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Applying a Systemic Approach for Sustainable Urban Hillside Landscape Design and Planning: The Case Study City of Chongqing in China

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Abstract[2]

Rapid urbanization has led some Chinese cities to extend to hillside sites with recurrent patterns of flattening sloping terrain to erect high rise buildings. This approach usually results in disturbing local ecosystems which protection is an important requirement towards achieving the UN 2030 Sustainable Development Goals. Studies examining the special patterns of urban extensions onto hills and the driving forces of behind the deterioration of environmental quality in cities are scarce. This paper aims to answer two questions; "What are the definitions and goals for sustainable landscape design for hillside urban extensions?" and "What are the real causes for the unsustainability of current urban hillside housing developments?" These questions will be approached, first through a literature review, and second through considering the case study of Chongqing Yue Lai eco-city and examining the limitation and remediation through the whole process of the land construction loop within the systemic approach. This article illustrates how sustainable urban hillside landscape design and planning can be achieved by balancing the priorities of four key stakeholders (government, developers, city dwellers, and local ecosystem). This calls for shifting from the central planning system dominated by local governments by including the equally important priorities of its citizens (human actors) and non-human actors (ecosystem).

Keywords: systemic approach; mountainous/hillside landscape; ecological system; urban expansion; nature-based solutions.

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1. Introduction

The rise of sustainable development concerns is of paramount importance for a planet threatened by many challenges, which were identified as early as the 1980s. Examining the current state of the various factors that prompted this challenge shows that we are no closer to achieving sustainable development goals, and in many cases, we are even further away from it (Ehrenfeld, 2019). In developing countries, the goal of achieving sustainable development may even be more difficult to achieve as these countries are under pressure from both the high development demands and the lack of control of ecological degradation due to rapid urban extensions.

Mountain cities referred to as “hillside cities”, in the United States and Europe are defined by their altitude and slopes, such as cities with a significant percentage of territory at or above 300m altitude and with over 25% of territory consisting of slopes. With this definition, it is estimated that 69% of the total land area of China consists of hillside cities / locations (Huang, 2021). Mountain landscapes are complex and fragile bio-geographical environments due to various natural factors such as the unique topography, water, vegetation, and ecosystems (Abbott & Pollit, 1981; Chance, 2009; Dorward, 1990; Friedman, 2007). In this paper, landscape refers to the external environment of hillside urban residential areas, including green spaces between buildings and ecological corridors between neighbourhoods.

In China, mountainous and hillside areas have witnessed rapid urbanization over the last 30 years, with a significant increase in the loss of existing ecosystems. Urban housing developments account for around 70% of the total construction volume (Liu, Fan, Yue, & Song, 2018).The default type of urban housing development in mountain regions is no different than that of the flat urban sites as the tendency is: to flatten topography of sloping sites in order to build high-density, high-rise dwellings. In doing so, urban extensions onto hill sides have not only encroached upon the native habitat patches and ecological corridors but have also lead to biodiversity decline and extinction of endangered species (JINGNAN, 2008; Wang, Huang, Wang, & Chen, 2020; Yang, Zeng, & Yang, 2020). The landscape design of the newly built – urban housing areas is merely focused on visual aesthetics rather than a concern for protecting the long-term sustainability of existing ecological and environmental systems. Numerous hillside cities have witnessed a decline in their environmental qualities with the loss of green open areas, severe air pollution, an expansion of urban heat island phenomenon, and frequent occurrence of natural disasters (Chen et al., 2010; Zhao et al., 2014).

This is the case of Chongqing, one of the mountain cities in China, which population grew from 4 millions in 1990 to 15.9 millions in 2020 and is expected to reach 18 million by 2035 (Bank, 2019b; Review, 2020). This has led to an increase of 254% of the urban built up area from 2008 (265 km^2 in) to 2019 (939 km^2) with most of the urban extension sites built on slope. This leads to a rapid decline in species richness in the urban area of Chongqing. Those artificial environments are poor in storage and capture of water. Especially on sloping terrain, where fast water flows after rain exceeds drainage capacity of the city, resulting in urban flooding. The extreme heat weather is another problem. From Chongqing Meteorological Service (Hao, Bao-gang, & Bing-yan, 2008), the temperature in city of Chongqing reaches over 40 degrees in summer. This not only putting more people in danger from negative health effects of extreme heat, but also results in significant energy consumption due to the requirements for climatic control within buildings and public service areas.

It has been seen that there is a fundamental dichotomy between human activity and ecosystem continuity in those mountain regions. However, there are limited studies examining the special patterns and the driving factors of urban environmental quality in hillside cities. This paper focuses on the environmental qualities of outdoor spaces of residential neighbourhoods in built on hillsides. The main body of this paper is divided into three parts. The first part illustrates how and why government-led mega housing projects on hillside sites might fail to meet sustainable development goals. This is achieved by examining taking the case study of Yue Lai eco-city at Chongqing. Second part integrates analyses for the perspectives of four key human and non-human actors: governmental organisations, developers, users, and exiting ecosystems to reveal how interrelations and interdependence under revealed by a systemic approach can inform key stakeholders' decision making. A number of strategies and guidelines to promote the development of sustainable hillside landscape design and planning for residential neighbourhoods are proposed at the end of the paper.

2. Literature Review

2.1. Sustainable Hillside Urban Development

Hillside urban extension is confronted with two main specific sustainable development concerns: reducing land erosion, and protecting sensitive existing ecosystem resources. Abbott and Pollit (1981), Dorward (1990) and Moser (1991) published general guidelines for design and construction on hillsides (Abbott & Pollit, 1981; Dorward, 1990; Moser, 1991). The concern of slope grading and erosion control also could be seen in 1980's regulation from erosion and sediment control (Goldman & Jackson, 1986). They demonstrate ways for minimizing grading on slopes by preventing steep slopes of 25% to 50%.The landmark study in the year of 1969 McHarg "plan for the valleys" first used ecological information to interpret land-use by Layer-cake model (1969). The prediction that the analysis produced was that plateaus would be most tolerant to development, valleys the least (Hundt Jr, Daniels, & Keene, 2016). In 1990 (Dorward), "Designing Mountain communities" established how to balance construction and mountainous landscape using density, scale, and topographic sensitivity. As shown in the literature review, hillside developments invoke numerous perspectives of thought, addressing topography, climate, and hydrology factors. Those initial investigations, which are used in the mountainous regions of North America and European countries, are not based on the theory of sustainability.

In 1987, a Brundtland Commission Report – Our Common Future – provided the following definition "sustainable development is to meet the needs of the present without compromising the ability of future generations to meet their needs" which targets where "multiculturalism and interdependence of nations in the search a sustainable development path". In 1992, the concept of National Sustainable Development Strategy (NSDS) was proposed, in which countries were called upon to integrate economic, social and environmental objectives into one strategically focused blueprint for action at the national level (UN, 1992). The 'Triple Bottom Line' (TBL) approach to sustainability is based on those three dimensions of sustainability. These have been increasingly referred to as equal underpinning goals in the planning of sustainable residential projects However, recent research has argued, that the sustainability convention, as anthropocentric and providing only minimal specifics, is failing to include crucial components into the sustainability equation such as “non-human actors”, (Ehrenfeld, 2019; Gibbons, 2020; Lovins, Wallis, Wijkman, & Fullerton, 2018; Wahl, 2016). The relevant literature call for rebuilding and re-connecting, by everyone having a stake in the issue, and aiming to bring dialogue and synergy between the specific agencies and agendas to include human and non-human actors and factors (Gibbons, 2020; Lovins et al., 2018; Wahl, 2016). John R. Ehrenfeld and Andrew J. Hoffman argue that human activity is valued by an obligation to reduce its environmental footprint, as humans have equal – neither privileged nor pejorative – roles within the overall ecosystem and biosphere (Nolt, 2014). Ecological concerns should therefore be included into the ‘Triple Bottom Line’ and the concern for ecological quality should be right at the forefront of landscape design.

2.2. The Research Gap

Although that series of sustainability criteria meant to take us beyond unbridled environmental damage, a critical review of the literature shows that there is little research specifically investigating hill side urban housing extensions and their surrounding landscape. More importantly, the elements and goals from social, economic, ecological, and environmental aspects are not separated but are in a mutually supporting relationship. Connections among the four dimensions are too complicated to be addressed by a single discipline or problem-solving technique (Ozbekhan, 1969). Systemic thinking thus becomes an important tool to be brought to the leading design process to address complex global issues. Given that most studies on the systemic approach were conducted in Europe and North America, this paper aims to investigate the patterns of urban extension in the city of Chongqing in China. It will not be sufficient to find causes of unsustainability in development within hillside urban areas, one must also illustrate how to change the situation by fostering their supporting relationships between the four main stakeholders (government, developers, users, and ecosystem) under the systemic approach.

3. Methodology

In anthropocentric design, systems dominated by governments have excluded the participatory non-human sectors and reduced the voice of the public. This paper seeks to demonstrate the combination of “top down” and “bottom up” approaches within the systemic thinking by different stages of multicentered, systemic co-design via collaboration with the four main stakeholders (government, developers, users, and ecosystem). Ecosystem here represents the non-human agenda involved in the project from start to the future and acts on behalf of the ecosystem, to represent the existing and potential stakeholders by investigating habitats, migrations, and edible landscape in the site (Nolt, 2014).

This paper examines the case study of Chongqing in China as a prime example illustrating the challenges of sustainable urban extension on hillside sites. Chongqing is a mountain city in inland China with fast economic growth. The natural mountainous topography and river features define the character of the city. The urban area of Chongqing has begun to respond to newly introduced sustainable development policies. These new policies and regulations have a direct impact on achieving sustainability of new urban extensions and determinate how different dimensions of sustainability can be integrated across different scales. Despite government policies and business commitments to sustainability, the rapid urbanization in last 30 years has resulted in serious disruptions to local ecosystems, which include decreasing woodland in the plains area, destroying the terrain of Four Mountains, and encroaching on the native habitat patches and ecological corridors through extensive construction activity. The city of Chongqing shows ecological bottlenecks similar to most mountainous cities in China, as well as those in other developing countries. The study proceeds in three stages.

First, examining the Chongqing Yue Lai eco-city as a case study, with a focus on the residential neighbourhood scale, a SWOT is first presented to illustrate the issues hillside developments face in China. This is followed by scaling up the analysis to the urban scale in order to understand the scale of land use changes in the city of Chongqing over three decades, from 1990 to 2020.

Second, considering enhancing the existing of ecosystem in mountainous cities, several studies agree that introducing natural patch areas and corridors have the greatest beneficial impacts on reintroducing biodiversity, whose habitat loss has been exacerbated due to fragmentation of natural landscapes (Beninde, Veith, & Hochkirch, 2015; Radford, Bennett, & Cheers, 2005). The patch area and corridors are made up of ecological canals, tree corridors, connecting parks, and open spaces, which collectively facilitate biotic interactions in an ecosystem (Beatley, 2012). Geographic Information Systems (GIS) is then used to examine the spatial and temporal dynamics of urban sprawl, analysing by urban land use and land gradient (slope). Eight land types are categorized by their distinct ecological values and vegetation structure. These eight land types are then examined through the perspectives of the four actors identified earlier in the paper.

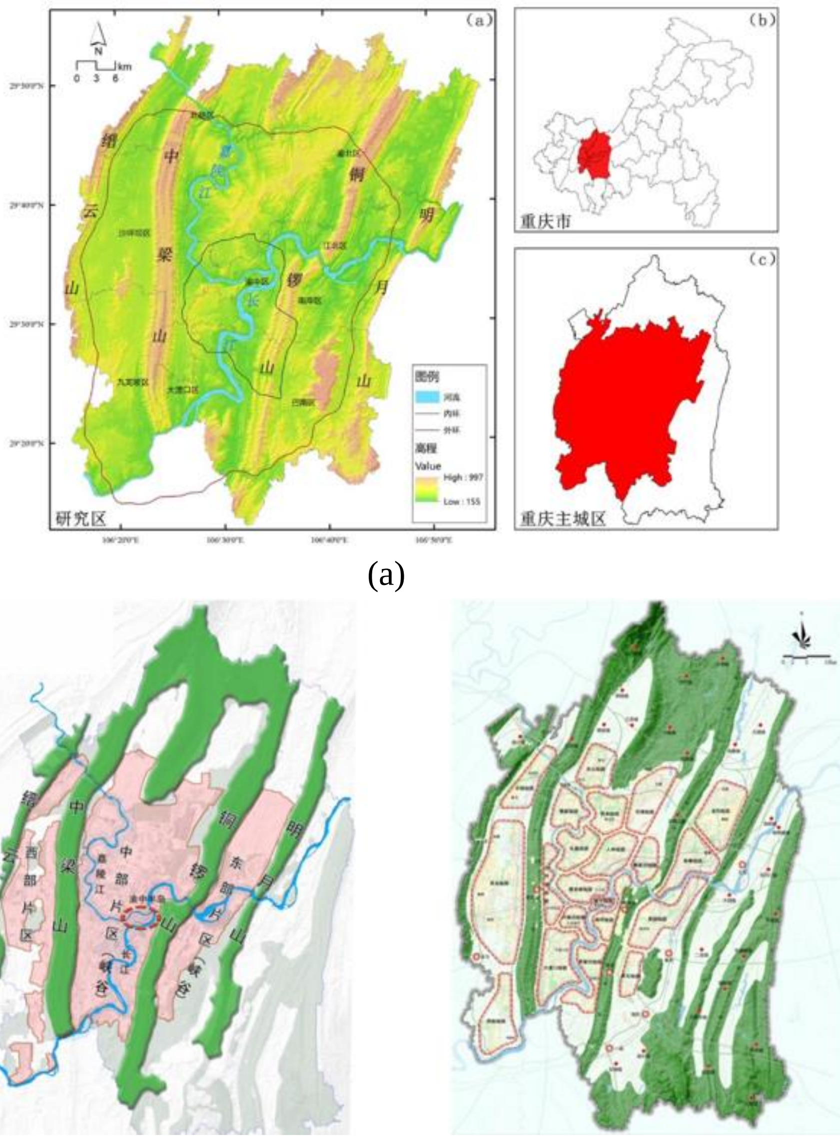
Third, taking into consideration the concerns and perspectives of the four actors, Minimaps are used to illustrate how the positive reinforcing is enhanced by the co-effect between them, the performance of the four main stakeholders will be taken into the analysis through the case study city (Chongqing) by using a Gigamap (Figure 6). The Gigamap supports a shared picture of a complex field of stakeholders and how they interconnect in the system (Sevaldson, 2018). It seeks to understand the nebulous gaps between goals of the four actors, in order to bridge breaks and to create new linkages that could support the finding of new solutions.

4. The Chongqing Yue Lai Eco-city

4.1. The Urban Area of Chongqing

Chongqing has been known as a "mountain city" located in the southwest of inland China with an area of 82,400 km^2 (Bank, 2019a). The study area is the city proper of Chongqing with nine districts (5472.68 km^2). The city is characterized by one peninsula (Yuzhong District), four mountains (east to west Jinyun Mountain, Zhongliang Mountain, Tong Luo Mountain and Mingyue Mountain) and two rivers (the Yangtze and Jialing Rivers) (Figure 1a,b). The altitude is 155-997m. There is 18% of plains land (<8% of slope), 45% of hilly terrain (8%-25% of slope), and 37% of mountainous areas

(>25% of slope). The local topography forms a unique landscape pattern in the city of Chongqing with 'polycentric, clustered' urban form (Figure 1c). Chongqing's economic development has maintained high growth rates since the city was first administered, with the city's economic growth rate remaining above 10% since 2002, compared with the national rate 6%; with developed countries such as the USA and UK at around 3%.



(a)

(b) (c)

Figure 1: Study area of Chongqing. (**a**) Topography of the study area; (**b**) One peninsula, two rivers, three valleys, four mountains; (**c**) Clustered pattern.

Source: Chongqing Municipal Planning Bureau, Chongqing Municipal Planning and Design Institute.

4.2. Evaluating the Chongqing Yue Lai Eco-city

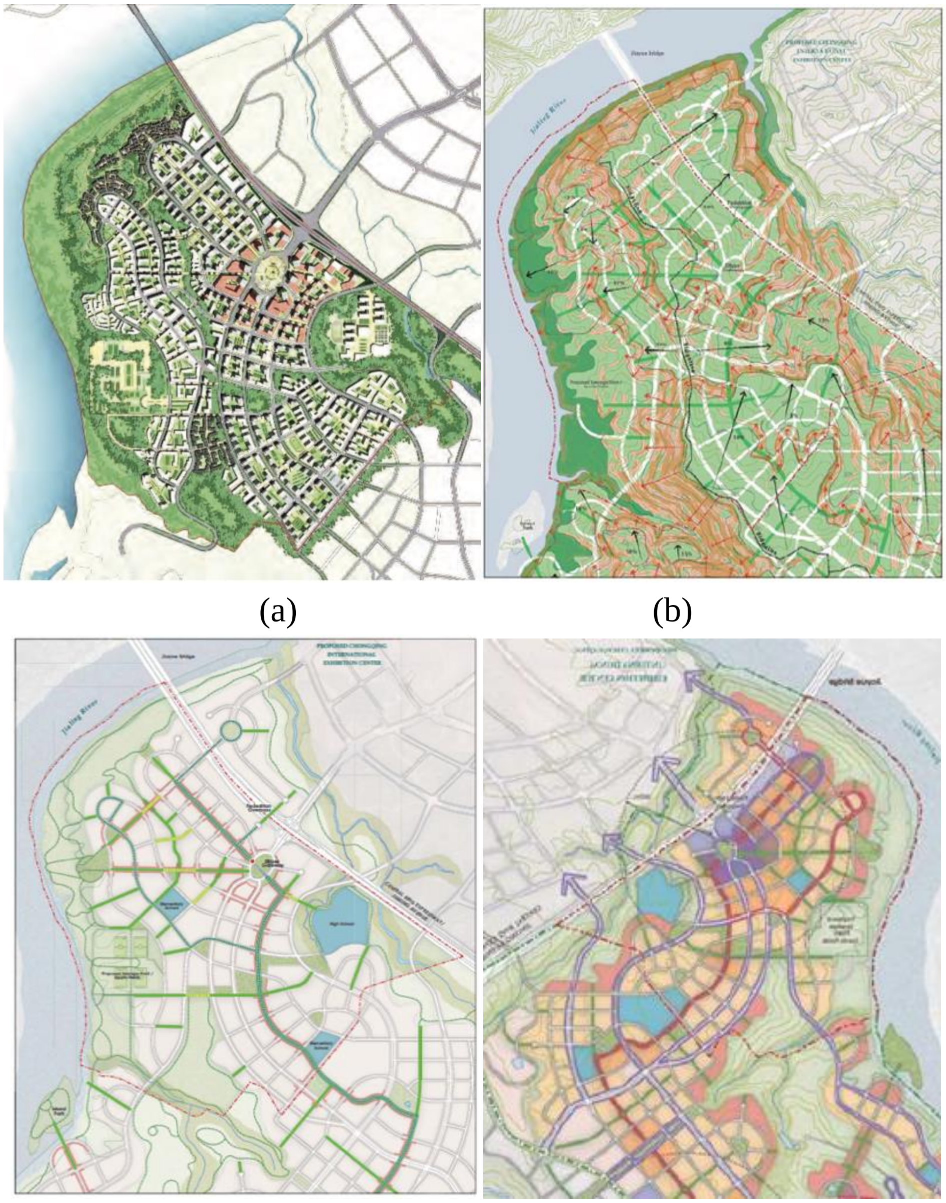
The eco-city is based on the philosophy of sustainable development (Yu, 2014). To minimize carbon emissions and promote ecological economic development, the Ministry of Finance in China has supported and funded in 2012 eight pilot projects for Green Ecological Urban Built-up Areas and funded the first eight pilot projects in China. The "Chongqing Yue Lai eco-city" is one of these eight projects. The leadership of Chongqing has identified this project as an opportunity to develop a regional model for sustainable urban development. This planning proposal of the project won the First Prize of "Chongqing Outstanding Urban and Rural Planning 2013".

Yue Lai Eco-City has a total land area of 1,031ha, where it is surrounded by lush hills and valleys along the Jialing River. The site has around 15% (160 ha) of slopes greater than 25 degrees (Figure 2b). The vertical height difference in the site is 228 meters, with the lowest elevation at 173.8 m on the river and the highest at 402.2 m at the top of the southern hill. The site land cover in the original site consisted mainly of three categories: farmland (57%), woodland (12%), and the villages and factory (8%). Woodland is mainly concentrated on the hill beside the riverbank whereas the farmland and built-up area are located in the middle valley.

The evaluation of the effects of the planning of the Yue Lai Eco-City will be accomplished by way of SWOT analysis as follows.

<u>Strengths (S)</u>

First, with respect to the natural mountains and rivers, the design is concentrated on ecological conservation through integrating ecological corridors and water elements into the planning scheme (Figure 2a). In the elevation analysis, the mountain area consists of slope gradient analysis (classified as 0-15%, 15-25% and over 25%) and slope analysis (east to southwest – low sensitivity; due north to due east medium sensitivity; and southwest to due north high sensitivity) (Figure 2b). The purpose of the slope gradient analysis is to create an efficient circulation network and maximum developable land without extensive modification of the natural terrain. In this plan, the key landmarks are located at higher elevations, with buildings stepping down the slope to provide the view of the river. The identification of hydro-ecologically sensitive areas resulted in both sides of the three streams being treated as highly sensitive areas. The ecological structure plan is a result of the upscale analysis, which connects the multiple patches trough ecological corridors (Figure 2b).



(a) (b) (c) (d)

Figure 2: New Town Master Plan Yue Lai Eco-City (Associates, 2012) (**a**) New Town Master Plan Yue Lai Eco-City; (**b**) Elevation analysis; (**c**) Ecological structure plan; (**d**) Road system.

Source: Building China's Sustainable Cities Future, China Sustainable Cities Program of the Energy Foundation; China Sustainable Transportation Centre; Selected Projects: Yue Lai Eco-city Chongqing, China 2012.

Second, stormwater management has been proposed after examining the geographical and morphological characteristics of the planned area. The infiltration surface is greater than 40%, and the naturalization rate of riverbanks is not less than 70%. Through the hydrological analysis, modelling the current water body and identifying seven catchment units was made possible (Figure 2c). This resulted in defining the stormwater management according to three systems that are working collaboratively: the runoff channel system, the lake layout system, and the wetland system (Figure 2c), enabling rainwater storage and stormwater purification.

Third, the project proposal aims at enhancing residents' accessibly to work within the constraints of the natural terrain. A pleasant and well-connected circulation network for pedestrians and cyclists is created as follows: (Figure 2d) (1) A cycling road system within the areas with a 5% slope gradient combined with the introduction of public bicycle service points, with service radius ranging between 120-150 m. (2) The pedestrian walking route system on gently sloping ground with stepping which is arranged in different ways according to a slope gradient varying between 3% and 10%. (3) 10%-25% with stepping combined with resting platforms and with lifts in mountainous walking areas where the slope is greater than 25%. In this way, improvements to the accessibility of green space within the community made.

<u>Weaknesses (W)</u>

Despite the existence of standards and targets for environmental conservation that could be implemented to enhance the ecological functioning within an area [46–48]. To implement the conservation targets at the appropriate temporal and geographical scale, a defined conservation strategy is needed, with a mitigation hierarchy to be adopted as part of the urban redevelopment plan [19, 39, 49]. Following this framework, landscape design is planned to contribute to biodiversity preservation while also balancing the need to introduce hard infrastructure.

First, the existing planning is missing a component of vegetation analysis in ecological corridors. The vulnerable landscape is dependent on the degree of diversity in its vegetation and the ability of vegetation to recover. Particularly that ecosystems in the forests on steep slopes are easily interrupted. In comparison to the ecological corridors in building zones converted from farmland, hillsides have distinct ecological characters, and are under the pressure of human activities associated with urban extensions.

Second, connectivity between ecological corridors has the strongest positive influences on biodiversity (Beninde et al., 2015). The ecological waterways, tree corridors, and connections between gardens in neighbourhood areas and buildings are the key components that form the ecological networks at a multiple level, which places them as significant contractors for the support of ecosystems (Beatley, 2012). Considering the plan of the new neighbourhood, it is clear that on its northern side, the ecological corridor is interrupted due to several motorways. The ecological corridors intend to provide connection and migration opportunities for habitat, However the fragmented landscape results in the degeneration of the existing ecosystem.

Third, green gardens (unlike ecological corridors) incorporate dense roads and building blocks which have little positive ecological impact, and therefore need to be supplemented by compensation strategies. For instance, promoting green roofs and living walls in buildings can facilitate the restoration of fragmented landscapes and reduce the heat load whilst promoting clean air (Lehmann, 2021).

<u>Opportunities (O)</u>

Yue Lai Eco-city is the first representative project of “The Preparation of a Special Plan for Sponge City in the Urban Area of Chongqing in 2015”. It shows that the government has paid significant attention to sustainable development, and its local governments have responded positively to the new initiative. Moreover, this project is frequently cited in planning and environmental literature (Cai & Tang, 2021; Sun, Liu, & Wang, 2016; Zhang, Kuang, Chen, Deng, & Chen, 2016). Academic evaluations may enhance the future direction and promote the implementation pf specific regulations for hillside urban extensions.

<u>Threats (T)</u>

Developers are driven by pursuit of maximum commercial profit within short-term funding cycles. This results in jeopardising various key components of the sustainable urban extensions, which will begin to become evident once the project is built and inhabited.

By examining the residential neighbourhood scale, we can see evidence of a lack of coordinated efforts between ecologists and other stakeholders, resulting in serious implications for the implementation of informed and sensitive landscape designs that respond to the specificities of hillside sites. However, when expanded into a larger scale, the development of urban extensions is the result of the joint actions of different agencies according to their own values, status, and interrelationships. However, there are decision-making imbalances between the different stakeholders leading to serious environmental implications.

5. The limitations of the Central Planned System

Within the central planned system of China, the exclusion of the important participation of ecosystem experts as well as of residents and citizens results in serious environmental problems for the hillside landscape. Figure 3 shows an illustration of land changes in urban areas of Chongqing and how the city has been transformed by government decisions.

The city of Chongqing is dealing with urgent urban extension policies, which bring about tremendous pressure on its land-use and its transformation. The rapid urbanization of the city can be divided into three main stages in Table 1.

The first urban extension stage was initiated in 2000, brought about by economic growth resulting in major construction projects. The second stage, between 2000 and 2010, was characterised by the General Environmental Protection Policy. The third period (after 2010) is characterised by the introduction of specific standards and regulations to promote the implementation of sustainable urban development into practice. The concept of eco-city was then introduced for the first time. (Table 1).

Table 1: Changes in Policies and Regulations from 1997 to 2015 in last three decades

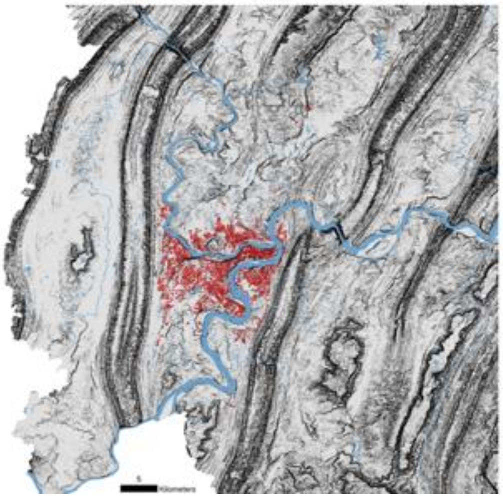
Year	Politics and Ordination
Before 2000	•**1997** The establishment of the multipolicy direct under central government
2000 To 2010	• **2000-2002** The Western China Development Program (WCDP) • **2006** Four Mountain Management • **2007** Chongqing urban-rural master plan 2007-2020
After 2010	• **2012** "Yue Lai Eco-city" The Green Ecological Urban Built-up Areas • **2015** The Sponge City "a pilot project in Liangjiang New District, Chongqing "

5.1. 1997: The Establishment of the Municipality Directly under the Central Government

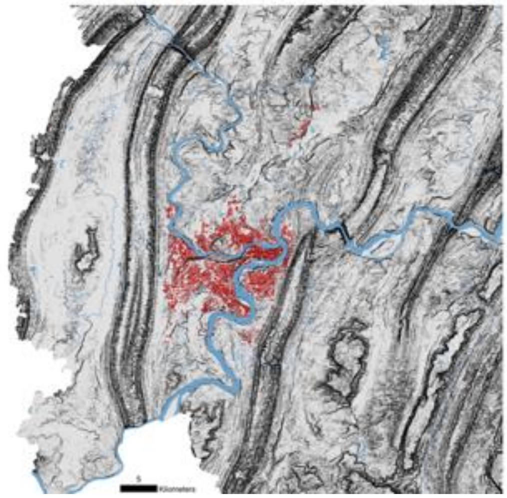
On March 14, 1997, Chongqing was established as the fourth Municipality directly under the Central Government (the other three being Beijing, Tianjin, and Shanghai) (Long, Wu, Wang, & Dong, 2008). The direct result of urbanization was the increasing urban settlements (Table 2). In 1990 the built-up area was 167.40km^2, at this period; and urban development at this earlier stage was centered on the peninsula, and then gradually expanded into its surrounding areas (Figure 3a). By 2000, the built-up area of 272.55 km^2 had expanded mainly between Zhongliang Mountain and Tongluo Mountain and extended in a north-south direction (Figure 3b). From 2000 to 2010, the built-up area began to develop across the two mountains with a built-up area of 602.51 km^2. In addition, at the west of Zhongliang Mountain and the east of Tongluo Mountain, new districts were introduced (Figure 3c). In 2010, Liangjiang New Area on the north part of Chongqing was formed. The sub-region's construction land development activities increased. Those changes can be found in the distribution of the built-up area in the year of 2020 which reached 775.78 km^2.

Table 2: Policies and regulation changes in last three decades

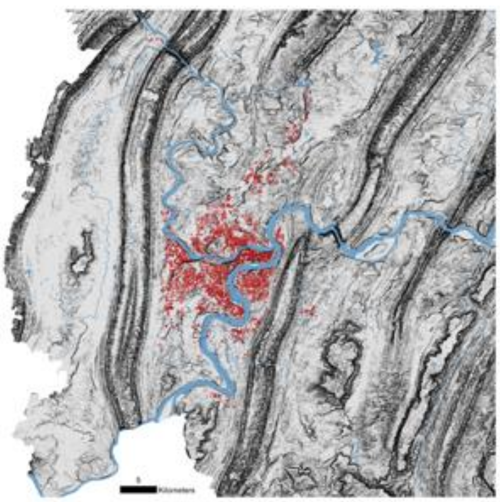
	1960	1980	1990	2000	2010	2020	2030
population (millon)	2.3	3	4	7.9	11.2	15.9	19.6
build up area (km2)			167.4	272.55	602.51	775.78	



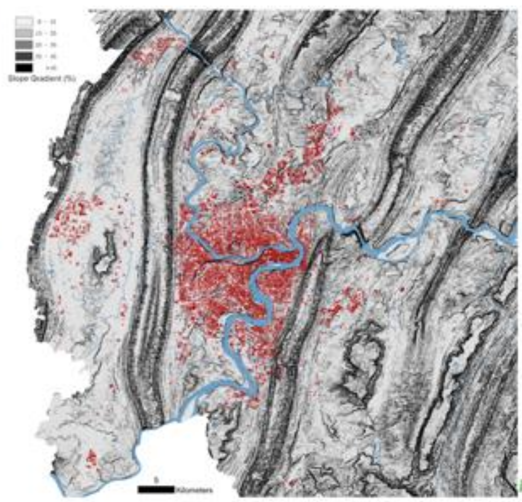
(a)1990



(b) 2000



(c) 2010



(d) 2020

Figure 3: Urban settlement in the city of Chongqing. (**a**) 1990; (**b**) 2000; (**c**) 2010; (**d**) 2020.

Note: The urban construction land expansion analysis is based on the gradient analysis with 5 levels, 1-15%, 15-25%, 25-35% and >45%. (Xiao Hu, 2021) Source: Digital Elevation Model (DEM) with 15m spatial resolution.

5.2. 2000-2002: The Western China Development Program (WCDP)

The foundation by the central government of the Western China Development Program (WCDP), has been the focus after 2000. This represents a positive change, largely resulting from two sets of guidance "Four Mountain Management 2006" in the city proper of Chongqing. The content is to re-establish forest land, preserve natural forests, and prevent and manage sandstorms (Long et al., 2008). Since the topography constrains the pattern of city expansion in mountain city, land-use changes by type of slope gradients were analysed through by GIS modelling. The following section illustrates how these standards and ordinates have influenced changes in land cover across different slope gradients.

Table 3: Chongqing land cover changes in the year of 2000 and 2018

CLASSIFICATION	YEAR		Increase / Decrease	
	2000	2018	Km2	Percentage
Irrigated paddy field	1495	1177	-318	-21%
dry farm land	2426	2072	-354	-15%
Forest	983	1005	23	2%
Scrub	90	62	-28	-31%
Grass	52	55	3	6%
Open water	132	134	2	2%
Reservoir	18	17	0	-3%
Urban area	265	939	674	254%
Bare soil	4	3	-1	-31%

Considering land cover change in slopes with a gradient higher than 25% (mainly located on the steep slope in four mountains), forest coverage has experienced an increase by 22.7km^2 from 2000 to 2018 (Table 3). In certain locations, populations and habitats of some species have returned [34]. There is an exception in the reduction of forest coverage in Zhongliang Mountain, which passes through the city's centre, where highways, trains, bridges, and tunnels have removed most of the mountain's flora. Moreover, the newly planted woodland has most often used -monoculture- species, which are weak in resisting disease and pest hazards, and the less mixed structure means less shrub and grass, more soil erosion, and less biodiversity (Chen et al., 2010).

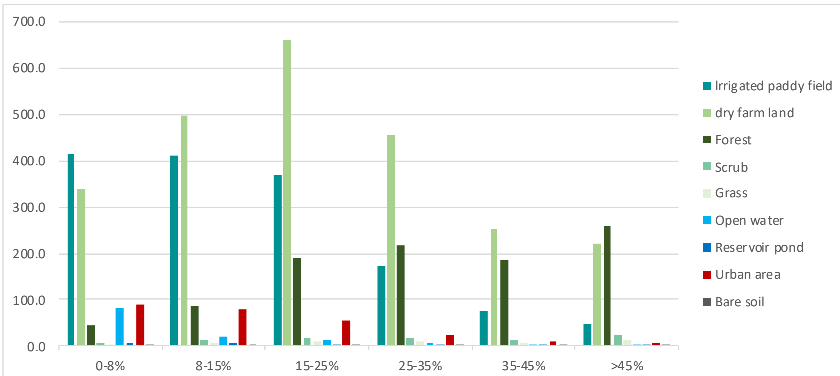
On the slope areas below a 25% gradient, increasing demand for land for the development of residential neighbourhoods is the result of rapid urbanization, causing the primary land-use shift (Verburg, Veldkamp, & Fresco, 1999). The GIS analysis (Table 4 b) reveals that under 87.7% of the built-up area

(823.7 km^2) occurs on land with gradient below 25%. Of this area, 64.7% (607.3km^2) lies in plains land and on areas with moderate slope at 0-15% degree, 9% (85.4 km^2) at the slope 25%-35%, and 5% (47.6km^2) built on the slope that greater than gradient of 35%. This impacts farmland and forest located on slopes with a gradient below 25% gradient, which have suffered a significant reduction. Comparing the data for year 2000 and year 2018, (Tables 3,4), farmland decreased to 36% (672km^2), with 83% of that area having a slope gradient less than 25%. Within the 83% area, irrigated paddy fields declined by 303.3km^2 and dry farmland by 256.7km^2. Forest has decreased by 1.2 km^2 in 0-8% gradient, from 43.1 km^2 (in 2000) to 41.9 km^2 (in 2019). This reduction is relatively small, reflecting the increase in green space (public parks and community gardens), largely compensating for the loss of natural forest. The increase in grass cover in 0-25% gradients largely results from grass being extensively used as a landscape element in urban green areas, including parks and community gardens. This mainly results from a mandate in national standards relating to construction on land with less than 25% gradient. Construction sites almost universally exhibit human-centered landscape development, clearing the original flora, demolishing natural landforms, and greatly altering natural hydrological systems. The spatial distribution of residential land is a mix of urban development and suburbanization, where high density sprawl for a single purpose increasingly becomes the common pattern, encroaching on ecological space. The patch area and corridors have the greatest positive impact on biodiversity and the structure of the vegetation. According to the research, the city of Chongqing has a severely fragmented landscape, with a patched area of less than 500 square meters (Wang et al., 2020). As a result, sustainable urban development has become a branding tool for developers included in a marketing pitch which is far from its intended meaning (Herdering & Kearins, 2014).

Table 4: The percentage and size of land-cover classes in elevation, Chongqing 2000 and 2018

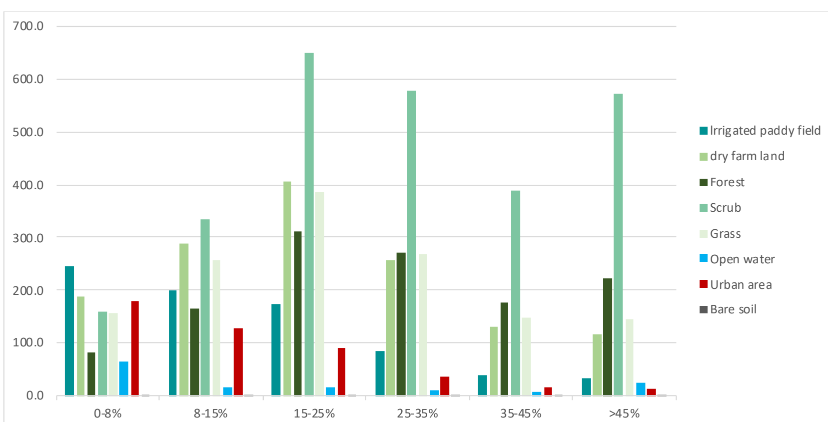
(a) 2000 percentage and size of land-cover classes by gradient

	0-8%	8-15%	15-25%	25-35%	35-45%	>45%
Irrigated paddy field	414.9	411.8	368.7	173.3	76.6	49.4
dry farm land	339.1	497.6	661.1	455.7	253.6	219.3
Forest	43.1	87.6	188.5	219.1	185.7	258.4
Scrub	7.4	12.3	17.7	15.7	12.8	24.2
Grass	3.0	6.0	11.6	9.9	7.1	14.2
Open water	82.9	19.2	14.3	7.5	3.8	4.2
Reservoir pond	7.4	5.1	3.3	1.4	0.5	0.3
Urban area	90.5	77.6	56.7	23.6	9.6	6.8
Bare soil	0.4	0.6	1.2	1.0	0.5	0.4



(b) 2018 percentage and size of land-cover classes by gradient

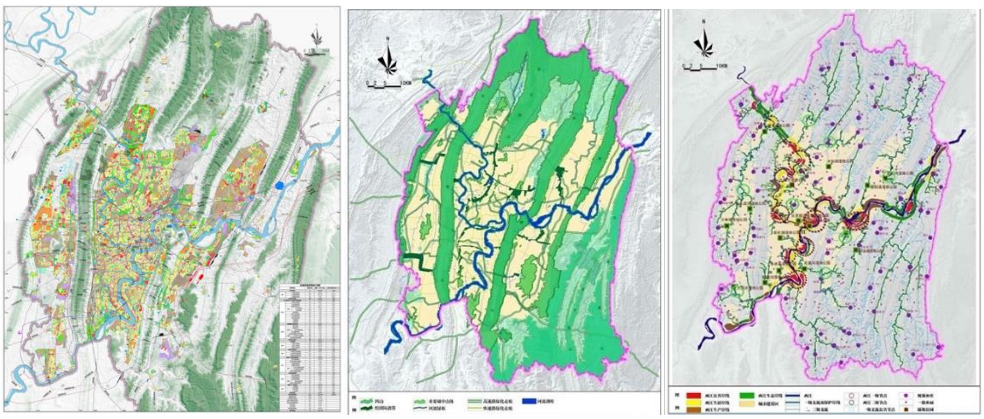
	0-8%	8-15%	15-25%	25-35%	35-45%	>45%
Irrigated paddy field	278.1	308.4	305.6	159.3	74.3	51.0
dry farm land	258.9	400.8	563.4	408.4	233.8	207.3
Forest	41.9	89.3	191.0	222.7	189.7	270.7
Scrub	6.0	9.0	13.5	11.5	8.8	13.6
Grass	4.8	7.2	12.6	10.2	7.1	12.8
Open water	82.2	19.9	15.4	8.1	4.0	4.5
Reservoir pond	6.3	4.6	3.6	1.7	0.8	0.5
Urban area	309.8	279.5	216.4	85.4	31.0	16.6
Bare soil	0.2	0.4	0.8	0.8	0.4	0.2



Note: The land cover classification by gradient is based on the gradient analysis with 5 levels, 1-15%, 15-25%, 25-35% and >45%. Source: Digital Elevation Model (DEM) with 15m spatial resolution. (Xiao Hu, 2021)

5.3. 2007-2020: Chongqing Urban-Rural Master Plan

The Chongqing urban and rural master plan developed a mountain, river, and ecology sensitive corridor in the central area of the city of Chongqing (Figure 4a) and includes the Mountain Ridge Ecological Corridor (Figure 4b); and the Water ecological corridor (Figure 4c). Although those new political and regulatory initiatives were directed at sustainable development, there was little actual impact on the process of urban environmental degradation.

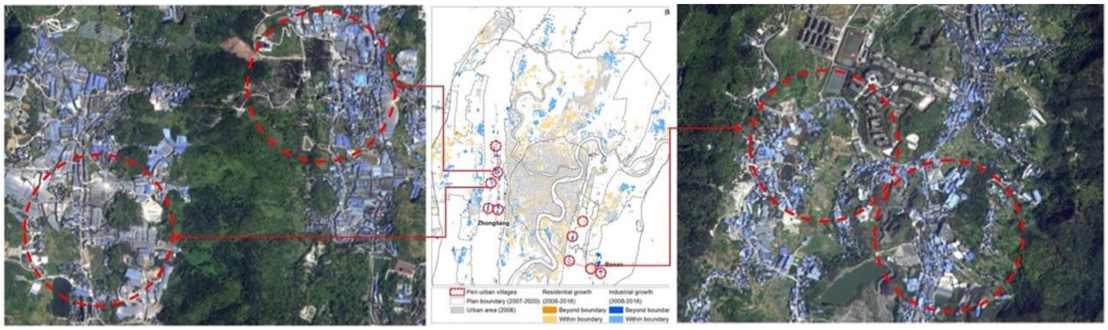


(a) (b) (c)

Figure 4: (a) Controlled Detailed Planning map of the central city of Chongqing; (b) The Mountain Ridge Ecological Corridor; (c) Water ecological corridor.

Source: Chongqing Municipal Planning Bureau, Chongqing Municipal Planning and Design Institute. Beautiful landscape city planning for the main urban area of Chongqing [Z], 2015.

In the edge of the city, the sprawl of semi-urban villages, mainly located on the tops of slopes and the foot of the Zhongliang mountain (Fig 5a) and Tongluo Mountain (Fig 5b), which is at the edge of the urban area having advantageous transport, farmers converted their pre-existing housing for rental purposes. Rural construction also brings pollution to the river, such as the Liangtan River.



(a) (b)

Figure 5: Peri-urban informal development in central Chongqing during 2006–2016 (a) Peri-urban informal development in Zhongliang mountain; (b) Peri-urban informal development in Tongluo mountain.

Note: The red circles indicate the areas with peri-urban informal development. Source: Impacts of land finance on urban sprawl in China: The case of Chongqing, Land Use Policy, 2018.

5.4. 2015: The Preparation of a Special Plan for Sponge City in the Urban Area of Chongqing

The Sponge City Programme aims to improve the resilience of cities to flooding and to allow 70% of rainfall to be absorbed and reused locally. In the year of 2015, Chongqing launched “The Preparation of a Special Plan for Sponge City in the Urban Area of Chongqing”, which is devoted to using the water resources to green the built-up area in this mountainous city. The plan was initiated as a pilot project in Liangjiang New District. The Yue Lai eco-city is one of the first areas in this district to lead the 'sponge city' concept 2012, piloting Green Ecological Urban Built-up Areas through the “Chongqing Yue Lai eco-city”. However, the main ecological focus was on water management. The lack of monitoring and evaluation systems are in large part due to a lack of baseline data on biodiversity [43]. Land value is the major cost of the investment, and the combination of insufficient regulation, lack of environmental protection monitoring [43], and an emphasis on quantity over of quality has led to a post-development decline in the value and quality of the landscape, and, in the urban area, to unfavourable environmental changes, including the loss of precious natural resources such as farmland and forest cover), impairment of the ecosystem, and the deterioration of the quality of life.

To sum up, there are numerous challenges associated with urban land development in hilly areas. It is argued that the government has set more strict standards in order to curb pressure to address a variety of environmental issues (Chen et al., 2010). While there is a strong case to be made that the national/local standards can certainly contribute to more sustainable urban center and urbanization patterns, the evident tension between universal standards and local characteristics and context may not be easily overcome. The systemic approach can facilitate the development of holistic rationale, and parameters/standards that can result in the least intrusive interventions with even a little leverage point. The existing, older system continues to operate with the prior information and goals, and is unlikely to change (Meadows, 1999). A new, "bottom-up" approach is needed to deal with the specific challenges of the different local contexts.

6. Integrating the Four Main Stakeholders into the System

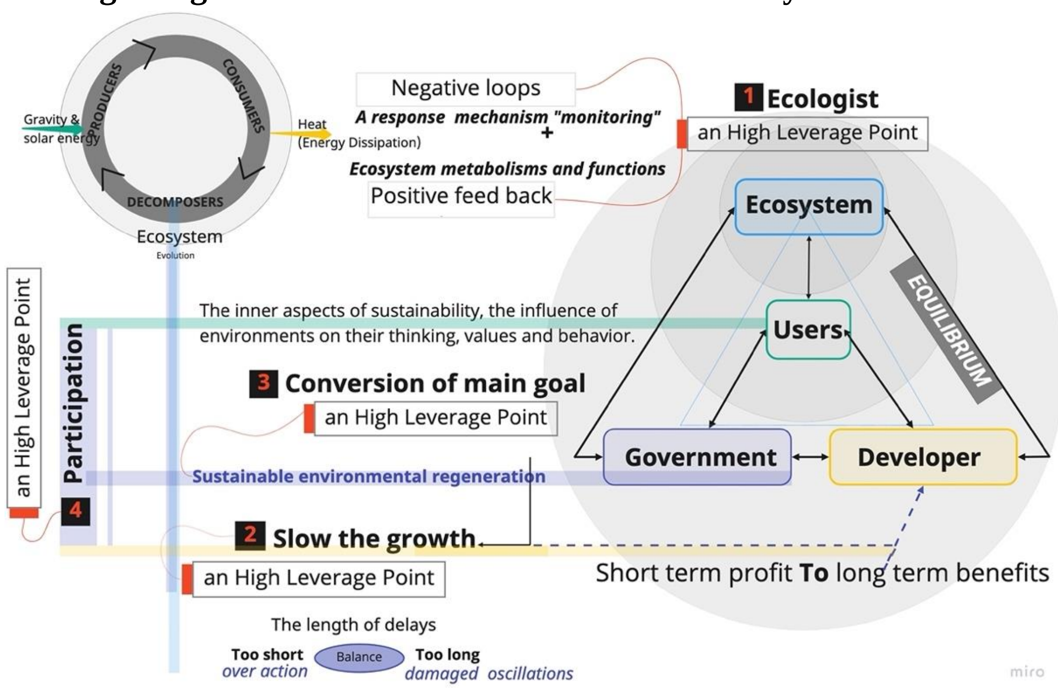


Figure 6: Gigamapping: Four main stakeholders Ecosystem: Urban dwellers, Governmental Organisations and Real EstateDeveloper (Xiao Hu, 2021)

The Gigamap above indicates the collaborative opportunities between the four key actors: governmental organisations, the ecosystem, the urban dwellers as users of the urban environment, and real estate developers, in a systemic co-design through participation of all stakeholders (Figure 6). This system requires a multi-centre perspective with their different views and visions regarding the challenge of a holistic sustainable urban development and extensions into hillside sites. In response to instability with diverse viewpoints and agendas, all stakeholders, even those who were previously just potential stakeholders, take an active role (Davidová & Zímová, 2021). This could significantly amplify the positive factors, strengths, and opportunities, while moderate decrease in weaknesses and external threats. Each stakeholder and its interrelations with the others are discussed below.

6.1. Governmental Organisations

In China, planning is dominated by the local government. At the back of the phenomenon of urbanization are policies implemented by central/local governments that actually drive the change [60]. In the Gigamap below (Figure 7), "The central planned system" and "government" occupy a central position as they control both the direction and the process of urban development. Five key policies have been introduced between 1997 and 2015 (see Gigamap in the top right corner (Figure 7)), which impact on new regulations that address sustainable planning on construction land and non-construction land in the city of Chongqing. Followed by local regulations, the second high impact stakeholders are the real estate developers, who are directly engaged with the whole design/construction process. Given the economic considerations, businesses are the ones who play the most significant role, in which rapid financial gains have adversely impacted on land-use and value (see left side of Pink (Figure 7)).

Residential land is the primary source of land premiums. From the Chongqing land finance statistics of the period 2003-2017, land concession revenue increased from RMB 10.073 billion in 2002 to RMB 274.479 billion in 2016, making land revenue account for over 60% of local revenue for revenue generation from land assets that result from buying and selling (Liu et al., 2018). The population grew by 1.6 times between 1997 and 2016 and the area of residential land increased by 5.2 times.

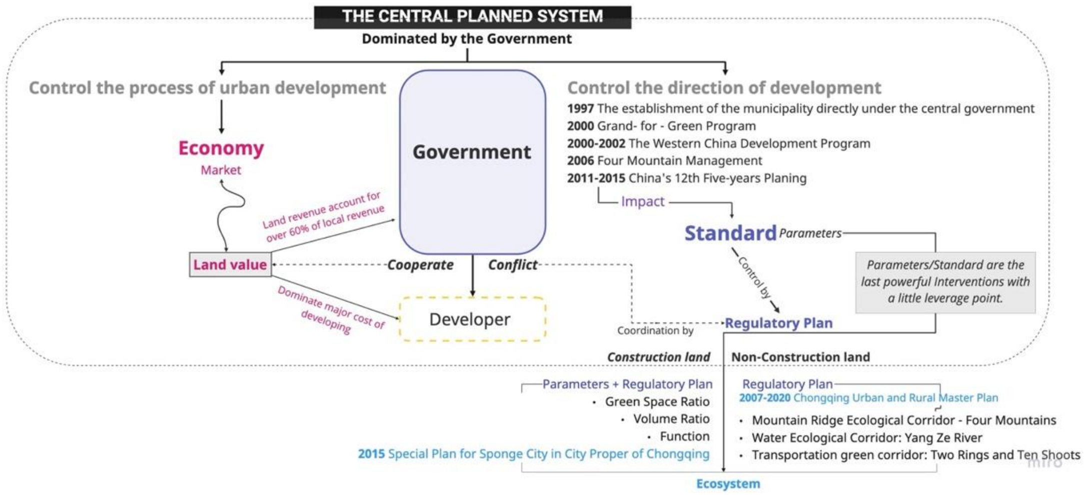


Figure 7: Gigamapping: The central planned system (Xiao Hu, 2021)

The reason for this is illustrated in the Minimap below (Figure 8), showing the loop of land development. In this government-controlled system, the land is converted from "farmland and forest land" through IN FLOWS into "construction land" that results in the number of "housing developments" in the OUT FLOWS. As "the process of the system is invisible", it forms a "discrepancy" between construction land and the practical need (see dotted sections in the middle of the figure (Figure 8). In a system, the length of delays would have high leverage points which are critical for the “change” (growth, fluctuation, delay) (Meadows, 1999). Delay in feedback loops is slow, as the process from planning land into the saturated market is lengthy. This in turn results in government being unable to modify development policies in time. Forecasting depends only on economic development goals, which encourage developers to accelerate land development for short-term profits. The extent of natural resource deterioration puts the ecosystem under pressure as housing construction leads to the destruction of green land, encroaching on the natural habitat and ecological corridors.

There are two main solutions applying to the role of the government.

First, the shifting of the main priority of the government from urban development for economic growth to urban development that is environmentally sustainable with long-term processes for environmental regeneration. Although there are difficulties in coping with the full complexity of the biodiversity of ecosystems within the landscape strategy or residential neighbourhood under current regulations and standard tools, clarified and well defined conservation targets can assist in avoiding or reducing the impact of urban extensions on the loss of biodiversity (Catalano et al., 2021). Such a shift in priorities by the government and its collaboration with ecologists to project conservation targets that are clear and well definedwill help political actors in setting a comprehensive ecological impact assessment system for future projects.

Second, current policies result in excessive delays when addressing environmental challenges, which can result in irreversible changes and possible collapse. Slowing down the rate of change (and limiting growth) can shorten the delay and allow systems to respond more quickly to such challenges, avoiding or minimizing ecological risk. Another benefit of slowing down growth is that it increases time for possible environmental regeneration of ecosystems. This can create a regulating circuit, allowing the renewable quantities to compensate for depletion of the environmental stock.

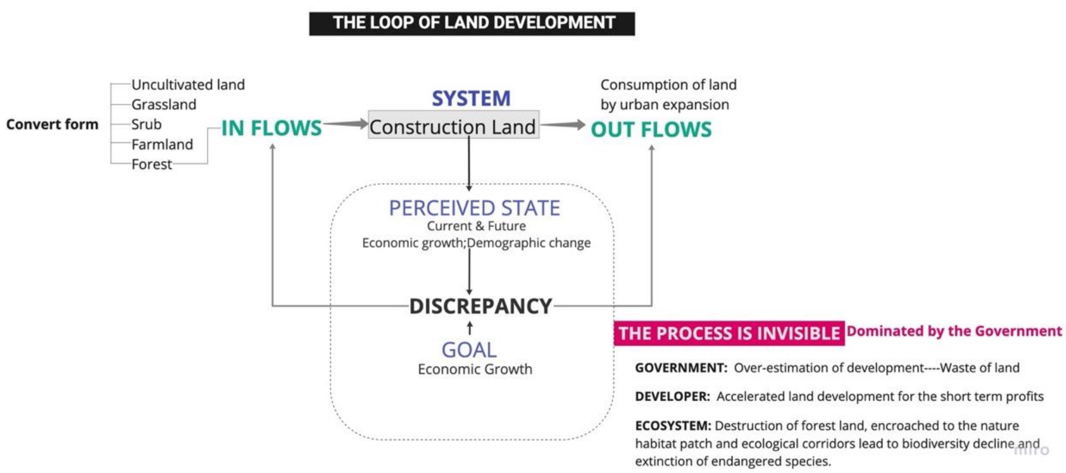


Figure 8: Minimapping: The loop of land devlopment (Xiao Hu, 2021)

6.2. The Ecosystem

Our health, well-being, and ultimately, survival depends on working with, not against, nature (Boehnert, 2015). The concern for ecological quality should be right at the forefront of landscape design. This requires an entirely different understanding of the way in which human activity is connected to the natural environment (Herdering & Kearins, 2014).

At the residential neighbourhood scale, environmental degradation in Yue Lai Eco-city planning can be predicted, as it completely overlooks the importance of the local ecosystems. The rapid biodiversity decline caused by the introduction of artificial landscape environments is beyond the scope of most design, especially in real-estate projects. Gated communities are dominated by the human-centred designs which result in the destruction of natural metabolisms and high maintenance costs. This has an enormous impact on biodiversity and ecological corridors at the city scale.

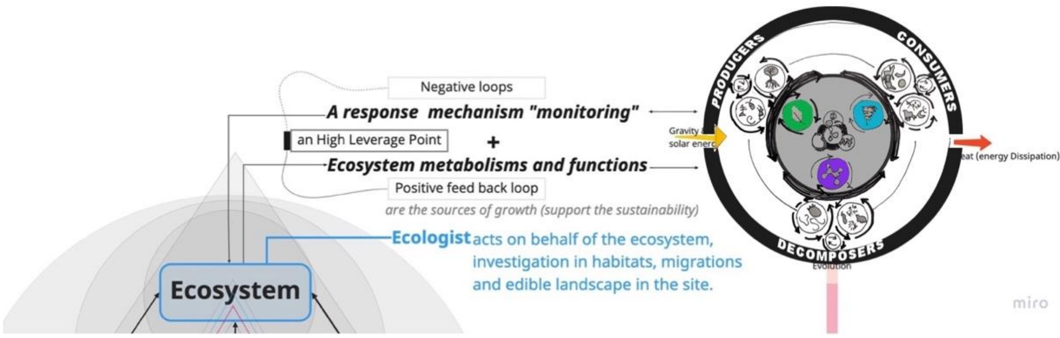


Figure 9: Minimapping: Positive feedback loop and Negative loops in Ecosystem (Xiao Hu, 2021)

An ecosystem is a closed loop with its own engine that maintains environmental sustainability (Snow, 2020). The non-human-centred design has the responsibility to minimize the impact of human activity on the environment, rather than living in a way that is detrimental to the interests of other actors (Davidova & Zavoleas, 2020). The participation of ecologists can add two leverage points to the system, a 'positive feedback loop' and a 'negative loop' (Meadows, 1999) as illustrated in Figure 9. This contradiction is particularly acute in mountainous terrain, where natural factors play an even more central roles than that of flat sites.

Firstly, through recombination of three functional groups/metabolisms “producers (Plants), consumers (Animals), decomposers (Bacteria and Fungi)” [27], we can generate 'positive feedback loops'. Secondly, to form “a negative loop” (Meadows, 1999) to help to build another leverage point into the system (Figure 9), by remaining open-ended through time-based agile design. Focusing on the development life cycle of both the implementation and in-use phases co-determine how successfully the target is met in future.

Under this approach, the results that nature presents can be rethought. Landscape design can incorporate the needs of the entire biosphere rather than catering exclusively to the human perception of visual beauty (Davidova & Zavoleas, 2020). The aim is to apply a platform for ecologists at the start of a project to determine the best land for human activities (urbanization and hard infrastructure) to minimize or eliminate their influence on vulnerable and rare ecosystems. It is also important to foster biodiversity functionalities and develop strategies that restore and regenerate habitat through the creation of biodiversity corridors. Therefore, eco-retrofitting entails the integration of incremental strategic improvements throughout the entire urban scale (buildings, cities, and infrastructure) to alleviate urban problems while also enhancing natural and social capital (Catalano et al., 2021).

6.3. Users

The urban dwellers/users are at the core of sustainable development: their thinking, values, and behaviour have a powerful impact on their environment and urban context (Gibbons, 2020). Thus, there is value in mobilizing them and integrating their various demands into the planning and design process of urban extensions onto hillside sites. Currently, people are paying more attention to land ownership and accessibility than to habitat fragmentation. The substantive input by various users (stakeholders) through the process of participation hopefully will help increase their sense of ownership and thus, strengthen the resonance of urban sustainability in their priorities. In this way, the platform works as a communication tool which generates shared information and meaning amongst various urban dwellers. In turn, the resulting acquired knowledge can imprint onto the participants' behaviour. Citizens thus shift from being environmental vandals to being advocates, and eventually environmental watchdogs. Meanwhile, by exchanging their views and goals in the initial planning and design stages of housing urban extensions, citizens can also impact on the demand of housing development at the time of purchase, changing from an emphasis on artificial landscaped gardens to value landscapes that support the biodiversity of local ecosystems. This in turn forces developers to seriously consider the ecological impact of their housing development as a desirable attribute for futures residents.

6.4. Developers

Developers have a powerful dynamic position in the systemic configuration of sustainable urban housing extensions. Profit and risk are the underlying forces of real estate companies. It is important to shift perspective from short-term profit to the long-term benefit from improving the quality of all aspects of their housing projects. There are two elements that could impact on the strategic planning of housing development companies.

First, the powerful influence of government in determining the type of housing development strategies. From the "Macro-level" perspective, when the government slows down growth, there is less land in action. This may increase bidding competition for the right to develop the land that is available. This facilitates the selection of more competitive contractors, including winning schemes that support sustainable development through cooperation with appropriate agencies. Based on the winning schemes with an common goal, real estate stakeholders would focus on estimate the market change land development intensity, a change from the current situation, where supply, driven by extensive construction, exceeds demand. In next step, to further improve the sustainability in practice, the government need to provide strong incentives and reduce financial risks in developing more efficient and environmental-quality-assured urban housing projects. The reason for this is that, specific to each project, the implementation of sustainable urban housing projects from new standards/regulations can incur additional development expenses. Additionally, the introduction of officially recognized certification, for project completion in compliance with the scheme's sustainability criteria, could improve the marketability of housing schemes.

Second, it is necessary to emphasize the participation of developers into the need for interdisciplinary cooperation during the design process. The objectives of sustainable development are multi-fold, and they are often incompatible with one another. The spread of the focus between architecture and landscape planning with their conflicting goals has not been fully explored. From the perspective of architectural design, sustainability focuses mostly on green building; energy efficiency, which relies on technological improvements, which in landscaping largely considers landform, hydrologic, and ecological aspects. Such a problem is more delicate in the fragile mountain environment, especially in the context of the desire to integrate human development into the natural hilly terrain.

In summary, in a central planning system, the absence of coordination among developers, ecologists and engineers, is a serious impediment on the production of environmentally sensitive architectural and urban designs, largely as a result of inadequate data availability and information gap in holistic systems, which will eventually lead to greater financial losses in the future. A bottom-up approach provides a useful platform for ecosystems, users, governmental organisations, and developers, providing an opportunity for multidisciplinary collaboration between all stakeholders. This advocates for inclusion of potential stakeholders to bring power and possibility into the same conversation. This forms a resilience system towards a desirable future that delivers numerous benefits to hillside urban housing extensions both for human and for nonhuman actors.

7. Summary

This paper has argued that the adverse impact on sustainability found in China can largely be attributed to high development velocity driven by large-scale urban extensions into hillside sites and calls for an equilibrium-driven approach, in which all potential stakeholders collaborate to support specific factors for environmental sustainability of hillside developments and the protection of their existing ecosystems.

Taking as a case study the 'experimental project of Yue Lai eco-city 'in Chongqing, the paper has demonstrated how the combination of “top down” and “bottom up” approaches within a systemic approach that brings together four main human and non-human actors (government, developers, users, and ecosystem) can help identify current weaknesses in current approaches and address them.

By examining the impact of rapid urbanization and extensive urban extensions on hillsides in the last 30 years in Chongqing, the paper illustrates the impact of flattening hillsides on the natural environment of mountainous terrain. The lack of specific standards for ecological protection of hillside sites and the lack of coordination between the monitoring systems of the various ministries are highlighted as a contributor factor. The paper argues that there are two main potential paths for action by which central-planning-focused stakeholders could contribute to the protection and regeneration of ecosystems. The first path is slowing down urban growth by changing levels of priorities in housing development goals from economic gain to environmental protection. The second path is accepting the paradigm shift from “top-down” to “bottom up” approaches to the development of hillside sites.

Minimap and Gigamap are used to illustrate the complex systems of sustainable development and the interrelationship of the sustainability factors in hillside landscape design and planning. The four main stakeholders represent human and nonhuman actors whose participation into the planning and design phases. This systemic analysis provides a clear overview of the complexities of current practices and their implications on ecosystems, highlighting the necessity to avoid overdesigning human-centred landscapes as standard models instead of regenerative open-ended solutions that are self-sustaining overtime.

This paper has evaluated the limitations and remediation strategies that can be adopted within a systemic approach the whole process of the land construction loop guide to ensure future sustainable landscape designs in hillside sites, which encourages policy makers, government, property developers, designers, and urban planners to reflect in current practices and apply more holistic approaches that promote the recovery of natural resources (Figure 10).

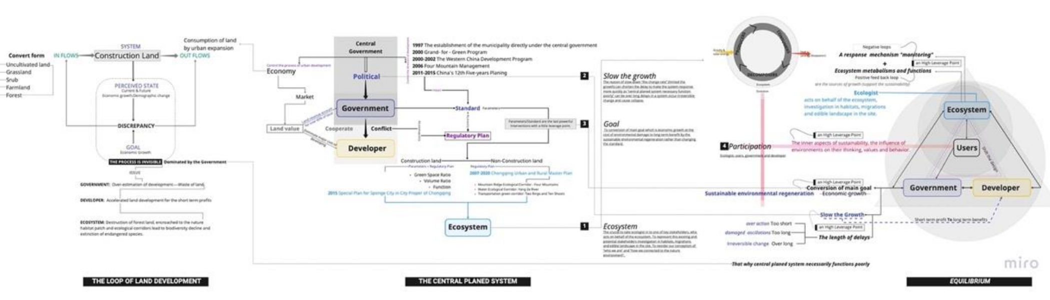


Figure 10: Gigamapping: Combination top-down and bottom-up approaches in landscape design (Xiao Hu, 2021)

Several ecological questions however remain unanswered. The importance of ecological corridors in maintaining the richness of native species trough landscape design from the conservation point view needs to be tested in future projects. However, determining a patch area threshold is only achievable if the conservation aim is well defined and specified (Beninde et al., 2015). In addition, there is a need to obtain more information on the impact of urban mountain climate on biodiversity, including the effects of prevailing winds, and the amount of sunshine in relation to slopes. In order to maintain populations of individual species, it is important to investigate the extent to which the loss of vegetation cover impacts on the decline of species? How does the transformation of the mountain climate impact on existing ecosystems? What are the native species that are mostly endangered by the combining effects of habitat fragmentation and loss?

8. Conclusion

China is one of the world's largest economies, experiencing rapid urbanization over the last 30 years. According to UN estimates, more than half of the world's population currently lives in cities, and global urbanization projections indicate that the urban population will reach 70% by 2050 (UN, 2015). The fragile landscape of mountainous area accounts for 2/3 of total land area of China, where habitat loss and fragmentation exacerbate the decrease of biodiversity and the extinction of some flora and fauna species. Thus, hillside urban expansions have to be urgently considered with extreme caution and informed by the experiences of Europe and North America with tackling the challenges of optimizing biodiversity levels in urban planning practices. Preserved or increased biodiversity through the protection of natural environments creates a more sustainable environment for urban biodiversity and ecosystem that offer habitat and nutrients for a variety of species. In turn, humans benefit from biodiversity in a variety of ways with providing nature-citizen interaction in hillside cities. Natural landscapes are also beneficial to urban dwellers' mental health, securing microclimates, purifying the air and combating climate change (Beninde et al., 2015; Davidová, 2020).

The systemic approach allows us to reflect upon and challenge existing paradigms and provide greater leverage for projects on future oriented vision, thus stimulating a new approach to landscape planning and designing. This calls for the transition of focus from aesthetic of an artificial nature to an interaction with ecosystems' life cycles to build sustainable communities. Thus, the findings of this paper highlight the importance of a healthy ecosystem to support biodiversity sustainability in hillside landscape design.

Landscape conservation is often maintained at great expense. Given the conflicting demands of landscape conversation and social economic development, balancing these contradicting priorities is a complex decision for both policy makers and developers. Furthermore, future urban neighbourhoods of hillside sites call for offering new forms of buildings that are fully integrated into the natural topography of the site while enhanced access to green areas should be enhanced through careful landscaping that promotes a healthy habitat for the local flora and fauna. There is a strong need to move away from flattening sloping sites for high rise buildings and integrate new forms of residential neighbourhoods that take full advantage of slopes while protecting the natural environment.

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References

1. Abbott, D., & Pollit, K. (1981). Hill housing: a guide to design and construction: Whitney Library of Design.
2. Associates, C. (2012). Selected Projects: Yue Lai Eco-city Chingqing, China. Retrieved from https://www.efchina.org/Reports-en/report-lccp-20121205-en
3. Bank, W. (2019a). Chongqing 2035: Spatial Transformation Strategy. In: World Bank.
4. Bank, W. (2019b). Chongqing 2035: Urban Growth Scenarios. In: World Bank.
5. Beatley, T. (2012). Green urbanism: Learning from European cities: Island press.
6. Beninde, J., Veith, M., & Hochkirch, A. (2015). Biodiversity in cities needs space: a meta-analysis of factors determining intra-urban biodiversity variation. Ecology letters, 18(6), 581-592.

7. Boehnert, J. (2015). Ecological literacy in design education-A theoretical introduction. FormAkademisk-forskningstidsskrift for design og designdidaktikk, 8(1).
8. Cai, Z., & Tang, Y. (2021). Toward a sustainable city: a scoping review of eco-cities development and practices in China. Chinese Urban Planning and Construction, 179-199.
9. Catalano, C., Meslec, M., Boileau, J., Guarino, R., Aurich, I., Baumann, N., . . . Laube, P. (2021). Smart sustainable cities of the new millennium: towards design for nature. Circular Economy and Sustainability, 1-34.
10. Chance, T. (2009). Towards sustainable residential communities; the Beddington Zero Energy Development (BedZED) and beyond. Environment and urbanization, 21(2), 527-544.
11. Chen, S., Tang, S., Zhang, Y., Chen, B., Mathew, P., Shao, Y., . . . Yuan, X. (2010). Biodiversity Strategy and Action Plan Chongqing, China. Chongqing Municipal Government.
12. Davidová, M. (2020). Synergy in the systemic approach to architectural performance: The integral multi-and cross-layered agencies in eco-systemic generative design processes of the post-anthropocene. FormAkademisk-forskningstidsskrift for design og designdidaktikk, 13(2).
13. Davidova, M., & Zavoleas, Y. (2020). Post-anthropocene: the design after the human centered design age.
14. Davidová, M., & Zímová, K. (2021). COLreg: The Tokenised Cross-Species Multicentred Regenerative Region Co-Creation. Sustainability, 13(12), 6638.
15. Dorward, S. (1990). Design for mountain communities: a landscape and architectural guide: Van Nostrand Reinhold Company.
16. Ehrenfeld, J. (2019). Flourishing: Designing a Brave New World. She Ji: The Journal of Design, Economics, and Innovation, 5(2), 105-116.
17. Friedman, A. (2007). Sustainable residential development: Planning and design for green neighborhoods: McGraw-Hill New York.
18. Gibbons, L. V. (2020). Regenerative—The new sustainable? Sustainability, 12(13), 5483.
19. Goldman, S. J., & Jackson, K. (1986). Erosion and sediment control handbook.
20. Hao, Z., Bao-gang, Y., & Bing-yan, C. (2008). Analysis of characteristics of climate change over last 46 years in Chongqing. Chinese Journal of Agrometeorology, 29(01), 23.
21. Herdering, K., & Kearins, K. (2014). Flourishing: A Frank Conversation about Sustainability. In: Taylor & Francis.
22. Huang, G. (2021). Theory of mountainurbanology: Springer Nature.
23. Hundt Jr, G., Daniels, T. L., & Keene, J. C. (2016). THE PLAN FOR THE VALLEYS: ASSESSING IAN McHARG'S VISION 50 YEARS LATER.
24. JINGNAN, H. (2008). Analysing and Modeling Urban Development and Its Impact in the Mountain Area; A case study of Chongqing city, China.
25. Lehmann, S. (2021). Growing Biodiverse Urban Futures: Renaturalization and Rewilding as Strategies to Strengthen Urban Resilience. Sustainability, 13(5), 2932.
26. Liu, Y., Fan, P., Yue, W., & Song, Y. (2018). Impacts of land finance on urban sprawl in China: The case of Chongqing. Land Use Policy, 72, 420-432.
27. Long, H., Wu, X., Wang, W., & Dong, G. (2008). Analysis of urban-rural land-use change during 1995-2006 and its policy dimensional driving forces in Chongqing, China. Sensors, 8(2), 681-699.
28. Lovins, L. H., Wallis, S., Wijkman, A., & Fullerton, J. (2018). A finer future: Creating an economy in service to life: New Society Publishers.
29. McHarg, I. L., & History, A. M. O. N. (1969). Design with nature: American Museum of Natural History New York.
30. Meadows, D. H. (1999). Leverage points: Places to intervene in a system.
31. Moser, W. A. (1991). Design for successful hillside development. Journal of urban planning and development, 117(3), 85-94.
32. Nolt, J. (2014). Flourishing: A Frank Conversation about Sustainability. In: JSTOR.
33. Ozbekhan, H. (1969). Toward a general theory of planning: Management and Behavioral Science Center, University of Pennsylvania.
34. Radford, J. Q., Bennett, A. F., & Cheers, G. J. (2005). Landscape-level thresholds of habitat cover for woodland-dependent birds. Biological conservation, 124(3), 317-337.
35. Review, W. P. (2020). Chongqing Population 2020. Retrieved from https://worldpopulationreview.com/world-cities/chongqing-population

36. Sevaldson, B. (2018). Visualizing complex design: The evolution of gigamaps. In Systemic Design (pp. 243-269): Springer.
37. Snow, T. (2020). Integrative Systems of Production. FormAkademisk - forskningstidsskrift for design og designdidaktikk, 13(4), 5. doi:10.7577/formakademisk.3791
38. Sun, W., Liu, J., & Wang, D. (2016). Report on China's Eco-City Development. In China's eco-city construction (pp. 49-103): Springer.
39. UN. (1992). Report ofthe United Nations Conference on Environment and Developm. Retrieved from New York: https://www.un.org/esa/dsd/agenda21/Agenda%2021.pdf
40. UN. (2015). Transforming our world: the 2030 Agenda for Sustainable Development,. Retrieved from https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf,
41. Verburg, P., Veldkamp, A., & Fresco, L. (1999). Simulation of changes in the spatial pattern of land use in China. Applied Geography, 19(3), 211-233.
42. Wahl, D. (2016). Designing regenerative cultures: Triarchy Press.
43. Wang, H., Huang, Y., Wang, D., & Chen, H. (2020). Effects of urban built-up patches on native plants in subtropical landscapes with ecological thresholds–A case study of Chongqing city. Ecological Indicators, 108, 105751.
44. Yang, C., Zeng, W., & Yang, X. (2020). Coupling coordination evaluation and sustainable development pattern of geo-ecological environment and urbanization in Chongqing municipality, China. Sustainable Cities and Society, 61, 102271.
45. Yu, L. (2014). Low carbon eco-city: New approach for Chinese urbanisation. Habitat International, 44, 102-110.
46. Zhang, S., Kuang, X., Chen, Y., Deng, X., & Chen, J. (2016). Low-Carbon Healthy City Planning and Design. In China Low-Carbon Healthy City, Technology Assessment and Practice (pp. 91-154): Springer.
47. Zhao, Y., Tomita, M., Hara, K., Fujihara, M., Yang, Y., & Da, L. (2014). Effects of topography on status and changes in land-cover patterns, Chongqing City, China. Landscape and ecological engineering, 10(1), 125-135.