture is mainly grain production (mostly rice, supplemented by wheat), fruit planting (Chinese bayberry and loquat) and livestock breeding (pigs, cattle, sheep, chickens and ducks). The secondary industry is the processing of agricultural products. The tertiary industry is mainly based on small scale retail. In recent years, increasing numbers of tourists have brought a gradual increase in the number of tourism-supporting services such as homestay hotels.

According to the statistics of the government of Yutou Township, there are 11 existing enterprises in Shatan village, employing nearly 200 people, creating an annual output value of 100 million RMB, and laying an economic foundation for the development of the village. Meanwhile, the village has close links with surrounding urban areas. It is about 35 kilometres from the centre of Taizhou City.

Context-specific challenges/opportunities are:

**Challenges**

- Social and environmental impact of new residential settlements, including strategies for integration with the locals and engagement in the community;
- Impact of touristic development on the traditional lifestyle;
- Spatial planning of the growing village supporting the preservation of architectural heritage and promoting a harmonious expansion;
- Risk of flooding in rainy season.

**Opportunities**

- Attraction of different kinds of new residents (retired people, young professionals and families attracted by the rural area)
- Public-private partnerships for business opportunities
- Creation of a "showcase" for sustainable spatial planning and closure of the water-energy-waste-food cycles with optimal performance in terms of environmental impact and energy generation
- Development of a new energy system, based on all the renewable energy sources exploitable in the area, aiming for complete self-sufficiency, which can attract companies and professionals to implement and operate it
- Integration of information technology into

*Fig. 3.1 Shatan village situation*


*Fig. 3.2* *Geographical Location of Shatan Village*

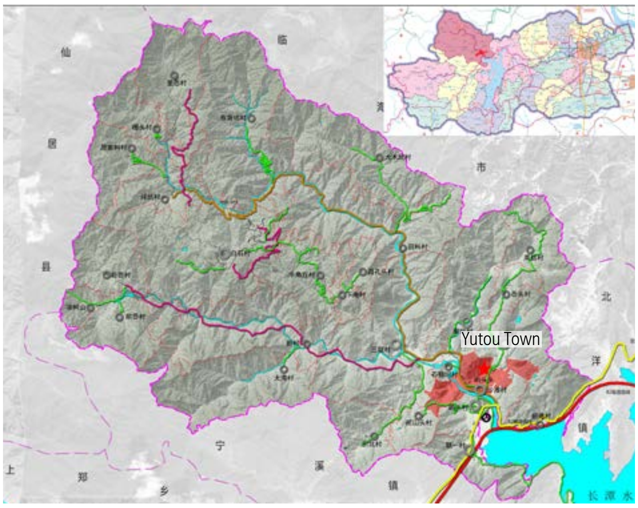



*Fig. 3.3* *Shatan Village in the map of Huangyan District of Taizhou(top right)*

agricultural production in order to shift from current agricultural practices to agro-ecology

- Regeneration of traditional fabrication activities for new residents and tourists
- Assumption of a key role in preserving the cultural heritage
- Reduction of flood risks through improved land management and urban structure

## APPLICATION OF THE 10 PRINCIPLES

In suggesting further actions for implementation, the approach followed was that of considering all the potentially exploited renewable energy sources, and combining them with currently available conversion technologies, which are already recognized as viable and cost-effective (or nearly so). The aim was to fulfil the conditions for a zero carbon settlement. The other approach followed was that of trying to close all the possible cycles: water, waste, food, including giving back to the soil the nutrients contained in food.

### Principle 1: Climate data and greenhouse gas inventory

Shatan village is actively and effectively utilising the collective buildings and land available from the 1960s and 1970s, transforming abandoned buildings and land resources into an important opportunity for creating a 'beautiful village', which would reflect the ideas of sustainable development, energy conservation and land saving. The average annual temperature of Shatan village ranges from 14 ~15 Celsius degree (the average temperature in January is 4.8 Celsius degree, and the average temperature in July is 26.3 Celsius degree).

The climate is pleasant. Shatan village's greenhouse gas inventory includes the direct energy consumption and indirect energy of buildings, transportation, solid waste, industry, etc. Villagers have a strong sense of energy conservation because of the economic benefits involved. These energy consumption data are based on household measurements. These data provide technical support for the establishment of greenhouse gas inventories in the village.

### Principle 2: Well-connected mixed-use nodes

To achieve zero carbon emissions, the layout of the streets must be properly defined at the urban design level. The aim of the present master plan for Shatan Village is to build a 'beautiful village'. In particular, it is trying to renovate Shatan's Old Street with the aim of transforming it into a cultural street for tourists attracted by the historic buildings of Taiwei Temple, Rouchuan College, and an old performance stage. In the Old Street, the existing buildings were renovated and, somewhere, rebuilt. A homestay was provided to bring some tourists from Shishitan Village, a small village nearby. The eastern side of the village is designated to be the main residential area and the location of the government administrative offices. Public service facilities such as hospitals and vegetable markets will also be placed mainly in the eastern part of the village (Figure 3.3).

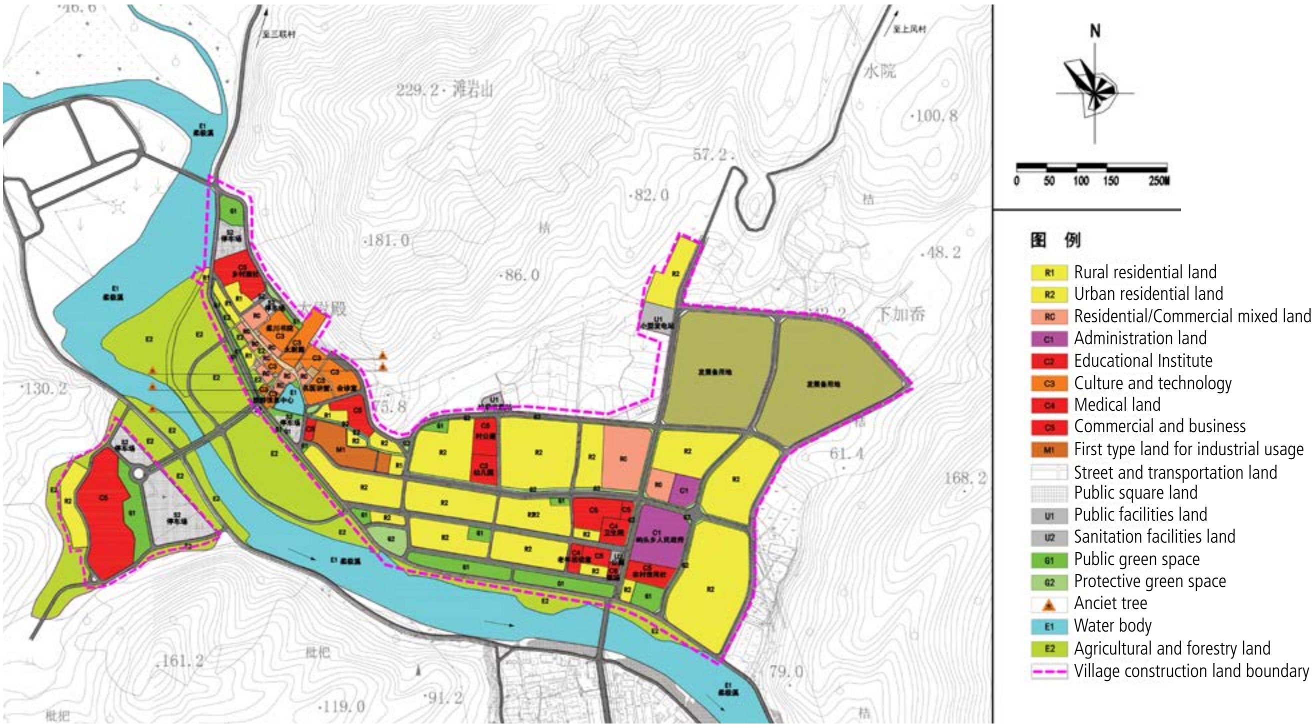



*Fig. 3.4* *New development plan of Shatan Village*


*Fig. 3.5* *Layout of buildings and streets in the development plan*

The layout of the streets is arranged in an organic form to echo the contour line of the mountain and the original street texture (Figure 3.4). In this way, excavation into the mountain can be reduced and the natural environment can be better preserved. The terrain in the central and eastern parts of the village is flatter. Buildings and streets in those parts are almost all in a north-south orientation to maximise the sunlight they can receive during the day. Local government and other administration and service facilities such as government offices, vegetable markets, and hospitals are also placed in the eastern part of the village to reduce interference with the Old Street, which is the main touristic attraction.

In the development plan, the main streets are approximately 14 metres wide and are north-south oriented. The inner road system is mainly 5 to 8 metres wide (Figure 3.5). A centralized parking lot is arranged around the large public facilities near the north part of the Old Street. There is a crop trading market with an area of about 400 square metres located near the Yutou town government office in the eastern part of the village.

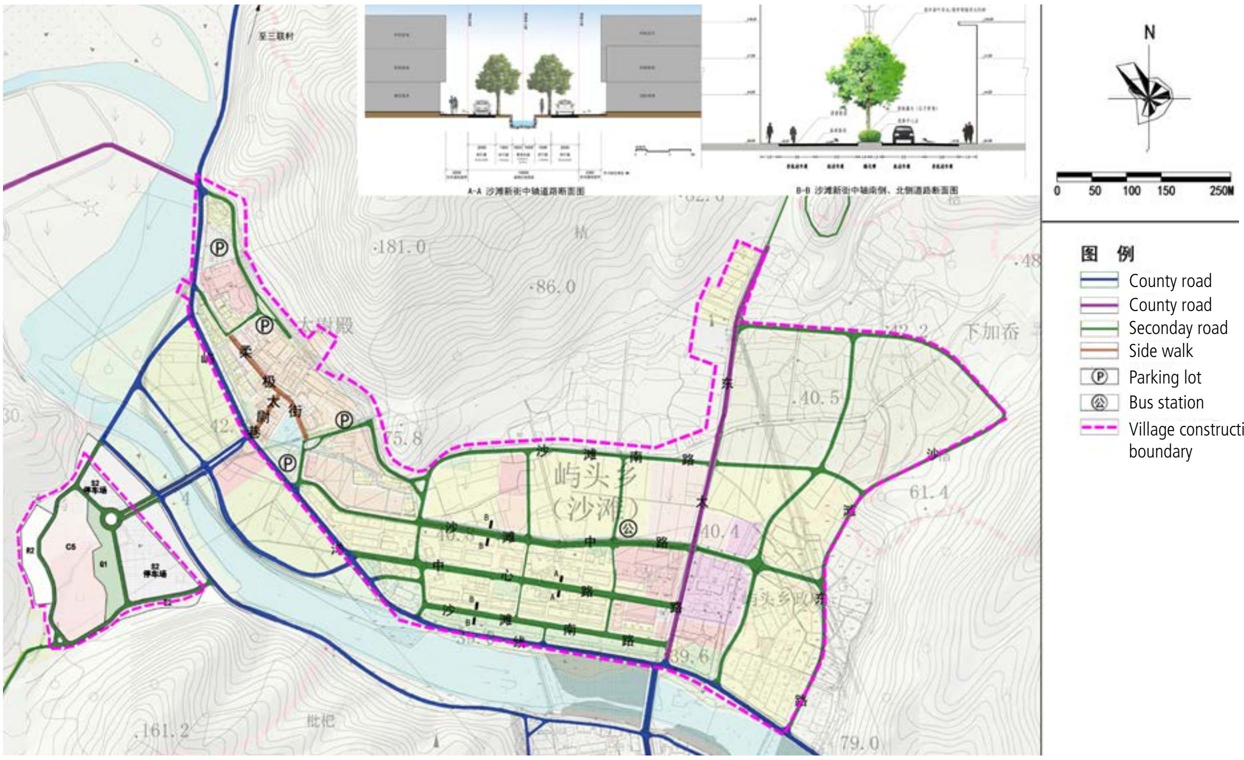



*Fig. 3.6 Road network of Shatan Village in the development plan*

The width and orientation of the streets in the village have also been designed in such a way that energy consumption in buildings can be reduced by exploiting solar gains. The main local streets, which are approximately 14 metre wide, are in a street grid oriented north-south/east-west. In the development plan, landscaped canals have been added in the middle of the main streets. The banks of the canals are piled up with large stones, paved with slate and pebbles on both sides, and planted with deciduous trees and trees with coloured leaves (Figure 3.6). On these main streets, pedestrians and vehicles are separated, and the roadways on both sides of the canals are one-way streets.

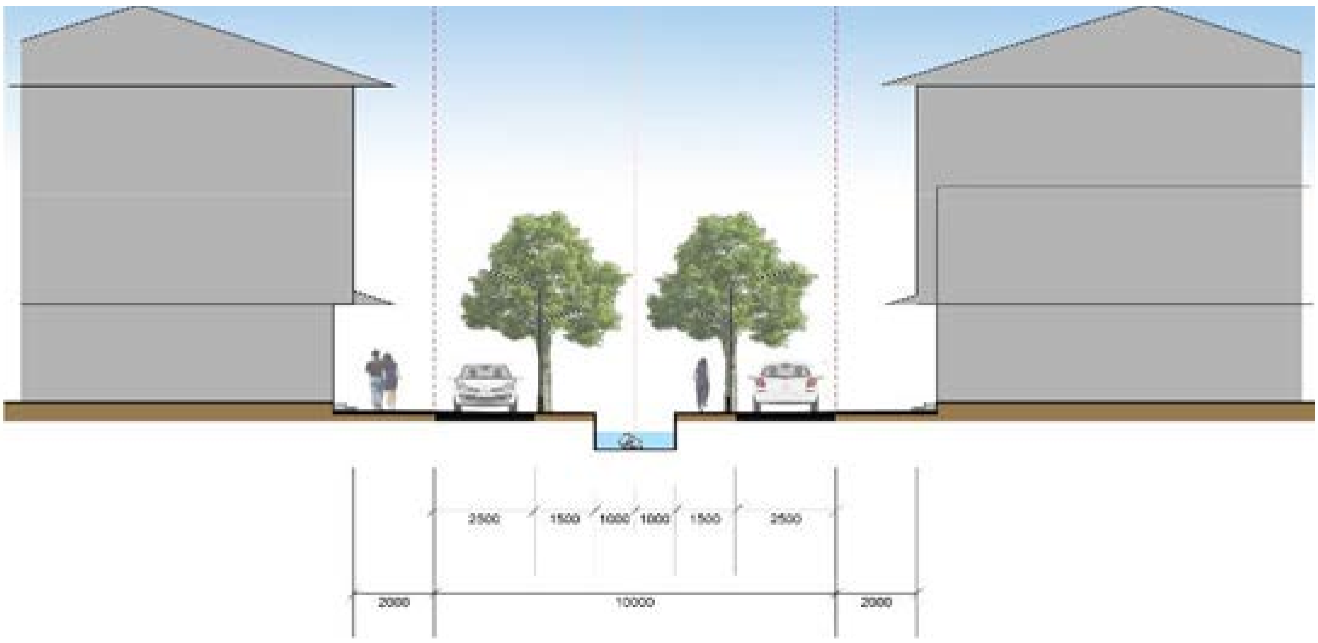



*Fig. 3.7 Section of the newly planned roads in Shatan village*

### Principle 3: Heating and cooling

Climate is the main driver of energy consumption for heating or cooling, and the way the buildings are arranged in a settlement plays a significant role in determining the amount of energy needed, because their orientation is a crucial issue for the exploitation of solar gains in winter and for protection from the sun in summer.

In the energy-saving design of the village buildings, the coefficient of the building height and shape is mainly controlled. The building height is generally controlled at three storeys, and the building shape coefficient is generally limited to below 0.3 (Figure 3.7).

The village is mountainous and has a subtropical monsoon climate with superior climatic conditions. The perennial dominant winds are the southeast wind and the northeast wind. The buildings should be oriented north-south, and the main facade should avoid the dominant wind direction in winter, so as to reduce energy consumption for heating in winter. Architectural windows are designed in series with north-south penetration, which forms a "cross-hall wind" in summer and reduces energy consumption for air conditioning and refrigeration in summer.

Three-dimensional greening is adopted in the design of building’s facades. Plants can reduce the absorption of solar radiation in summer, and play an energy-saving and cooling role. In winter, insulation and heat preservation can be achieved by shielding the building’s main facade from the wind.

In old buildings, renovations include a reasonable number of skylights, and natural daylighting is introduced through roof skylights to achieve uniform and soft indoor daylighting. If the skylight is opened at the appropriate time it can achieve the natural ventilation effect of vertical permeability and improve the indoor air quality. Low-e glazing should be used for skylights, because it provides good thermal insulation and can effectively reduce energy loss from a building.

Some existing buildings in the village have already been retrofitted as energy efficient buildings. A typical case is the renovation project of a house located in the Shatan Old Street (Figure 3.8). This building, called ‘Liangsu’, was a former granary. Figure 3.9 illustrates all the new technologies used in this building to transform it into an energy efficient building. Generally speaking, a new building envelope and energy-saving equipment have been used. The envelope’s heat losses were reduced by insulating the roof, walls and foundation, and using appropriately insulated doors and windows.

- Roof technology: The original sloping roof has been renovated. In order to retain the skeleton of the original sloping roof, the rotten wooden beams were removed and some new wooden beams are added according to the new load bearing requirements. The problems of water leakage and poor performance in heat preservation have been solved.
- Wall technology: Restoration is carried out with the aim of protecting the style and historical features of the building. Spraying a colourless protective agent on the concrete masonry on the outside of the wall has a good protective effect on the original stone and brick wall. While resolving the problems of protection of the style of the exterior façade, insulation of the exterior wall and moisture protection, it also solves the problem arising from the fact that the sunny wall of residential houses in mountainous areas is prone to dew due to the temperature difference between the wall and the indoor air, and this then breeds mould.
- Door and window technology: Double-deck low-radiation aluminium alloy doors and windows

*Fig. 3.8 Energy saving design*

*Fig. 3.9 The ‘Liangsu’ building under construction*

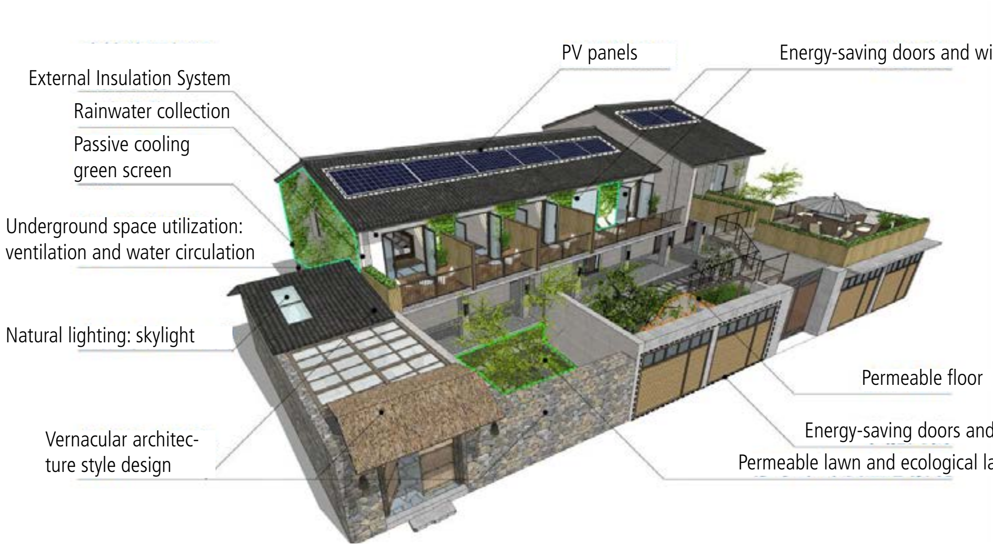



*Fig. 3.10 Energy efficient technologies used in the adaptive reuse of 'Liangsu'*

with hollow broken bridges are used in construction. These can effectively reduce the frequent exchange of indoor and outdoor heat caused by the cold and heat conduction of doors and windows, and so reduce energy consumption. At the same time, the doors and windows have high sound insulation performance and improve indoor comfort.

- Floor technology: Clean the original indoor floor and lay moisture-proof and waterproof layers on the concrete base to solve the problem of indoor flooding caused by rain in some mountain areas.

Geothermal heat pumps, rainwater collection and utilization technology have been applied in this project, resulting in lower energy consumption and a comprehensive economic benefit. The renovation of the "Liangsu" building has a positive social impact, too. In this sense, the project shows how the application of energy efficiency technologies can generate a good economic, social and environmental impact.

### Principle 4: GHG emissions

As mentioned in the 'Liangsu' building renovation case, bamboo, wood and other natural materials were also used in some residential buildings and roads.

Local, environmentally friendly materials have been used for building construction and renovation in Shatan Village. In the project to renovate the Local Villagers' Activity Centre (Figure 3.10), the roof of the building was rebuilt. Based on its original sloping skeleton, the decaying wooden beams were removed, and some new wooden beams were added according to the new load bearing requirements. In addition, double-layer 30mm wood fibreboard, fully cast 30mm fine sand concrete,

*Fig. 3.11 Extension of residents centre using local materials and methods.*

*Fig. 3.12 New road using existing local rocks*

*Fig. 3.13 Utilization of timber*

brush weather resistant waterproof coating, an adhesive plastering insulation layer and local tiles have been added to the building.

In addition, wall technology has also been used in the renovation project. As mentioned, Shatan Village has windy weather and many typhoons occur at the turn of the summer and autumn. Considering the weather conditions, a layer of a colourless protective agent designed for concrete masonry has been sprayed on the outside of the walls to better protect the original stone and brick. Meanwhile, on the inner side of the wall, the original masonry wall has been repaired, the original bricks have been cleaned and stone joints have been filled with cement mortar. In accordance with the local weather conditions, a thin layer of insulation has been added to the inner surface of the wall.

In addition, in the new development plan, the newly paved roads are all made of local paving stones, which are sourced locally to reduce energy consumption for transport (Figure 3.11).

Building and road materials like stone, timber, bamboo, stabilised compressed bricks, etc., which have low embodied emissions, should be favoured. They are consistent with the cultural heritage and can also be produced locally, reducing the need for transport energy and reinforcing the local economy (Figure 3.12).

### Principle 5: Renewable energy sources

As mentioned in the 'Liangsu' building renovation case, in some residential buildings and hotels, geothermal heat pump technology has been adopted to provide heating in winter. This technology utilises the effective heat storage and cold storage capacity of the underground soil, providing a suitable indoor temperature both in winter and summer.

In the village, the existing renovated "Liangsu" roof is equipped with photovoltaic panels, which have been distributed to the households. These directly convert solar energy into electricity and give access to the user-side power grid to realize "self-use, residual power grid" of photovoltaic power generation.

Some buildings in Shatan Village have solar water heaters and water storage tanks on their roofs. Converting solar energy into heat energy to heat cold water can provide

*Fig. 3.14 eco-pool designed for rainwater storage*

*Fig. 3.15 The permeable surface of a walkway to an ecological public restrooms*

a part of residential hot water demand.

Local agricultural wastes and organic wastes are used for energy production and composting. On the east side of Shatan Village, an organic waste compost/reuse facility and a small waste compression transfer station were established. Through the composting of agricultural straw and domestic refuse, the efficient utilization of biomass energy can be realized.

The village is close to the river and has permanent rivers, which provide a basis for the conversion of water energy into electricity. In order to utilize natural resource of water, six hydropower stations have been installed in the village.

The village road lighting facilities use solar photovoltaic street lamps, which can reduce the cost of road lighting and pollutant emissions by converting solar energy into electric energy.

### Principle 6: Water cycle

Rainwater harvesting technology has been used in Shatan Village. A rainwater collecting pipeline has been installed on the roofs of residential and commercial buildings to channel rainwater into the underground reservoir. When it comes to water supply, an ecological reservoir has been built around the village's residential area, and various households are connected to the tap water pipeline through purification systems. A drainage system has also been installed with rain and sewage diversion. The treated wastewater is used for irrigation and planting. In addition, in combination with existing canals, an ecological pool has been set up to increase the capacity for rainwater storage during periods of heavy rainfall (Figure 3.13).

Two ecological public restrooms (Figure 3.14) have been built to reduce the release of human organic waste in the local environment. In combination with a sponge city construction, permeable pavements have been adopted to reduce road rainwater runoff on rainy days.

### Principle 7: Solid waste

The village has improved its garbage sorting and collection methods. Solid waste is divided into two types: organic and non-organic. Meanwhile, a long-term mechanism for garbage cleaning, transport and recycling has been established in the village. A reuse facility of organic garbage compost and a small garbage compression transfer station have been built on the east side of the village. A waste sorting treatment station has also been built in the town.

### Principle 8: Energy, water, food and waste cycles

Organic waste has been used for energy production in Shatan Village. Local agricultural production waste and organic waste, for example, are used for energy production and irrigation. The typical waste from agricultural production —— corn straw is collected and anaerobically digested. The biogas slurry is reycled and reused. The generated biogas is stored in the gas storage cabinet and then transported to the farmer's house through the pipeline for daily energy use. The generated biogas residue mainly flows to the nearby farmland and vegetable base. Since it is all biogas residue, it is also convenient to transport it to other places where it is needed as a fertilizer. Meanwhile, in the village, rainwater has also been reused. Families have already begun to collect rainwater for flushing toilets, washing clothes, cleaning floors and plant irrigation. Besides, the use of solar and biomass energy has been piloted.

### Principle 9: Employment opportunities and leisure

The village has convenient external traffic connections, a well-developed tourism service industry, and a large number of homestays and country hotels, so the village attracts a large number of tourists from Taizhou and the surrounding areas on weekends and holidays. During 2017-2018, the average annual number of short-term visitors to the village was over 440,000. They are mainly weekend visitors. Those visitors result in a large number of family farmhouses in the village, especially in the Shatan Old Street, being leased out as one- or two-day bed and breakfast hotels. These projects create economic activities and employment for about 2,000 people and they promote innovation, which attracts young people from cities to live and work in the village.

### Principle 10: Ecological awareness

The village has some historical and cultural heritage sites such as the Taimiao Temple (Figure 3.15), an old performance stage and the Songyun Cultural Park. Those heritages have been preserved to support local tourism, which can be an eco-friendly industry for the village. In the development plan, the areas in front of the Taimiao Temple and the old performance stage have been preserved and redeveloped into a major public space not only for local residents but also to attract tourists (Figure 3.16). These spaces, in this way, promote the local economy and provide public activities for the public in an ecological way.

*Fig. 3.16 Taiwei Temple*

## SUGGESTED FURTHER IMPLEMENTATION ACTIONS

1. Develop an energy and carbon audit, and establish a comprehensive monitoring platform for energy resources in villages.

2. In designing the new residential development in the eastern part of the village, a variety of housing types should be provided, creating a socio-economic mix. This also helps to fulfil the needs of different family types. The same approach should possibly be followed when refurbishing buildings, when there is a change of ownership, to avoid gentrification.

The ground floor of buildings should host shops and other services, to promote mixed use.
A centralized parking lot should provide PV canopies and e-car, e-bicycle and e-scooter charging points; its pavement should be pervious.

3. The most important aim both in refurbishing existing buildings and building new ones is to minimize their energy demand by optimising the envelope's thermal insulation, the window size and the glazing's thermal and optical characteristics. This is best obtained by means of computer simulations.

As minimum requirements, however, wall and roof insulation should be not less than 10 cm thick with a thermal conductivity = 0.03 W/m K (or equivalent thickness for different conductivity value). For south facing facades, the Window to Wall ratio (WWR) should range between 0.3 and 0.5, while the WWR of north facing façades should be the minimum allowed by lighting and health standards. Low-e glazing should be used.

Whenever possible or applicable, both in new or existing buildings, operable sunspaces on south facing balconies should be considered, as well as appropriately sized overhangs (these could be the roof's eaves or balconies) protecting south facing windows from the sun in summer.

Roofs should be designed with PV panel area sufficient to provide the electricity needed for both heating, cooling, hot water and all the plug electricity consumption. Thus, the maximum height of new buildings should be limited accordingly.

In designing the new residential and commercial developments in the eastern part of the villages, ensure that the height to width ratio H/W of the east-west canyons is < or =1, calculated according to the deviation from true south of the buildings' façade, and that the buildings' main façades face south. In office and hospital buildings WWR should not exceed 0.5.

The new residential apartment buildings apartment in the eastern part of the village should be designed in such a way as to allow cross ventilation, in order to favour the exploitation, in summer, of the cooling effect of dominant winds. This can be obtained with apartments facing both south and north and by limiting the thickness of the buildings.

*Fig. 3.17 New public space in front of old performance stage*

4. Insulating materials made of natural fibres such as sheep's wool, paper, cotton, coconut fibre and wood fibre should be considered as sustainable alternatives to fiberglass or Polyurethane Foam or Polystyrene (EPS). The new or renovated farmhouse and road projects of Shatan village, reduce the consumption of building materials by optimizing design. Make choices that ensure reduction of scrap materials, this is very significant particularly for high embodied energy materials. Reuse construction debris and use products or materials with reduced packaging.

5. Underground water, or river water, should be considered as heat well/sink for heat pumps for heating and cooling in both residential and commercial buildings in the new development in the eastern part of the village. The reason for this is that water source heat pumps are very efficient and generally less expensive than ground source heat pumps. In the existing buildings air-to-air or air-to water heat pumps are more suitable, because of the cost of retrofitting. In hotels, hot water should be produced with heat pumps.

Biomass cogeneration should be considered (see Principle 4), with its waste heat used for heating and cooling government buildings or for industrial processes requiring low temperature heat, such as processes in the food industry.

The occupiers of new residential buildings especially, but in general all the village's families, should be incentivized to use induction cookers instead of gas cookers.

Concentrated parking lots in the village suggest that measures could be taken to set up shading measures, combining the shading of parking lots with solar photovoltaic panels, alleviating power shortages and improving the urban "heat island" effect. According to the demands of agricultural planting, a "photovoltaic agricultural greenhouse" should be set up, and the roof of the agricultural greenhouse roof could be used to meet the demand for agricultural electricity. Solar photovoltaic street lamps or wind-solar complementary street lamps could be used in village road lighting facilities to reduce road lighting costs and emissions of pollutants.

The energy resources of the village are significant and diverse and should be exploited as much as possible. Besides solar photovoltaic systems on the rooftops of all buildings and as canopies in the parking areas, three more sources of renewable energy can be used: wind, water and biomass. PV on rooftops should be sized to fulfil the full electricity demand of the building it is installed on. Hydropower is already being used, but opportunities for further exploitation should be evaluated. Wind energy, given its almost constant availability, is an option to evaluate for both micro and mini turbines. Micro turbines could be installed both on top of the public lighting poles, to power the lamps, in conjunction with a solar panel or alone, and also on the roofs of buildings. Mini turbines could be installed in the parking areas, along the river and in other places where an open space is available.

Biomass has significant potential as a source of energy. For example, it could derive from the management of the surrounding forests. This biomass, chipped, could feed a gasifier and the gas used to power a cogeneration unit. The biochar produced by the gasifier can be used by farmers for improving soils, sold for other uses, or spread on the forest from which it comes, closing a cycle. Another source of biomass derives from wastewater (see Principle 5) and from food waste from restaurants by feeding a digester. The biogas produced could also power a cogeneration unit, whose waste heat could be used for heating, cooling and hot water production in government buildings or in hotels, as an alternative to the heat pump, or for industrial processes.

The slurry, a by-product of the anaerobic digestion taking place in the digester, can be used, after appropriate treatment, as a fertiliser, helping to close the nutrients cycle. Such a large reliance on renewable energy sources calls for appropriate storage systems integrated into a smart grid. Usually electricity storage is provided by means of batteries, but in Shatan Village other solutions should be considered, such as:

1. Creating a water reservoir on top of the nearest hill (or in another convenient place providing the same hydraulic head) and use it to contain water pumped from the already existing rainwater reservoir in the village during the periods of the day in which there is excess production of renewable electricity. When electricity demand is higher than the electricity supply from renewable sources, water from the upper reservoir flows towards the lower one, where a turbine (or the same pump, acting as a turbine) connected to a generator converts the water energy into electricity, feeding the mini grid.
2. Storing the gas produced by the gasifier and/or the digester in a gasholder, and then using the gas to feed the cogeneration unit according to the needs of the grid.
3. Setting up a smart grid system in order to manage electricity demand and supply.

6. Consider the possibility of modifying and upgrading the wastewater treatment plant for biogas production. This would allow reuse of not only the treated wastewater for irrigation, but also the slurry (after appropriate treatment), thus nearly closing the nutrient cycle.

Biogas production, feeding a CHP system or simply an electricity generator, could be used as a supplemental storage system (see Principle 4).

7. Consider using the food waste produced by restaurants for feeding a biogas digester (might be the same as that used for wastewater treatment).

Instead of dividing the solid waste simply into organic and inorganic solid waste can be classified more thoroughly into hazardous waste (i.e., waste batteries, waste medicine, waste paint buckets), recyclables (i.e., waste glass, waste metal, waste plastic, and waste paper), wet garbage (i.e., leftovers, expired food, peels and kernels) and dry garbage (domestic waste other than hazardous waste, recyclables and wet garbage). There should be a reasonable layout of recycling stations. Furthermore, the awareness and knowledge of the villagers should be improved through educational programmes.

8. The implementation of a variety of renewable energy systems (PV, wind, biomass, water) requires local capacity for their construction and maintenance, thus creating new jobs at different skill levels. Other employment opportunities will arise from the implementation of sustainability actions as appropriate forest management, the treatment and management of wastewater and local waste, and the implementation of the village smart grid. Consider cost-effectiveness; an action plan for the promotion of more advanced economic activities could be envisaged in Shatan Village, which should:

- Implement a transitional path towards organic production in the local agricultural value chain. Delivery of local, healthy and organic food should be considered a key factor of the touristic offer;
- Identify and promote traditional vegetables, fruits, and animal breeds as the unique identity of the local agro-food offer;
- Plan guided visits to the small agro-food industries together with the implementation of informative spaces and company shops;
- Introduce a comprehensive village brand, bringing together food production, hospitality, and culture;
- Launch additional services (cultural weeks and festivals, gastronomic tours, nature excursions, revitalization paths, family-oriented offers) in order to expand the average number of nights spent by the tourists;
- Promote circular economy activities in connection with the waste cycle, such as the implementation of 3R labs (reuse, recycle and repair) with the introduction of new technologies engaging young people (3D printing and digital manufacturing);
- Implement a pilot action on precision agriculture, bringing together local farmers, young digital makers, and academic researchers for innovative local agriculture.
- The implementation of a digital community hub accessible to all the villagers is suggested, where a position of community innovation manager should be created for managing the innovation process towards the medium-long term goals

9. Starting from heritage sites, a novel narrative of the village should be created. Writers, poets, video-makers and artists could be invited to collect and publish memories of the villagers, remarkable natural facts, quality of lifestyle, stories of wilderness, etc.

The traditional stage offers the opportunity for promoting a cultural festival. This can be done initially through residential grants, sponsorships, and volunteer support, thereafter a start-up could be created to support the self-sustainability of this event.

The values adopted by the village should be presented to all the visitors. A modern multimedia visitor centre should be established. It could be in the same place as the digital community hub (see Principle 9), possibly in an energy efficient restored building and it should represent a must-see point where the sustainable approach embraced by the community is explained, the way of living of the village is represented, local products are introduced and sold, and the energy system and the closure of cycles being implemented are described.

In the visitor centre, tourists should also be informed about the rules they are asked to respect in order to help the community to fulfil its commitment towards sustainability: appropriate waste management, avoidance of chemical detergents, respect for the natural and cultural heritage, respect for fauna and flora, and the positive impact of buying local products, could be among the advice given.
Tourists should become ambassadors of the community; the appropriate use of social networking channels should support this process of follow-up and their management should be part of the task appointed to the community innovation manager (see Principle 9).

Digital guiding equipment could be set up in cultural and tourist attractions, and a mobile app could be designed to enable tourists to visit scenic spots more easily. The visitor centre could also recruit volunteers to disseminate cultural values and the concept of sustainable village construction.

# Xinjian Community, Zhoushan

Located in the south of Ganlan Town, Dinghai District of Zhoushan city, Zhejiang Province (Figure 3.17), Xinjian Community consists of three villages, namely Huangsha, Lichen and Nandong (South Cave). It sits in a shallow valley in the mountains with 450 ha of administration area, and 28.52 ha of built area at present. In 2015, the population was 1,563 in 578 households, 797 of whom are male and 766 are female. Over 500 of them are over 60 years old.

As it is located in the subtropical east of the Pacific Ocean, bordering Eurasia, it is cold in winter and hot in summer, with abundant rainfall, wind and light throughout the year. It has the overall climatic characteristics of the subtropical monsoon humid climate. Winter has more north winds, while summer has more south winds, spring and autumn are the monsoon transition periods (Figure 3.18).

According to the community plan (2015-2030), by 2030, the population of the Xinjian community will be around 2600, the maximum number of visitors is expected to be around 1,000 people per day. Considering the land supply conditions of Xinjian community and the development of rural tourism, the total construction land area is 39.13 hectares, and the construction land area per capita is 145.78 square meters (Figure 3.19&3.20).
Community income mainly comes from agriculture, aquaculture, tourism and migrant workers' income from other cities.

The community is moving from primary to tertiary industry, and there is a change in employment direction to independent entrepreneurship. In recent years, with the development of tourism, Xinjian Community has increased its capacity for the receiving tourists. The community operates old army barracks and homestays with more than 100 rooms. By the end of 2014, tourism in the Xinjian Communities accounted for 57.6% of the whole tertiary sector output.

Context-specific challenges/opportunities are:

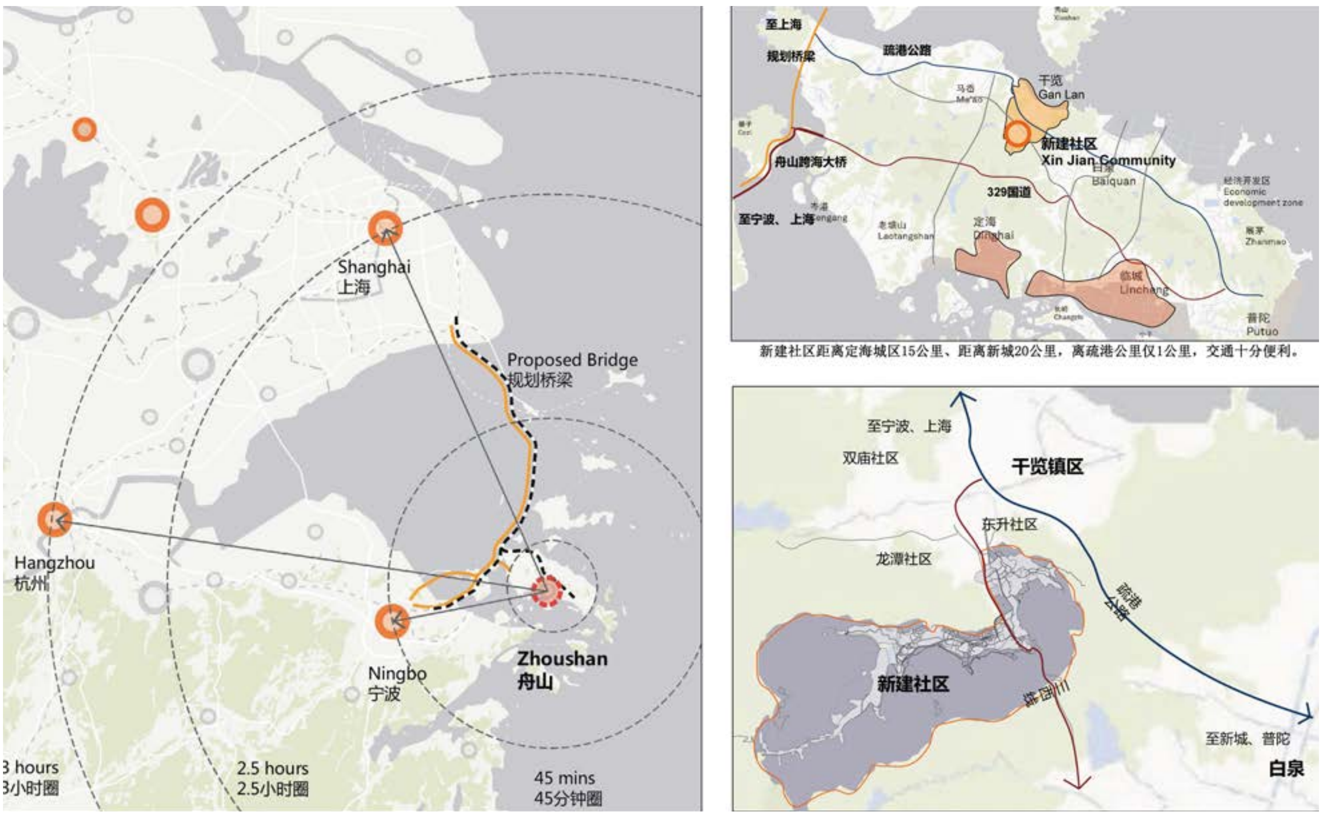



*Fig. 3.18 Location of Xinjian Community*

*Fig. 3.19 Bird's eye view of the community*


*Fig. 3.20 Xinjian Community 2030 Master Plan*

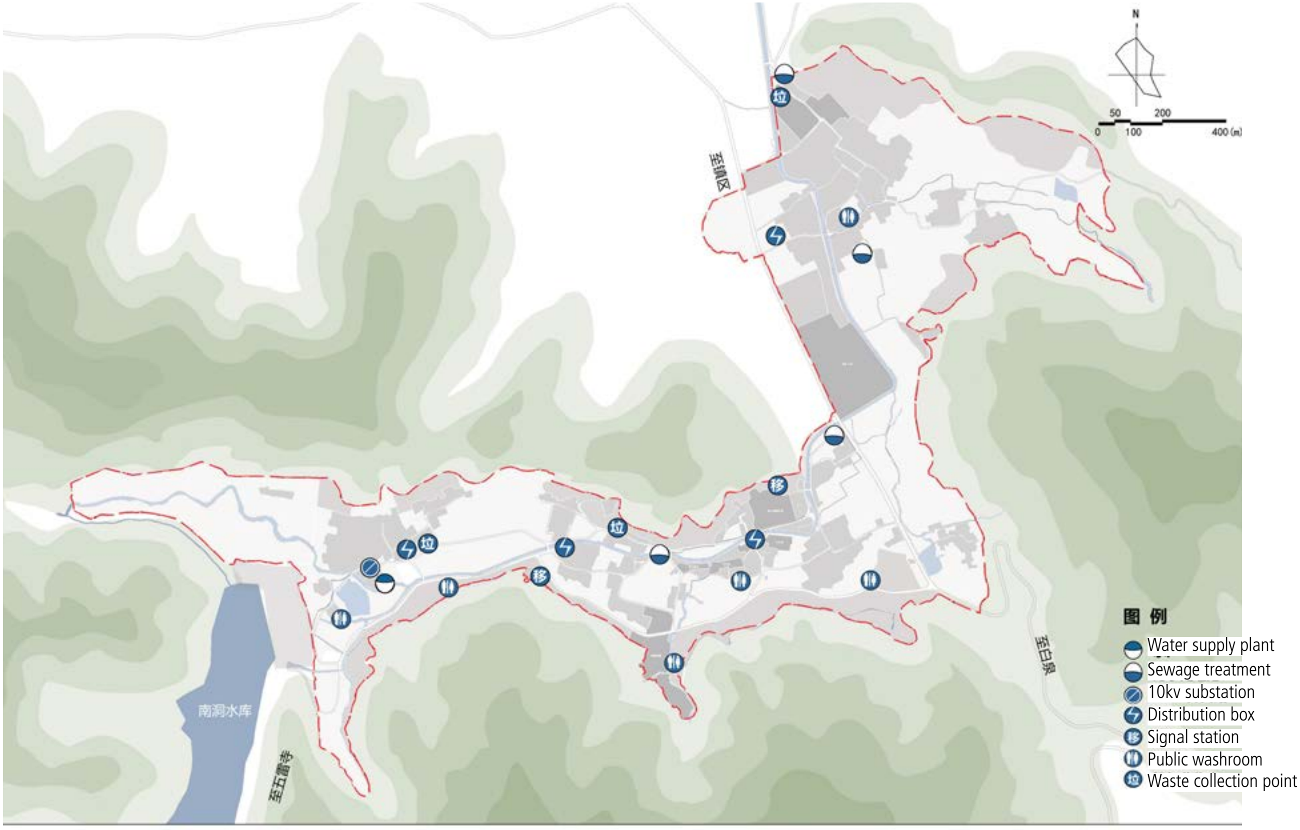



*Fig. 3.21 Xinjian Community 2030 Master Plan, infrastructure facility plan*

**Challenges**

- Sustainable management of the touristic flow, minimizing the material and cultural impact on the existing community
- Spatial planning of the growing village and preservation of the architectural heritage
- Appropriate management of relevant water resources
- Preservation of small-scale farming models

**Opportunities**

- Revitalization of the village with new economic activities attracting young people back from the nearby urban areas, via tourism, innovative agricultural production, creative industries, ICT related production and services
- Closing the energy-water-waste-food cycles
- Development of a new energy system, based on renewable energy sources, aiming for complete self-sufficiency, which could attract companies and professionals for its implementation and operation
- Improvement of the attractiveness of the village through the appropriate promotion of the zero carbon model.

## APPLICATION OF THE 10 PRINCIPLES

The Xinjian case study is ideal for showing how natural resources and pre-existing infrastructures can be combined for outlining a path towards a zero carbon village. The aim of the 10 principles' suggested further implementation actions is to show how the concept of a zero carbon village is closely linked to the concept of a smart grid and how the smart grid is highly dependant on the storage capability of the energy system. At the same time the implementation of the energy system and the closure of the water, food and waste cycles are shown to be able to trigger employment, tourism and economic development.

### Principle 1: Climate data and greenhouse gas inventory

Xinjian Community is characterized by what climatologists define as "marine monsoon subtropical climate". The summers are short, warm, oppressive, and mostly cloudy; the winters are cold and partly cloudy; and it is wet and windy all year round. Over the course of the year, the temperature typically varies from 3.9 to 30.6°C and is rarely below 0.6°F or above 33.3°F.

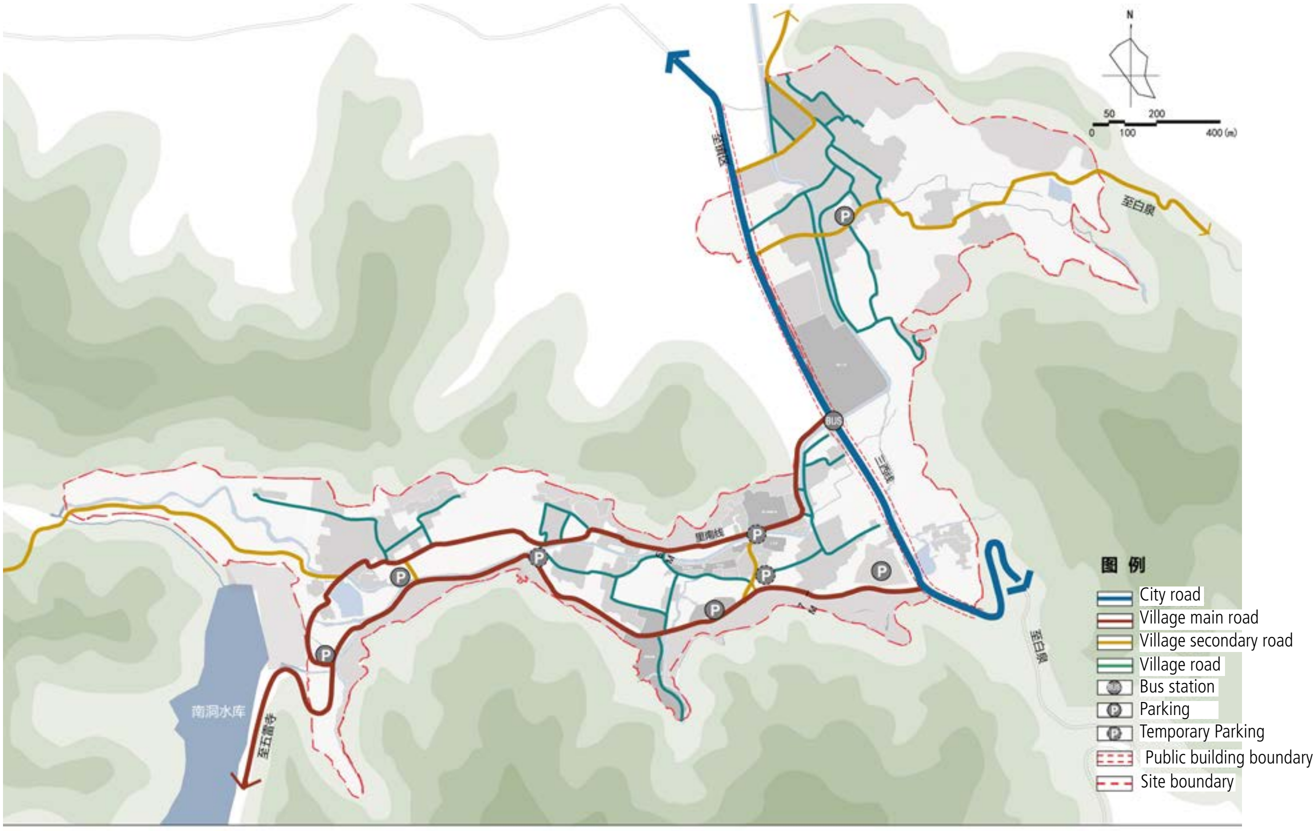



*Fig. 3.22 Road system in Xinjian community*

**Solar Energy**
The average daily incident shortwave solar energy ranges from the brighter period of the year, from April 21 to June 18, with an average daily incident shortwave energy per square meter above 5.3 kWh, to the darker period of the year, from November 8 to February 5, with an average daily incident shortwave energy per square meter below 3.5 kWh.

**Humidity**
The more humid period of the year lasts for 5.4 months, from May 9 to October 22, during which time the comfort level is low because the weather is muggy, oppressive, or miserable for at least 25% of the time.

**Wind**
The windy part of the year lasts for 6.7 months, from September 1 to March 22, with average wind speeds of more than12.0 miles per hour. The calmer time of year lasts for 5.3 months, from March 22 to September 1.

## Principle 2: Well-connected mixed-use nodes

Xinjian Community is 15 km from Dinghai District. The road and transportation facilities include one bus stop and 3 parking lots occupying 5 ha. The road width is 4-7 meters. It takes a maximum of 15 mins to walk to the only bus stop (Figure 3.21).

With a US$150,000 investment in 2016, the village roads have been improved and are now more pedestrian friendly. Another 114,000 million yuan were invested for landscaping of the roads and the farm houses (Figure 3.22).

The Dinghai Changchun Reservoir to the South Cave Road (Figure 3.23), which connects the new community with the northern traffic road, has been in operation since 2017. The district's first main scenic road with "ecological leisure" characteristics, its total length is 4.239 kilometers. The road is winding, like a charming ribbon floating between the green mountains and rivers. Along the road, bike lanes and viewpoints have been added.

Non-motorized transit networks have been established in Xinjian Community, including pedestrian and cycling roads. A characteristic green, non-motorized transit road has been built to connect the Wu Leishan hiking trail with local beauty spots like the Wulei temple, as well as the East China Sea Grand Canyon. Special tourist sites have been designed and constructed to provide the necessary services to tourists.

*Fig. 3.23 Road renovation (before and after)*

### Principle 3: Heating and cooling

No higher than 3 floors, local houses are south-facing with good solar exposure and air movement. Specific energy saving requirements have been emphasized during the planning phase, including the shape coefficient of buildings, the main facade, the area ratio of window to wall, the thermal performance of the building envelopes (walls, floors, roofs, doors, windows, etc). Smart design of the cooling and heating system within the community, and better design of the municipal pipeline network with better insulation measures taken can help save more energy. For the lighting system, highly efficient fluorescent lights and small capacity gas discharge lamps have been installed with multiple control modes configured with both relatively centralized control, and decentralized control. Outdoor lighting is controlled both by timing and actual sunlight interaction, for better performance in energy saving.

### Principle 4: GHG emissions

In the planning process for construction and renovation in Xinjian community, preservation of the village's natural geographic texture as well as local historical and cultural heritages, folk customs and living habits are emphasized. The development planning has been incorporated into the natural, historical and cultural background with the aim of better rural rejuvenation.

Clear directions and small green landscapes have been designed at the village entrance, and on the main connecting roads, with special indigenous plants selected to emphasize the local natural environment as well as better protection of the local species.

Basic design principles for local residential houses can be summarized as "economic and practical, obtaining building materials locally, and being well-spaced with an artistic layout" with a Zhoushan style of island dwellings. The existing stone processing plant will be retained and upgraded to further promote the local brand of "South Cave Art Valley", featuring high-end stone processing, and product exhibitions etc.

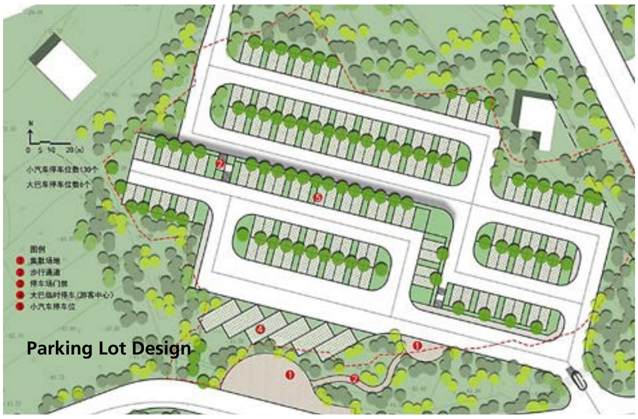



*Fig. 3.25* *The road connecting Dinghai Changchun Reservoir to the South Cave Road*[82]

*Fig. 3.26* *Eco parking lot (before and after)*

## Principle 5: Renewable energy sources

There are three main sources for household water heating, with 30% from solar, 40% from electricity and 30% from gas. The average consumption per household on electricity is 70-80Kwh per month, and on liquefied gas is 15kg.

The total annual radiation is 4126-4598 $MJ/m^2$, and the community is planning to install solar PV panels on the roof of the community art museum for the daily use of electricity in community service centres and surrounding public buildings. It is estimated that with a total area of 523.8 $m^2$ PV panels, around UN$11,900 in electricity costs can be saved. The eco parking lot also installed PV of 250$m^3$ and batteries to utilize solar energy to charge electric cars. All families have at least one electric bike for village or town-wide transportation, in total there are around 600 bikes.

In the future, agricultural activities will be concentrated in a few development zones, and scaled operation and management will be adopted instead of the traditional individual farming operations, in order to enhance energy efficiency as well as farming profitability.

Meanwhile another known planned step is the shift from present energy sources to natural gas, whose advantage, in comparison with other fossil fuels, is its lower GHG emissions per energy unit provided.

## Principle 6: Water cycle

By 2030, it is estimated that with residents and tourists, water consumption will be around 584 $m^3$/day. Currently the community has 1 reservoir and 4 ponds. The South Cave Reservoir has a capacity of over 1 million cubic metres. Rainwater is collected by these water storage systems as well as a separate drainage system and is reused for farmland irrigation.

According to questionnaire survey of the villagers in 2015, among the important problems to be solved, the improvement of sewage facilities is the issue of most concern to the residents, followed by the demolition of dangerous houses and road renovation.

Lichen and South Cave Village have installed sewage

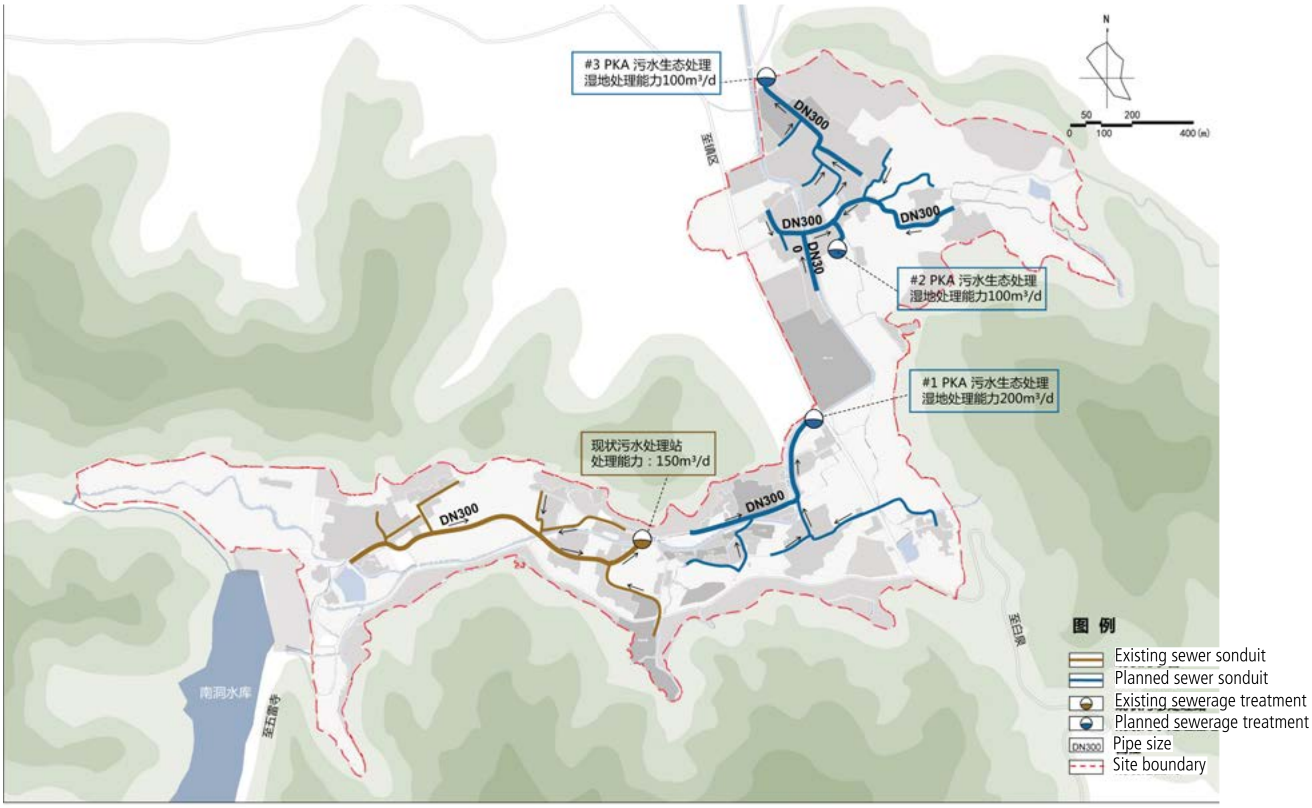



*Fig. 3.27 Waste water system plan*

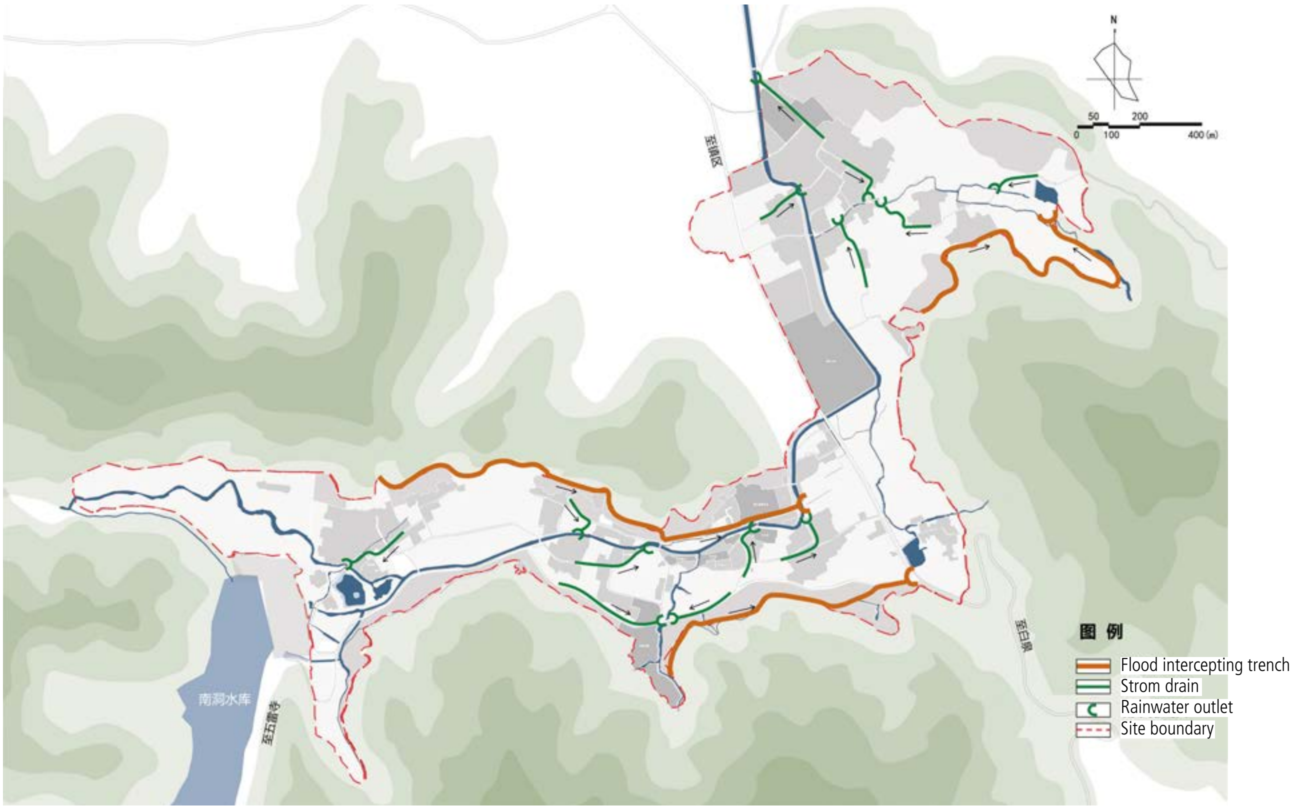



*Fig. 3.28 Flood discharge channel, rain channel and flood cutting ditch*

pipe lines, and a wastewater treatment plant with 150 $m^3$/day capacity. But mostly due to the diameter of the pipes not being large enough, causing blockages and other problems, which has resulted in sewage spills, the number of respondents expressing dissatisfaction reached 88.78% and 91.97%. Huangsha Village has not installed sewage pipes, and nearly 90% residents are not satisfied with the status quo.

A rainwater and sewage diversion system will be built according to the development plan. An existing sewage treatment station, which is used for the treatment of South Cave village household sewage, will, after the pipeline network is completed, treat the all the sewage of the South Cave area.. Chencun Village, Huangsha village in the lower terrain will set up a PKA sewage ecological treatment wetland to treat sewage in the area. After treatment, the sewage will be discharged to the water body or for farmland irrigation (see Figure 3.26 & 3.27).

The original village swimming pool has been converted into an ecological swimming pool. The current size is 15m×25m with 6 lanes. the water depth in the shallow end is 0.7m, and in the deep end is 1.5m. The most distinctive feature of the swimming pool is the use of a natural filtration system designed to create an area of aquatic plants in the surrounding area. This area is used for natural filtration and purification. The swimming pool uses a completely ecological water purification system to achieve a new fusion of humans and nature.

Making use of the drop from the water reservoir, stones have been piled in the floodway to slow the water velocity, create more oxygen and purify water (Figure 3.28). The system of pond chain technology has been used in the main junctions and flowing areas of the main flood channel of the Daxi Reservoir, the bottom of the river channel of Daxi Pit has been specially treated, and the water flow of the river bed has been directed along the section descending from the vertical height of the terrain (Figure 3.29). This has increased the oxygen content of the water body and beauties the river landscape.

The two newt public restrooms, built in 2017, have adopted technology to separate urine from faeces in order to conserve water and reduce waste (Figure 3.30).

Storm water conveyance systems will be built along with newly constructed roads, while runoff in rural areas will be directed to local catchment areas before flowing into rivers through open drains or closed conduits

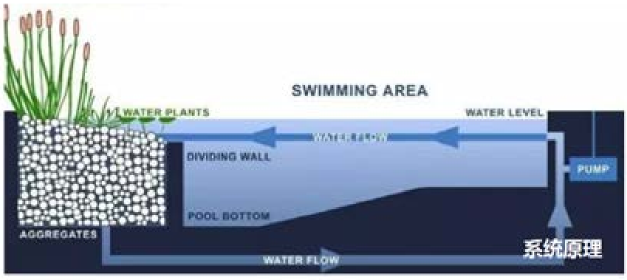



*Fig. 3.29 water purification pool system*

*Fig. 3.30 pond chain system in the floodway*


*Fig. 3.31 Eco-friendly restrooms*

### Principle 7: Solid waste

The community has established two new waste collection points. Garbage is divided into compostable and non-compostable waste, and households are equipped with the corresponding classified garbage collection bins and garbage collection bags. The community has set up rubbish bins at a radius of 60 metres from services. However, compostable garbage is collected and transported to the nearby town for centralized treatment, instead of being treated locally.

A series of educational campaigns has been organized on municipal solid waste classification in the community to better enhance the reuse and recycling of local waste.

### Principle 8: Energy, water, food and waste cycles

There are two centralized agricultural zones and some prime farmlands, most of the products of which are for local consumption. A community water supply plant provides drinking water for local use. Rainwater will be directed to local catchment areas through existing open drains or closed conduits, which will also be used as agricultural irrigation.

### Principle 9: Employment opportunities and leisure

A public participation mechanism has been established to invite different stakeholders to take part in the decision-making process for the community's development planning, construction, and operation. Local communities thrive along with the rejuvenation of rural life, through sharing responsibilities in local business operations as well as sharing the economic benefits.

There are 105 households which have started private business operations or workshops with the support of the local community, and the local authority also encourages local business-owners to strengthen self-management and self-discipline.

The community relies on agriculture (mainly for self-consumption) and tourism. Tourists mainly come at the weekends or on public holidays. Tourists who come on weekdays are usually retired people. The community per capita net income reached US$4360 in 2018, an increased of over 20% from the previous year.
Employment opportunities are now created through "Internet+tourism" mechanism. The home stay hotels have a maximum 400-bed capacity. By the end of 2014, tourism accounted for 57.6% of the community's economy. The renovation of train carriages, traditional Mongolian music, train themed restaurants (Figure 3.31), train cinemas and other places were built and opened during the 2018 National Day holiday. In 2018, the Xinjian community's improved tourism facilities and other measures to attract tourists, received a total of more than 300,000 visitors from all over the world, a 600% increase from the previous year.

Xinjian community promoted the construction of art colleges based on student internships. In 2018 The National Academy of Sciences and the Zhejiang Academy of Vocational Arts established teaching practice bases in the community, and there are now 38 institutions collaborating with the community.

A cultural and creative base, along with the provincial City Photographers Association, includes 20 literary and artistic units which encourage exchanges and cooperation, and a team supporting fishermen's painting and other folk-art creations, has been established, with successful development of cushions, lacquer plates, silk scarves and other merchandise (Figure 3.32).

In 2017, Xinjian Community invested US$150,000 in murals depicting marine culture for more than 60 houses. After the completion of the murals, the village had a more cultural and artistic atmosphere (Figure 3.33).

### Principle 10: Ecological awareness

On the afternoon of May 25, 2015, President Xi Jinping visited Xinjian community, pointing out that "lucid waters and lush mountains are invaluable assets". With the continuous influx of tourists into the Xinjian community, many people will choose a classic route, the road that President Xi took when he visited the Xinjian community. In the community cultural auditorium, there is a TV screen, which continuously broadcasts the video about the General Secretary's commitment to build a more beautiful village and landscape.

## SUGGESTED FURTHER IMPLEMENTATION ACTIONS OF THE 10 PRINCIPLES

1. Build-up a baseline emissions inventory to use as a starting point in the process towards the zero carbon status.

Set up a path from the baseline to the zero carbon status, with milestones to be periodically reached.

Create a structure with the task of monitoring of the emissions inventory, carrying it out on a regular basis (every four years), to check compliance with the milestones and for highlighting possible critical issues.

2. In each of the three hamlets comprising Xinjian Community mixed use should be promoted, avoiding the need to move from one hamlet to another or from one hamlet to the nearest city to satisfy basic daily needs. This implies that each hamlet should host the most


*Fig. 3.32 Themed restaurants on the train*


*Fig. 3.33 Culture activities*

frequently used services, such as groceries, shops, cafes and restaurants, at walkable distances from housing, in order to reduce the need for transportation. Streets can have shops and services on the ground floors and residences on the upper floors.

If any new development is planned, or an existing area is being refurbished, it should host a mixed income social structure; the affordability of housing should permit this requirement.

3. Since many houses will be progressively refurbished to cope with the tourists' demand for accommodation, it is crucial to make them as energy efficient as possible. Therefore, great attention should be paid to the thermal insulation of the envelope, which should be at least 10 cm thick with thermal conductivity = 0.03 W/m K (or equivalent thickness for different conductivity value); low-e glazing should be used. If any change in the size of the windows is intended, the south facing ones should not exceed a Window to Wall Ratio WWR higher than 0.5. Balconies on south facing façades can be transformed into openable sunspaces. Light coloured plaster should be used for external walls to reduce heat gains in summer. In new buildings the same rules should be followed, and it is recommended that, in the absence of balconies, overhangs should be used for shading windows and walls in summertime.

Whenever possible, streets with should be lined with deciduous trees and provided with light coloured and pervious pavements.

If any new development is planned, the north-south/east/west grid should be maintained and the height of buildings to street width ratio H/W should be $< 1$; great attention should be paid to the design of the streets.

4. In new and retrofitted buildings timber, stones and other locally available materials should have priority over other construction materials. Natural fibre insulation materials should be used.

5. Maximise efficiency of energy conversion technologies Heating and cooling can be provided by heat pumps, and a feasibility study should be carried out to find out which one of the three options, ground, water or air source, is the most cost-effective in the Xinjian climate and in relation to the foreseen usage pattern. Hot water production should also shift, progressively, from solar


*Fig. 3.34 Wall painting on village houses (before and after)*

water heaters to heat pump water heaters. CHP units could be planned to be powered by biogas and syngas (see next section).

Xinjian Community can rely on quite good renewable energy potential: solar and wind energy, hydropower and biomass. To best exploit the solar energy potential, all buildings – except the ones that have to be preserved because of their historical value – should host PV panels on their roofs; the same roofs could host wind microturbines, which could also be used for public lighting by installing them at the top of the lampposts together with a PV panel. Building Integrated PV (BIPV) systems are to be preferred to ground PV installations in order to preserve the farming land.

Hydropower is available by exploiting the head (height difference) between the bigger reservoir created by the dam and the smaller one at the village level: a turbine connected to an electricity generator could be installed at the level of the lower reservoir, producing electricity when water is flowing from the upper to the lower basin. Moreover, the existence of the two water reservoirs makes it possible to pump water from the lower to the upper one when excess electricity is available from solar and wind systems and return it back to the lower one – activating the turbine and producing electricity – when solar and wind energy is not available or insufficient. In other words, the two basins can act as a very efficient and relatively inexpensive (compared with batteries) storage system.

Biomass can have two sources: waste and forest. The first source is wastewater that could be treated at individual hamlet scale, with a treatment system allowing the use of a biogas digester. The biogas production can be increased if the digester is also fed by the food wastes of the restaurants. Biogas can be used to power a CHP unit, providing electricity and heat, or simply an electricity generator. The second source is the wood deriving from forest management; wood should be chipped, then conveyed to a gasifier; the syngas produced can be used for powering a CHP unit or a generator. The waste heat produced could be partially used for drying the wood-chips.

6. Sponge-city design should be applied in the renovation of roads and other facilities, and more permeable pavements should be constructed instead of hard surfaces.

Rainwater could be collected from roofs, stored by individual buildings or at hamlet scale, and used for all non-potable uses and/or for water table recharge.

In order to recover energy and nutrients, the wastewater treatment system should be transformed, where it exists, and designed when it does not yet exist, in such a way as to allow the exploitation of the wastewater's energy potential by means of the anaerobic digestion process. This implies the use of a wastewater treatment such as DEWATS or similar, where a biogas digester is the first stage or where decanted sludge is conveyed to a biogas digester. To close the water cycle, treated wastewater should be used for irrigation. The slurry made available after the anaerobic digestion process, in turn, should be returned – as it is or after further treatment, such as drying or composting – to the agricultural land.

7. Organic waste should be conveyed to a local composting plant, and the resulting compost used as fertiliser for the farms around the village, thus partially closing the nutrients cycle. Food waste from restaurants, which is more controllable than domestic food waste, should go to an anaerobic digester, possibly the same one that is fed by the wastewater, for producing biogas to be used for the production of electricity and heat; the slurry can then be used as fertiliser, closing another part of the nutrient cycle.

Disposable goods should be gradually phased out in local restaurants and accommodation.

8. Energy, water, waste and food cycles could be closed and integrated by means of:

- using forest wood to feed a gasifier powering a CHP unit or a generator, with resulting biochar returning to the forest or used as soil improver in farms
- using wastewater and restaurants' food waste to feed a digester producing biogas, and returning nutrients to the soil via the produced slurry
- using treated wastewater for irrigation
- using the water head between the two reservoirs to produce electricity and providing storage
- rainwater harvesting for non-potable domestic use

9. Economic initiatives, complementing the hospitality industry, should be promoted. In particular, small activities for the production and processing of traditional, organic food should be implemented. A shared food processing lab could be implemented in the civic centre and made available to families, and especially to women, who could generate additional income for their families.

The presence of artists should be increased and consolidated, by residencies and festivals. Artists, designers and craftspeople who may be attracted by the rural lifestyle, should be promoted by identifying a "craft street".

The digital and creative capacities of the villagers should be enhanced with training and the opening of a digital village hub, where digital technologies could be accessed, as well as the creative activities to be applied in daily life and especially to the improvement of the farming and touristic activities.

The opportunity to nominate a community innovation manager should be considered.

10. The visit of President Xi has focussed the attention of the country on the community, attracting a growing number of visitors. This opportunity should be capitalized on by a comprehensive informative system, explaining the relevance of internal rural areas in maintaining the environmental and spiritual equilibrium. A community cultural auditorium should be designed in order to host multimedia installations, explanatory panels, and local products. Visitors should be invited into the centre for a short welcome, with an introduction to local products and culture. An explanation of the integrated use of resources, showing how the principles of zero carbon village and circular economy are being implemented, should come from the village leaders. This will be an opportunity to introduce the visitors to the appropriate behavioural rules for responsible tourism.

# Meilin Village, Changzhou

Meilin Village is located in Xixiashu Town, Xinbei District, Changzhou City. It is 11 km to the south of the Yangtze River. Meilin Village is 22 km from Changzhou, the nearest city. Meilin is connected with the central area of the city by buses. Changzhou is a prefecture-level city in southern Jiangsu province, China. Located on the southern bank of the Yangtze River, Changzhou borders the provincial capital of Nanjing to the west, Zhenjiang to the northwest, Wuxi to the east, and the province of Zhejiang to the south. Changzhou is located in the highly developed Yangtze Delta region of China extending from Shanghai to the northwest. The population of Changzhou city was 4,710,000 in the 2017 census.

The total area of the village is 9.17 square kilometres. It covers 35 natural villages made up of 60 groups of villagers, 2245 households with a total population of nearly 7800. Among them, 8 natural villages with 578 households and 2020 people and a total area of about 3 square kilometres have been included in the 'beautiful village' project. The study area of this case is the southern part of Meilin Village, separated from other part of the village by road No.122 (Figure 3.34). This part consists of 3 natural villages: Longwang Temple, Xiangli and Yanjia (Figure 3.35). This area has 194 households with a population of 783. 40.25 million yuan has been invested in the construction of the first phase of the 'beautiful village' project. From this, 7.11 million yuan was used for the construction of rural roads and bridges, 1.52 million yuan was invested in the construction of a water system, 7.18 million yuan was used for new houses, 7.18 million yuan was invested in front and rear house arrangement, 4.46 million yuan was invested in the construction of a sewage pipe network, 15.18 million yuan was used for greening the landscape, 2.8 million yuan was used for housing storage and renovation, and 2 million yuan was used for third-party service agencies.

The land is 65% agricultural, a total of 24.75 hectares. Paddy fields are the main type of agricultural land, accounting for half of all agricultural land (land classification, including grassland and other crop types). The river and lake system is 15.44%. The built-up area is 19.56%, totalling 6.87 hectares. The buildings in the village are mainly composed of one to three storeys and are brick structures (see Figure 3.36 and Table 3.1). The villages were built along rivers, with white walls and grey tiles, the characteristics of the south of the Yangtze River, and are well combined with the distribution of river system (Figure 3.37).

According to the questionnaire interviews with villagers in 2017, the income of farmers in this village is mainly income from wages, supplemented by financial and operational income such as farming. The average monthly income of the villagers is 3,000-4,000 yuan. Villagers aged 50 or 60 are generally engaged in turf farming near their villages for 100 yuan per day, with an annual working day of 300 days or so. Financial revenue is mainly from land transfer, households generally have about 3 mu of arable land (contracted land), mostly transferred to turf planting households or village collectives, each mu of contracted land can earn about

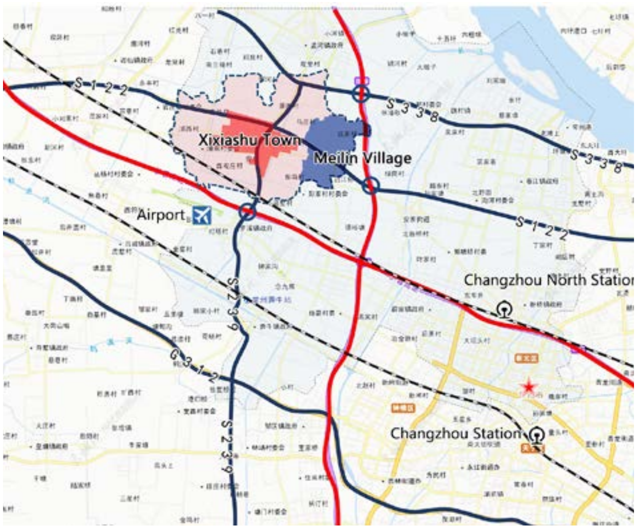



*Fig. 3.35 Location of Meilin*

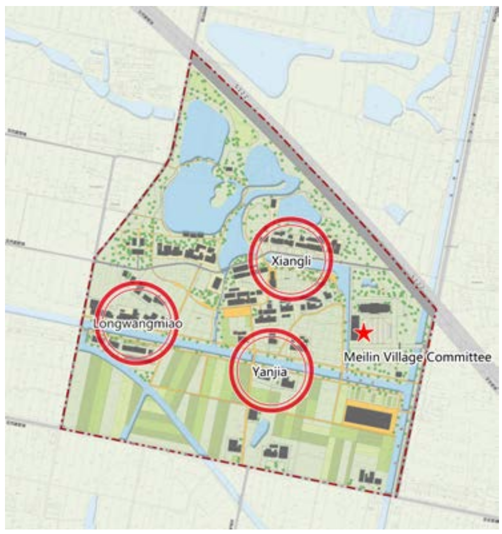



*Fig. 3.36 The southern part of Meilin administrative village include 3 natural village: Longwangmiao, Xiangli, Yanjia*

1000 yuan in transfer costs, bringing about 3,000 yuan of income for each household. In general, a villager’s per capita income in Meilin is 20,551 yuan in 2017 which still lags behind the average income of Changzhou peasants. Compared with the income of urban residents in Changzhou city, which in the same period is 46,000 yuan, the gap is even bigger.

The pillar industry is turf planting, the planting area is 10.67 hectares, accounting for nearly 70% of the total cultivated land,1/3 of the Meilin Village administrative area. Vegetables and rice grown in the land are mainly consumed locally. Grasses for turf are planted in succession with a bottom paving of yellow sand and sprinkler irrigation facilities. The farmers engaged in turf planting account for 70% of all farmers. Large turf planting areas have formed unique rural landscapes, which provide support for the development of rural tourism.

Tourism contributes significantly to the local economy. The main tourist types are day visitors. Longwang Temple is a place of Taoism and the local people believed in harmony during the Northern and Southern Dynasties. On important days such as the New Year's Festival, the Temple is not only a place to display religious culture but is also an important carrier for traditional culture.
The recent improvement work carried out in 2018 aims to make Meilin a model countryside village, including: better ecology and environment, beautiful landscape and buildings, upgraded agriculture, income growth through tourism and the service industry, a stronger village fiscal economy, an attractive and harmonious culture

| Land use code | Land use type | | Area (ha) | percentage |
|---|---|---|---|---|
| V | Construction land | | 8.9 | 26.65% |
| | include | residential | 5.37 | 16.08% |
| | | public facility | 3.19 | 9.55% |
| | | industrial | 0.29 | 0.87% |
| | | infrastructure | 0.05 | 0.45% |
| N | Construction land for external transportation facilities | | 1.02 | 3.05% |
| E | Non-construction land | | 23.48 | 70.30% |
| | include | water surface | 6.35 | 19.01% |
| | | Farm and wood land | 17.13 | 50.99% |
| total | | | 33.4 | 100% |

*Fig. 1 2018 land use plan balance sheet*

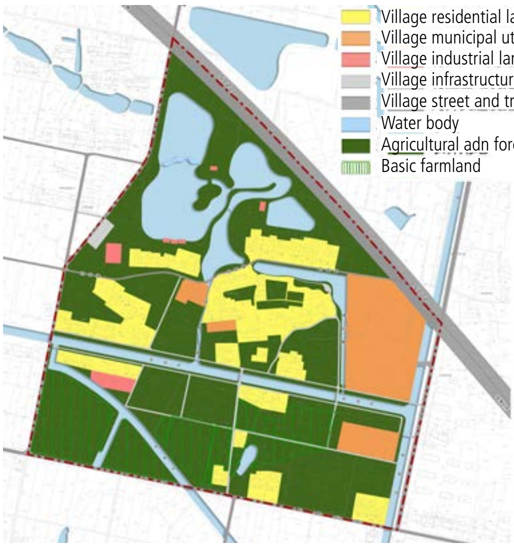



*Fig. 3.37 Land use plan 2018*

*Fig. 3.38 Animation of characteristic village plan for Meilin Village 2018*

## APPLICATION OF THE 10 PRINCIPLES

### Principle 1: Climate data and greenhouse gas inventory

As Meilin Village is part of Changzhou city, in this case study we use the climate data of Changzhou to reflect the climate situation in Meilin Village. Changzhou is located in the transitional climate area from the north subtropical zone to the warm temperate zone. The monsoon has a significant impact on the climate and belongs to the humid monsoon climate of the north subtropical zone. It is a Mmild and humid climate with abundant rainfall, abundant sunshine, a long frost-free period, year-round dominant wind from the east-southeast, and four distinct seasons, spring, summer, autumn and winter, four distinct.

The four seasons in Changzhou are short spring and autumn, long winter and summer, of which winter is the longest, followed by summer, spring is the second, and autumn is the shortest. Winter is cold, summer is hot, spring and autumn are mild. Due to the significant influence of the monsoon, precipitation and temperature rise and fall simultaneously. When the temperature is low in winter, the precipitation is less; when the temperature rises in spring, the precipitation gradually increases; when the temperature is at its highest in summer, the precipitation brought by the plum rain, the local name for the rainy season, rainstorms and typhoons is at its greatest; when the temperature drops in autumn, the precipitation decreases significantly. Table 3.2 below shows major climate data in Changzhou city.

Energy in Meilin Village is relatively cheap. The unit price of electricity in this village is 0.52 yuan/kw, liquefied gas is 95 yuan per bottle (15kg net weight). Electric water heaters are also used in the village. The average household electricity cost in this village is 115 yuan per month. Gas costs 50 yuan per month, and 95% households in the village have a solar energy water heating system, which serves as another way to provide cheap daily energy. As a result of the cheap energy costs, 80% daily energy needs such as boiling water, cooking and heating are met by using electricity, and 20% such needs are met by using gas. Table 3.3 below shows energy consumption of the 3 natural villages in the study area.

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Temperature | 3.1 | 4.5 | 8.7 | 14.9 | 20.3 | 24.3 | 28.0 | 27.6 | 23.2 | 17.8 | 11.5 | 5.5 |
| Average Maximum Temperature | 7.1 | 8.6 | 12.9 | 19.6 | 25.1 | 28.3 | 31.8 | 31.6 | 27.1 | 22.2 | 16.0 | 10.0 |
| Extreme Maximum Temperature | 21.2 | 26.7 | 30.6 | 33.6 | 35.2 | 37.8 | 39.4 | 38.2 | 38.2 | 32.1 | 29.4 | 22.2 |
| Average Minimum Temperature | 0.0 | 1.4 | 5.2 | 10.9 | 16.3 | 20.9 | 25.0 | 24.7 | 20.1 | 14.3 | 7.9 | 2.0 |
| Extreme Minimum Temperature | -12.8 | -8.8 | -4.2 | -1.0 | 6.8 | 13.3 | 17.0 | 17.8 | 10.4 | 2.9 | -4.2 | -11.2 |
| Average Precipitation (mm) | 44.6 | 53.7 | 89.2 | 81.2 | 102.4 | 189.3 | 171.7 | 116.1 | 92.2 | 68.7 | 52.7 | 29.6 |
| Days of Precipitation | 8.7 | 9.8 | 13.0 | 11.4 | 11.7 | 12.8 | 12.8 | 11.3 | 9.5 | 8.7 | 7.0 | 6.1 |
| Average Wind Speed (m/s) | 2.4 | 2.6 | 2.9 | 2.9 | 2.9 | 2.7 | 2.7 | 2.8 | 2.5 | 2.3 | 2.3 | 2.2 |

*Fig. 2 Basic climate data in Changzhou city (Celsius degree)*

| Natural village | Households | Population | Electricity consumption kw.h/ month | Electricity cost (yuan) | Bottled gas/month/ bottle (15kg/bottle) | Gas cost (yuan) |
|---|---|---|---|---|---|---|
| Longwang Temple | 66 | 198 | 14520 | 7550.4 | 33 | 3135 |
| Yanjia | 58 | 230 | 12760 | 6635.2 | 29 | 2755 |
| Xiangli | 70 | 355 | 15400 | 8008 | 35 | 3325 |
| Total | 194 | 783 | 42680 | 22193.6 | 97 | 9215 |

*Fig. 3 Energy Consumption in the 3 natural villages in study area*

### Principle 2: Well-connected mixed-use nodes

In Meilin Village, the width of the rural roads is less than 4m, and they run north-south and east-west. Based on the existing village roads and ridge roads, the recent work identified the tourist routes and combined them with the texture of existing village houses and farmland. Road pavements are mainly made of "soft" materials, rather than "hard" ones. Priority should be given to the use of soil or simple pavements, so as not to emphasize the setting of hard pavements. The village signs, recycling facilities and drainage facilities all adopt simple and ecological design methods and integrate them into the surrounding local environment.

In order to encourage walking and reduce car usage, a system of pathways has been planned within villages, connecting various types of landscape nodes in series. In 2018 two types of pathway were built, the wood path and the stone one. The paving of walkways with crushed yellow stone with its width controlled at 1.5 meters formed a local walkway (Figure 3.38). The waterfront space has been laid with a wooden trestle road to provide a more hydrophilic environment. Large areas of tall plants and herbs have been planted on both sides of the wooden trestle road to create a feeling of being integrated with nature.

### Principle 3: Heating and cooling

Houses in the southern part of Meilin Village are of 3 heights (Figure 3.39). The single floor houses mainly consist of houses (mostly auxiliary houses or livestock houses) and the restored Longwang Temple. The two and three storey buildings are residential or public service facilities. Local houses are no higher than 3 floors and are mostly south-facing with good solar exposure and air movement. There are more one and three-storey-than two-storey buildings. Most buildings were built in the 1980s, a few were built after 2000.

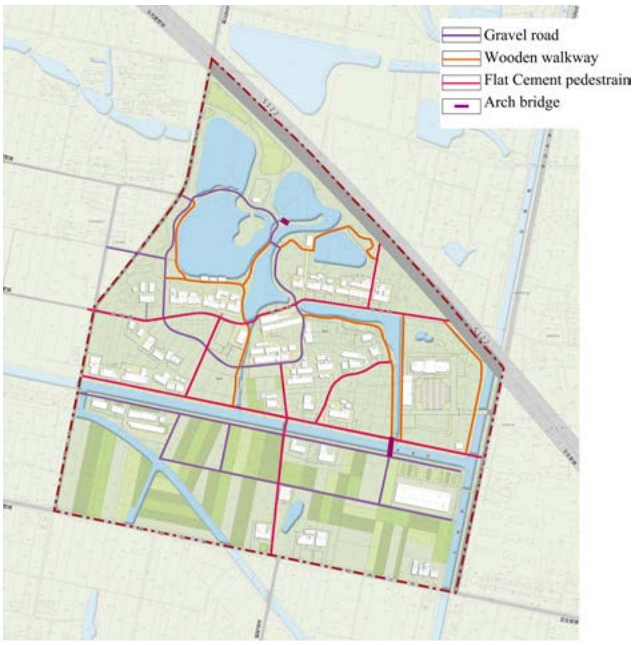



*Fig. 3.39 Walkways plan*

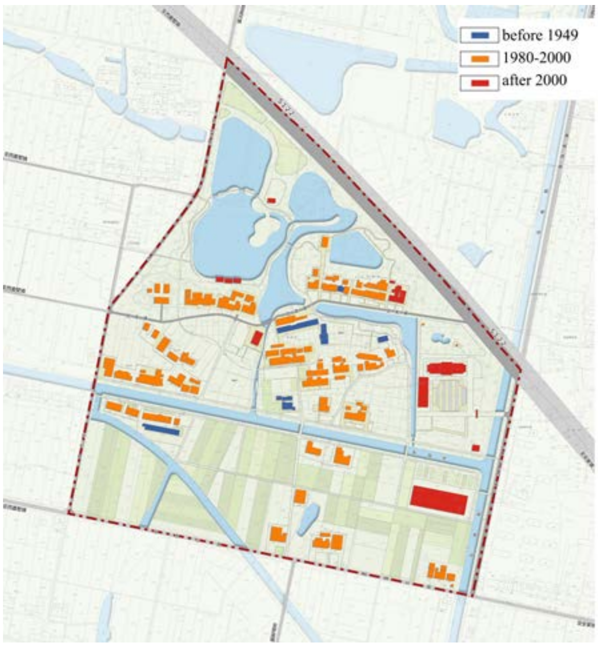



*Fig. 3.40 Year of construction of existing buildings*


*Fig. 3.41 Height of existing buildings*

The village has invested over 2.1 million to develop assembly buildings. Light steel assembly building design can reduce pollution of the environment. Compared with other buildings, it uses fewer building materials and consumes less energy, and its performance is far superior to that of traditional buildings. The walls of the assembled building can be repeatedly disassembled and reused, and construction waste will not be generated due to wall disassembly. Locally Meilin Ju is one example of a light steel assembly buildings (Figure 3.40). It was built by the village government as a tourist reception facility and also as a demonstration of a green building. It is a prefabricated building, using an insulated envelope to reduce energy consumption. The total investment is 1.5 million yuan.

### Principle 4: GHG emissions

In 2018, with the designer's help, local villagers utilized building waste to construct walkways with pastoral viewpoints with the strong local culture of reducing energy consumption for transportation of resources. Villagers laid waste bricks and adopted the local style to form an idyllic trail, waste roof tiles were reused to build small retaining walls. Recycling the building waste locally has greatly reduced the purchasing and shipping of granite for pavement from outside. Local villagers also get paid 150RMB/day when they worked on the construction themselves (Figure 3.41).

Some of the existing old houses with a long history and regional characteristics have been transformed and repurposed with new functions such as residential accommodation and tea rooms. The renovation work actively uses local materials, adopts local construction technology, excavates the characteristics of the existing green tile grey wall of residential houses, continues and properly strengthens the renovation of residential houses, reflects the continuation of characteristic elements, and forms a coherent spatial relationship (Figure 3.42).

Reuse has saved a large number of building materials. 58,000 bricks have been reused, including 15,000 pieces for paving pastoral roads, 35,000 pieces for laying half walls round vegetable gardens and 8,000 pieces for other purposes. 12,000 abandoned bamboo scaffolding poles have been used during the process, including 11,000 for bamboo fences and 1,000 for other purposes. Old tiles, tanks, cylinders and farm tools have

*Fig. 3.42 Recycle building waste for pavement and landscape elements*

*Fig. 3.43 Local workers recycle building waste for landscape elements*

also been reused. 155 villagers participated in the reuse process and helped to take 40% of the total workload. Processing, labour and transportation for the utilisation of waste materials cost 1.1 million yuan.

### Principle 5: Renewable energy sources

Solar energy as a sustainable energy source has been widely used in the southern part of Meilin Village. By 2018, 95% of farmhouses in the village have installed solar water heaters. The average cost of a solar water heater is 2500
yuan.

In order to gradually replace bottled gas, in 2018, Meilin village decided to build a low-pressure gas pipe network. The project will lay DN100 pipes along the road into a ring arrangement; gas pipelines generally use HDPE pipes. The gas source is West-to-East gas transmission and Sichuan-to-East gas transmission. Gas is supplied by municipal medium-pressure pipelines, and low-pressure surge stations or boxes are set up in villages to supply gas by low-pressure pipeline networks. The service radius of medium and low voltage surge stations or boxes ranges from 500 to 1000m.

### Principle 6: Water cycle

In Meilin village administrative area, the natural rivers include the Yan'an River and the Dongfeng River. The total length of the Dongfeng River is 7070m of which 630.74m run through Meilin. The total length of the Yan'an River is 2550m of which 343.78m are in Meilin. The channel is narrow, with an average cross-section width of about 5-10 meters, showing a T-shaped structure. Pit and pond water systems intersect each other, covering an area of 4.48 hectares. The total water coverage rate was 18.5%.

The 2018 improvement strategy is to upgrade the homesteads along the river, leaving ecological corridors and passages, vacating the open spaces, revitalizing the stock assets, and laying the foundation for resource activation.

The big step forward taken in 2018 was to connect the rivers, the pits and the ponds, forming the water system network. Meilin village has also improved the shoreline in the village. Separated waters have been integrated into the whole water system, the irrigation and drainage channels of farmland have been dredged, and a multi-level water grid of "canal-lake-ditch" as a whole has been formed.

Residential buildings on both sides of Dongfeng River have been controlled, dilapidated houses and self-construction in violation of regulations have been demolished to create ecological river corridors and promote the mutual penetration of river bank, village and farmland landscapes. Recent work has also protected the plants on the open water surfaces, trying to retain the original vegetation, and use reeds, calamus, scallions, bananas and other native aquatic plants to purify water, improve water quality, reduce agricultural non-point source pollution while forming the original ecological landscape and increasing hydrophilicity.
There was no rural sewage treatment facility in Meilin village before 2018. The decentralized sewage treatment

*Fig. 3.44 Longwang Temple Cultural Square animation*

*Fig. 3.45 Tourist rout and activities*

system is used to solve the problem for 200 households or so. The effluent quality reaches the B1 standard and is discharged into the river. Combined with decentralized sewage treatment facilities, small wetlands have been constructed to realize reclaimed water recycling and create a diverse landscape experience.

Investment in equipment and construction of sewage treatment facilities in Meilin was 7.29 million yuan, the facility covering an area of 660 square meters. The monthly operational input of the sewage treatment facilities, such as electricity cost 2000 yuan, including maintenance personnel, monthly maintenance times and main work: 2 times, equipment maintenance, greening maintenance. The number of pipe network connections to households of treatment facilities is 578, with an average daily sewage treatment capacity of 275 tons per day.

### Principle 7&8: Solid waste and energy, water, food and waste cycles

In Meilin Village, discarded construction material is recycled for making walkways and fences. The kitchen waste, mostly from the 3 major farmhouse restaurants, is converted into organic fertilizer and returned to the fields for use in organic vegetable gardens. Meilin Village has invested 800,000 yuan in kitchen waste treatment facilities, which occupy 50 square metres of land. The maximum capacity of the treatment facility is 1 ton/day, and the treatment cycle is 3 days. Two to three times a week, a total of 10 tons of kitchen waste can be collected. After treatment, every ton of kitchen waste can be converted into 0.1 ton fertilizer.

*Fig. 3.46 Use grass land to attract more activities such as football, kiting, ect*

The fertilizer output is equivalent to the same weight of fertilizer purchased from outside, so there is no longer any need to purchase. The treatment of 1 ton kitchen waste will produce 0.2-0.3 tons of waste water. The quality of the waste water is in line with the national standard. The monthly operational cost of electricity of the kitchen waste treatment facilities is 2550 yuan/month (0.85 yuan/kw, unit power consumption 0.1 kw/kg/day). , with which 6 tons of organic waste can be sorted out. The converted fertilizer can meet the demands of 50mu (1mu=667sqm) of organic vegetable gardens. The village's other 25mu of vegetable gardens for outside buyers have also used the converted organic fertilizer. Its annual output is 300,000 yuan. To rent the farm land, the annual cost is 30,000 yuan, and to manage the garden, the labour cost is 105,000 yuan. The cost of using ecological equipment, such as insect trap lamps, is 30,000 yuan per year.

### Principle 9: Employment opportunities and leisure

The main historical and cultural resource of the area is the Longwang Temple, a Taoist spiritual place. The Longwang Temple is a place where Taoism and local residents expressed their belief in harmony during the Northern and Southern Dynasties. On the important days of the holidays, the Longwang Temple is a focal point for displaying religious culture and is an important carrier for the inheritance of traditional culture.

The Longwang Temple is the core of the surrounding upgraded public venues which carry forward the regional culture and the spirit of the times. Relying on the temple fair on March 3rd and traditional festivals, the villagers' collective activities are organized to encourage the inheritance of traditional activities and traditional skills.

The recent construction around the Museum of Agricultural Folk Customs promoted farming culture. Combined with the vegetable gardens around the farmhouse, it provided personal experience of farming. Through the development of family farms, vegetable gardens and other leisure and sightseeing agriculture, the recent work has stimulated the villagers to pay keen attention to the micro-environment, such as the fronts and backs of their houses and the public environment of the village, and this continues to improve spontaneously, enhancing the villagers' participation and sense of ownership of the development of the village, and at the same time creating a good basic landscape for rural tourism.

To strengthen the existing turf planting industry, Meilin Village has carried out strategic cooperation with provincial agricultural research institutes, and research and development of turf products has intensified, focusing on the cultivation of cold and drought-resistant varieties of turf.

Combined with turf planting, Meilin Village has promoted rural a sightseeing and leisure industry. In combination with the current land transfer work of the two committees of the village, the village has opened up special experience areas for recreational activities, such as kite flying, football and so on.

The main tourist projects include Meilinju Homestay, the Longmen Yuxiang Ecological Park built beside the borrowing pit, and the traditional B&B (Longmen Inn) built by the Meilin Village Committee, which has 26 beds. They have reconstructed the traditional cultural carriers of the village - the Longwang Temple, and the Agricultural Culture Museum, which was transformed from the disused factory building of the village office.

The recently built Longwang Temple Cultural Square (Figure 3.43) includes the original basketball court, echoing the Longwang Temple, rebuilding of the the stage, reproducing the scene of the temple fair, refining the pavement, softening and hardening the site, planting local vegetation, making it into a place for festival activities and villagers' leisure and entertainment.

Special cultural activities have been carefully organized for each season. There are 2-3 special thematic activities in each season, and the route for the cultural activities tour was built. Meilin Village has formed an organizational mechanism for the participation of all villagers, taking village collectives as the main body for organizing folklore and cultural activities, mobilizing talented people, big families, joint ventures and schools in the villages, encouraging the full participation of everyone. Longwang Temple and the Plaza Cultural Square are used as the main venues and carry out colourful folklore and cultural activities in conjunction with the cultural tours (Figure 3.44&3.45).

### Principle 10: Ecological awareness

Meanwhile, Meilin Village plays an important role in educating local professionals and government officials. Chao Bin, a member of the Changzhou 'Beautiful Village' project's group of experts , was trained in the Meilin Beautiful Village Project. The construction team which has practised in Meilin has accumulated 50 experienced constructors and team leaders. Moreover, more than 7 800 people have been invited to study, including more than 2000 students of all ages, in Meilin Village. It has also been arranged for students to study vegetable planting and farming knowledge in small vegetable gardens when they visit Meilin

## SUGGESTED FURTHER IMPLEMENTATION ACTIONS OF THE 10 PRINCIPLES

1. Meilin Village needs to monitor its energy usage and establish a comprehensive monitoring platform for energy resources in villages. Based on the energy data, it needs to set up its carbon inventory.

2. To reduce carbon emissions, mixed land use should be further promoted, where most frequently used services such as groceries, shops and restaurants should be located, very close – at walkable distance - to housing – in order to avoid the need for using a car. Streets could have shops and services on the ground floor and residences or offices on the upper floors.

3 The use of energy could be more efficient. Parking spaces should be minimized and equipped with PV canopies and with charging points for electric vehicles. In both newly built and existing buildings, the use of timber is recommended as a structural material and for the envelope, as well as stones, and natural fibre insulation materials. Whenever possible or applicable, both in new and existing buildings, operable sunspaces on south facing balconies should be considered, as well as appropriately sized overhangs protecting south facing windows from the sun in summer.

To increase carbon sinks, a fruit tree claim system can be established. The system means the collective purchase of fruit tree seedlings by the village, the villagers can claim seedlings, are responsible for planting and maintenance, but the fruit trees belong to the village collective ownership, and the fruit belongs to the villagers.

4. Building strategies such as reusing the waste bricks and tiles of demolished houses, using bamboo scaffolding and making bamboo fences after use, should be encouraged and further promoted by the local government. The farmer's houses should be further upgraded. The current farmers' houses do not meet the requirements for earthquake resistance, have poor energy-saving performance, inadequate anti-seepage function and there are potential safety hazards, but they also invisibly increase energy consumption.

5. There is significant potential for sourcing biomass. One could derive from the management of the surrounding forests. This biomass, chipped, could feed a gasifier and the gas used to power a cogeneration unit. The biochar produced by the gasifier can be used by farmers for improving soils, sold for other uses, or spread on the forest from which it comes, closing a cycle. Another biomass source derives from wastewater (see Principle 5) and from the food waste from restaurants, which could be used to feed a digester. The biogas produced could also power a cogeneration unit, whose waste heat could be used for heating, cooling and hot water production in the government buildings or in hotels,

as an alternative to the heat pump, or for industrial processes.

The case of Meilin Village offers some valuable lessons. There is mixed land use and the use of multiple energy sources. Farmers have already used energy according to the principle of minimum cost in their daily life. On this basis, they can optimize and advocate the comprehensive use of energy. At the same time, the recycling of biomass in farmland is not good enough, and the source of organic matter is insufficient in the process of biogas production (there is less kitchen waste in rural areas). Should the improvement of combustion efficiency, for example by promoting high combustion efficiency stoves be considered?

6. The possibility of modifying and upgrading the wastewater treatment plant for biogas production should be considered. This would allow the reuse of not only the treated wastewater for irrigation, but also of the slurry (after appropriate treatment), thus nearly closing the nutrient cycle.

Biogas production, feeding a CHP system or simply an electricity generator, could be used as a supplemental storage system (see Principle 4).

7. As for garbage disposal, in the small vegetable garden project, organic garbage is transformed into fertilizer by equipment designed for such treatment and returned to the small vegetable garden, basically achieving economic balance. More of this type of organic food production should be promoted.

8. Rural construction needs appropriate design and a good system of construction. It should not copy the system and experience of the city directly into the countryside. It should consider the lifestyle characteristics of the countryside and the differences between it and the city.

9. At present, the mechanization of rural areas in China is relatively low, especially as regards the popularization of small agricultural machinery. With a strong manufacture chain nearby in Changzhou city, Meilin may be a testing ground for advanced small agricultural machinery, which can create more jobs and attract more tourists.

10. Rural education is geared to urban students; in the process of construction, villagers and village cadres are also educated and trained, and villagers' ideas are promoted by arranging for the their participation (along with scattered workers in construction); at the same time, special skills are taught during the process of construction, cadres familiar with rural construction are trained to spread the skills to other places, and construction teams capable of rural construction are also trained.

Shanxing Town, Chongming Island

# 4 Village planning and design methodology: Xiebei Village

# Village planning and design process: Northeast Xiebei Village conceptual plan as an example

## INTRODUCTION TO METHODOLOGY

In order to better contextualize net-zero carbon village planning in the Yangtze River Delta, Xiebei Village on Chongming Island is given here as an example. An analysis of government plans as well as existing connections, land use, natural resources, ecological and public spaces, and settlement typologies on Chongming Island was conducted. From this preliminary study, a clearer picture of Xiebei Village's situation in Gangxi Town and on the Island as a whole was formed, which allowed for more culturally and geographically informed recommendations in the conceptual plans for the planning zone within the Village. The process for developing a series of plans is illustrated in the following section, which precedes more outcome-oriented recommendations for five villages in the Yangtze River Delta (including Xiebei Village). It should be noted, however, that while the ultimate aim of The Guidelines is carbon neutrality, the planning and design process undertaken for the northeast quadrant of Xiebei Village is meant to set a precedent for how social, cultural, heritage, and economic values can and should also be considered when promoting sustainable planning principles.

The proposal includes: 1) a settlement typology based on a hybrid between traditional regional (YRD) settlement patterns and a more compact model of development whereby daily needs can be met within walking distance of all homes; 2) an incremental development model which includes the infill and renovation of buildings in central nodes and phasing empty buildings and strip-style developments towards agricultural and ecological lands (carbon sinks); 3) the conversion of empty or underutilized buildings into public and social amenities; 4) transportation networks that encourage primarily non-motorized transit, with options for electric vehicles and public transportation for disabled persons and for longer-distance travel; and 5) new social and economic opportunities for residents and visitors to the Village.

The proposed set of plans aims to align with local planning documents, including the Chongming Island Master Plan (2016-2040) and Shanghai's 13th Five-Year Plan, but it is critical that elected officials, village residents, and other stakeholder groups that might be affected by the development of the Village are also consulted before implementing any of the suggestions that follow.

## CHONGMING ISLAND CONTEXT

Chongming Island occupies an area of 1,267 km$^2$, sandwiched between the Yangtze River's northern and southern branches as it empty into the East China Sea. It is the third largest island in China and the largest alluvial island in the world. Formed through the deposit of sediment from the Yangtze River, it has fertile soil and a moderate climate for agriculture, abundant wetlands and botanic resources, which contribute to its diverse ecology. Chongming Island has a typical mild and humid maritime climate with an average temperature of 15.20°C, an average rainfall of 1.025 mm per year and a relative air humidity of around 80%. The Island is both physio-geographically and sociologically unique due to its physical formation and distinct mixture of rural-urban administrative boundaries and economic bases, which has resulted in a complex administrate system under which rapid changes and land use have led to poorly coordinated village planning.

The Island, together with Changxing and Hengsha Islands, form Chongming County, the northernmost area of the provincial-level municipality of Shanghai. At the time of the 6th Chinese Census (2010), the County had a population of 660,000.

Chongming Island's 2016-2040 Masterplan outlines an overall strategy which emphasizes achieving a balanced population, economy, society, resources and environment through sustainable development. It also prioritizes ecological protection and restoration to preserve natural resources for future development. Alongside the promotion of a circular economy, low-carbon development is also referenced in the Island's masterplan, whose plans include supporting low-carbon eco-industries and positively and effectively controlling carbon intensity via technological innovation

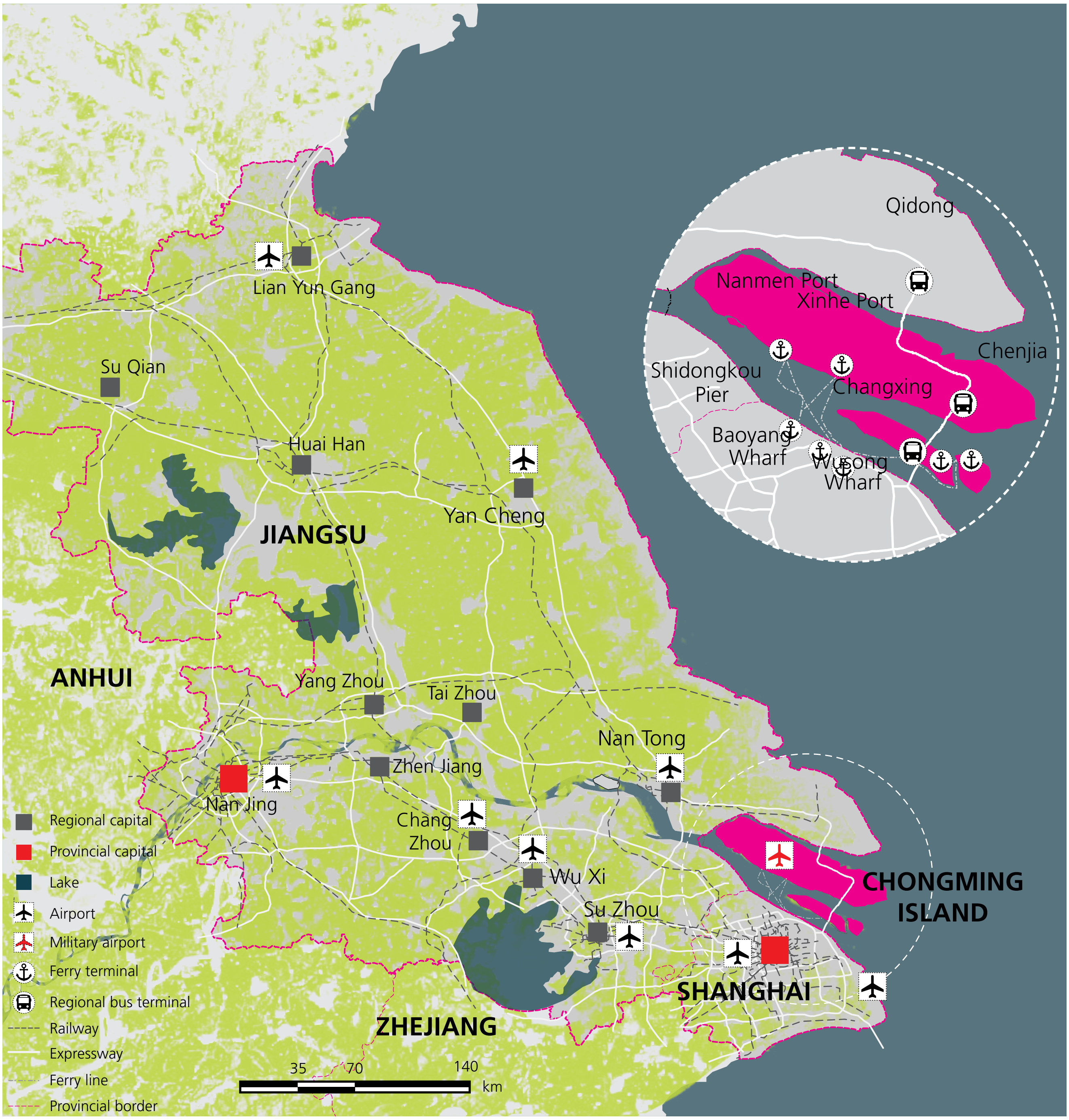



*Fig. 4.1* *Chongming Island regional context*

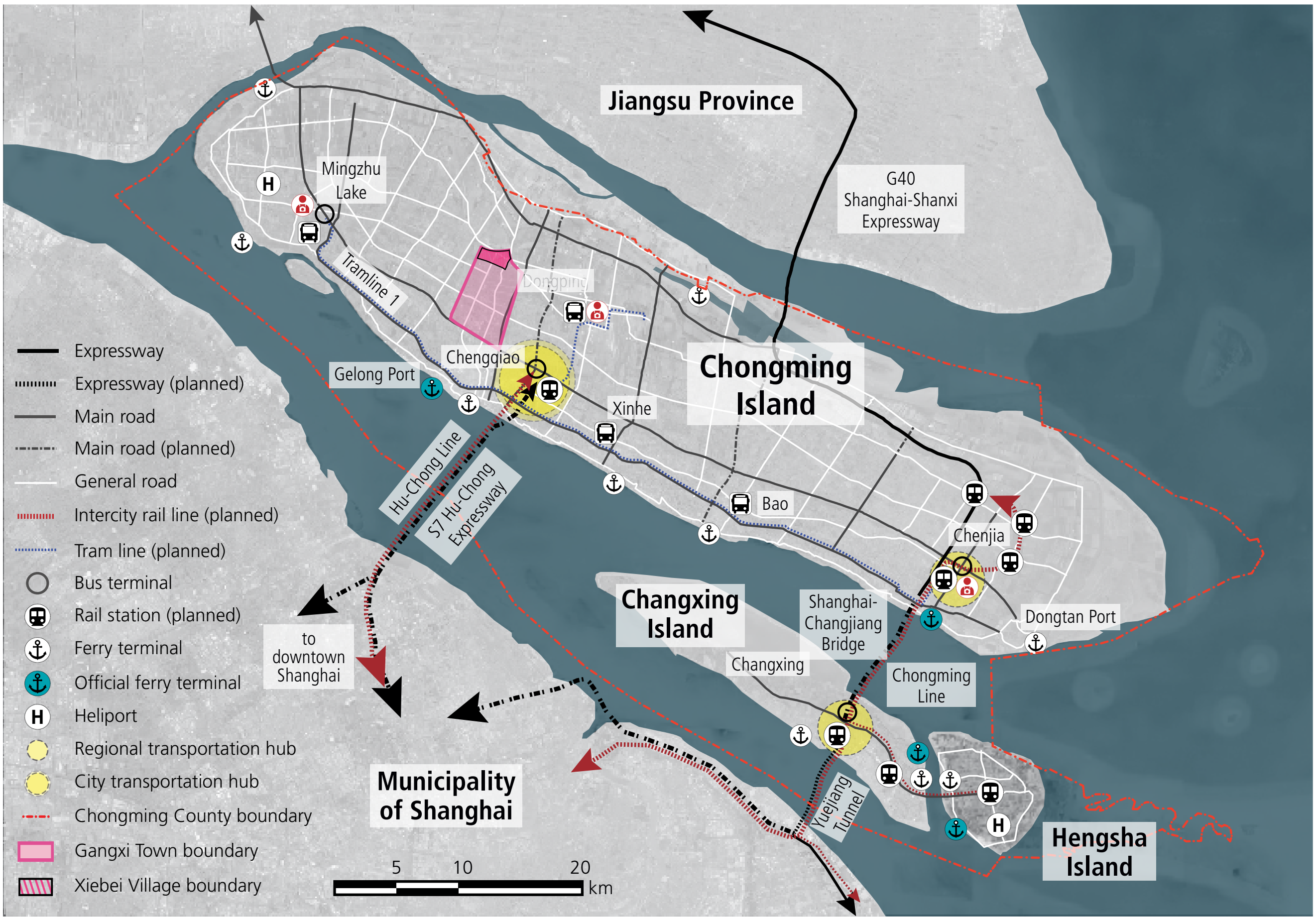



*Fig. 4.2* *Chongming County transportation network*

## Transport planning

Chongming Island's master plan promotes the diversification of public transportation modes and green and low-carbon development models through the establishment of a multi-modal public transport development model with rail transit as its "backbone", bus transit as its "main body" and a ferry system which supplements land transport.

A strategic trunk road network is intended to enhance connections between Chongming Island and Shanghai. A "two vertical" expressway system will connect Chongming to both Jiangsu to the north and Shanghai to the south. The G40 Shanghai-Shaanxi Expressway already connects Chongming to Jiangsu in the north and Chongming Island to Shanghai via Changjiang Bridge, Changxing Island, and the Shanghai-Changjiang Tunnel to the south. The S7 Huchong Expressway is currently under construction and will connect Chongming Island to Shanghai.

Parallel to the expressways connecting Chongming Island to Shanghai, two intercity rail lines are planned. The Hu Chong Qi Line will serve as the westbound passage connecting Chengqiao City on Chongming Island to Shanghai while the Chongming Line will run parallel to the Shanghai-Changjiang Tunnel and Bridge, providing public transportation between Chenjia Town on Chongming Island, Changxing Town on Changxing Island and Shanghai.

A "one horizontal and one vertical" tram line network is also proposed in the Master Plan. "One horizontal", Tram Line 1, will mainly serve as an east-west connection between the southern towns (Chenjia, Baozhen, Xinhe) on Chongming Island, and link the Chengqiao Town Hub with the Chenjia Town Hub. "One vertical", Tram Line 2, will mainly serve to alleviate inbound and outbound traffic and tourist traffic from Chengqiao to the Dongping eco-tourism development areas. Chenjia Town and Changxing Island will be established as the two main regional-level passenger transit hubs.

Central transport hubs are intended for Bao, Ximen and Xinhe to optimize the existing conventional bus network, support an integrated urban-rural bus network, and increase public transportation services across the Island and between Chongming and Shanghai. According to Chongming's masterplan, bus routes and smaller transport hubs should be planned in conjunction with residential areas, commercial centres, industrial zones,

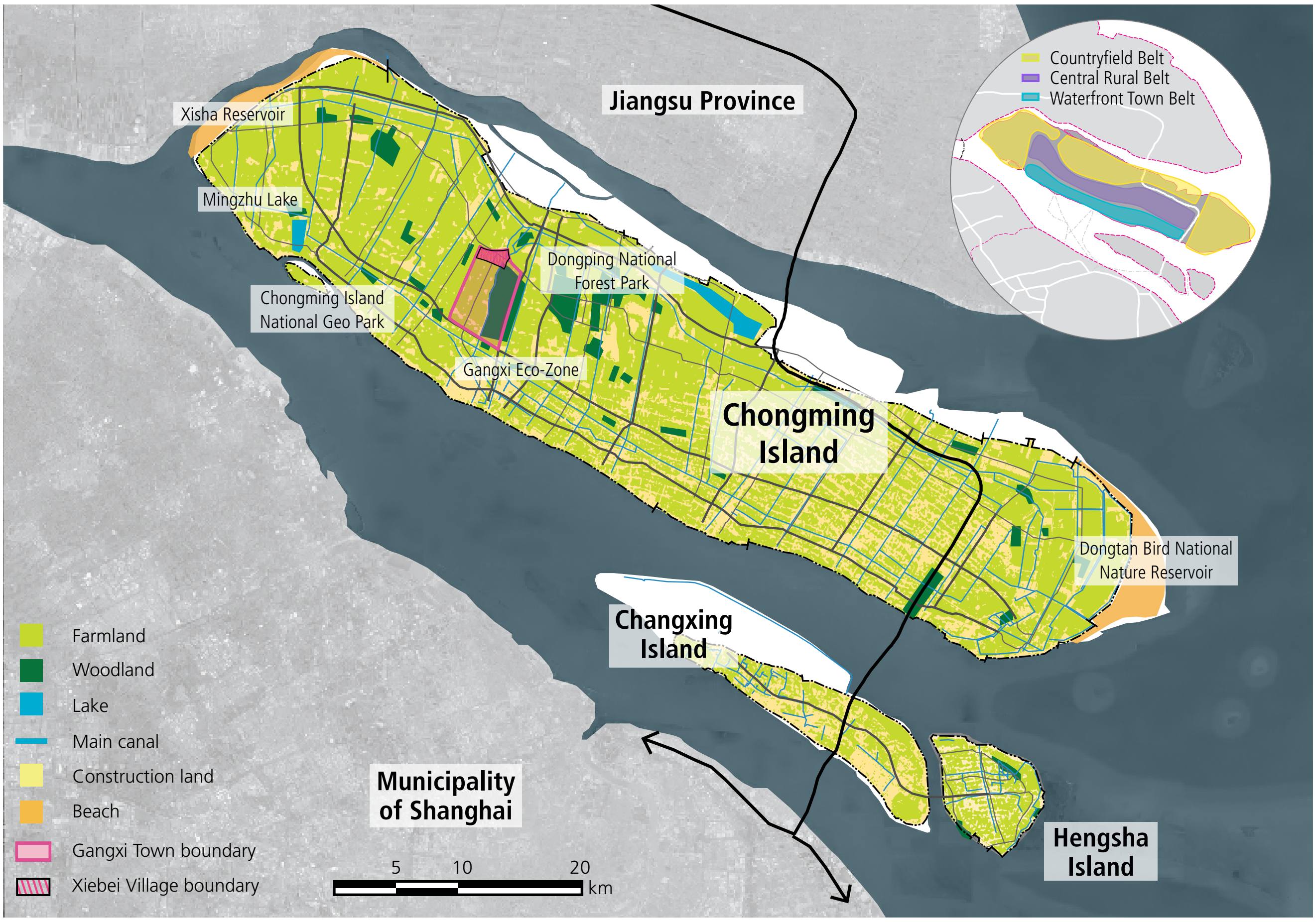



*Fig. 4.3 Chongming County land use*

public and recreational spaces and tourist destinations. Ten port areas and terminals are also designated for construction in the master plan.

In terms of electric vehicles, by the end of 2018, all buses in the County are intended to be electric-powered. With over 200 electric vehicle rentals constructed in Chongming–covering transport hubs, tourist attractions, main residential areas, schools and hospitals—electric cars have become a mainstay in the County[83].

Bicycle touring is promoted on the Island, with … race and 256km of cycling routes across the County. Bike routes link Dongtan National Bird Reserve, Dongtan Wetland Park, Chongming Island National Geopark, Mingzhu Lake, Xisha Wetland and the International River and Island Cultural Museum, among others. Within villages, bicycles are often used by senior citizens, although dedicated lanes are scarce.
Similarly, walking is common amongst older residents within villages, but the lack of sidewalks and often sprawling settlement typologies make the future prospects for non-motorized transport amongst tourists and younger generations accustomed to driving, slim.

## Land use and natural resources

Agricultural land accounts for 74% of land use and provides most of the food supply in Chongming County. Other important land uses include water bodies, rivers and canals (11.9%), residential areas (9.7%) and shoals (5.9%)[84]. (Master Plan and General Land use Plan of Chongming District, Shanghai, 2016 – 2040)
Land use on Chongming Island is horizontally stratified from north to south. The northern "Countryfield Belt" is composed mainly of modern farms that are operated on a large scale; the "Central Rural Belt" makes up most of the Island and its rural areas; the southern "Waterfront Town Belt" is divided into several riverside towns, including Sanxing, Chengqiao, Xinwan, and Chenjia.

## Ecological Spaces

With an extensive water system, Chongming boasts beautiful scenery, including Mingzhu Lake, Bei Lake, and nearly 20,000 rivers, which a total length of more than 10,000 kilometres. Natural wetland ecosystems are widely distributed along the coastline and provide vital habitats for many wildlife species.

The Island has a total tidal flat area of 132 $km^2$ and

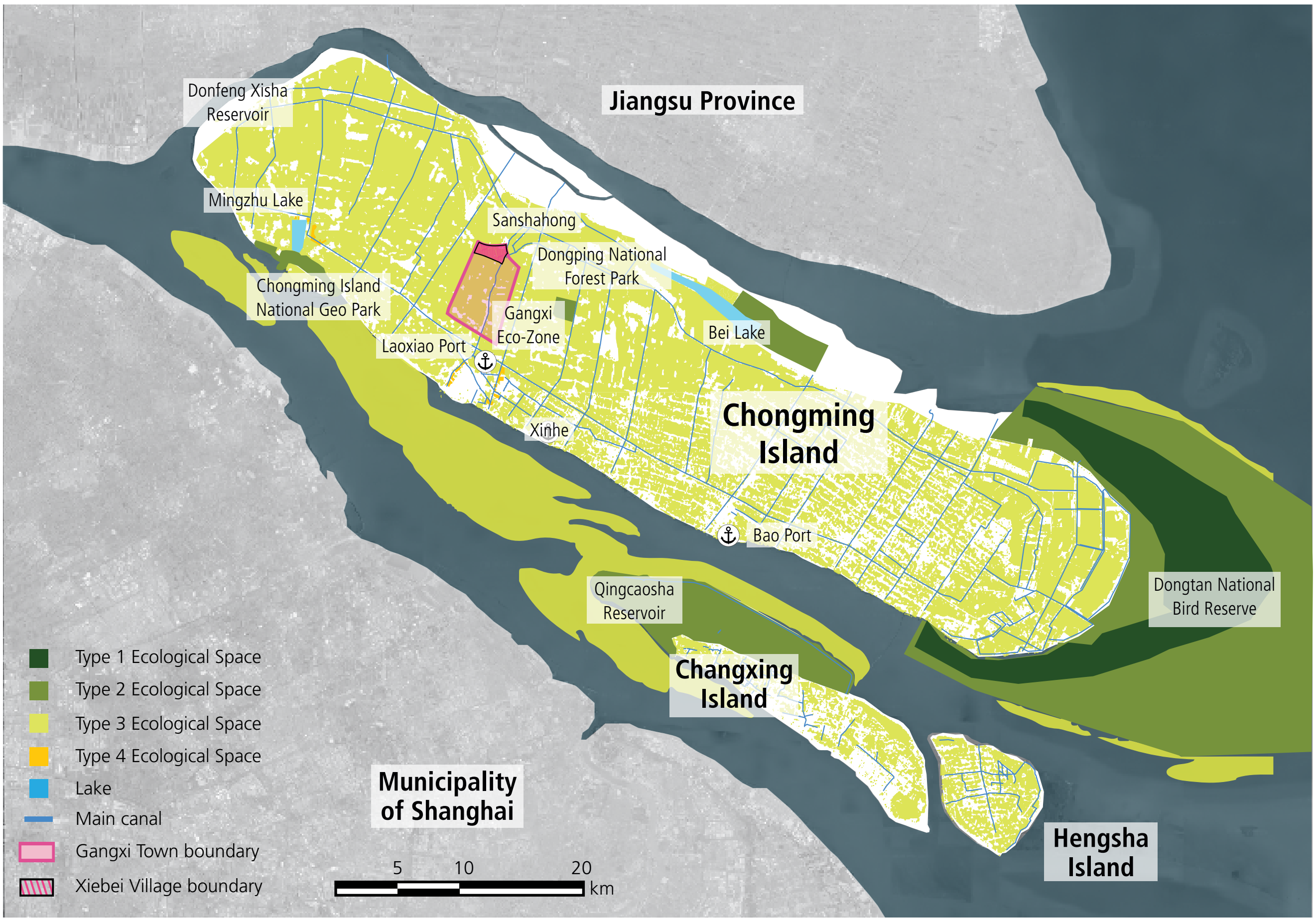



*Fig. 4.4 Designated ecological spaces in Chongming County*

three major river beaches—Chongxi, Chongbei and Chongdong. Xisha-Mingzhu Lake and Wetland in the west, Dongping Forest Park and Bei Lake in the north, and Dongtan Wetland in the east, recognized as a wetland of international importance under the Ramsar Convention, are also important ecological zones and have prompted the development of many small and medium-sized tourism projects and featured farm/guest houses.

According to Chongming's master plan, 1401.1 $km^2$ is planned as open space in the County. Shanghai's municipal ecological space requirements define Type 1-4 Ecological Spaces as follows:

**Type 1 Ecological Space**
The First Type of Ecological Space is comprised of the core area of Chongming Dongtan Bird National Nature Reserve (located within the boundary of Chongming District), which encompasses a total area of about 102.4. $km^2$ (including the offshore area of the Yangtze River Estuary).

**Type 2 Ecological Space**
The Second Type of Ecological Space includes the non-core area of Chongming Dongtan Bird National Nature Reserve and the Yangtze River estuary, China Huayu Nature Reserve, Dongfeng Xisha Reservoir, the primary protection zone of Qingcaosha Reservoir, and the core area of Dongping National Forest Park. Important wetland space such as Bei Lake, with a total area of about 157.0 $km^2$ is also included in the Type 2 delineation.

**Type 3 Ecological Space**
The Third Type of Ecological Space includes an area of 1137.8 $km^2$ (including the Yangtze River estuary and offshore waters) and incorporates the Dongfeng Xisha Reservoir, the secondary protection zone of the Qingcaosha Reservoir, permanent basic farmland, significant forest land, ecological restoration areas such as wetlands, lakes and rivers, and significant nature paths.

**Type 4 Ecological Space**
The Fourth Type of Ecological Space includes Sanshahong and Laoxiao Port, space along the Xinhe Port in Xinhe Town, and space around Bao Town's Bao Port. Type 4 Ecological Space amounts to a total area of about 3.9 $km^2$.

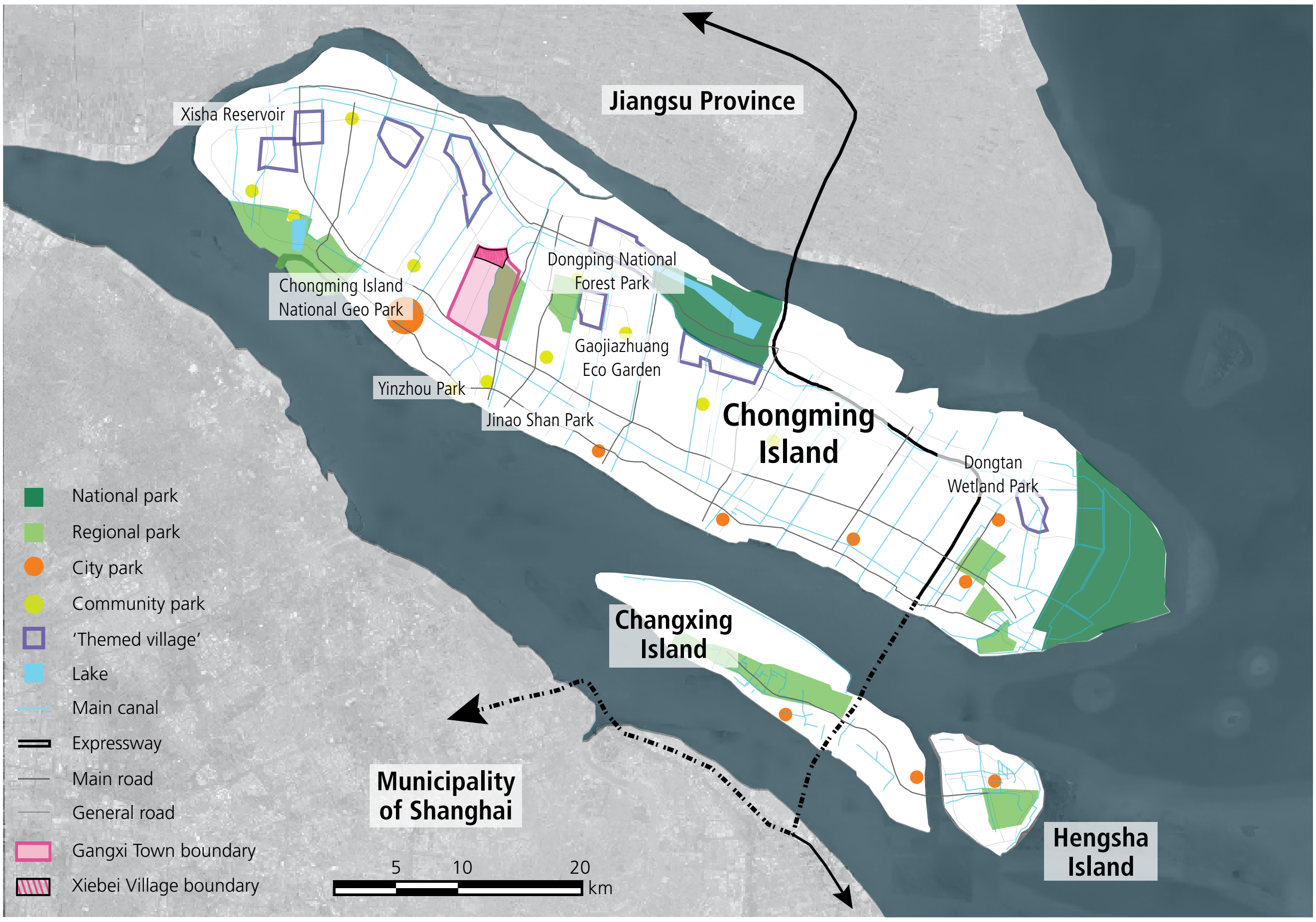



*Fig. 4.5 Chongming County public space network*

## Public Space Network

As of 2016, over 500m² of green park space was serviced by Chongming County, which equals approximately 20m² per capita. By 2020, the amount of public open space is outlined in Chongming's Masterplan as 8m² per capita; by 2040, 3000km² is aimed for within the development boundary of the whole district.

By 2040, public open space (green spaces, squares, etc.) should be accessible within a 5-minute walk of 100% of the population in the urban areas of Chongming Island. It is also stated that commercial and entertainment functions are to be encouraged in public open spaces to boost the vitality of those areas. Recreational sports venues, including track and field facilities, football fields, basketball courts, table tennis courts, tennis courts, etc. should also be available to residents in Chongming County[85].

Despite the Master Plan's goal for 80% of the population to be within a 5-minute walk of public open space by 2040, the current number of public open spaces in rural areas is minimal. To gradually improve their distribution in small towns and agricultural villages, they can be combined with traditional marketplaces to serve different age groups at different times of the day or week.

Plans for a system of public spaces on Chongming Island include the development of and investment in multiple sizes of parks organized at the national, county, city and community level. "Theme Villages"—designed and constructed with attractions under a specific theme—are also characteristic of semi-public spaces on the Island.

**National parks**
Key ecological protection zones, Dongtan and Beihu, will be renovated and upgraded in accordance with national park standards

**Regional parks**
Twenty regional parks cover an area of over 4ha on Chongming Island, but are relatively sparsely distributed in the northeast

**City parks**
Bridge City Park covers an area of over 100 ha and is the only city-level park on the Island

**Community parks**
Community parks of approximately 1km² are planned for inclusion in village and town planning measures both in rural and urban areas of the Island

**Themed villages**

Eight 'themed villages', including Yueqi, Yuejin, Luhua, Changzheng, Bei Lake, Dongping, Qianjin and

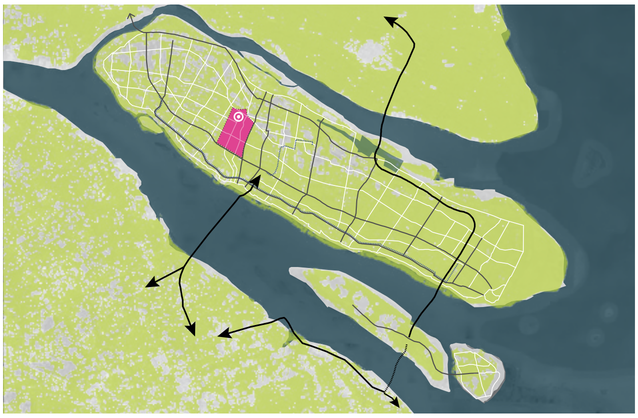


*Fig. 4.6 Location of Gangxi Town On Chongming Island*

Qianshao, provide outdoor recreation spaces mainly in the northwestern part of the Island, but could be expanded for more even distribution across Chongming County

## GANGXI TOWN: LOCAL CONTEXT AND CONNECTIVITY

### Gangxi Town

Gangxi Town is one of the 18 township-level administrative units under the jurisdiction of Chongming District, Shanghai, China. It is located just west of central Chongming Island, to the east of Dongping National Forest Park, and 8 km from Chongming's main port. Gangdong Highway runs from north to south on the eastern edge of Gangxi.

With a surface area of 49.39 km², Gangxi Town has 12 villages under its jurisdiction, and a population of

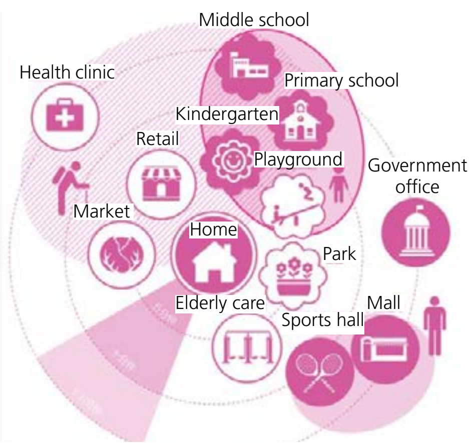



*Fig. 4.8 Distribution of Social amenities[94]*

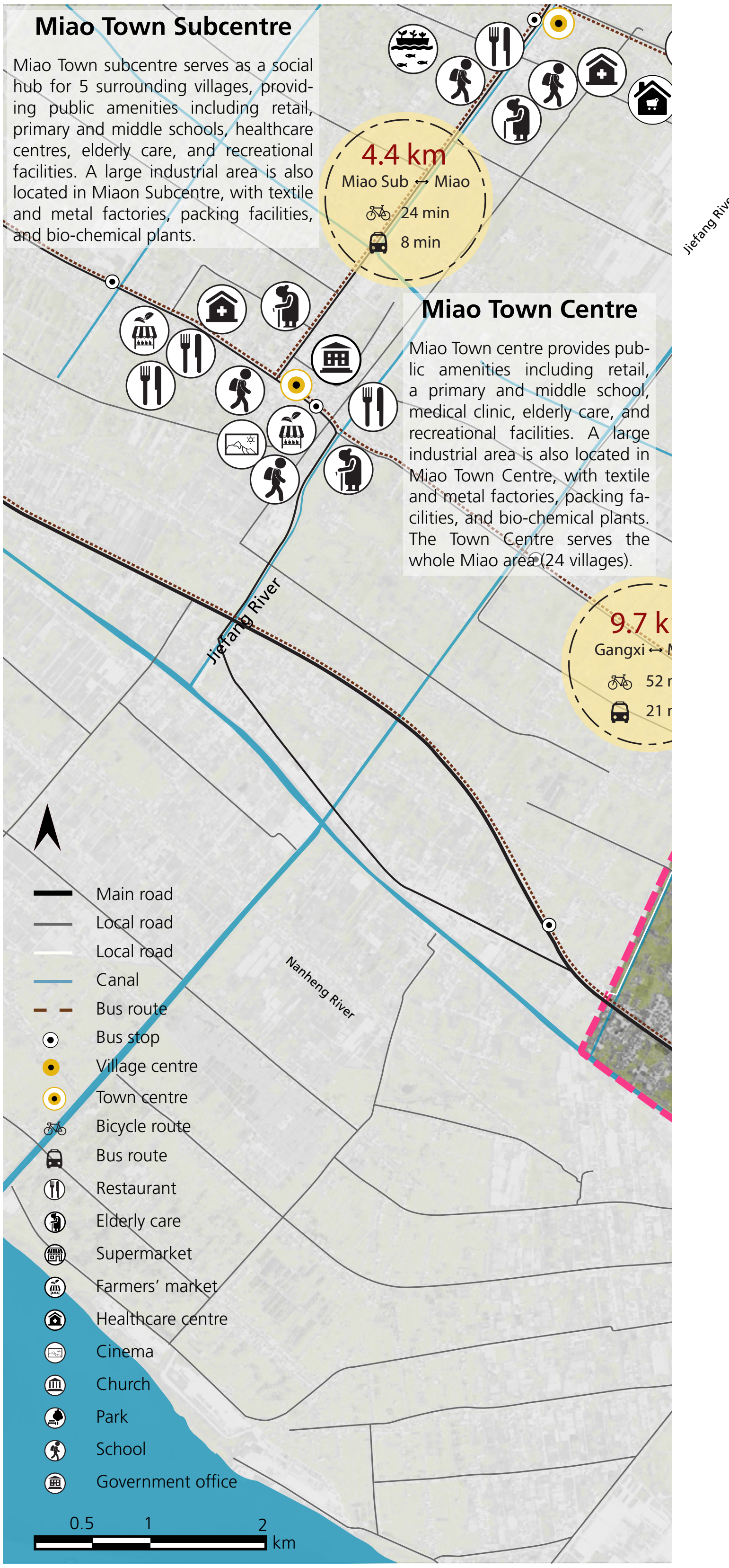
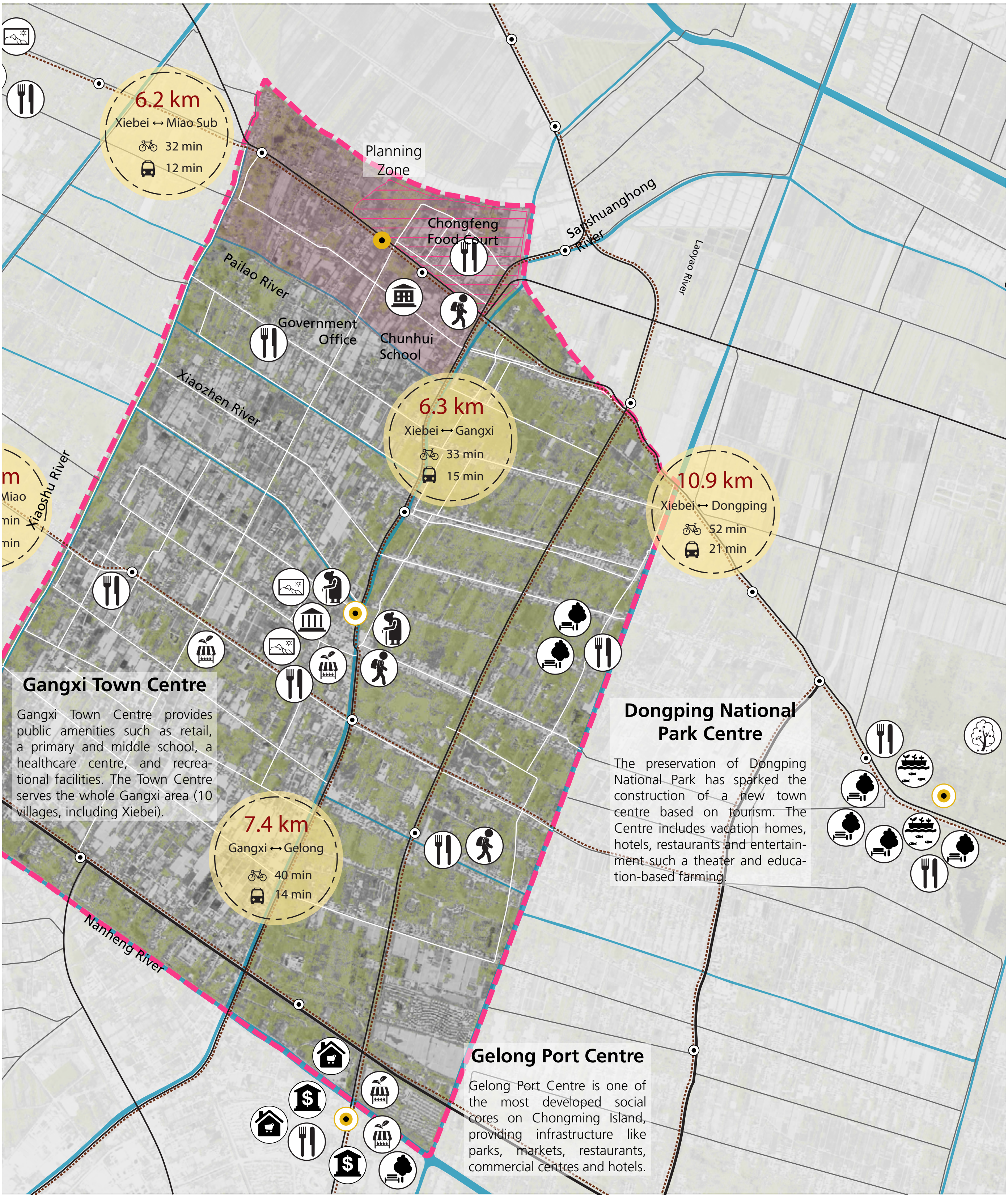



*Fig. 4.7 'Distance to amenities' outlined in Chongming Island Masterplan*


6.2 km
Xiebei ↔ Miao Sub
32 min
12 min
Planning Zone
Chongfeng Food Court
Sanshuanghong River
Laoyao River
Pailao River
Government Office
Chunhui School
Xiaozhen River
6.3 km
Xiebei ↔ Gangxi
33 min
15 min
10.9 km
Xiebei ↔ Dongping
52 min
21 min
Xiaoshu River
Gangxi Town Centre
Gangxi Town Centre provides public amenities such as retail, a primary and middle school, a healthcare centre, and recreational facilities. The Town Centre serves the whole Gangxi area (10 villages, including Xiebei).
Dongping National Park Centre
The preservation of Dongping National Park has sparked the construction of a new town centre based on tourism. The Centre includes vacation homes, hotels, restaurants and entertainment such a theater and education-based farming.
7.4 km
Gangxi ↔ Gelong
40 min
14 min
Nanheng River
Gelong Port Centre
Gelong Port Centre is one of the most developed social cores on Chongming Island, providing infrastructure like parks, markets, restaurants, commercial centres and hotels.

23,416 at the time of the Sixth National Census in 2010.

Chongming Island's Masterplan (2016-2040) outlines a strategy for the "social core" of towns with populations between 3000-10000. This strategy outlines the dispersal of public and social amenities within 6-10km of the town centre. However, the distribution of amenities in smaller towns and villages is unclear hinting at uncertainty about future demographic trends in prototypical rural towns and villages.

## XIEBEI VILLAGE

### Introduction to Xiebei Village and the northeast planning zone

Xiebei Village has a population of 2432 (998 households) and occupies 483 ha. The northeast quarter (planning zone) has been identified for the purposes of these recommendations due to its typical agricultural and residential typologies and challenging development demands, including pressure from a developer to build residential and tourist blocks in the quarter, Xiebei's negative population growth and "ghost town" phenomenon in recent years, and rapid regional economic expansion.

The planning zone includes 113 ha and a population of 533 (304 households). The current density of the Village is between 13-17 people/ha. Most residents hold agricultural citizenship, meaning they have the right to develop and/or lease their residential plot for residential use and develop and/or lease their agricultural plot for agricultural use.

Private developers are currently working with the local government to develop the northeast planning zone. Approved plans include widening Xiebei's traditional canal system. Plans still undergoing discussion and awaiting approval include the conversion of 4.93 ha of farmland into commercial and residential land, the construction of 90 residential units in townhouse-style buildings and a five-star hotel on a 2.43 ha plot, and the erection of an agricultural museum, conference hall and library.

As in other agricultural villages in Chongming County, the distribution of land use in Xiebei Village is divided between agricultural land and development land. Twenty-nine per-cent of Xiebei Village is designated as construction land, while 27% is woodland, 21% is general farmland, 19% is agricultural forest (mainly fruit trees) and 4% is used for vegetable fields. However, the total farm acreage is declining due to the expansion of construction land despite efforts by Chongming County to preserve farmland on the island.

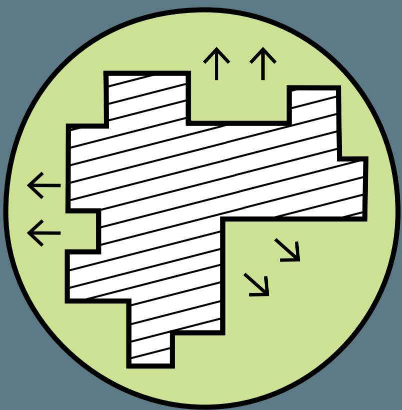

*Fig. 4.9 Xiebei Village: general context*


northeast planning area
Chongfeng Foodcourt
Sanshuang River
Sanshuang Highway
Beiyan Road
Pailao River
Xiebei Village
Government House
Chunhui Primary School
Beiyan Road
Changzhen Highway

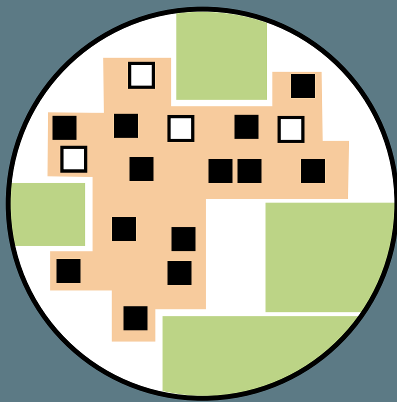
# ISSUES

Xiebei Village has multiple challenges at the scale of the spatial plan which will need to be addressed in order to reach net-zero- carbon. The following four issues have been identified in the northeast planning zone of Xiebei Village and are likely to be areas deserving attention in other villages on Chongming Island, in the Yangtze River Delta region, and potentially on a more global scale.

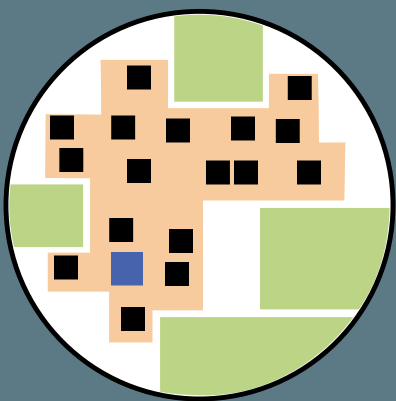
- Sprawl resulting from a lack of coordinated planning and design at the town and village level
- The under-utilization of buildings which have been abandoned or left empty for years
- A dearth of public space, both outdoors and indoors which can be used for community gatherings and for strengthening social cohesion amongst villagers and visitors
- A limited network of internal and external multi-modal transit connections
- In the section following Issues, Actions will be proposed to address these challenges from a spatial perspective.



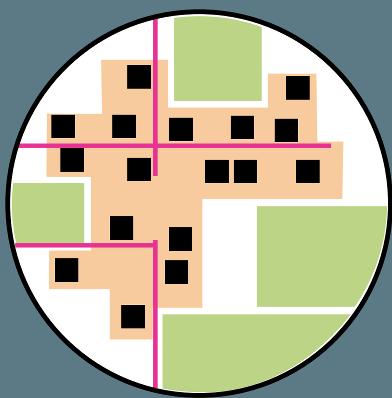
UNPLANNED SPRAWL



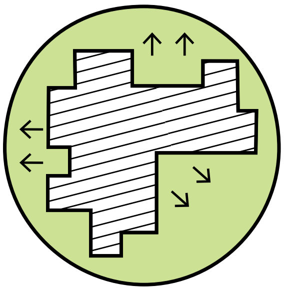
UNDER-UTILIZED BUILDINGS



LACK OF PUBLIC SPACE



LIMITED ALTERNATIVE TRANSPORTATION NETWORK



# Unplanned sprawl

### Farmer cooperatives and traditional settlement in the YRD region

As illustrated in Figure 4.12, traditional villages in the Yangtze River Delta region were typically situated at the intersection of roads and canals which connected to other villages in the region.

These villages began as farmer cooperatives composed of three to four households. Farmer cooperatives are small groups of rural residents who work on agricultural land collectively. Usually, rural residents jointly own the land that they work on and individually own houses that are also built on this land, with property lines delimiting the space they are allowed to build on, but with shared agricultural land zoned as a non-development area.

Since farmers live in the same neighbourhood that they work in, and therefore share the same public and social infrastructure and services, cooperatives also serve social, economic and political functions.

### Existing settlement typologies

With rapid urbanization and population increase in the YRD region over the last few decades, cooperatives in rural areas have also seen drastic development changes. The population in the region alone has grown from 0.15 billion in 2010 to 0.22 billion in 2018. A study conducted on the expansion of the Yangtze River Delta Urban Agglomeration, showed that between 1993 and 2007, urban expansion mainly occurred through infill within already established villages. After 2007, sprawl and suburbanization outside traditional villages became the dominant means of urban expansion.

In rural villages across Chongming Island, cooperatives and the area of developed land also began to grow. A comparative analysis of satellite imagery at different points in time shows the mushrooming of "isolated" (see figure 4.14) models of development across the YRD region, particularly in the early 2000s. Without sustainable planning mechanisms in place, cooperatives have grown in an uncoordinated way, leading to "linear"

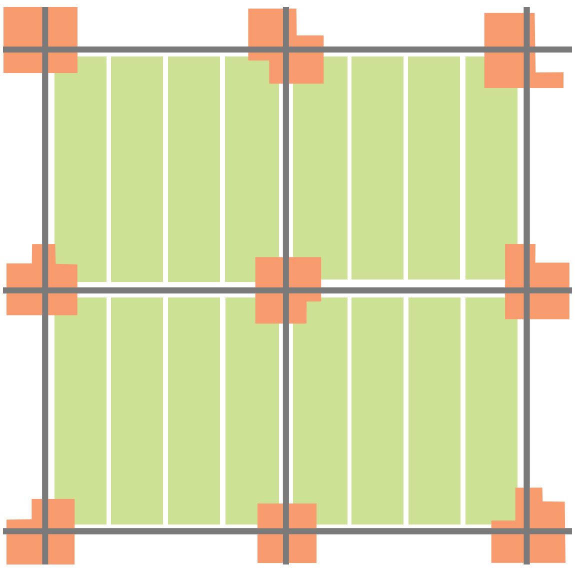


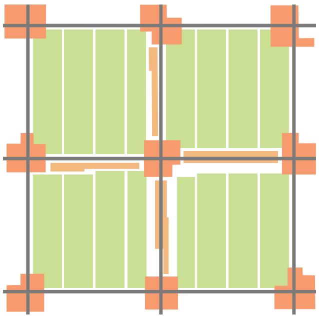
*Fig. 4.11 Diagrammatic representation of the traditional farmer cooperatives*

- Traditional farmer cooperative / village cores
- Linear development typology
- Clustered development typology
- Expanded development typology
- Isolated development typology

*Fig. 4.10 Traditional farmer cooperatives as initial imprint for settlement typologies*

- Industrial Zone
- Farmland
- Local road
- Canal

Linear settlement typologies are characteristic of rural areas in China today, where settlements sprawl along streets and gradually line farmland with single-family houses that, because of the low-cost they require to build, are often abandoned when residents move to urban areas, die, or upgrade their dwelling.



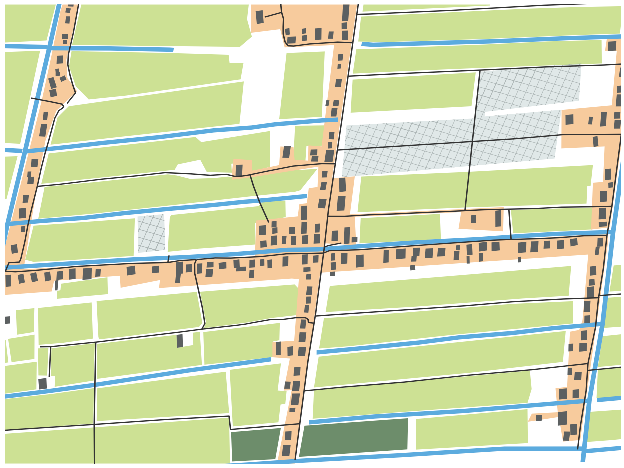


*Fig. 4.12* *"Linear" settlement typology in Gangxi Town*

Typically, this is the organic growth of residential areas where single-family houses are built in a row-like formation parallel to houses built along main access roads.

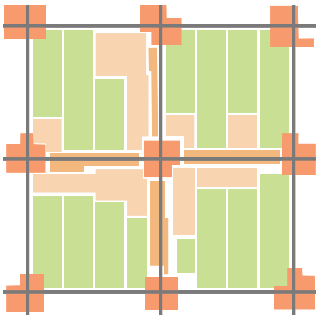
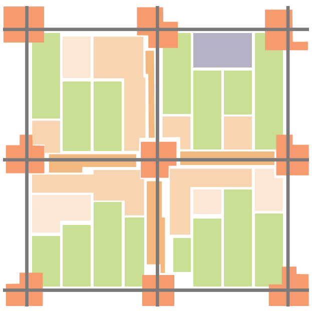


*Fig. 4.13* *"Clustered" settlement typology in Gangxi Town*

Expanded settlement typologies are denser, more built-out version of clustered housing, commonly forming the core of towns and villages in the YRD region.



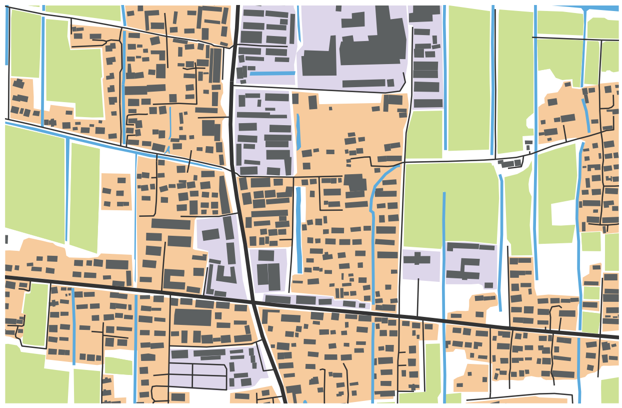
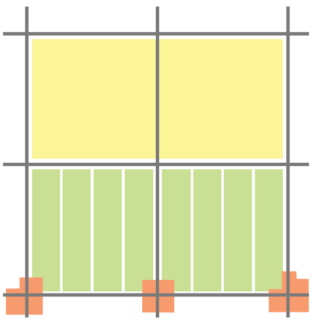


*Fig. 4.14* *"Expanded" settlement typology in Gangxi Town*

Isolated settlement typologies are large-scale residential areas that often lack mixed-uses, social amenities, and non-automotive connections to other areas.



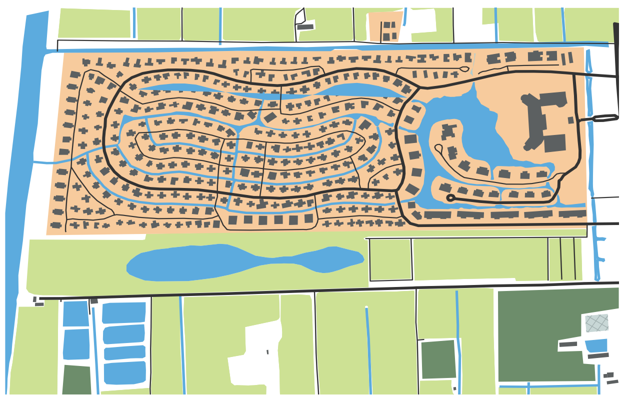


*Fig. 4.15* *"Isolated" (developer-driven) settlement typology in Gangxi Town*

and "clustered" development typologies and associated unrestricted sprawl, low-density building, insufficient social amenities and services, and inconvenient, car-dependent transportation. Unfortunately, the construction of physical and social infrastructure in rural villages has not caught up with the rapid construction of houses, leaving the number of services available to residents disproportionate to the number of residents living in rural villages.

Although the "five small industries"[86] operate on the Island, future economic plans focus primarily on Chongming's niche in eco- and agri-tourism. For this reason, along with fact that the built environment is primarily composed of residential areas which lack many of the core services that planned neighbourhoods in cities provide, settlement typologies remain the focus of the analysis.

In the northeast planning zone of Xiebei Village, there are seven existing cooperatives (working groups), which have formed organically formed along the canal system characteristic ofto the region. Due to lax coordination and formalization of zoning and building permits, over time, construction land occupied by these cooperatives has expanded unsustainably.

Rural strip developments, or "linear" settlement typologies, that typify the region generally have a higher carbon footprint and environmental impact due to the decentralization of services and the high level of energy needed to deliver utilities. As such, given the critical importance of the region's ecological assets and the growing risks to its security, there is a need to work for further work to createon potential urban planning strategies that fully consider ecologically sensitive planning, water management and low-carbon development that can support in leading the YRD region towards a sustainable future in a way that builds upon the relevance of its existing development patterns.

*Fig. 4.16* ***Schematic identification of traditional farmer cooperatives in Gangxi Town***

- Main Road
- Local road
- Local road
- Canal
- Traditional farmer cooperative / village cores
- Linear development typology
- Clustered development typology
- Expanded development typology

*Fig. 4.17* *Schematic expansion of cooperatives in "linear" and "clustered" develpment typologies in Gangxi Town*

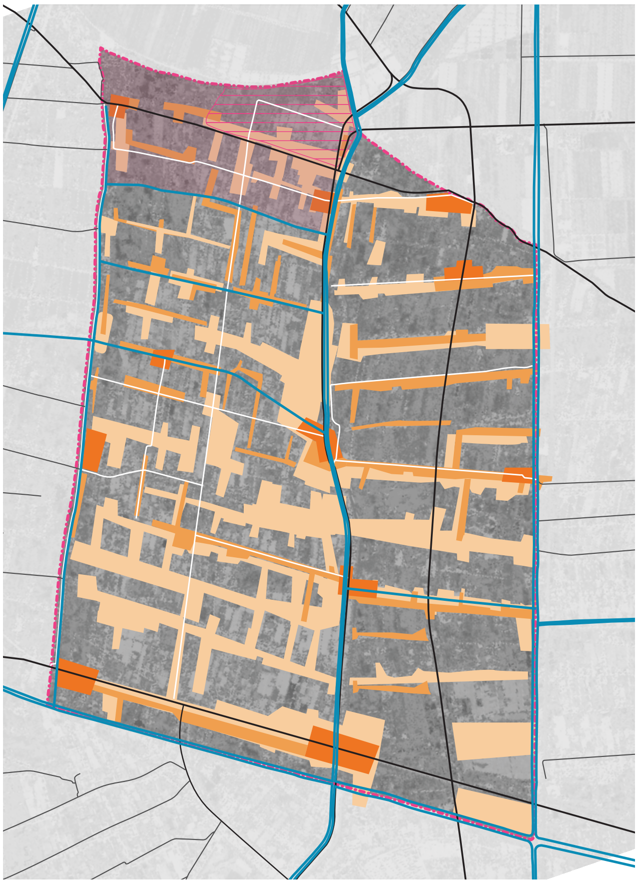
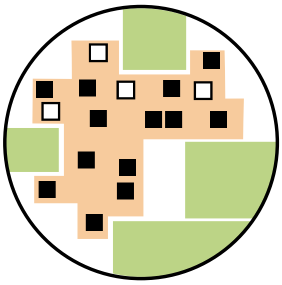


*Fig. 4.18* *Existing "linear", "clustered" and "expanded" development typologies in Gangxi Town*



# Under-utilized buildings

Nearly 90% of the 3.4 billion people living in rural areas reside in Africa and Asia. In 2014, China alone was home to 635 million rural residents[87]. However, by 2050 approximately half of China's current rural population will become urban, a net loss of around 300 million people in rural areas[88]. At the same time, China's State Council approved a plan that aims to transform the Yangtze River Delta region—alongside the Pearl River Delta and the Beijing-Tianjin-Hebei region—into a "world-class city cluster" by 2030. The aim is for these world-class clusters, in contrast to 16 medium- and small-sized clusters, to be the economic power-houses of China, capitalizing on innovative and internationally competitive industries[89].

It is proposed that the YRD city cluster specifically, will be a link to the Silk Road Economic Belt, which, under China's Belt and Road Initiative connects China to Central and South Asia and onwards towards Europe over land. The YRD city cluster also harbours the world's largest shipping ports and serves as a gateway for maritime trade between China and the world. When fully connected, primarily through bullet trains, the YRD city cluster is projected to be home to 150 million people – almost four times the population of Tokyo (40 million), which is currently the largest urban agglomeration in the world[90]. What's more, a set of plans for Hangzhou Bay—connecting Zhoushan to Ningbo, Ningbo to Shanghai, Shanghai to a primarily artificial archipelago of islands in the East China Sea which then connect back to Ningbo via over-sea bridges—will be likely to further increase development pressures across the YRD region.

This demographic paradox leaves the fate of villages in the Yangtze River Delta somewhat unknown. Perhaps faster transportation between rural areas and urban economic centers will catalyze citizens' interest in living in ecological villages[91]. Or perhaps the central and/or provincial governments will invest in the development of these areas. Alternatively, it is also possible that technology and intensive agricultural processes will continue to replace the need for agricultural workers and as rural populations age, villages in the YRD region will shrink or disappear (facilitated by the displacement of those residents left behind).

Regardless of future speculation, what is currently known is that 40% of homes in Nanjing, Jiangsu are vacant and it can be inferred that similiar numbers exist elsewhere in the YRD region[92]. This is due to a brain drain coupled with the upward mobility of village residents who choose to construct new homes instead of renovating their old ones. These "hollowed villages", composed of a constellation of "ghost houses" and low-density settlements not only diminish the area of land available for agriculture, but also prohibit sustainable transportation options and social mixing due to the long distances residents are required to travel to access services and amenities.

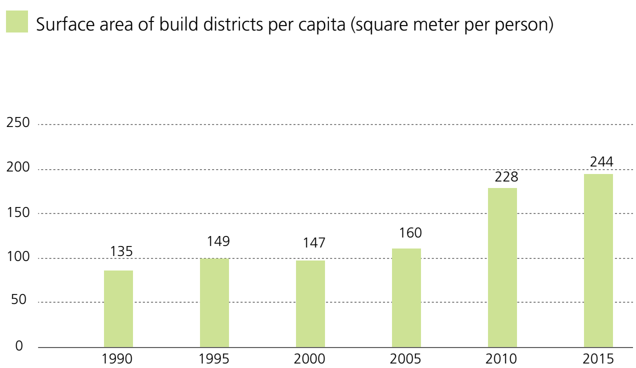



*Fig. 4.19 Surface area of built districts per capita over time[95]*

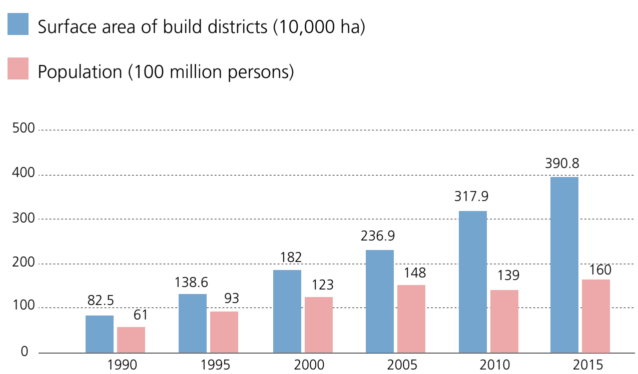
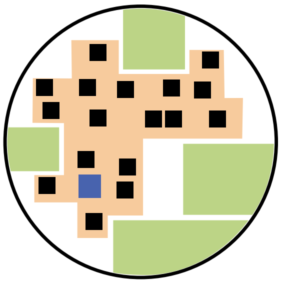



*Fig. 4.20 Construction land (blue) in relation to population (pink) over time[96]*



## Lack of public space

While Gangxi Town's central core offers many of the social services and public amenities described in the Chongming Island Masterplan (see Figure 4.25), the provision of and access to services and amenities needs to be re-conceptualized for villages like Xiebei, especially given the recent interest in converting agricultural land into construction land for additional residents.

Currently, the only existing social amenities available in the planning area are a primary school, a local administrative office, and a food court, which also serves as a public gathering space for events such as the annual cherry festival and elections for local government representatives. However, if the area is developed for additional residential units and hotel rooms, the number and scale of amenities that provide the opportunity to learn, play, exercise, socialize and enjoy the natural environment should be increased and aligned with net-zero carbon goals.

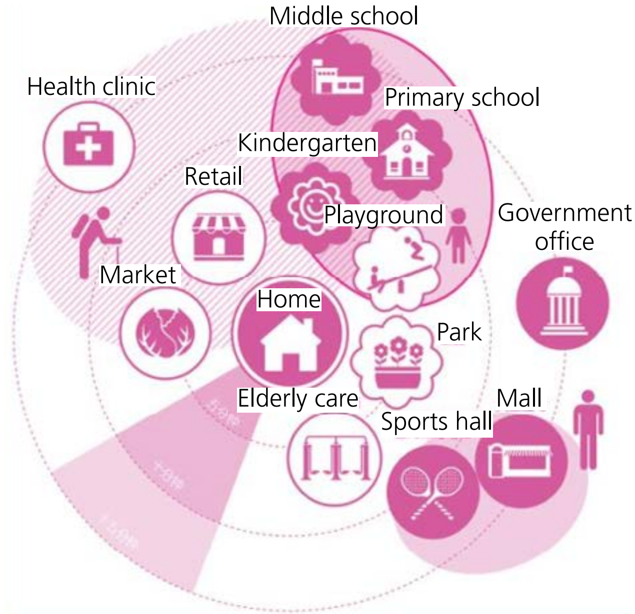



*Fig. 4.25 Social amenities distribution[97]*

- Main Road
- Local road
- Local road
- Canal
- Developed land
- Linear development typology
- Clustered development typology
- Expanded development typology

### SCHOOLS

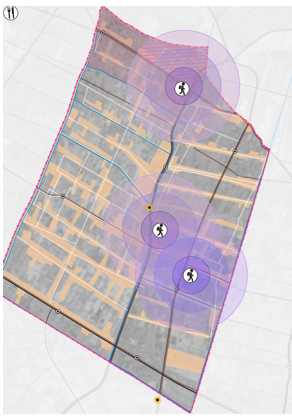


*Fig. 4.23 Schools within a 5-, 10- and 15-minute walk in Gangxi Town*

### HEALTHCARE

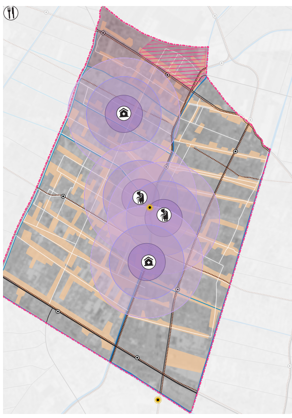


*Fig. 4.24 Healthcare facilities within a 5-, 10- and 15-minute walk in Gangxi Town*

### FOOD / RETAIL

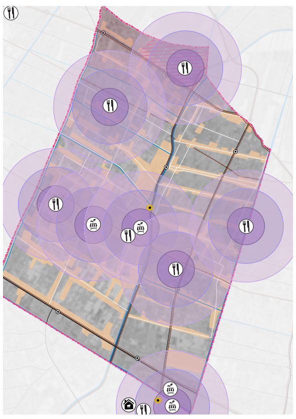


*Fig. 4.21 Retail amenities within a 5-, 10- and 15-minute walk in Gangxi Town*

### RECREATION

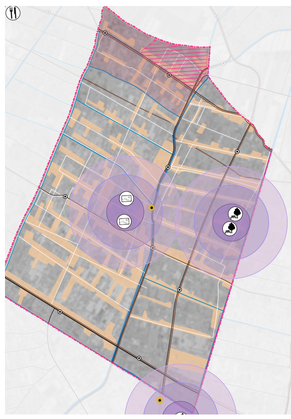


*Fig. 4.22 Recreational amenities within a 5-, 10- and 15-minute walk in Gangxi Town*

## SCHOOLS

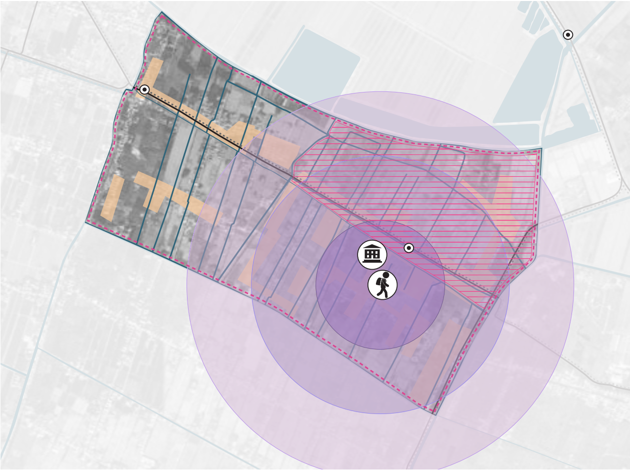


*Fig. 4.26 Educational amenities within 5-, 10- and 15-minute walk in Xiebei Village*

## HEALTHCARE

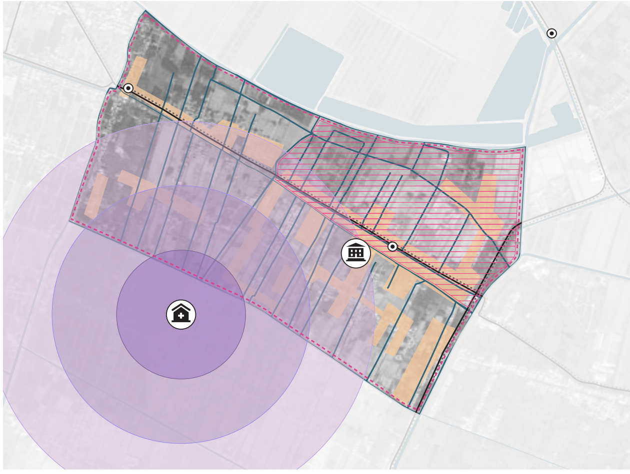


*Fig. 4.27 Healthcare amenities within 5-, 10- and 15-minute walk in Xiebei Village*

## FOOD / RETAIL

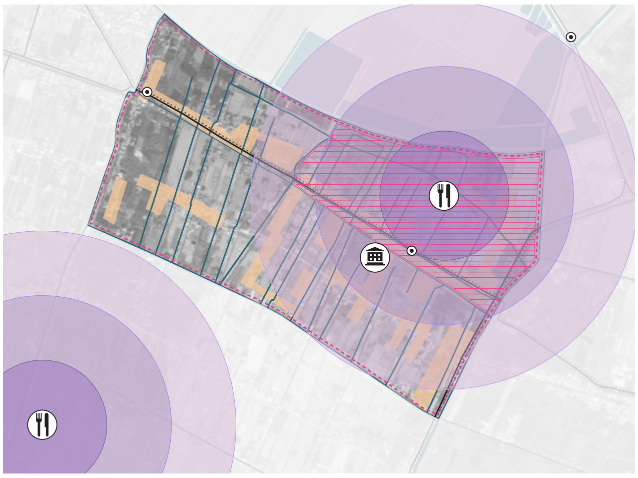


*Fig. 4.28 Retail amenities within 5-, 10- and 15-minute walk in Xiebei Village*

## RECREATION

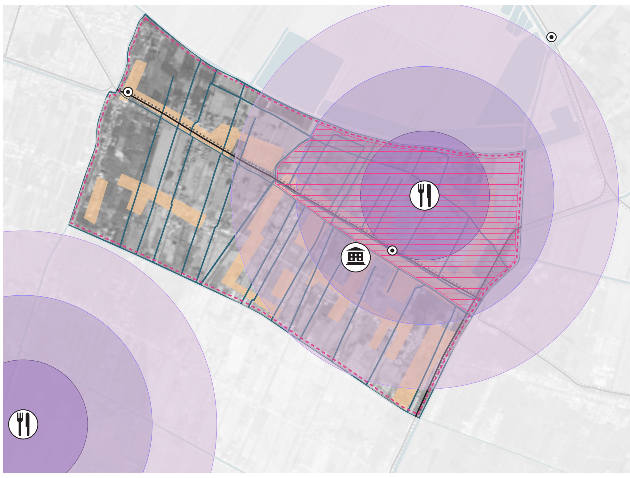


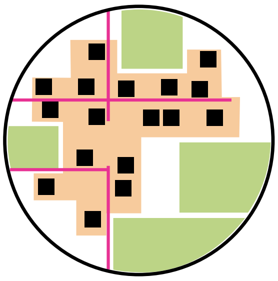
*Fig. 4.29 Recreational amenities within 5-, 10- and 15-minute walk in Xiebei Village*

| | Number of amenities recommended in The Masterplan | Number of existing amenities |
|---|---|---|
| Kindergarten | 20 | 3 |
| Retail | 20 | 4 |
| Market | 20 | 6 |
| Government office | 12 | 12 |
| Sports hall | 10 | 0 |
| Park | 30 | 2 |
| Healthcare centre | 10 | 1 |
| Playground | 30 | 0 |
| Primary school | 20 | 1 |
| Middle school | 10 | 1 |
| Elderly care | 30 | 4 |

*Fig. 4.30 Amenities in Gangxi Town*

| | Number of amenities recommended in The Masterplan | Number of existing amenities |
|---|---|---|
| Kindergarten | 3 | 0 |
| Retail | 3 | 1 |
| Market | 3 | 0 |
| Government office | 1 | 1 |
| Sports hall | 2 | 0 |
| Park | 3 | 0 |
| Healthcare centre | 1 | 1 |
| Playground | 3 | 0 |
| Primary school | 2 | 1 |
| Middle school | 1 | 0 |
| Elderly Care | 3 | 0 |

*Fig. 4.31 Amenities in Xiebei Village*



# Limited alternative transportation network

Three typologies of routes exist in the northeast planning zone. Beiyan Road is a one-lane road with space for motor vehicles and a sidewalk for pedestrians. It is on the southern border of the planning zone, and connects Xiebei to other villages across Chongming Island in the east-west direction. Two bus lines pass through Beiyan Road, and there are two stops. Most of the other paved streets in the planning zone are single-lane, one-way streets without separation between automobile, bicycle, and pedestrian lanes. All the paths that connect agricultural plots to residential land are unpaved and primarily used by pedestrians and scooters. Inherently, these typologies are not problematic; however, if the number of residents in the area grows as planned, improvements should be made to renovate existing routes to encourage alternative transportation and incorporate green technologies into the public life of the Village.


*Fig. 4.32* *Existing footpath typology*

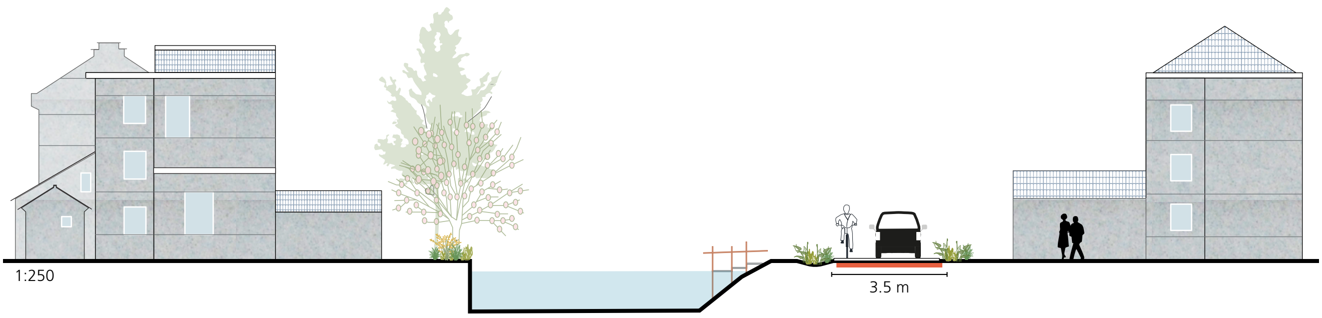



*Fig. 4.33* *Exisiting street typology*

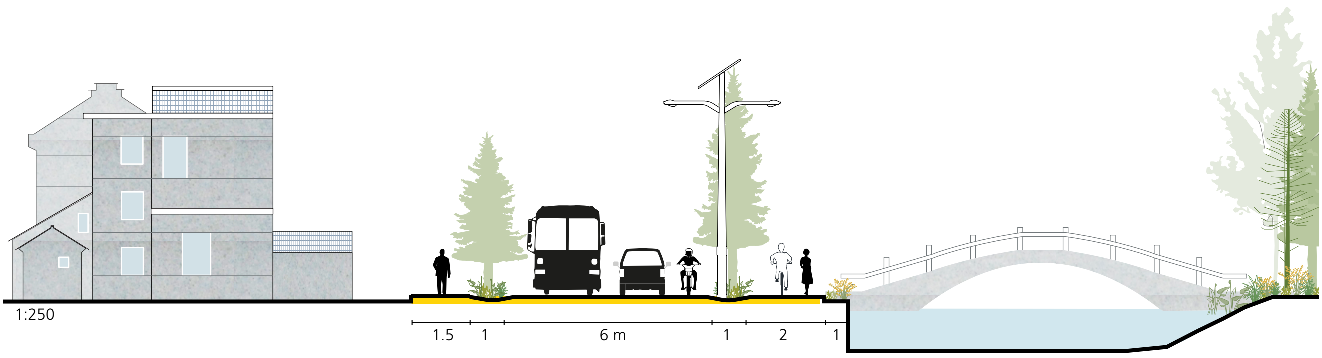



*Fig. 4.34* *Existing main road typology*

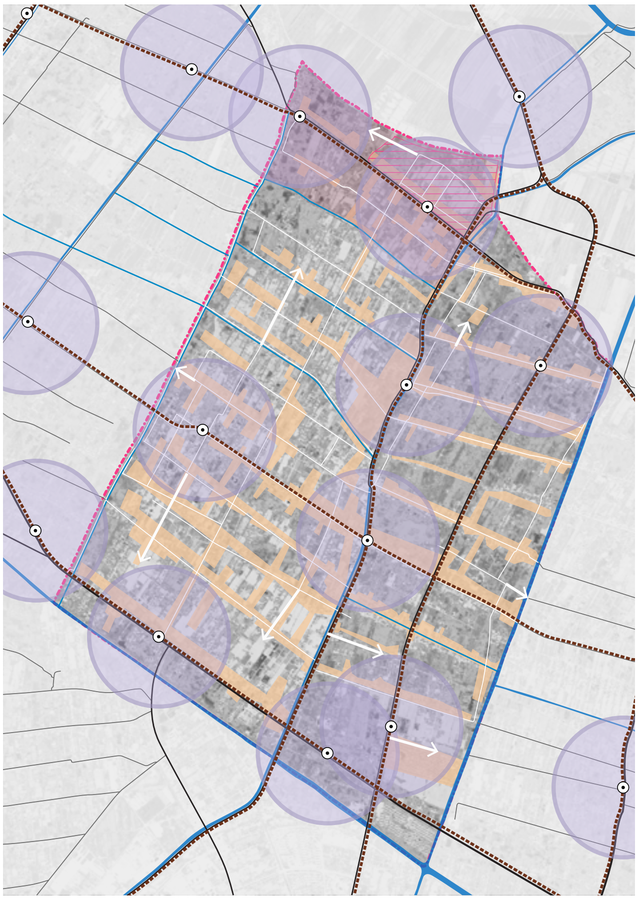
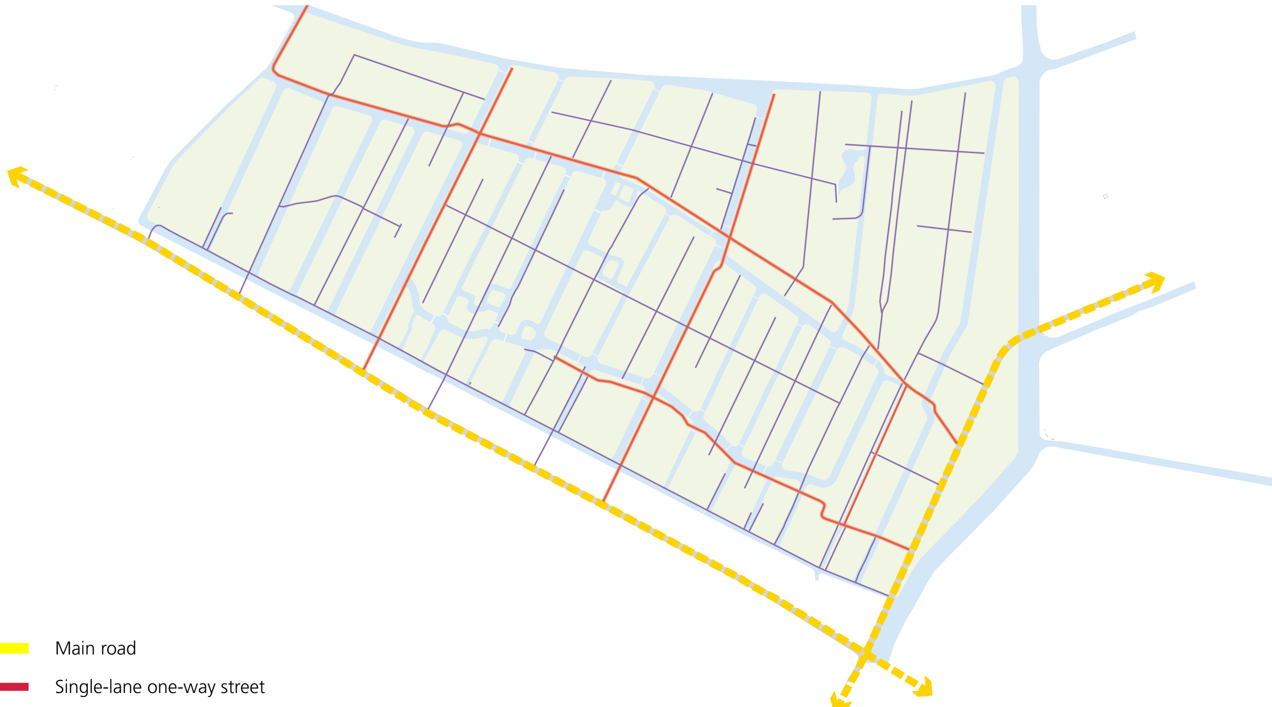


*Fig. 4.36 Limited connectivity in Gangxi Town*

*Fig. 4.35 Limited connectivity in Xiebei Village*

Main road
Local road
Local road
Canal
Developed land
Five-minute walk to bus
Missing linkage

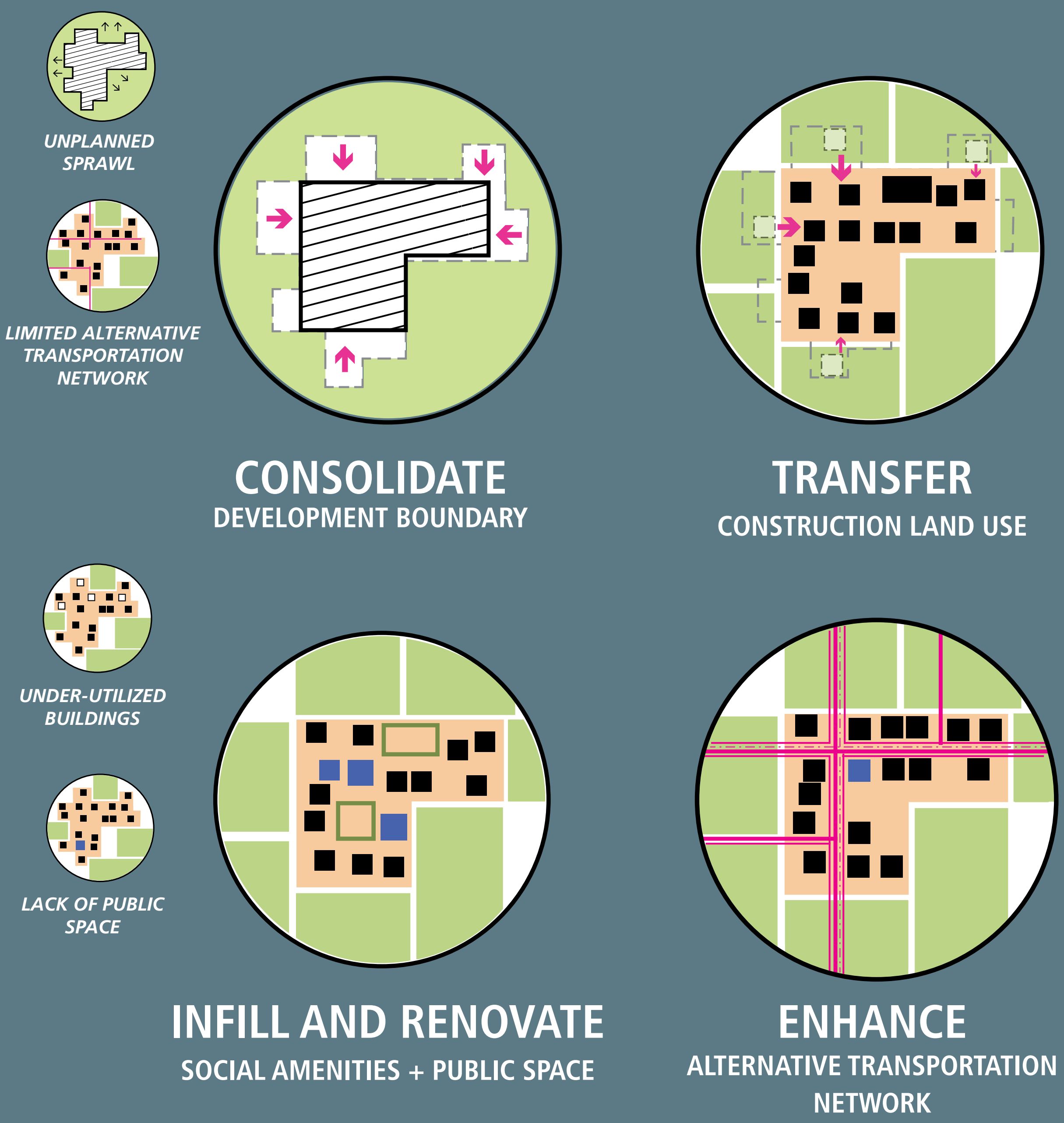


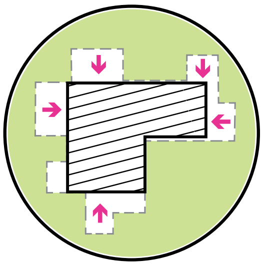
Main road
Single-lane one-way street
Footpath

*Fig. 4.37 Existing transportation network*

# ACTIONS

Since these challenges are not unique to Xiebei Village's northeast planning area, the case has been approached as an example of how villages in the region could evolve into sustainable examples for other rural as well as urban areas through spatial planning. The ACTIONS that follow guide readers through recommendations at the village planning scale, which could help shape a net-zero carbon village.


UNPLANNED SPRAWL
LIMITED ALTERNATIVE TRANSPORTATION NETWORK
CONSOLIDATE
DEVELOPMENT BOUNDARY
TRANSFER
CONSTRUCTION LAND USE
UNPLANNED SPRAWL
UNDER-UTILIZED BUILDINGS
LACK OF PUBLIC SPACE
INFILL AND RENOVATE
SOCIAL AMENITIES + PUBLIC SPACE
ENHANCE
ALTERNATIVE TRANSPORTATION NETWORK
LIMITED ALTERNATIVE TRANSPORTATION NETWORK



# Consolidate the development boundary

A "condensed cooperative" development typology is proposed for the northeast planning area of Xiebei Village. Residential, as well as commercial and public buildings and public spaces, should be concentrated within a compact development boundary strategically centered around well-connected roads and transit hubs. This development boundary should be clearly communicated to residents to help prevent encroachment, but the benefits to residents should also become clear.

Limiting the area of land available for development will help densify residential land, promoting more sustainable land use and day-to-day access to key social and cultural amenities and public space. Over time, residential areas will be concentrated at the intersection of well-connected transportation routes forming a walkable, mixed-use community where people are able to meet their daily needs either on foot, by bicycle, or via public transportation.

- Traditional farmer cooperative / village cores
- Linear development typology
- Clustered development typology
- Expanded development typology
- Isolated development typology
- Industrial zone
- Farmland
- Main road
- Local road
- Local road
- Canal

## CURRENT TYPOLOGY

*Fig. 4.38 Xiebei Village: current typology*

## PROPOSED CONDENSED TYPOLOGY

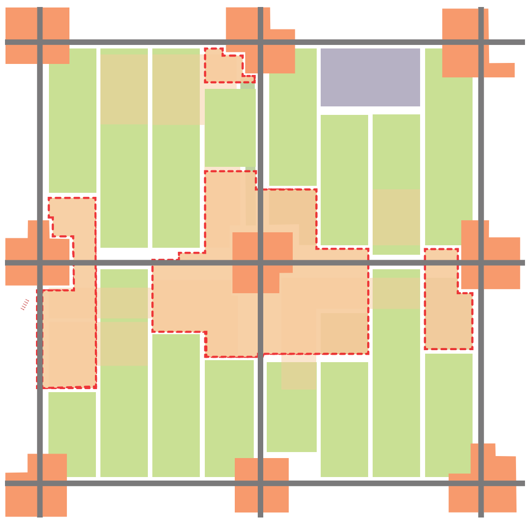


*Fig. 4.39 Xiebei Village: proposed typology – 'condensed cluster'*

## CURRENT DEVELOPMENT BOUNDARIES

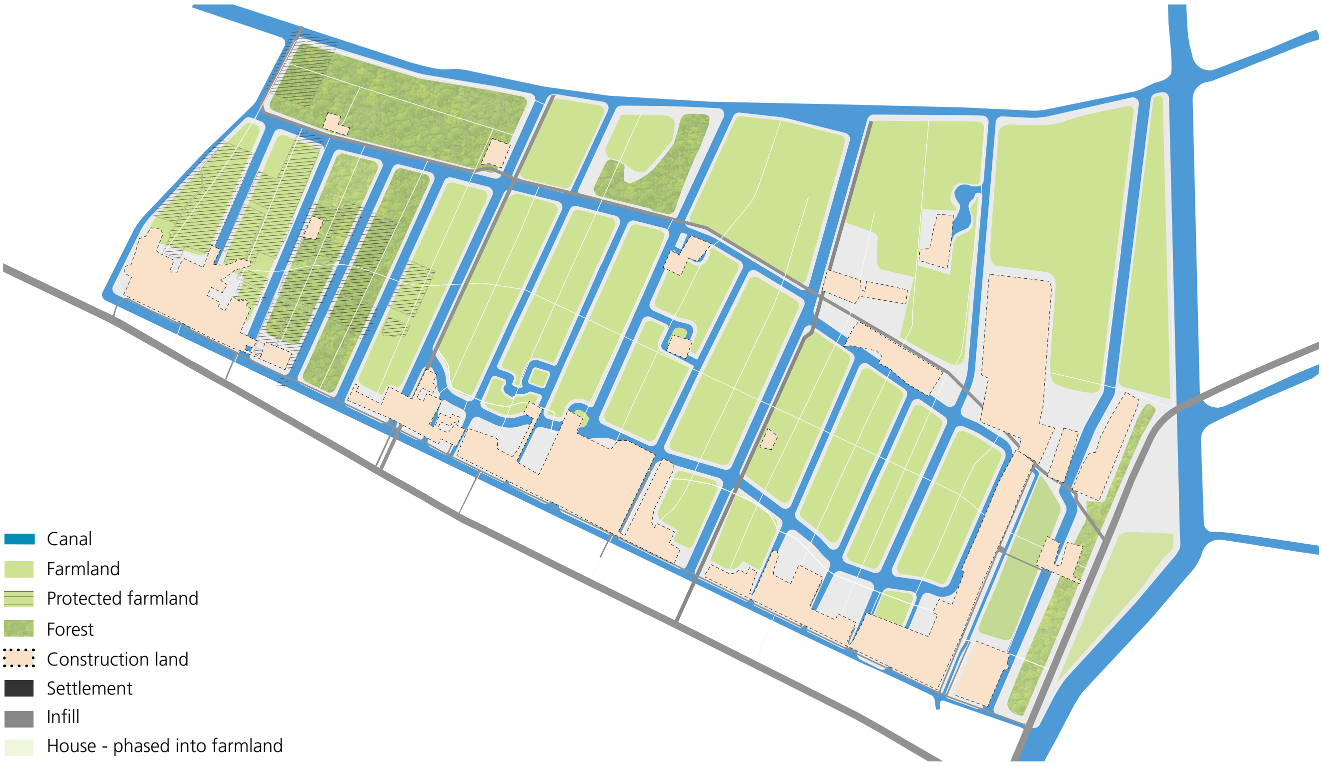



*Fig. 4.40 Current spread of development in the northeast planning area of Xiebei Village*

## PROPOSED DEVELOPMENT BOUNDARIES

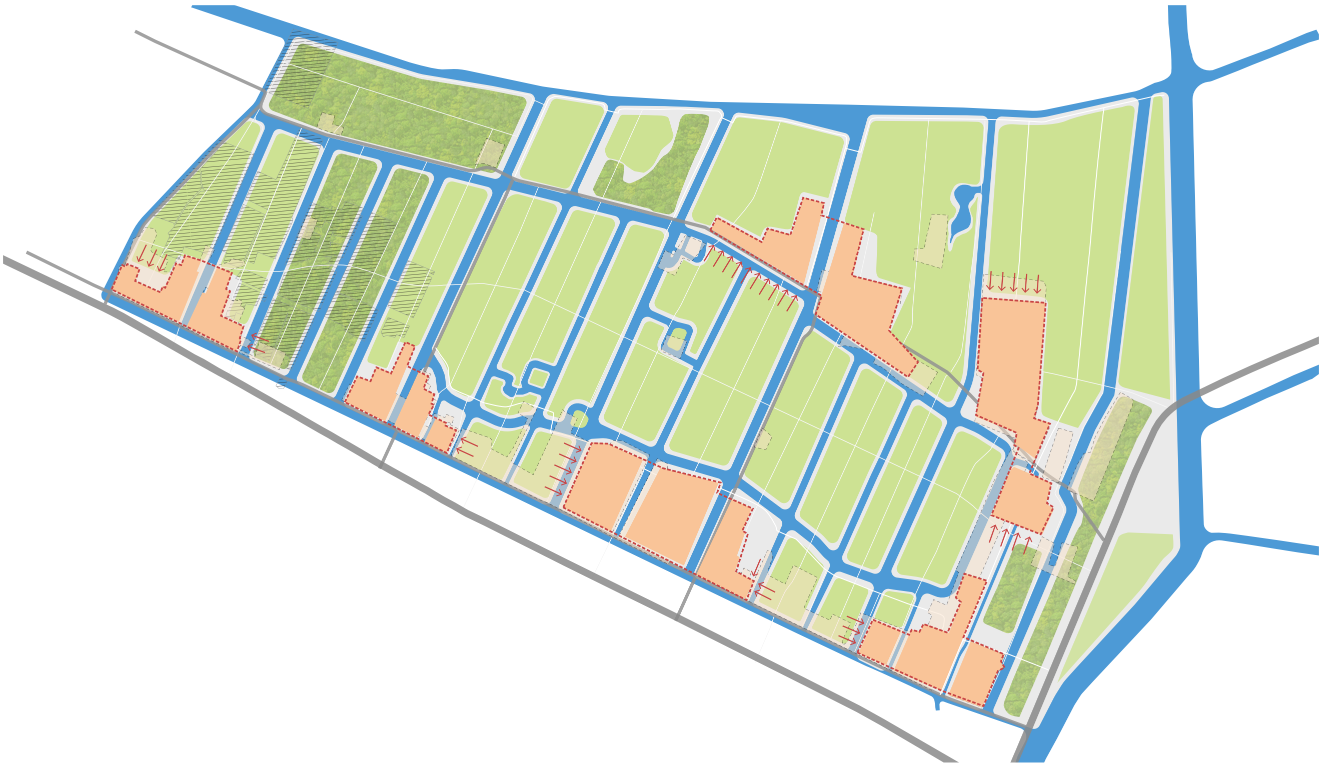
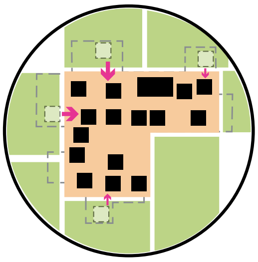


*Fig. 4.41 Proposed condensed model of development in the northeast planning area of Xiebei Village*



# Transfer construction land use

The re-appropriation of land use is proposed through a phased approach to encourage ownership in both the process of reclaiming land for agriculture and residents' involvement in the creation of a sustainable village model, as well as to avoid relocating villagers.

- **Identify unoccupied buildings outside the development boundary**

Buildings that have been abandoned or are used as vacation homes outside the development boundary could be considered for phasing back into farmland with an option for their owners to time-share vacation homes within the development boundary.

- **Incentivize moving inside the development boundary**

To reduce sprawl and increase agricultural land, which contributes to rural economies and carbon sinks, residents living in houses outside of the development boundary could be incentivized to move inside the development boundary.

- **Re-zone land for mixed-use and agriculture**

Single-use land (residential) covers an area of 2.4 ha in Xiebei Village's northeast planning zone. In the new plan, 2.1ha are proposed for mixed residential and commercial use. This number includes some ha for the new development proposed by private developers (but is structured differently), the recovery of 0.7 ha of empty land to be converted into construction land, and 1 ha of existing construction land to be phased into farmland, which could also be seen as an investment in agri-tourism.

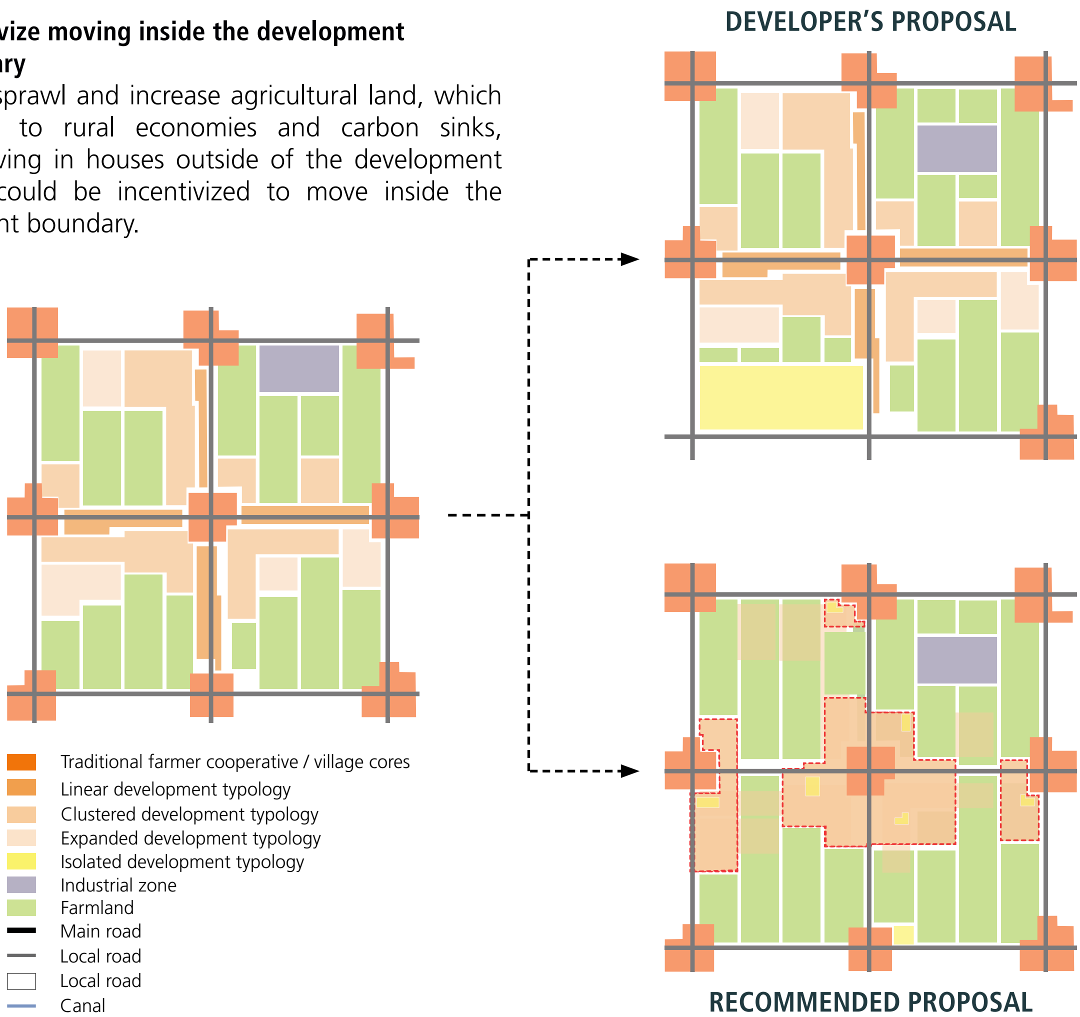


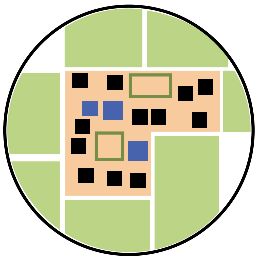

*Fig. 4.42 Conceptual diagrams of current and proposed development typologies in Xiebei Village*

## CURRENT BUILDING FOOTPRINT


*Fig. 4.43 Current building footprints in the northeast planning area of Xiebei Village*

## PROPOSED BUILDING FOOTPRINT

*Fig. 4.44 Proposed building footprints in the northeast planning area of Xiebei Village*



# Infill and renovate social amenities and public space

Unoccupied buildings located within the identified development boundary, particularly those in central locations along main roads and canals, should receive investment for their renovation and re-purposing as social and public amenities. Investment in key amenities would not only enhance the livability and social connections in and amongst cooperatives, but also promote walkability and a decreased reliance on fossil fuels with their subsequent emissions to meet daily needs. For an area with a population of 750[93], the following uses are suggested:

Should there be additional need for housing, unoccupied buildings within the development boundary that have not been identified for social and public amenities should be renovated for residential use. Once these have been occupied, infill could provide additional housing within the development boundary. This is proposed as a more sustainable and heritage-minded solution to the need for additional housing and should be considered before new developments are built.

*Fig. 4.45 Marketplace*

*Fig. 4.46 Garden cafe*

*Fig. 4.48 Playground*

*Fig. 4.47 Guesthouse*


*Fig. 4.50 Health clinic*

*Fig. 4.49 Education-based farm*

- Main Road
- Local road
- Local road
- Canal
- Developed land
- Linear development typology
- Clustered development typology
- Expanded development typology

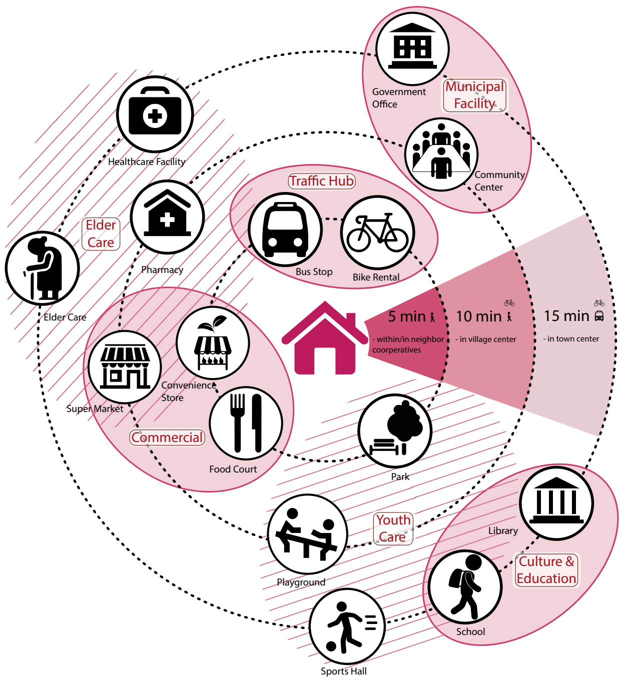



*Fig. 4.51 Proposed walking, bicycling, and bus distances from social amenities*

*Fig. 4.52 Schools within 5- and 10- minute walk in Xiebei Village*

*Fig. 4.53 Healthcare facilities within 5- and 10- minute walk in Xiebei Village*

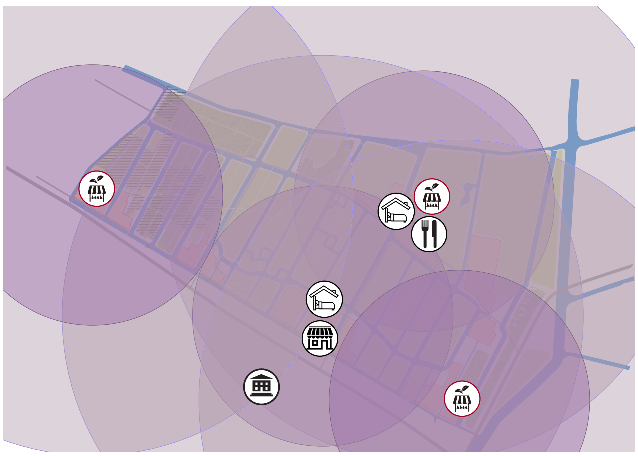
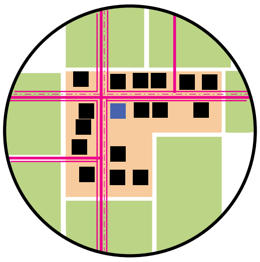
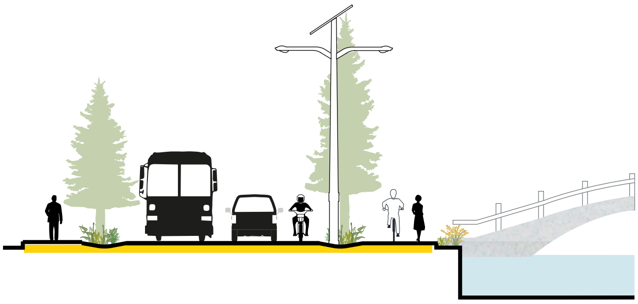


*Fig. 4.54 Retail amenities within 5- and 10- minute walk in Xiebei Village*

*Fig. 4.55 Recreational amenities within 5- and 10- minute walk in Xiebei Village*



# Prioritize alternative transportation network

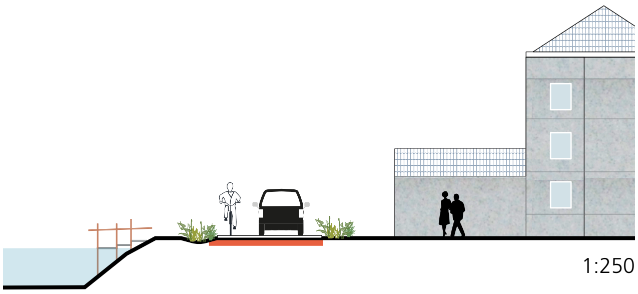


1:250

Fig. 4.56 *Existing main road typology*

In many rural areas in Europe, North America, and Australia, people depend on private motor vehicles to meet their daily needs. However, in the Yangtze River Delta region, senior citizens, who form the majority of the population, commute by foot or bus. Three hierarchies of streets are thus proposed not only as a way to accommodate the demographic living in YRD villages, but also to support modes of transit that do not rely on fossil fuels, instead promoting healthier (i.e. walking and cycling) and more public-good-oriented (i.e. mass transit) forms of transportation.

Mini transit-hubs are also proposed at the centre of each cooperative (condensed-cluster). Such hubs could include bus stops, bicycle services (such as bike pumps, shared tools, and parking), and electric-vehicle charging stations, and would further serve to encourage residents to move within the development boundaries.



1:250

Fig. 4.57 *Exisiting street typology*

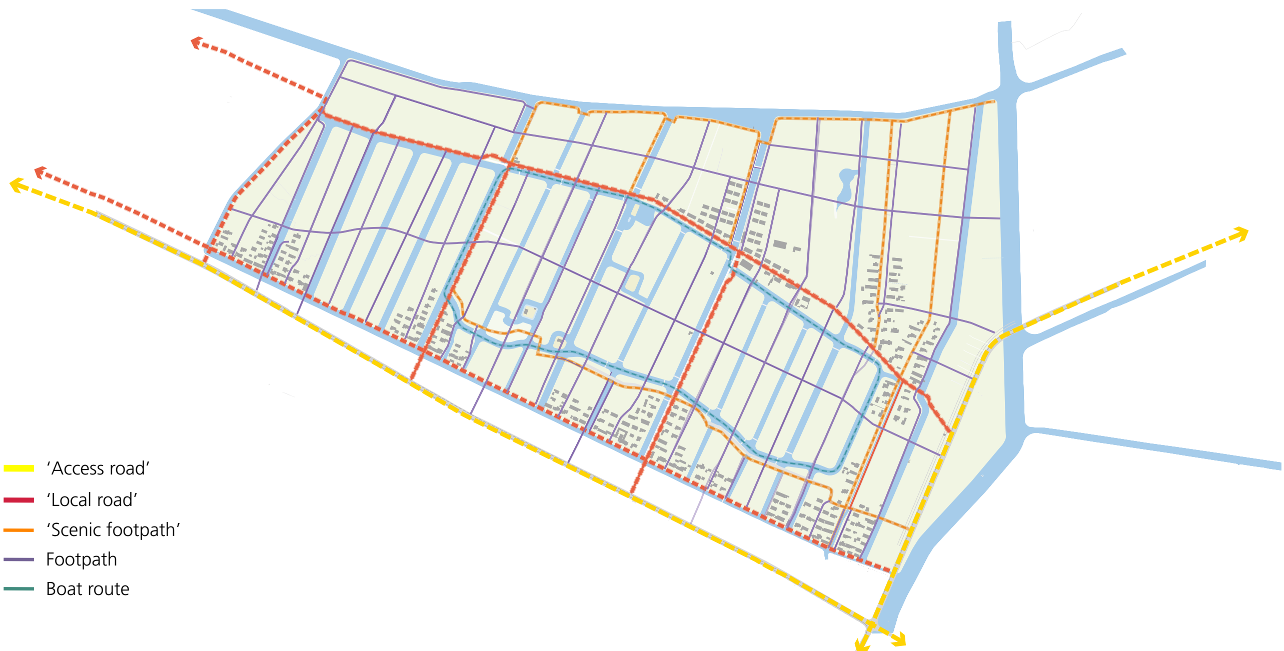



Fig. 4.58 *Proposed transportation network*

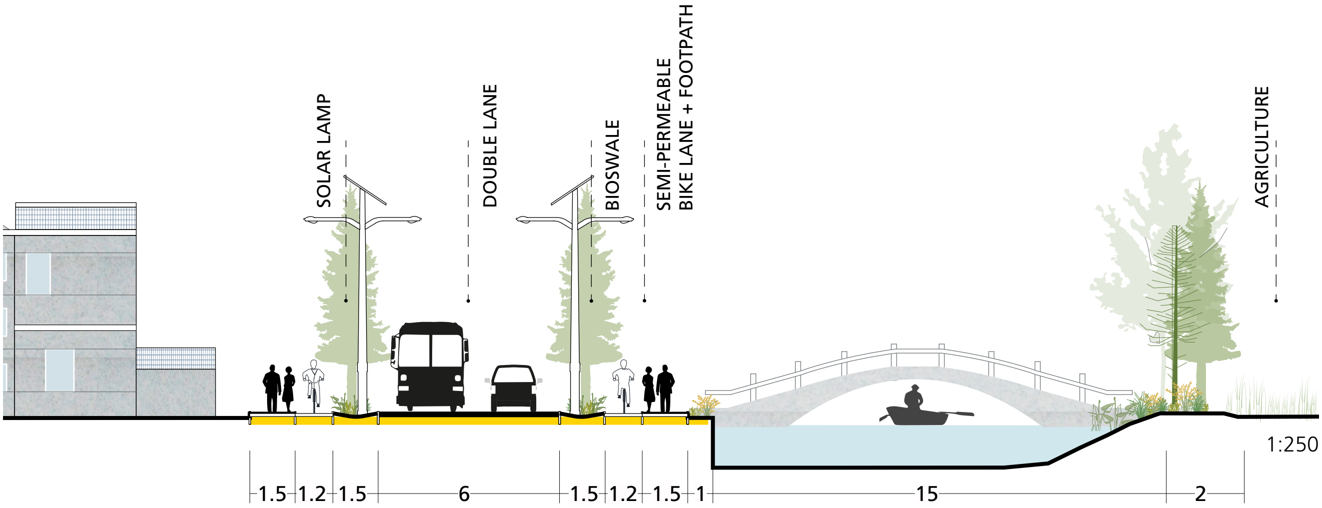



*Fig. 4.61* *Access road*

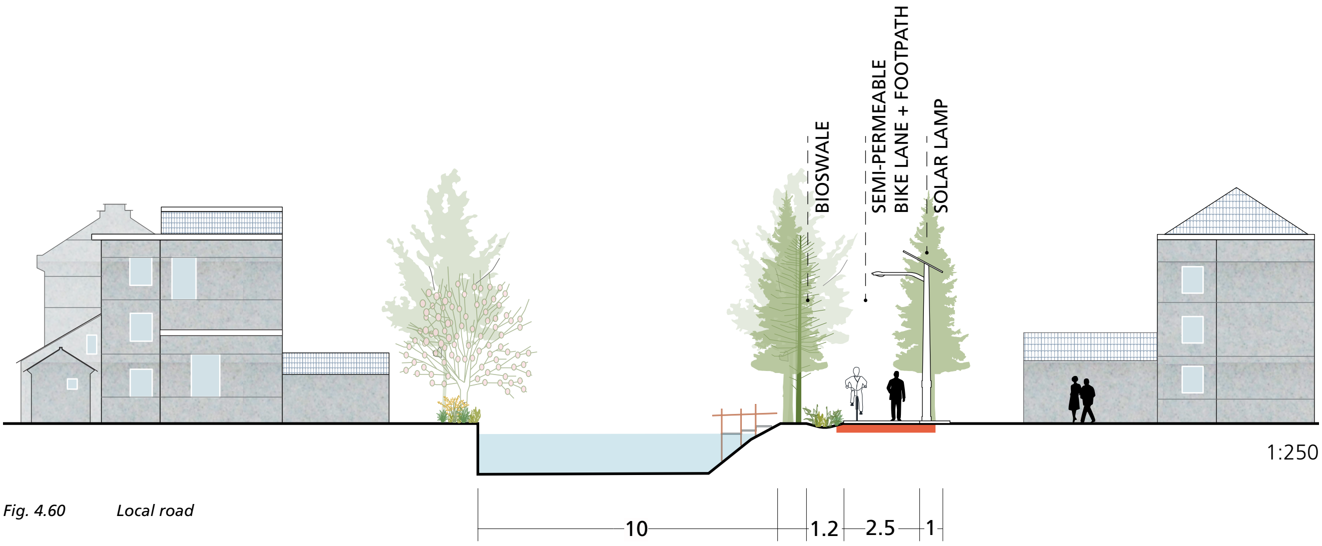



*Fig. 4.60* *Local road*

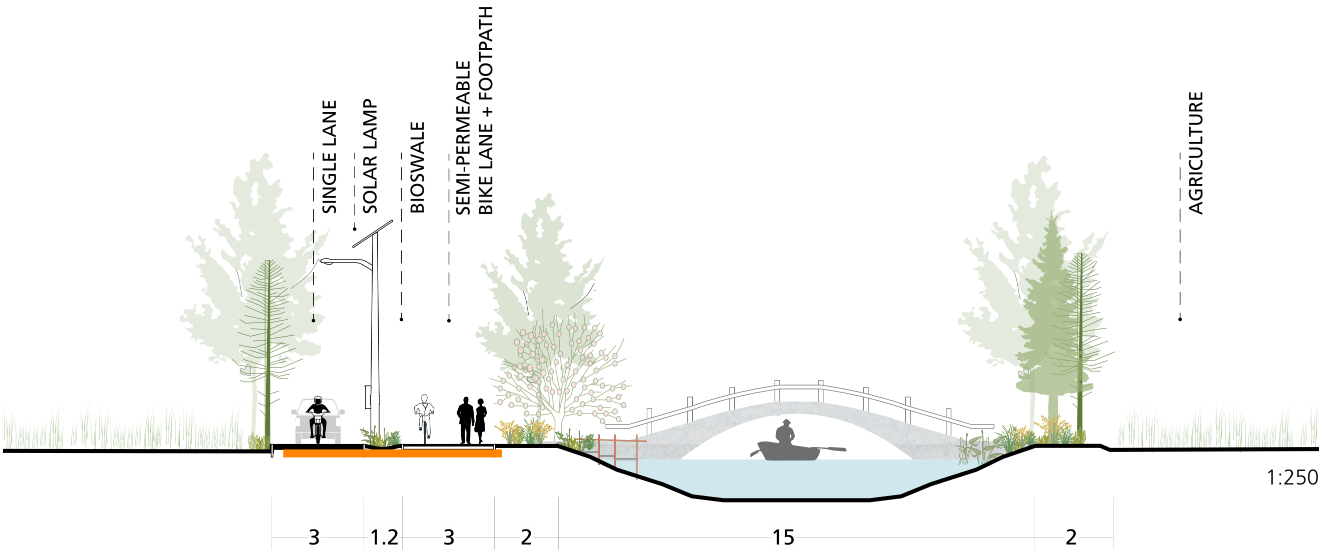



*Fig. 4.59* *Scenic footpath*

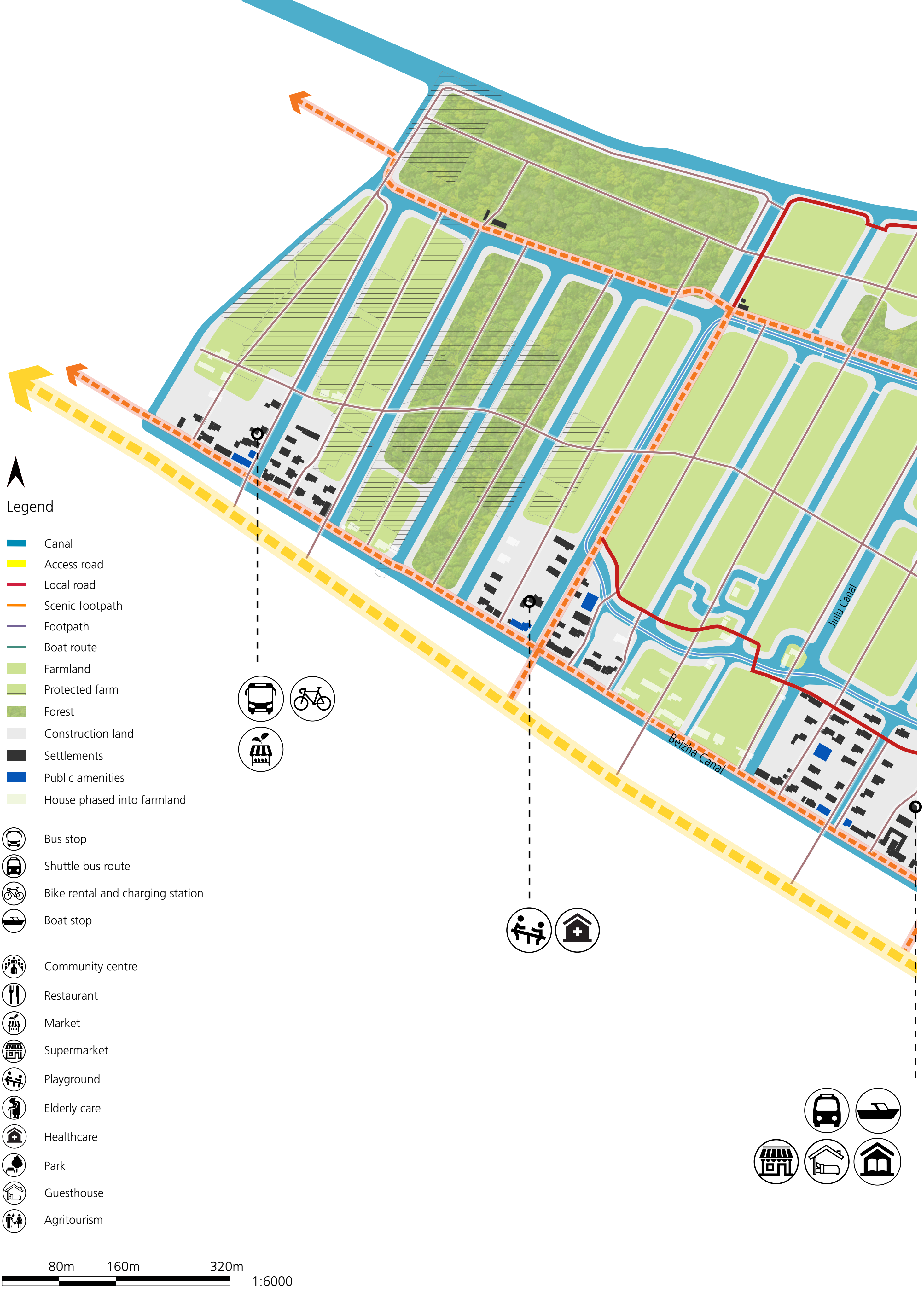



*Fig. 4.62 Proposed Masterplan for Xiebei Village*

Xia Hong River
San ShanHong River
Jinman Canal
Yuancunnan Canal
SANSHUANG ROAD
BEIYAN ROAD

## ENDNOTES

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