STUDY ON ZHUJI SHADOOF IRRIGATION SYSTEM AND HERITAGE VALUES

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ABSTRACT

Shadoof-well irrigation is one of the oldest type of lift irrigation. The groups of Shadoof irrigation projects located at Zhaojia town, Zhuji city in Zhejiang Province of China are irrigation heritages, which are still in-use. This paper studied on the history, heritage components, engineering characteristics and heritage values of Zhuji Shadoof Irrigation System through field work and literature research. It has been found that the history of two villages the Shadoof irrigation heritage located at could be traced back to 12th century AD when the immigrants of He and Zhao families migrated here. Based on the superior use of groundwater resources by simple Shadoofs and wells, the irrigated agriculture and population gradually developed and villages were built. Shadoof irrigation projects had been widely used in 17th century at latest in Zhaojia by the records of historical documents. It is also showed that ancient people had scientifically realized the mechanism of groundwater cycle and artificially built a dam in the brook to augment groundwater recharge. The paper argues that Zhuji Shadoof Irrigation System with important historical, cultural and technological values is living fossils which witness to history of irrigation civilization, with the suggestion that we should protect this heritage scientifically in view of its better anthropological value more than pragmatic reference for groundwater management for agriculture in the present times.

Keywords: Shadoof, Irrigation, water-lifting machinery, heritage, values.

1. INTRODUCTION

Jiegao, or shadoof is one of the most time-honored water-carrying devices and it was extensively applied in irrigation in ancient Babylon and Egypt before the 15th century B.C. (Joseph Needham, 1999; Chales Singer et al, 2004). The earliest records about Jiegao as a tool for well irrigation are found in the book Zhuang zi written in the 4th century BC. The story told that Zi Gong, a student of Confucius, advised irrigation farmers: "Jiegao is a wooden gadget that is heavy in the back and light in the front and pumps water out of well efficiently ", and "this gadget helps to irrigate 100 pieces of farmland in one day but requires limited workload" (Zhuangzi 300s BC.). It was proved that 2400 years ago, Shadoof irrigation had been used in China. Because of its simple construction and low cost, well-Shadoof irrigation was widely applied during more than two thousand years history in China, especially in the areas rich in groundwater (ZHOU Kuiyi, 2002; GUO Tao, 2013; WANG Jialun, 1990). The Agricultural Book composed by WANG Zhen in Yuan Dynasty also described that at that time Jiegaos (Shadoof) were set in the most farmland nearby water, and shadoof is really universal tool not only ancient time but also “nowadays”. (WANG around 1300). Until the 19th century, this traditional irrigation method existed in many rural areas of China. Since modern times, with rapid development of economy, science and technology in China, traditional water lifting machinery such as Shadoof has been phased out. But...
in Zhaojia Town of Zhejiang Province, Shadoof well irrigation is still practiced by people with special natural and cultural background.

This paper is based on the study of the history, heritage components, engineering characteristics and heritage values of Zhuji Shadoof Irrigation System through field work and literature survey and tried to explore objective reasons leading to its continued use at Zhaojia Town. The study would be a reference of scientific protection and reasonable utilization to Zhuji Shadoof Irrigation System Heritages.

**Figure 1.** Jiegao picture in the book *Tiāngōng Kǎiwù* written in 1637 VS Lifting water from well with Jiegao in Zhaojia Town of Zhuji

The Zhuji Shadoof Irrigation System is located at Quanfan and Zhaojia villages in Zhaojia Town and on the alluvial basin of Huangtan Brook at the foot of the main peak of Zhoumagang of Kuaiji Mountain with an average annual rainfall of 1462mm affected by subtropical monsoon climate (Compilation Committee of Water Conservancy Chronicles in Zhuji County 2007). Huangtan Brook has rapid flows and considerable fluctuation in water level during flood and drought seasons, hence resulting in a low guarantee rate of irrigation. However, the basin mainly contains sandy soils and rich groundwater resources which are buried shallow and replenished rapidly: groundwater are buried at a depth of only 1-3m in the drought period and within 1m in the rainy season. As such, in the last hundreds of years, digging well and carrying water with Jiegao, or shadoof have become a main mode of irrigation for the people of the two villages. Now, the two villages have more than 7700 population and cultivated land area of 5331 mu, with annual per capita income of ¥14572 (2014).

2. **ORIGIN AND HISTORICAL EVOLUTION**

The history of Zhuji Shadoof Irrigation dates back to the Southern Song Dynasty. According to the genealogy, the inhabitants at Zhaojia Town of Zhuji are descendants of migrants from Central China in the 12th century and they primarily belong to two families—the He's and the Zhao's. Their ancestors dug well and carried water for irrigation and agricultural development and hence the births of Quanfan and Zhaojia villages (Genealogy of Zhao’s Family in Lantai, Jiyang. between1875-1908; Genealogy of He’s Family in Tanxi, Jiyang. between1911-1948). Although there is few clear records about the origin and early development of the Shadoof irrigation system here, the result according to the inscriptions and genealogies through the field
investigation shows that Shadoof and well irrigation was already the main irrigation mode of the Zhao’s in the 17th and 18th century at the latest and the ancient people already had a scientific understanding of groundwater circulation.

There is a “Lantai Gushe Stele” engraved in 1809 inside the ancestral temple of the Zhao’s family. The stele states that the Zhaojia Village “prospered with well-ploughed farmlands which had bumper harvests even in years of drought thanks to the unique irrigation mode here” (Lantai Gushe Stele 1809). In the Kangxi years of Qing Dynasty (1662-1722), Yongkang Weir was constructed on Huangtan Brook to store water and increase groundwater supply via infiltration (Notes beyond the genealogy 1895). According to the Zhao’s genealogy, “All households dig wells for rice paddy irrigation in drought seasons. But the wells are also dried if drought persists and the wells won’t be replenished until water flows around. The lands have sandy soils so that water can easily infiltrate underground” (Discussions of ban on Yongkang Weir 1840). It shows that the ancient people already had a scientific understanding of groundwater circulation and a systematic planning of the conservation and mining of groundwater.

Figure 2. The shadoof wells in the core zone of Quanfan Village

There were many Shadoofs and wells in Zhuji historically and their combinations were called “Ao Well” by the local people. Ao Well also refers to the process of well irrigation and water carriage. There used to be more than 8,000 wells in this basin before the 1930s and 3,633 wells in 1985 with an irrigated area of 440 hectares (Compilation Committee of Water Conservancy Chronicles in Zhuji County 1994). However, many wells have been buried in the urbanization process in the past 30 years. Today, the number of Ao Wells in Quanfan Village is the largest: in the core area of well irrigation, there are still 118 ancient wells which irrigate about 27 hectares of farmland (Figure 2). The traditional Ao Well irrigation mode is well preserved till today. Yongkang Weir was flushed away in the middle of the 20th century and thereafter a new river dam was constructed on the upper reaches to restore the historic functions of the project.
3. FEATURES ANALYSIS OF THE HERITAGE

Zhuji Shadoof Irrigation System has its natural and cultural basis. The composition of shadoof well irrigation system, distribution of heritage and irrigation management show the uniqueness of the heritage.

3.1 Components of Zhuji Shadoof Irrigation System

Zhuji Shadoof Irrigation System comprises two parts: one is the river weir located on Huantan Brook, which serves to increase infiltration of surface water and the water-carrying capacity for irrigation; another is field Shadoof well irrigation system, consisting of more than hundred irrigation units.

It is commonly known as “one field, one well” in Zhaojia Town. Each irrigation unit is independent with one ancient well, one Shadoof, one piece of farmland and several field canals for irrigation or drainage. Such field is called “Jishui Field”; “Jishui” meaning “water-lifting”. Each field area is about 1 to 3 mu (1 mu = 0.16 acre), but some fields are up to a dozen mu or even dozens of mu in recent years after integration. A well is normally 2-5m deep and takes the shape of an inverted bell. The diameters of the well mouth and bottom are usually 1-2m and 1.5-2.5m respectively. The well walls are dry-laid with pebble stones and some of the wells in silt field have pinewood supports at the bottom. The exterior circumference of the well walls has broken stones and sand as the reverse filter (Figure 3).

A Jiegao, or shadoof, comprises a pile named Ao Zhuang, a lever named Ao Cheng, a rod named Ao Gan and counterweight stone named Ao Stone. Jiegao is an very ancient Chinese word which explains the composition and characteristics of the machinery by the word itself, likewise the word Ao(拗) means the action lifting water up from the well using Jiegao in Chinese. It was described as “bow under pull, up under loose ” in the book Zhuang zi (Zhuangzi 300s BC.), and as “Jie is the standing, and Gao is the pitching ” in Agriculture Book (WANG around 1300), which additionally quoted the book Shuowen as “Jie is a tie so that fixed, and Gao is a bank so that rotate or means slowly that the pitching could not be fast ” (WANG around 1300). According to the description, Jie(桔) is the pile of the shadoof with the local name Ao Zhuang, and Gao(槔) is the level of the Shadoof with the local name Ao Cheng. Through measuring in Zhaojia Town, the Ao Zhuang is normally 4m tall and made using a pine trunk with diameters of more than 10cm; Ao Cheng is normally 6.5m long and made with large bamboo, witch binds a heavy stone to the thick end that is 2m apart from the tie connected Ao Zhuang and Ao Cheng, simultaneously binds Ao Gan made with thin bamboo normally 5m long to the thin end of Ao Cheng (Figure 3). The tailor-made water-carrying barrel comprises a wooden axle which is connected to the lower end of the pile. To lift water, the operator stands on two bamboo beams or a wooden plate set up at the well opening and push the rod so that the barrel sinks into well water. The use of the lever reduces effort needed to lift a barrel of water. A straw braid is located where the water flows out from the well to protect the barrel from damages. A “rain factory” (a simple hut) is distributed among several wells for shelter from rain, rest and farming tool storage.
3.2 Management characteristic

Zhuji shadoof well irrigation structures and facilities are constructed, maintained and used by farmers themselves. One well is normally owned by a household and a small quantity of them is jointly owned by two to three households. Two wells located nearby each other are called “intercommunity wells” because of the walls of two wells are so close to each other and the groundwater fillers are almost coincident, so that if lifting water from one well, the water level and yield of another will be influenced immediately. The owners of intercommunity wells always lift water with Shadoof by turns such as half a day per family to keep the normal water lifting efficiency. One well owned by several families is called “alternate well” which supplies irrigation water for different fields by turns.

3.3 Irrigation benefits

The ancestors of the He’s and the Zhao’s family migrated to Zhaojia Town in the 12th century and they settled down here, dug wells and carried water for irrigation, developed agricultural and hence the births, gradually formed Quanfan and Zhaojia Villages. Jishui Field could provide a stable harvest and became the economic pillar of local peasant family. According to the record in epitaph of He Xingqi who died between 1875-1908 AD, his family was relatively affluent so that successfully proped up three funeral events and four wedding events during four years’ time just depending on dozen mu field irrigated by Shadoof-well (SI Guoxiang 1905). In fact, most of fields in Zhaojia Town depends on Shadoof-well irrigation for a long time, and there were 6600 mu irrigation area with Shadoof until 1985. However, the irrigation
range and benefits has been decreased by a large margin compared with history. Today, there are still 118 ancient ao wells with an irrigating area of more than 400 mu in the core area of well irrigation in Quanfan Village. The rice paddies have been partly converted into orchards of the more valuable cherries, and agriculture still offer an important role for income of local peasant family.

4. CULTURAL CHARACTERISTIC

In early China, Jiegao (or Shadoof) had a special meaning of Chinese culture. Zhuangzi considered jiegao as a metaphor of human behavioristic principle with the saying: "Didn't you see the Shadoof? It is bow under pull, up under loose. It is the passive one, rather than the active one. So with pitching it would not offend any people." (Zhuangzi 300s BC.) And in another story, when Zigong recommended the utilization of Jiegao for irrigation, it was rejected by the elderly of Chu Kingdom as an opportunist tool (Zhuangzi 300s BC.). However, the residents in the heritage area of Zhuji Shadoof Irrigation System cherish Ao Wells with simple sentiment. Farmers write the words "Operating the shadoof and loving its sufficient irrigation water as a timely rain" to show their love with the heritage. There is a ballad that tells the characteristics of well irrigation and the character of farmers in villages of Zhaojia Town, with the words "The resident of Quanfan with surname of He and Zhao has hard head tipped on the neck. With one well in each field, three hundred barrels of water is lifted every day, and goes back to quondam hole in the night". Ao well has been also written into local traditional drama Miss. Jiujin as a cultural symbol. All of these reveal the deep historical and cultural foundation of Zhuji Shadoof Irrigation System.

5. HERITAGE VALUE ANALYSIS

The Irrigation System of Zhuji is a living fossil of the ancient water-carrying device of Shadoof, and its unique historical value, scientific and technological value and cultural value should be realized.

6. HISTORICAL VALUE

Through thousands of years, water-carrying and irrigation devices have developed along with the human civilization from Jiegao (shadoof) and Lulu at the early stage of human civilization, to various types of watermills and then to the fossil-powered or electricity-powered water pumps after the industrial revolution. As the most time-honored water-carrying device, Jiegao has a special position in the human history of irrigation civilization. As a unique water-carrying and irrigation mode, the Zhuji well irrigation project and Jiegao have been well preserved till today. It is a living fossil that provides irrigation benefits and witnesses the ancient irrigation civilization and culture. It is a historical witness of sustainable support of irrigation to regional development in agricultural society, besides a witness of regional development of society, economic and culture.

7. SCIENTIFIC AND TECHNOLOGICAL VALUE

Zhuji Shadoof Irrigation System make full use of regional natural conditions and played a full irrigation efficiency with the most simple type of ancient works. The ancestors of the villagers had realized the mechanism of groundwater circulation scientifically and an artificial weir was constructed on Huangtan Brook to store water and increase groundwater supply via infiltration in about 200 years ago. Rational arrangement of well group make every field in different level enjoyed irrigation water. The ownership and right of use of every shadoof irrigation facility are identified with the field, besides the equitable distribution of groundwater resources and reasonable
coordination mechanism of lifting work from the same well or same groundwater between different families through village regulation and agreement, the water dispute was eliminated to a great extent.

8. **CULTURAL VALUE**

Jiegao bears a special meaning of Chinese traditional culture and philosophy. Ao well culture with strong regional characteristic was derived through fused with Yue culture in the evolution process of Zhuji Shadoof Irrigation System. It is reflected in local residents’ life, and appears in local ballad or drama as a cultural element. Additionally, residents of Zhaojia Town highly identify ao well culture with deep sense of pride.

**CONCLUSIONS**

This paper studied on the history, heritage components, engineering characteristics and heritage values of Zhuji Shadoof Irrigation System through field work and literature research based on the view of irrigation heritage. We can draw some conclusions as follows.

Firstly, the construction of Zhuji Shadoof Irrigation System and continuous utilization in Zhaojia Town base on its unique natural conditions. The landscape of basin, geological condition of overlaying sandy loam on the bed rock, abundant rainfall and copious groundwater circulation created the objective basis for shadoof well irrigation. Huangtan Brook has rapid flows and considerable fluctuation in water level during flood and drought seasons, hence with low irrigation potential. So, in the relatively closed small basin and simple technology and social economy in the ancient times, traditional shadoof well irrigation almost became the inevitable choice for agriculture development of Zhaojia Town.

Secondly, despite rapid development of economy in China, the ancient Shadoof well irrigation is still retained and utilized in Zhaojia Town. The reasons are: (1) under the special natural background the rich groundwater of high quality is preference for small-scale agriculture irrigation; (2) local residents tend to continue to use shadoof irrigation facility with historical inertia due to its simple construction, low cost and easy to use; (3) shadoof irrigation with manpower could meet the demand of the small area of each field, so that famers lack of driving force to erect a cable for pumping water from the well with extra cost; (4) the local villagers have profound cultural identity to shadoof well irrigation which has been part of their agricultural lives, additionally local government also pay attention to the heritage in recent years.

Thirdly, Zhuji Shadoof Irrigation System is a living fossil of the earlier irrigation civilization with unique historical value, scientific and technological value and cultural value. As one of the oldest irrigation style shadoof-well irrigation still retained and in-use at Zhaojia Town of Zhuji County is such valuable and rare. It is a historical witness of origin and spread of irrigation civilization, besides a witness of social history including immigrant of He’s and Zhao’s families, and regional development of agriculture, population and culture. There has research value in the environmental suitability of irrigation type, scientific planning and design of the well distribution and structure, simple and efficient management, and even the cognition and utilization of mechanism of groundwater circulation by the ancient people. Jiegao bears a special meaning of Chinese traditional culture and philosophy in the history, and now Ao well culture with strong regional characteristic has derived in the evolution process of Zhuji Shadoof Irrigation System.
Fourthly, the existence and continuation of Zhuji Shadoof Irrigation System is facing challenges of modern development including rapid urbanization which has led to shrinking farmlands and the low agricultural income for farmers which has weakened their positivity of agricultural work. Zhuji Shadoof Irrigation System was approved to include in the World List of ICID Heritage Irrigation Structure. In consideration of the unique and outstanding heritage values, we suggest the local government to protect the living fossil through specialized planning which will consider the heritage protection with new rural construction, transformation and upgrading of agriculture economy and development of cultural industry as a whole, and this planning should be scientific and multi-party participation with the same purpose of promoting the protection and sustainable development of the irrigation heritage.

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