Landscape Design of Rural Rainwater Utilization Based on LID Concept

Yu Gui and Ruixuan Zhang
School of horticulture and landscape architecture, Tianjin Agricultural University, Tianjin China
*Corresponding author e-mail: 201806428@tjau.edu.cn

Abstract. This article takes farmland, roads, and rural residential areas as the starting point for effective rainwater planning and utilization. It is useful to purifies and reuses rural water sources, and promotes the improvement of rural ecosystems. Rural rainwater resources are lost and pollution is serious. The design of Low Impact Development rainwater use in rural landscape has become the focus of this article. This article mainly combines the rural terrain and environment, optimizes rainwater ecology, combines the use of storage gutters to form an ecological water cycle, builds rooftop gardens in rural residential areas, transforms landscape ecological vegetable gardens, and transforms permeable courtyards, and conducts landscape design. Through the ingenious combination of technology and art, landscape design such as rural rainwater collection, runoff mitigation, purification and infiltration, and agricultural applications is realized to meet the needs of household water and green irrigation, while improving the environmental quality of rural landscapes. By adopting the Low Impact Development rainwater landscape design, it highlights the sustainable development of rural landscape ecology.

Keywords: Low Impact Development, Rainwater Utilization, Rural Landscape, Permeable Garden

1. Project Overview
The concept of low impact development (LID) has existed since the end of the 20th century. Canada and the United States have defined LID as using land planning and engineering design methods to manage rainwater runoff, emphasizing on-site protection and the use of in-situ natural characteristics to protect water quality. It is used to control the heavy rain and use the excessive rainwater produced by the heavy rain, so that the water resources can achieve the purpose of recycling [1]. LID mainly uses measures such as roof greening and shallow vegetation to restore and improve the original ecosystem, controls runoff pollution, reduces pollution emissions, and achieves sustainable water cycling in the development area [2]. (As shown in Figure 1)
Figure 1. Low Impact Development

With the development of society and the emergence of a large number of factories, the natural environment is destroyed. The recycling and utilization of water resources in environmental protection have become the main issues for ecological protection in various regions. Reasonable use of rainwater is more and more valued by people, especially in rural areas, the amount of rainwater in the dry season is small, and the rainwater resources in the rural areas are lost and polluted. However, most cities in China are water shortage cities. The use of rainwater infiltration can supplement groundwater. Purified rainwater can not only reduce the pollution of surface runoff to urban water bodies, but also serve as a supplementary water source for urban landscape water bodies and miscellaneous domestic water, so as to achieve the purpose of saving fresh water sources.

1.1 Situation Analysis of Fan Xiangdian

With the development of technology and growth of economic, the living standards of rural residents have improved, but rural environmental governance is still a problem to be solved by environmental landscape design. The domestic waste and sewage of the residents have not been systematically solved, leading to the loss and pollution of natural resources such as rainwater, and a large amount of rainwater slowly flows into the rural quagmire or piles up in the mud pits with a lot of water, bringing inconvenience to the lives of the villagers.

1.1.1 Waste and Pollution of Water Resources

In Fan Xiangdian, the utilization rate of water resources is very high, but there is no reasonable utilization. Many rural irrigation is flood irrigation. The method of flood irrigation uses large amounts of water, but it cannot be fully irrigated, resulting in harvest cannot be guaranteed. Large-scale production of domestic garbage in the village is piled up on free land, garbage, debris and other pollutants. The garbage soaked in rainy days molds, causing the contaminated rainwater to seep into the ground, contaminating some of the groundwater sources and affecting the rural people's health and rural development of society and economy. However, in many areas in the north of China, the drought is low and the groundwater level is low. Rainwater is often not replenished. But in Fan Xiangdian area in the south, the annual rainfall of rainwater is more than 800mm. Rainwater utilization technology can effectively supply water to the South-to-North Water Transfer Project. In some extent, it has solved the problem of drought in the north, saving resources and recycling water resources.

1.1.2 Flood and Drought in Fan Xiangdian

In recent years, after a long period of drought in the plains, sudden downpours have caused small-scale water circulation systems to collapse. In Fan Xiangdian, due to the accumulation of dirt on both sides of the road, rainwater storage was not timely, and a large amount of rainwater could not be drained out to slowly gather in the depression, causing inconvenience to pedestrians. Rainwater could not
penetrate the ground in time, resulting in rapid evaporation of a large amount of surface rainwater and groundwater could not be replenished, causing the groundwater level to drop.

Figure 2. Fan Xiangdian

1.2 Regional Analysis of Fan Xiangdian
Fan Xiangdian is located in the Huaihe River Basin, near the two lakes, Hongze Lake on the west side and Gaoyou Lake on the south side. The annual rainfall is more than 800mm. It is located in Huai'an District, Huai'an City, Jiangsu Province, with a long history and outstanding people. The entire rural village households are distributed in three areas, forming a strip-shaped village situation. It is adjacent to the Beijing-Shanghai Expressway and National Road 233 in the west, 29 kilometers from the urban area, and more than 23 kilometers from Baima Lake. It has an area of 1.95 square kilometers, a residential area of 25,000 square kilometers, a total population of more than 700 people, and more than 2,000 acres of arable land.

Because of the rain in the project village, more aquatic plants and aquatic plants are planted. The vegetable planting area is nearly 500 acres. Many farmers grow a large number of vegetables and fruit trees. It is a village that develops vegetables, fruits. (As shown in Figure 2)

1.3 Goals of Low Impact Development Rainwater Landscape Design in Fan Xiangdian
The design will use most of the rainwater savings of Fan Xiangdian to transform a large area of garbage dumps in the countryside to purify the fundamental problem of polluted water sources. Planting a large number of green crops and aquatic plants can not only form a rural landscape but also increase the income of villagers. Renovation of ditch can facilitate storage of rainwater and irrigation.

2. Design Principles of Fan Xiangdian
In the design, the six principles of rainwater utilization are used, and aquatic plants are used to clean rainwater runoff. Optimize the unreasonable use of water resources in rural areas, control rainwater pollution within a reasonable range, and carry out rural landscape design with less damage to the rural environment.

2.1 Combining Rural Terrain and Optimizing Rainwater Ecology
Make full use of the idle land in Fan Xiangdian Village, and change it to a rainy storage pond. Plant grass, shrubs, and trees around the pond to prevent large amounts of water from evaporating. Runoff flows into the pond, and dogtails are planted around the pond. Utilizing the plant's characteristics of resistance to moisture and drought, it can effectively prevent pollutants and sediments from flowing
into ponds with runoff. The root system of the plant has a function of locking water, which can effectively retain rainwater. Water ponds and other aquatic plants are planted in the ponds to optimize the ecosystem in the ponds and form an effective rainwater ecological cycle system.

Plants around the pond can maintain soil and water loss. Aquatic plants in the pond can effectively reduce water evaporation. Aquatic plants with strong adsorption can absorb harmful substances in rainwater to a certain extent. The large pit is transformed into a pond. The pond plays the role of storing rainwater. The pond can supplement the underground water source and supplement the water resources. Planting green plants around it can purify the water environment and prevent silt accumulation at the bottom of the pond, and build a complete pond biological chain.

2.2 Combining the Use of Storage Ditch into A Branch of Recycled Water

The storage ditch design can form a good induction and regulation function for the circulation of water sources. Improve the road and drainage system of Fan Xiangdian to facilitate the timely drainage of rainwater. Trenches are dug on both sides of the road, and the concave green space is lower than the rural road. The idea is to use artificial diversions to collect rainwater.

The storage ditch stores rainwater in rainy days and forms rainwater runoff around the cultivated land. In this way, it can not only irrigate with rainwater in the runoff every day, but also prevent the dry land problem in three volts days. Reeds, rushes and other aquatic plants are planted on both sides of the storage ditch to solidify the soil and purify the water. It can also be used to raise cattle, sheep and other poultry.

Combined with aquatic plants, it is conducive to the restoration of ecological nature, thereby controlling the problem of rainwater pollution in rural areas. The rainwater resources are converted and reprocessed to achieve short-term and long-term rainwater restoration and treatment. [3-4] The aquatic plants automatically decompose oxygen for the survival of animals and plants. Provide bio-oxygen to organically convert the polluted components of rainwater into various nutrients needed by plants and animals for survival.

Due to economic development, the factory's production and exhaust emissions affect air quality. Rainwater absorbs pollutants and toxic substances in the air, and the storage ditch uses natural sludge and surrounding plants to purify pollutants and microtoxic elements in rainwater to achieve short-term or long-term rainwater pollution repair and treatment, which can ensure water quality. Besides, it can also achieve effective sedimentation of the silt and have a small impact on the surrounding ecological environment. Excess pits can be transformed into ditches for storing rainwater. Trees are planted on both sides to prevent soil erosion and play a role in solidifying soil and regulating water sources. (As shown in Figure 3)

![Figure 3: Savings Gutter](image)

2.3 Using Village Roofs and Collecting Roof Rainwater

Consider the income of rural residents, and the rural roof can collect rainwater to a larger extent. Considering the cleanness of rainwater and roof drainage, suitable climbing vegetables can be planted on the sun-lit surface of the roof, and green plants can be used to purify and buffer the pollutants in rainwater and roof drainage.
Among them, the drainage of the roof is the key to determining the success of the roof landscape. In order to ensure the effective collection of rainwater on the roof, a layer of iron sheet can be laid on the roof to prevent the rainwater collected by the roof from seeping. This can also solve the problem of water leakage in some houses.

The plants around the roof of the residential area should be easy to climb, grow fast, and have good water content, and then combine some residents' favorite to grow some common climbing vegetables. In addition to common roof greening plants, climbing vegetables such as loofah and peas are attached to the wall. The flowers and leaves of this kind of vegetables form a natural green landscape, which saves land, enriches the effect of the façade space, makes the roof rainwater purify, and saves water for vegetable gardening. Roof rainwater collection is mainly used in villagers' buildings. Ecological water utilization structures are used to climb plants to beautify rural landscapes and play a role in purifying rainwater. (As shown in Figure 4)

![Figure 4. Rainwater collection on the roof](image)

2.4 Small Vegetable Garden Combined with Rural Residential Area and Transformation of Landscape Ecological Vegetable Garden
Landscape ecological vegetable garden is an ornamental vegetable garden that uses farmers to plant a variety of vegetables, fruits, and flowers of ornamental value. Use the unused land next to each house of Fan Xiangdian for renovation, considering the economic cost without affecting the environment, and decorating the vegetable garden with vegetables that are often eaten to create a green atmosphere in the vegetable garden. The function of intercepting rainwater, reducing the speed of rainwater runoff, and using the root system of plants to effectively store water and purify rainwater. This will also help alleviate the problems of serious water accumulation and water pollution in low-lying rural areas. The wall of the small vegetable garden can be set with bamboo poles and thin wood to plant climbing plants such as creepers, loofah, etc. These plants have strong drought resistance, easy growth, and high survival rate. They are contrasted with the vegetables in the garden to provide an ecological landscape. The landscape ecological vegetable garden can also attract some beneficial birds and insects, and there are many mosquitoes in the countryside in summer. In this way, the beneficial insects are used to combat pests, naturally against nature, and the use of trace toxins such as pharmaceuticals is reflected, reflecting the ecological chain cycle. The landscape ecological vegetable garden is well-planned, which will help the beneficial insects and birds to reproduce in the vegetable garden and provide a good growth environment for green vegetables. [5]

2.5 Combined Village Courtyard and Remodel APermeable Courtyard
Village permeable courtyards are mainly reconstructed with permeable paving to solve the problem of severe water accumulation in village courtyards. The use of the gaps between the stones in the permeable courtyard is effective for the infiltration of rainwater and solves the problem of inconvenience for the villagers [6]. The permeable paving uses permeable stone to lay geometric
patterns in rural courtyards. It is used with garden fruit trees, vegetables and other plants to create a bright rural landscape.

The permeable courtyard has the function of facilitating the infiltration of rainwater and purifying rainwater in a small area. In some places with large stone gaps, some ground vine and melon crops can be planted, and the limited narrow space can be used to purify rainwater.[7-8]

The scope of use of permeable paving is mainly the front pavement of the villagers and the ground in the courtyard.[9] Laying lawns, pebbles and permeable bricks in accordance with the needs of residents. The use of pebbles and permeable bricks for the placement of landscape sketches enhances the aesthetics of the courtyard. Set up space for debris to prevent debris from infiltrating the rainwater. Because there are many pores in the pervious pavement, the surface area is large, and it has a strong adsorption force for dust, which can reduce the dust pollution.[10-11] the permeable ground can be permeated with Ground Air, making the ground warm in winter and cool in summer, permeable in the rainy season, and melting snow in winter, which can increase the comfort of rural living, so as to build a rural landscape as a whole.

The permeable pavement has more pores and strong penetration ability, and can be applied to various sites in rural residential areas, especially the grounds and walkways of villagers’ courtyards. Walkways are a slow-moving system in rural living environments. Local laying and gravel can promote rainwater seepage and reduce rainwater runoff.

3. Conclusion
The core of the LID concept of rainwater utilization is to reduce rainwater runoff and pollution of rainwater. The application of the design in the rural landscape design is a systematic project, which adopts the measures adapted to local conditions to promote the Seepage, Storage and Purification in the six principles can be used. Through the use of the LID concept of rainwater landscape design, the rural landscape ecology is combined with the water body, the former rural environment has been improved and controlled, the diversity of the rural ecological environment has been restored, and a beautiful living environment has been created for the lives of rural residents.

Acknowledgments
This work was financially supported by Tianjin Suburb Development Investigation and research project (203002/DK0268) fund.

References
[1] Wang Tong. Overview of Low Impact Development Theory Research [J]. Huazhong Architecture, 2013, 31 (12): 29-32.
[2] Yu Liping. Sanya Sponge City Landscape Planning and Design Based on Low Impact Development Concept [J]. Art Education, 2016 (08): 200-201.
[3] Chang Jiang, Chen Yingjie. Study on the parameters of the elevation and depression depth of the recessed green space overflow mouth [J]. Journal of Jiangsu Institute of Architectural Technology, 2017, 17 (01): 20-24.
[4] Zhao Jing. Rural landscape design based on "low-impact development" rainwater utilization: Taking Zhao Huanghaiang as an example [J]. Decoration, 2018 (04): 138-139.
[5] Yang Zhuo, Peng Jiwei. Preliminary Exploration of Urban Shallow Lake Management Technology [J]. Environmental Science and Management, 2016, 41 (07): 105-108.
[6] Xie Jingjing. Application of green rainwater infrastructure in low impact development mode [J]. Resource Conservation and Environmental Protection, 2016 (12): 62.
[7] Liu Yueqin, Lin Xuanquan. Comprehensive design and application of permeable pavement mode in human space——Taking Lujiazui Loop Ecological Pavement Demonstration as an example. Chinese Garden, 2014, 5: 87-92.
[8] Zhao Fei, Zhang Shuhan, Chen Jiangang, Kong Gang, Gong Yingan. Research on rainwater infiltration collection and runoff reduction technology of permeable pavement [J]. Water
Supply and Drainage, 2011, 47 (S1): 254-258.

[9] Kim R H, Lee S, Lee J H, et al. Developing technologies for rainwater utilization in urbanized area [J]. Environmental Technology, 2005, 26 (4): 401-410.

[10] Zhao Xining, Feng Hao, Wu Pute, etc. Research progress and research focus of modern rainwater utilization technology [J]. Journal of Irrigation and Drainage, 2009, 28(04): 1-5.

[11] Yin Lu. Study on rainwater utilization design of urban parks under low impact development [D]. Nanchang: Jiangxi Normal University, 2016