

Jianfeng Zhang

Study of Ecological Engineering of Human Settlements

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Foreword

In the past 40 years since the implementation of reform and opening up, China's social economy has undergone tremendous changes, and the people's living standards have greatly improved. At the same time, environmental issues have become increasingly prominent. Especially with the acceleration of the urbanization process, the problem of human settlements has attracted more attention. In particular, in recent years, driven by economic development, some enterprises only look at the present benefits, regardless of the long-term social interests; sewage management is not up to standard, resulting in pollution of water sources in some regions. Some rural livestock and poultry breeding industries have developed rapidly, with a large amount, more free-range breeding, and the random discharge of manure. In addition, the increase in the application of pesticides and chemical fertilizers has led to a shortage of drinking water for rural residents and a drop in water quality. In some places, farmers are less aware of environmental protection, discarding garbage at will, and the living environment is deteriorating, seriously affecting the health of the people. To solve the problem of human settlements, we must firmly implement the new development concept, implement the rural revitalization strategy, adhere to the priority development of agriculture and rural areas, adhere to lucid waters and lush mountains are invaluable assets, focus on urban and rural integrated development, coordinate the relationship of production, living, and ecology, and build beautiful China.

The residential environment is a space for human work, life, rest and recreation, and social communication. It is significant to integrate human beings as a whole and study them systematically and comprehensively from political, social, cultural, and technological aspects. Thus, it is necessary to understand and master the objective laws of the occurrence and development of human settlements, so as to better build a healthy living environment that conforms to the ideals of mankind.

Obviously, forestry plays a pivotal role in this regard. Prof. Jianfeng Zhang from Institute of Subtropical Forestry of the Chinese Academy of Forestry has long been concerned about the topic of human settlements. He has done a lot of effective researches in applying ecological theory, adopting ecological engineering methods to explore and solve the soil environment, water environment and atmospheric

environment problems related to human settlements. Based on the works he writes the book *Study of Ecological Engineering of Human Settlements* and it will be soon published by Springer Nature. Congratulations! In the book he focuses on the interaction of forest, vegetation and environment, from the aspects of problem occurrence, influencing factors, treatment approaches and solutions, and mainly introduces relative countermeasures of soil degradation, water source protection, non-point source pollution control, noise pollution and air purification. The vital problems in the human settlements and the ecological restoration-based treatment measures also are discussed. At the same time, the relationship between rural ecological landscape construction and biodiversity conservation is approached, and combined with examples, biodiversity conservation measures are proposed.

At present in implementing the rural revitalization strategy, it is necessary to fully tap the rural natural landscape, mountain water resources and rural local characteristics culture, and develop distinctive leisure agriculture and rural tourism; reasonably plan the layout of afforestation, strengthen the ecological transition zone greening in the suburbs, expand the green space and improve the greening level; promote village greening, make full use of idle land to carry out afforestation and wetland restoration, and build green ecological villages. I believe that the publication of this work will not only help to improve the residential environment but also help to better play the role of forestry in rural revitalization, so that more people will recognize the ecological functions of forests and wetlands, and thus pay much more attention to forests. Let us care for the forests and wetlands and work together to write a beautiful picture of blue sky, clear water and green earth.



June 2019

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Preface

Human settlements are a global issue. In October 1977, the 32nd UN General Assembly adopted Resolution 162 and decided to establish UN Commission on Human Settlements. Its members are elected by the UN Economic and Social Council, which have 58 member states including 16 in Africa, 13 in Asia, 6 in Eastern Europe, 10 in Latin America and the Caribbean, and 13 in Western Europe and other countries. Members are appointed for a term of four years. The committee meets every two years, the Council meeting, and is headquartered in Nairobi, Kenya. UN-HABITAT was formally established on January 1, 2002. It is the UN agency responsible for human settlements. Its purpose is to promote sustainable social and environmental development in order to achieve the goal of a suitable home for all. The reason why the Habitat issue is so concerned is because the global population is growing. According to estimates by the German World Population Foundation (DSW), the global population reached 7.5 billion in 2018, and DSW believes that Africa's population will increase rapidly in the coming decades. In 2050, the global population will raise by 2.53 billion.

Urbanization is the only way for human development. As the population continues to expand, the process of urbanization has greatly accelerated. In 1950, the level of urbanization in the world was 29.2%. In 1980, it rose to 39.6%, an increase of 10.4% points. In 2010, it reached 51.8%, that is, the number of people living in cities in the world exceeds the population living in the countryside. In 2015, China's urbanization rate reached 56.1%. At the same time, since the 1970s, the urban population of developing countries has begun to exceed that of developed countries, and by 2020 the ratio will be 3.5:1. This shows that the urbanization of developing countries has become the main body of urbanization in today's world. Obviously, the higher the level of urbanization, the greater is the environmental pressure, and the much more environmental problems. Both developed and developing countries face some of the same problems in the human settlements: crowded, inadequate provision of basic services, lack of adequate housing, deteriorating infrastructure, and so on; 40–50% of the world's urban dwellers live in slums; more than one billion people in the entire human settlement (towns and villages) lack housing or living conditions. In developing countries, at least 600

million urban dwellers live in poor quality housing, and drinking water, sanitation, drainage and garbage collection are all imperfect, resulting in continued threats to their lives and health. On the other hand, unrationed human activities and natural disasters cause air pollution, water pollution, poor sanitation and disasters.

Over the past four decades, along with the rapid economic development, China has been in the process of rapid urbanization, and its speed and scale of urban development have attracted worldwide attention. At the same time of obtaining great achievements, the urbanization process has inevitably brought about various social and economic development problems and challenges, typically “urban diseases” such as traffic congestion, environmental pollution, and housing shortages. Some rural villagers have poor environmental and health awareness. Indiscriminate use of pesticides and fertilizers and random disposal of domestic and industrial wastes are common, rural biodiversity is destroyed, and soil, lakes and groundwater are polluted, the rural ecological environment is deteriorating, and it is easy to induce various diseases.

The living environment is a space for human work, living, rest and recreation. It is necessary to integrate human beings as a whole, and to study systematically and comprehensively from political, social, cultural, and technological aspects, to understand and master the objective laws of the occurrence and development of human settlements, so as to better conform to the ideal living environment for human beings. Judging from the concept of human settlements, the issue of human settlements involves wide aspects. To solve the problem of human settlements, we must work together on all sides and at different levels to help solve problems and build beautiful, healthy, sustainable, and livable environment. Based on this, I have been paying attention to the living environment from the perspective of an ecologist, trying to solve the problem of human settlements by using ecological theory and ecological engineering methods. In 2014, I presided over the book writing of “Ecology of Human Settlements (Chinese)”, published by China Forestry Press; currently, this “Study of Ecological Engineering of Human Settlements” is about to be published; it is also planned to write “Ecological Culture of Human Settlements” in the near future. I hope these three works as troika can constitute my viewpoints on Ecology of Human Settlements; the goal is to observe the living environment from an ecological perspective and to solve the related living environment problems with ecological engineering technology. So that do a little bit contribution to realize the millennium dream of “each resident has a house” and realize UN 2030 sustainable development goals.

Especially when preparing the manuscript, Academician of Chinese Academy of Engineering, former President of Nanjing Forestry University, Prof. Dr. Fuliang Cao writes the forewords, which gives me a huge inspiring to complete the book. During the process of the relative research and the book writing, I get much more helps from the teammates, that is, Prof. Dr. Guangcai Chen, Dr. Qihua Shan, M.Sc. Ying Wang, M.Sc. Zebo Li, M.Sc. Qingbing Wang, M.Sc. Hao Wu, M.Sc. Hui Sun, M.Sc. Li Wang, M.Sc. Yongqing Li, Dr. Rongjia Wang, Dr. Shiyong Sun, Dr. Zeyu Cai, Dr. Yini Cao, Dr. Xiaogang Li, Dr. Handan Zhang, Dr. Huasen Xu. Colleagues from Institute of Subtropical Forestry of Chinese Academy of Forestry

Prof. Dr. Yangdong Wang, Dr. Xuezhi Fang, Dr. Tonggui Wu, Dr. Bin Wang, and Dr. Jiuxi Shi, in addition colleagues from Shandong Academy of Forestry Prof. Shangjun Xing, Dr. Zhenyu Du, M.Sc. Guanghua Qin, Dr. Zongtai Li, and Prof. Yumin Song, and so on provide a lot of efforts to the topic. I would like to express my heartfelt gratitude for their warm aid. Also thanks to my family, my wife Junqing Cao and my son Kai Zhang; their encouragements and expects excite me to go forward.

The book must have many problems and mistakes as it has been rushed drafted. I hope that readers will point out the faults so as to revise it later.

Hangzhou, China
July 2019

Jianfeng Zhang

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About the Author

Dr. Jianfeng Zhang is now Professor at Institute of Subtropical Forestry of Chinese Academy of Forestry, where he was chair of the research group of human settlement environmental engineering for years. His research activities are mainly devoted to ecology of human settlement, silviculture, and degraded land ecological amelioration, especially saline soil ecological rehabilitation and non-point source pollution control in water source areas. He did Post-doctoral research at the Institute of Forestry, Chinese Academy of Forestry in Beijing during 2003–2007; studied for Ph.D. at Forest Recourses and Environment College of Beijing Forestry University during 1999–2003. He studied at the International Institute for Forestry, Technical University of Dresden, and won M.Sc. of Forestry Management during 1995–1997. Three books have been published in Springer Nature as well as 120 papers published by journals.

Chapter 1

Environmental Problems of Human Settlements and Countermeasures Based on Ecological Engineering



Abstract China's urbanization rate has exceeded 50% by 2018. This rate is far lower than the average of nearly 80% in developed countries. From the perspective of modernization and development, China's urbanization rate is expected to continue increasing in the next decade or two. A considerable rural surplus labor and population migrates to cities annually and generates a substantial increase in investment and a rapid increase in consumption. Urban development provides multiple levels of human resources. However, the urbanization process is not a simple increase in the proportion of the population and expansion of the urban area. What is more important is the realization of an important shift from "township" to "city" in aspects such as industrial structure, employment mode, human settlement environment, and social security. Promoting urbanization and improving the living environment will be one of the important tasks for China in the future to build a prosperous society and achieve two "100-year goals." This task is also consistent with the goals of "Everyone has adequate housing" and "Improving the quality of life of people around the world" proposed by the Habitat Agenda of the United Nations at the Second Habitat Conference. With the acceleration of industrialization and urbanization in China, environmental pollution has occurred at different degrees in urban and rural areas. Environmental problems, such as smog and dust storms in North China, acid rain in the southwest, and water pollution in coastal areas, have had a serious impact on human settlements. One of the ways to deal with these environmental problems is to implement ecological engineering in human settlements. Environmental protection must be considered when building cities and villages. Countries must pay attention to the greening and enhancement of cities and villages, and provide people with leisure spaces, healthy environments, and beautiful communities.

Keywords Human settlements · Environmental problem · Ecological engineering · Beautiful communities · Industrialization · Urbanization

With the rapid development of China's social economy and the continuous improvement of living standards, people's requirements for a living environment have involved not only the pursuit of a certain space as a habitat. Improving human physiology, behavior, psychology, society, and many other aspects require a high-quality living environment. While enjoying the achievements of contemporary civilization, people have neglected the importance of the natural environment consisting of sunshine, air, wind, and water. Their lifestyle relies excessively on modern technology, such as air conditioning in summer and heating in winter. The intimate relationship between humans and nature is harmonious. Thus, returning to the affinity with nature has become a health necessity. From the perspective of maintaining human health, many problems persist in residential construction: improper site selection, peripheral noise interference, improper layout resulting in damage to the natural environment, loss of affinity between people and nature, unreasonable design that reduces living comfort, windows and doors that are opposite to each other and cause visual pollution, functional space areas that cannot meet the minimum standards, and a mismatch of the community's service facilities, health care facilities, sports facilities, and elderly and disabled service facilities. More importantly, some materials for residential buildings and decorations are improperly selected, and the equipment is inferior, causing air, sound, light, heat, water quality, soil, and other types of pollution to pose a direct harm to human health. These problems are exactly related to the vital interests of the residents. Therefore, in today's well-established society, providing a healthy and vibrant living environment for people is a concentrated expression of the implementation of scientific developments (Wang 2004).

A healthy living environment should reflect the harmony between humans and the natural environment, and a complete and balanced social environment. A healthy living environment must start from the occupants and meet the mental and physical health requirements of the residents, so that the occupants live in healthy, safe, comfortable, and environmentally friendly indoor and outdoor living spaces (Luo 2004). In this process, human settlement ecological engineering has emerged and plays an active role in studying the internal change mechanism and laws of human settlements under natural/human disturbances; solving environmental problems through ecological measures; and ensuring the safety, health, and sustainable development of human settlements. That is, applying ecological theory clarifies the interaction between people and the living environment and explores ecological approaches to solve the problem of human settlements. The central goal of this study is to find ways to comprehensively improve the quality of human settlements, protect the natural environment, maintain people's physical and mental health, and achieve the goal of "livable, healthy, environmentally friendly, beautiful, and sustainable" communities that enhance humanity, society, and the environment.

1 Evolution of Human Settlements

1.1 *The Concept of Human Settlements*

The broad environment defined in ecology refers to the sum of biological and abiotic factors around the individual. The environment is relative to the target subject. When the subject varies, the size and content of the environment also differ. “Habitat” refers to the place where organized, human collective activities take place. The living environment (human settlements) denotes not only the size of a single house, town, or city, but also the place where human beings live and gather, that is, the space where work, life, culture, education, health, entertainment, and social activities are located. Such environment is the scope of human daily production and life (Wu 1996).

A generalized living environment consists of three parts: social, economic, and physical. The narrow human settlement refers to the comprehensive environment of people living in the community (Zhou and Zhu 2002). From the time point of view, the connotation of human settlements is constantly changing with the development of human society. The harmony and unity between people and the environment are embodied in this process. With the continuous development of human production and life, different organizational forms and the settlement of cultural characteristics has gradually formed and replaced, and the connotation of the living environment has been continuously modified and expanded. From the spatial point of view, human settlements can be divided into different levels. Doxiadis (1970), the founders of ekistics, which is the science of human settlements, divide the community into six levels according to the population size and land area.

Overall, the human settlement environment consists of two systems: natural and human. The formation of it is a cross-integration of the human environment with human activities. Within a certain scope, the human environment affects the natural environment and is also restricted by the natural environment. The two are constantly carrying out material circulation, energy flow, and information exchange.

The natural environment in the human settlement mainly includes the climatic, geographical, biological, and various physical settings (such as water, soil, atmospheric, and photothermic environment). The human environment includes substances and non-materials formed by human labor. The substances in the human system mainly include gardens, green spaces, architecture, various facilities, utensils, cultural relics, and historic sites. Non-material achievements primarily include culture and art, economic structures, rules and regulations, laws, customs, lifestyles, social relations, language, and text (Zhang 2014).

The human settlement environment is the result of people adapting to nature and transforming it. The natural environment is always the dominant factor which determines the structural characteristics of the human settlement environment and also affects the non-material achievements such as human values and life behaviors in the human environment (see Figs. 1, 2, 3, and 4).



Fig. 1 Old house in Fuyang, Zhejiang (photograph taken by Jianfeng Zhang)



Fig. 2 Ancient stage in Fuyang, Zhejiang (photograph taken by Jianfeng Zhang)



Fig. 3 Former home of Zedong Mao in Xiangtan, Hunan (photograph taken by Jianfeng Zhang)



Fig. 4 Former home of Fu Du in Chengdu, Sichuan (photograph taken by Jianfeng Zhang)

The human settlement environment can be divided into rural and urban according to the type of living space, and rural areas can be divided into towns and countryside (Wu 1997). The rural habitat environment is a combination of materials and non-materials required for human agricultural production and life in rural areas, and is a dynamic and complex system. The expansion of the population and upgrading of production methods have led to the evolution of rural settlements to urban habitats. The urban human settlement environment is a form of time and space in which human beings interact with their living environment. In a certain geographical background, activities such as residence, work, culture, education, health, and entertainment are conducted, so that an environment is created in the process of urban three-dimensional advancement.

The living environment encompasses the unification of the natural and human environments. The formation of human settlements is the result of human activities acting on the natural environment, the natural environment after human transformation, and the unification of the natural and human environments. Humans emphasize the preference for the natural environment in the choice of living space by focusing on the need to understand, respect, and adapt to nature. After settlement, human beings always influence and transform nature according to their understanding and preferences. Thus, the living environment is an organic whole formed by the combination of natural geographical conditions and human activities.

The living environment contains a combination of ecological and artistic beauty. Human beings gradually transform these into a living environment according to their own will. The ideal living environment is livable, comfortable, safe, healthy, and beautiful. The essence of livability, comfort, and safety in the human settlement is ecological beauty, which emphasizes the rationality and functional diversity of the structure of this environment. The beauty of human settlements, which is embodied in visual, olfactory, and tactile aspects, refers to the subjective feelings of people toward the environment. Any living environment is a fusion of ecological and artistic beauty, and is a combination of science and art. The essence of ecological beauty is balance, which refers to the unity of the structure and function of the human settlement ecosystem. The external manifestations are harmonious beauty, which is the characteristic of making people feel that the space is livable, comfortable, healthy, safe, lasting, and stable, and artistic beauty, which refers to the result of human creativity. The appearance of the ecosystem refers to the characteristics of the human habitat system acting on human senses.

The living environment also involves the integration of historical culture and the spirit of the times. This environment must contain the heritage and local culture, and the varied material composition and spiritual needs of environmental art in different regions, nationalities, and historical periods. Regional natural conditions (climate, topography, and property) have led to the regional characteristics of human settlements. The national culture (social concepts and folk customs) formed by human settlements has led to the national characteristics of the human settlements. Furthermore, social development and productivity advancement have led to the characteristics of current human settlements.

1.2 Development of Human Settlements

The formation of human settlements is the result of constant changes in the way humans live in the development of social productive forces. The living environment is caused by the emergence of humans, evolves with the survival and development of humans, and is also restricted by natural factors. With the development of production and the progress of human civilization, the ability of human beings to transform the environment is continuously strengthened and the requirements of the living environment are constantly changing. Housing is the most fundamental condition for human survival and is also the most important component of human settlements. With the emergence and development of humans, their choice of settlements, residential forms and styles, and residential environments vary continuously (see Figs. 5, 6, 7 and 8).

Early human settlements experienced a process of passive and active selection. In the primitive period, humans lived by hunting and fishing, and they were often attacked by beasts and natural disasters. This wild mode is an extremely important period in the history of human habitation. The wild mode can be roughly divided into cave dwellings (from natural to artificial, from deep to semi-cave to shallow) and nesting (from trees). In the early stage of human settlements, humans' understanding of the natural environment was simple, attached to nature, and formed



Fig. 5 The earth building in Zhangzhou, Fujian (photograph taken by Jianfeng Zhang)



Fig. 6 The new house in North pole Village, Heilongjiang (photograph taken by Jianfeng Zhang)



Fig. 7 Old wooden house in Changning, Sichuan (photograph taken by Jianfeng Zhang)



Fig. 8 Modern wooden house in Changning, Sichuan (photograph taken by Jianfeng Zhang)

while productivity involved a simple ecological outlook. With the transformation from hunting to a farming civilization, humans chose their place of residence near water sources and settled down to plant and harvest, thereby gradually creating a form of settlement. For example, the four ancient civilizations recognized by the world are from the Yellow River, the Nile River, the Euphrates River, and the Indus River. The residential form of habitats has also changed from cave dwellings and nesting to the three basic types of cave dwellings, dry-column buildings, and timber-framed buildings. The traditional settlements reflect the values of holistic thinking and comprehensive functions in the location and layout. In the construction of human settlements, we follow the simple concept of “heaven and man” to maintain the natural environment and ecological balance. Examples in China include the single-sloping roof in the arid area of the northwest, the cave dwelling in the Loess Plateau, and the hanging foot of the Jiangnan water town.

With the development of productivity and the progress of social civilization, the degree of human concentration has continuously improved, the humanity of human settlements has been progressively enhanced, the requirements of people for the quality of their living environment have been constantly expanded, and the human settlement environment under different social civilizations has been greatly divided. The Chinese are reserved and introverted, and they desire a quiet and peaceful atmosphere. Therefore, China’s buildings mostly consist of closed courtyards, in which plants are introduced and natural landscapes are built. Houses and landscapes

are combined. After a long evolution, various styled Chinese gardens were gradually formed. Moreover, people of all ethnic groups in different regions of China have slowly created a distinctive style of human settlements, such as courtyard houses in the north, Huizhou architecture, Fujian Tulou (earth building), and Yunnan folk houses.

Judging from the development of human settlements, the changes in human settlements are affected by factors such as social productivity, population, science and technology, economic development, and social values. Such changes are also constrained by natural geographical conditions and climate change (see Figs. 9, 10, 11, and 12). The evolution of human settlements has the following four characteristics: (1) The degree of aggregation is highly increased and the housing density is increasing. The most direct manifestations are the process of group settlement, acceleration of urban construction and urbanization, and expansion of scope. (2) Diversification of the type and form of the house and a separate functional area in the house. (3) Various functions arise from the emphasis on practicality to the evolution of ecological and landscape art, and commercialization of production. In addition to residential buildings, modern residential areas include parks and green spaces, shopping places, schools, hospitals, and other facilities with diverse functions. (4) Human settlement construction pays greater attention to ecological and landscape art, building beautiful homes, creating a livable environment, saving



Fig. 9 House with small bridge flowing water in Wuzhen, Zhejiang (photograph taken by Jianfeng Zhang)



Fig. 10 Ruins of ancient city in Rome, Italy (photograph taken by Jianfeng Zhang)



Fig. 11 One corner of the street in Madrid, Spain (photograph taken by Jianfeng Zhang)